Report No.: 8003-093
Rev. No.: 2

FINAL DRAFT
MIDDLESEX SAMPLING PLANT
FEDERAL FACILITY SI REVIEW
DOCUMENTATION PACKAGE
PREPARED UNDER

WORK ASSIGNMENT NO. 019-2JZZ
CONTRACT NO. 68-W9-0051

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VOLUME 1 OF 8

SUBMITTED BY:

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216216

FEDERAL FACILITY SITE SI REVIEW FORM

EPA REGION II

Federal Facility Name: Middlesex Sampling Plant (MSP)

Aliases: _____

EPA ID: NJ0890090012

Address: 239 Mountain Avenue

City: Middlesex

County: Middlesex

State: New Jersey

1. Provide the name of document(s) reviewed and organization responsible for its preparation.

   Prepared for the United States Department of Energy (DOE) by Bechtel National, Inc. for the United States Environmental Protection Agency (EPA), Preliminary Assessment Scoresheets and Site Inspection Report, March 1992.

2. HRS Score or Priority given by the federal facility: Further Action Needed

   Check one

X	Agree	(Go to line 7)
	Disagree	(Go to line 3)
	No priority given	(Go to line 4)

3. If disagree, why?

4. Is information adequate to provide a recommendation?

   X Yes (Go to line 6) _____ No (Go to line 5)

5. If information is not adequate, check the type of information needed to complete the PA/SI review, then go to line 7.

_____	Waste source type(s)	_____	Site Slope
_____	Containment	_____	Topography
_____	Physical state of waste	_____	Surface water uses
_____	Hazardous constituents	_____	Location of sensitive environments
_____	Aquifer description	_____	¼ - mile radius population
_____	Site geology	_____	½ - mile radius population
_____	Groundwater uses	_____	1 - mile radius population
_____	Groundwater populations	_____	2 - mile radius population
_____	Water supply well locations	_____	3 - mile radius population
_____	Surface water intakes	_____	4 - mile radius population
_____	Private well locations	_____	Wellhead protection area
_____	Onsite workers	_____	Surface water population
_____	Site sampling	_____	Schools, day care centers

Note that the information aforementioned is, but not limited to, the type of data required to complete an evaluation of the site.

6. Is there sufficient environmental sampling data to support the migration assessment and to evaluate any potential imminent health threats?

   __X__ Yes

   _____ No

7. Recommendation: **Higher Priority for Further Action**

8. Comments (if any): provide the rationale for the recommendation.

The groundwater migration and soil exposure pathways are of primary concern at the MSP site. Groundwater samples collected during the environmental monitoring program indicate the presence of radiological constituents including uranium, as total uranium, (230.2 pCi/L), radium - 226 (1.7 pCi/L). The total population served by groundwater within a four mile vicinity of the site is 11,039 (0-0.25 mi, 0; 0.25-0.5 mi, 0; 0.5-1 mi, 0; 1-2 mi, 1,162; 2-3 mi, 6,972; 3-4 mi, 2,905). Waste Unit No. 2 exceeds the regulatory limit for Toxicity Characteristic Leaching Procedure (TCLP) for lead. However, a lack of any background samples prevents the characterization of the pile in terms of non-radiological constituents.

Access to the MSP site is limited by a fence along the site's property and nine private residences are located on or within two hundred feet of observed contamination associated with the MSP site. In addition, external gamma radiation measurements indicate higher than background conditions for the soil exposure pathway at a level of 157 mR/yr. The Vicinity Property Pile (Waste Unit No. 1) consists of the contaminated soil which was excavated and placed into a pile on the MSP site as a result of a two phased remedial action on the properties in the MSP site vicinity. The contamination of these vicinity properties was due to MSP's operations. The Phase I and II Remedial Actions do not constitute qualified removal actions, as defined by the *"Revised Hazard Ranking System: Evaluating Site's After Waste Removals"*, October 1991, since the MSP Site is not a Nuclear Regulatory Commission (NRC)-permitted disposal facility. As a result, the abovementioned removal actions were classified as unqualified causing several of the vicinity properties to the site to be identified as waste sources (Waste Unit Nos. 3-8). The presence of the radiological waste (contaminated soil) on these vicinity occupied residential properties, leads to Level I and Level II populations for the Residential Population Threat of the Soil Exposure Pathway.

SITE SUMMARY

The Middlesex Sampling Plant (MSP) is situated on approximately 9.6 acres in Middlesex, Middlesex County, New Jersey. The MSP property includes four buildings and two storage piles that are comprised of 66,372 cubic yards (yd^3) of radioactive waste and are currently being used for interim storage of contaminated soil. The site is entirely fenced and public access is restricted. MSP is part of the Formerly Utilized Sites Remedial Action Program (FUSRAP), a DOE program to decontaminate or otherwise control sites where residual radioactive materials remain from the early years of the nation's atomic energy program or from commercial operations causing conditions that Congress has authorized the DOE to remedy.

The MSP facility was established in 1943 by the Manhattan Engineer District (MED) to sample, store, and/or ship uranium, thorium, and beryllium ores. In 1955, the Atomic Energy Commission (AEC), successor to MED, terminated the operation and later used the site for storage and limited sampling of thorium residues. In 1967, AEC activities ceased, on-site structures were decontaminated, and the site was certified for unrestricted use under applicable criteria current at that time.

Between 1968 and 1980, the site ownership changed, first to the General Services Administration, and then to the Department of the Navy for use as a U.S. Marine Corps reserve training center. In 1980, custody of MSP was returned to the Department of Energy (DOE). From 1976 to 1980, many radiological surveys were conducted in the Middlesex area to determine the extent of radiological contamination which may have occurred as a result of MSP activities. Additionally, these radiological surveys identified areas of contamination which resulted in a Middlesex Remedial Action Program (MRAP) being developed. This program was designed to consist of three phases of remediation. Phase I was to provide for the construction of storage pads and a drainage system at the MSP site, followed by the decontamination of five nearby offsite properties. Phase II Remedial Action consists of the decontamination of the remaining properties adjoining the MSP site. Phase III Remedial Action comprises the decontamination and decommissioning of the MSP site. Presently the first two phases of the MRAP have been completed. However, the Phase I and II Remedial Actions do not constitute qualified removal actions, as defined by the

"Revised Hazard Ranking System: Evaluating Site's After Waste Removals", October 1991, since the MSP Site is not a Nuclear Regulatory Commission (NRC)-permitted disposal facility. As a result, the abovementioned removal actions were classified as unqualified causing several of the vicinity properties to the site to be identified as waste sources (Waste Unit Nos. 3-8).

The Middlesex Municipal Landfill (MML), a vicinity property to the MSP site, was established in the mid-1940's and subsequently began to receive soil contaminated with pitchblende (high-grade uranium ore) in 1948, which resulted in contaminated soil being placed over existing fill at MML. By 1974, solid waste disposal ceased at MML. Early radiological surveys indicated that 0.5 acre of MML required remediation; in 1984, approximately 16,000 yd^3 of contaminated soil was returned to MSP for interim storage. Later investigations showed the contaminated area to be 3.0 acres. By 1986, remediation at MML was considered complete with an additional 31,200 yd^3 of contaminated soil returned to MSP for interim storage. In 1987, MML was turned over to the Borough of Middlesex.

An annual environmental monitoring program was established at MSP in 1980 by the DOE under the FUSRAP program. This monitoring program functions to characterize the effects of site operations on human health and the environment, confirm adherence to DOE environmental protection policies; and to ensure compliance with legal and regulatory requirements imposed by federal, state, and local agencies. During this monitoring program, both radiological and non-radiological samples were collected from the MSP site's groundwater and surface water/sediments. Radiological samples were also collected from the air (as radon) and soil (as external gamma) on-site.

The residential population within four miles of the site relies on surface water and groundwater sources for potable water. The Elizabethtown Water Company supplies residents with potable water from an intake that is not located along the surface water pathway. There are nineteen municipal drinking water wells located within four miles of MSP, with the closest active well located approximately two miles west of the site. Surface water runoff from MSP flows generally in a southerly direction and is drained through an engineered

system to a drainage ditch south of the site. This drainage ditch discharges to a creek named Main Stream before emptying into Ambrose Brook. The Ambrose Brook joins with the Green Brook, which then flows into the Raritan River.

The groundwater migration and soil exposure pathways are of primary concern at the Middlesex Sampling Plant site. Groundwater samples collected during the environmental monitoring program indicate the presence of radiological constituents including uranium, as total uranium (230.2 pCi/L), radium - 226 (1.7 pCi/L). However, the majority of the drinking water supply in the site's four mile vicinity is obtained from a surface water intake which is not located along the site's surface water pathway. Radiological constituents including uranium, as total uranium, (5.4 pCi/g), radium-226 (3 pCi/g), and thorium-232 (3 pCi/g) were detected in the surface waters/sediments after analysis of both surface water and sediment samples along the surface water pathway. Although a release to the surface water pathway is indicated, there is no information available to substantiate actual contamination of a fishery or intake. In addition, external gamma radiation measurements indicate higher than ambient conditions for the soil exposure pathway at a level of 157 mR/yr. Access to the MSP site is limited by a fence along the site's property and there are private residences located within two hundred feet of the MSP site. However, affected vicinity residential properties were decontaminated in accordance with Department of Energy guidelines. Analytical results of the radon measurements for the air pathway did not indicate the presence of radon at levels above background conditions.

SITE ASSESSMENT REPORT: SITE INSPECTION

PART I: SITE INFORMATION

1. Site Name/Alias Middlesex Sampling Plant

   Street 239 Mountain Avenue

   City Middlesex State NJ Zip 08846

2. County Middlesex County Code 023 Cong.Dist. 7

3. CERCLIS ID NO. NJ0890090012

4. Block No. _____ Lot No. _____

5. Latitude 40°33'43"N Longitude 74°29'32"W

   USGS Quad. Plainfield, New Jersey Quadrangle

6. Approximate size of site 9.6 acres

7. Owner Dept. of Energy, OR operations Telephone No. 615-576-0948

   Street P. O. Box 2001

   City Oak Ridge State TN Zip 37831

8. Operator DOE Telephone No. 609-538-6677

   Street _____

   City _____ State _____ Zip _____

9. Type of Ownership

   ___ Private X Federal ___ State

   ___ County ___ Municipal ___ Unknown ___ Other _____

10. Owner/Operator Notification on File

    ___ RCRA 3001 ___ Date ___ CERCLA 103c Date _____

    X None ___ Unknown

11. Permit Information

Permit	Permit No.	Date Issued	Expiration Date	Comments
Unknown				

12. Site Status

___ Active X Inactive ___ Unknown

13. Years of Operation: 1943 to 1967

14. Identify the types of waste sources (e.g., landfill, surface impoundment, piles, stained soil, above- or below-ground tanks or containers, land treatment, etc.) on site. Initiate as many waste unit numbers as needed to identify all waste sources on site.

(a) Waste Sources

Waste Unit No.	Waste Source Type	Facility Name for Unit
1	Contaminated Soil Pile	Vicinity Property Pile
2	Contaminated Soil Pile	Middlesex Municipal Landfill (MML) Pile
3	Contaminated Soil	432 Williams Street
4	Contaminated Soil	312 Mountain Ave.
5	Contaminated Soil	650 Harris Ave.
6	Contaminated Soil	233 Mountain Ave
7	Contaminated Soil	223 Mountain Ave.
8	Contaminated Soil	217 Mountain Ave.

(b) Other Areas of Concern

Identify any miscellaneous spills, dumping, etc. on site; describe the materials and identify their locations on site.

Elevated levels of inorganic constituents were reported in waste unit nos. 1 and 2. However, the lack of a background sample prevents them from being characterized.

Ref. No. 18, p. 27

15. Information available from

Contact Joseph Hudek Agency U.S. EPA Telephone No.: (908) 321-6713
Preparer David Kahlenberg Agency MALCOLM PIRNIE, INC. Date: September 30, 1992

PART II: WASTE SOURCE INFORMATION

For each of the waste units identified in Part I, complete the following items.

Waste Unit 1 - Vicinity Property Pile

Source Type

_____	Landfill	_____	Contaminated Soil
_____	Surface Impoundment	X	Pile
_____	Drums	_____	Land Treatment
_____	Tanks/Containers	_____	Other (leaking pipelines)

Description:

In 1980, DOE initiated remedial action to clean up properties in the vicinity of MSP, with the cleanup continuing in 1981. Contaminated soil from this remedial action was transported to MSP where an asphalt pad was constructed as a base for an interim storage pile. The pile is enclosed with concrete curbing to prevent migration of the stored materials. Synthetic geomembrane fabric is attached to the curbing to cover the stored materials.

Hazardous Waste Quantity

Approximately 25,793 yd^3 of material was placed into the pile, which is approximately 93,969 ft^2 in size, is the result of the Phase I and II Remedial Actions. It should be noted that the previously cited volume represents the volume based upon non-qualified removal actions as described in reference number 20.

Hazardous Substances/Physical State

The pile consists primarily of soil contaminated with uranium-238 (16.52 pCi/g), radium-226 (10.2 pCi/g), and thorium-232 (1.0 pCi/g). It should be noted that the abovementioned levels are concentrations minus background. The physical state in which these substances are deposited as is solid.

Ref. Nos. 12, pp. 9, 13, 75-76; 18, pp. iii - iv; 20; 21

PART II: WASTE SOURCE INFORMATION

For each of the waste units identified in Part I, complete the following items.

Waste Unit 2 - Middlesex Municipal Landfill (MML) Pile

Source Type

_____	Landfill	_____	Contaminated Soil
_____	Surface Impoundment	X	Pile
_____	Drums	_____	Land Treatment
_____	Tanks/Containers	_____	Other

Description:

MML, a vicinity property established in the 1940s, began to receive contaminated soil in 1948, which resulted in contaminated soil being placed over the existing fill at MML. By 1974, solid waste disposal ceased at MML. Early radiological surveys indicated MML required remediation and contaminated soil was returned to MSP for interim storage in 1984. Later investigations showed additional contamination and by 1986, remediation at MML was considered complete. The MML Pile is constructed similarly to the Vicinity Property Pile (Waste Unit No. 1).

Hazardous Waste Quantity

The MML pile contains approximately 31,200 yd^3 of contaminated soil and is approximately 69,659 ft^2 in size.

Hazardous Substances/Physical State

The pile contains primarily soil contaminated with pitchblende, a high-grade uranium ore. In addition uranium-238 (17.72 pCi/g), radium-226 (17.8 pCi/g), and thorium-232 (0.9 pCi/g) have been detected. It should be noted that the abovementioned levels are concentrations minus background. The physical state in which these substances are deposited as is solid.

Ref. Nos. 12, pp. 9, 14; 18, pp. iii - iv, 7-8; 21

PART II: WASTE SOURCE INFORMATION

For each of the waste units identified in Part I, complete the following items.

Waste Unit 3 - 432 Williams Street

Source Type

	Landfill	X	Contaminated Soil
	Surface Impoundment		Pile
	Drums		Land Treatment
	Tanks/Containers		Other

Description:

A radiological survey of the vicinity properties to the MSP site identified elevated levels of radiological constituents at this property. The origins of these constituents on the residential property arose when a previous owner of the property used soil from the MSP site as fill dirt in the yard at this residence. As part of the MSP Phase I Remedial Action, contaminated soil was excavated from this property and placed into the MSP Vicinity Property Pile (Waste Unit No. 1).

Hazardous Waste Quantity

Approximately 1,780 yd^3 of contaminated soil was excavated from this property during the Phase I remedial action. Radiological concentrations detected during a 1981 survey of this property indicated radium-226 and uranium-238 levels of 4,498.1 pCi/g and 5,798.22 pCi/g, respectively. The average radium-226 concentration of contaminated soil detected at the property during the Phase I Remedial Action was 54.25 pCi/g and the maximum concentration detected on the property was 171.1 pCi/g. It should be noted that the abovementioned levels are concentrations minus background.

Hazardous Substances/Physical State

The contaminated soil consists primarily of radium-226 and uranium-238. The physical state in which these substances were deposited as is solid.

Ref. Nos. 20; 21; 23, pp. 49-60; 24, pp. 2-6, 3-11, 4-4, 6-17, 6-36, 6-41, 6-46, A14 - A20; 25, pp. 122-137

PART II: WASTE SOURCE INFORMATION

For each of the waste units identified in Part I, complete the following items.

Waste Unit 4 - 312 Mountain Ave.

Source Type

_____	Landfill	X	Contaminated Soil
_____	Surface Impoundment	_____	Pile
_____	Drums	_____	Land Treatment
_____	Tanks/Containers	_____	Other

Description:

A radiological survey of the vicinity properties to the MSP site identified elevated levels of radiological constituents at this property. As part of the MSP Phase I Remedial Action, contaminated soil was excavated from this property and placed into the MSP Vicinity Property Pile (Waste Unit No. 1).

Hazardous Waste Quantity

Approximately 190 yd^3 of contaminated soil was excavated from this property during the Phase I remedial action. The average radium-226 concentration of contaminated soil detected at the property during the Phase I Remedial Action was 3.36 pCi/g and the maximum concentration detected on the property was 6.1 pCi/g. It should be noted that the abovementioned levels are concentrations minus background.

Hazardous Substances/Physical State

The contaminated soil consists primarily of radium-226. The physical state in which these substances were deposited is solid.

Ref. Nos. 20; 21; 24, pp. 3-2, 3-13, 4-3, 4-4, 6-38, 6-43, 6-48, A-22 - A23

PART II: WASTE SOURCE INFORMATION

For each of the waste units identified in Part I, complete the following items.

Waste Unit 5 - 650 Harris Ave.

Source Type

_____	Landfill	X	Contaminated Soil
_____	Surface Impoundment	_____	Pile
_____	Drums	_____	Land Treatment
_____	Tanks/Containers	_____	Other

Description:

A radiological survey of the vicinity properties to the MSP site identified elevated levels of radiological constituents at this property. The origins of these constituents on this property arose when used soil from the MSP site was used as fill dirt in the yard at this property. As part of the MSP Phase I Remedial Action, contaminated soil was excavated from this property and placed into the MSP Vicinity Property Pile (Waste Unit No. 1).

Hazardous Waste Quantity

Approximately 5,943 yd^3 of contaminated soil was excavated from this property during the Phase I remedial action. Radiological concentrations detected during a 1981 survey of this property indicated radium-226 and uranium-238 levels of 868.9 pCi/g and 1,198.22 pCi/g, respectively. The average radium-226 concentration of contaminated soil detected at the property during the Phase I Remedial Action was 35.88 pCi/g and the maximum concentration detected on the property was 128.6 pCi/g.

Hazardous Substances/Physical State

The contaminated soil consists primarily of radium-226 and uranium-238. It should be noted that the abovementioned levels are concentrations minus background. The physical state in which these substances were deposited is solid.

Ref. Nos. 20; 21; 23, pp. 3-38; 24, pp. 2-6, 3-10, 4-4, 6-16, 6-34 - 6-34A, 6-39, 6-45, 6-49, A-8 - A-9, A-11 - A-13, A-19 - A-20; 25, pp. 138-152

PART II: WASTE SOURCE INFORMATION

For each of the waste units identified in Part I, complete the following items.

Waste Unit 6 - 233 Mountain Ave

Source Type

_____	Landfill	X	Contaminated Soil
_____	Surface Impoundment	_____	Pile
_____	Drums	_____	Land Treatment
_____	Tanks/Containers	_____	Other

Description:

A radiological survey of the vicinity properties to the MSP site identified elevated levels of radiological constituents at this property. As part of the MSP Phase II Remedial Action, contaminated soil was excavated from this property and placed into the MSP Vicinity Property Pile (Waste Unit No. 1).

Hazardous Waste Quantity

Approximately 802 yd^3 of contaminated soil was excavated from this property during the Phase II Remedial Action. The average radium-226 and uranium, concentration of contaminated soil detected at the property during a radiological survey was 12.7 pCi/g and 48.1 ppm, respectively.

Hazardous Substances/Physical State

The contaminated soil consists primarily of radium-226 and uranium. It should be noted that the abovementioned levels are concentrations minus background. The physical state in which these substances were deposited is solid.

Ref. Nos. 20-21; 22, pp. 15-16, 46, 51, 62, 66, 80; 25, pp. 9 - 27; 26, pp. 39, 86; 27, pp. 12-25

PART II: WASTE SOURCE INFORMATION

For each of the waste units identified in Part I, complete the following items.

Waste Unit 7 - 223 Mountain Ave.

Source Type

_____	Landfill	X	Contaminated Soil
_____	Surface Impoundment	_____	Pile
_____	Drums	_____	Land Treatment
_____	Tanks/Containers	_____	Other

Description:

A radiological survey of the vicinity properties to the MSP site identified elevated levels of radiological constituents at this property. As part of the MSP Phase II Remedial Action, contaminated soil was excavated from this property and placed into the MSP Vicinity Property Pile (Waste Unit No. 1).

Hazardous Waste Quantity

Approximately 410 yd^3 of contaminated soil was excavated from this property during the Phase II Remedial Action. The average radium-226 concentration of contaminated soil detected at the property during a radiological survey was 11.6 pCi/g.

Hazardous Substances/Physical State

The contaminated soil consists primarily of radium-226. It should be noted that the abovementioned levels are concentrations minus background. The physical state in which these substances were deposited is solid.

Ref. Nos. 20-21; 22, pp. 15-16, 46, 51, 66, 80; 25, pp. 27 - 44; 26, pp. 39, 86; 27, pp. 26 - 35

PART II: WASTE SOURCE INFORMATION

For each of the waste units identified in Part I, complete the following items.

Waste Unit 8 - 217 Mountain Ave.

Source Type

_____	Landfill	X	Contaminated Soil
_____	Surface Impoundment	_____	Pile
_____	Drums	_____	Land Treatment
_____	Tanks/Containers	_____	Other

Description:

A radiological survey of the vicinity properties to the MSP site identified elevated levels of radiological constituents at this property. As part of the MSP Phase II Remedial Action, contaminated soil was excavated from this property and placed into the MSP Vicinity Property Waste Pile (Waste Unit No. 1).

Hazardous Waste Quantity

Approximately 254 yd^3 of contaminated soil was excavated from this property during the Phase II Remedial Action. The average radium-226, thorium-230, and uranium concentrations of contaminated soil detected at the property during a radiological survey were 62.4 pCi/g, 4.1 pCi/g, and 126 ppm, respectively.

Hazardous Substances/Physical State

The contaminated soil consists primarily radium-226, thorium-230, and uranium. It should be noted that the abovementioned levels are concentrations minus background. The physical state in which these substances were deposited is solid.

Ref. Nos. 20-21; 22, pp. 15-16, 46, 51, 62-63, 66, 80; 25, pp. 45-64, 26, pp. 39, 86; 27, pp. 44 - 51

PART III. EXISTING ANALYTICAL DATA

Bechtel National, Inc. (BNI), as part of FUSRAP, conducted a radiological survey of MSP in November 1977. This survey included the measurement of residual alpha and beta-gamma contamination levels, radon and radon daughter concentrations in buildings, external gamma radiation levels both on and off-site, and radium concentrations in soil both on and off-site. As a result of this survey it was determined that elevated levels of radiological constituents existed in areas both on the MSP property and on nearby properties including the identification of waste unit nos. 6-8 (Ref. No. 22, pp. 1, 15-16, 21, 46, 51, 62-63, 66, 80).

In June 1978, Oak Ridge National Laboratory (ORNL) conducted a radiological survey on properties, previously identified to be radiologically contaminated, in the vicinity of the MSP site. The purpose of these surveys was to determine the extent of radiological contamination on the properties. The primary radiological measurements included external gamma radiation levels and radionuclide concentrations in soils. As a result of these surveys it was determined that elevated levels of radiological constituents existed on vicinity properties to the MSP site identifying waste unit nos. 3 and 5 (Ref. No. 23, pp. 2-38, 49-60).

As a result of the past radiological surveys, a Middlesex Remedial Action Program (MRAP) was developed. This program was designed to consist of three phases of remediation. Phase I was to provide for the construction of storage pads and a drainage system at the MSP site, followed by the decontamination of five nearby offsite properties. Phase II Remedial Action consists of the decontamination of the remaining properties adjoining the MSP site. Phase III comprises the decontamination and decommissioning of the MSP site (Ref. No. 24, p. 3-1). The remedial action criteria which was established for radium-226 concentration in soils, following decontamination, was not to exceed 5 pCi/g (Ref. No. 24, pp. 6-30 - 6-31). Confirmation that these levels were achieved was accomplished through soil samples/analyses which were collected in a grid system throughout each area of interest (Ref. No. 24, pp. 6-33a, 6-44). Presently the first two phases of the MRAP have been completed (Ref. Nos. 24; 26-27). The Phase I Remedial Action activities included the compilation of pre-remedial contaminant levels, excavated volume of contaminated soil, and post-remedial contaminant levels. These levels were measured through radium-226 surface soil samples and external gamma measurements (Ref. No. 24, pp. 3-10 - 3-14, 4-4, 6-30 - 6-44). The Phase II Remedial Action activities included the compilation of excavated volumes of contaminated soil, and post-remedial contaminant levels. These levels were also measured through radium-226 surface soil samples and external gamma measurements (Ref. Nos. 26; 27). As a result of these surveys it was determined that elevated levels of radiological constituents existed on vicinity properties to the MSP site identifying waste unit nos. 3-8.

Characterization of the two interim storage piles at MSP was conducted in 1990-1991, by BNI, to determine whether the piles contain hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA) and to determine the average radionuclide concentrations present in the piles. This characterization was completed by taking both surface and subsurface soil samples from the piles. Analytical results of the samples collected from the Vicinity Property pile (VP) indicated average concentrations of uranium-238 (16.52 pCi/g), radium-226 (10.2 pCi/g), and thorium-232 (1.0 pCi/g). Samples collected from the MML pile indicated average concentrations of uranium-238 (17.72 pCi/g), radium-226 (17.8 pCi/g), and thorium-232 (0.9 pCi/g) have been detected. It should be noted that the abovementioned levels are concentrations minus background. Chemical analysis of the VP pile indicated that the pile does not exceed regulatory limits that define RCRA-hazardous waste. Analytical results of soil samples from the MML pile indicate that the pile exceeds the regulatory limit for Toxicity Characteristic Leaching Procedure (TCLP) lead. (Ref. Nos. 18, pp. iii-iv, 9-19; 21)

BNI, as part of the FUSRAP also performs annual environmental monitoring at MSP. During the 1990 monitoring, both radiological and non-radiological samples are collected from the site's groundwater and surface water/sediments. Radiological samples are also collected from the air (as radon) and the soil (as external gamma) on site. All non-radiological samples were analyzed by a Contract Laboratory Program (CLP) certified laboratory in accordance with CLP protocols. All radioanalyses were performed by a laboratory which participates in the collaborative testing and interlaboratory comparison program with the US Environmental Protection Agency (EPA); the Quality Assurance (QA) program was in accordance with the Department of Energy (DOE) Order 5700.6B. Analytical results indicate the presence of uranium, as total uranium (230.2 pCi/L), radium-226 (1.7 pCi/L) based on the groundwater samples collected from on-site monitoring wells. Surface water and sediment samples collected from the Main Stream indicate the presence of uranium, as total uranium (5.4 pCi/g, 2 pCi/l), radium-226 (3 pCi/g), and thorium-232 (3 pCi/g). In addition, external gamma radiation measurements indicate higher than ambient conditions for the soil exposure pathway at a level of 157 mR/yr. Analytical results of the radon measurements for the air pathway did not indicate the presence of radon at levels above background conditions. (Ref. Nos. 12, pp. 194 - 195; 13, p. A-4; 14, pp. 26 - 57, 64 - 91, 107 - 111)

PART IV. HAZARD ASSESSMENT

GROUNDWATER ROUTE

1. **Describe the likelihood of a release of contaminant(s) to the groundwater as follows: observed release, suspected release, or none. Identify contaminants detected or suspected and provide a rationale for attributing them to the site. For observed release, define the supporting analytical evidence.**

   There is an observed release to the groundwater beneath this site. Contaminants detected in groundwater samples collected from on-site monitoring wells include radium-226 (1.7 pCi/L), uranium, as total uranium (230.2 pCi/L), and thorium-232 (0.3 pCi/L).

   Ref. Nos. 12, p. 21; 14, pp. 48 - 57, 78 - 91

2. **Describe the aquifer of concern; include information such as depth, thickness, geologic composition, areas of karst terrain, permeability, overlying strata, confining layers, interconnections, discontinuities, depth to water table, groundwater flow direction.**

   The soils at the MSP site represent weathered bedrock and fill material composed primarily of unconsolidated silty to sandy loams. The depth of this layer ranges in thickness from 1.5 to 8 feet and has a low to moderate permeability. Material underlying the site soils consists of Red Shale of the Brunswick Formation interbedded with siltstone and occasional layers of sandstone. The Brunswick Formation is relatively impermeable and its thickness under MSP has not been delineated, however regionally the unit can be greater than 5,000 feet thick. The depth of the groundwater table in the upper aquifer ranges from depths of 2 to 10 feet with flow to the south. The depth to the groundwater in the Brunswick Formation ranges from depths of 8 to 30 feet below the ground surface. The directional flow of the groundwater in the lower aquifer under MSP tends towards the south to southeast (under north end of site) and to the north to northeast (under the south end of the property). Regionally the Brunswick Formation is an important source of groundwater for both industrial and drinking water purposes.

   Ref Nos. 12, pp. 23 - 24; 14, pp. 92 - 93

3. **What is the depth from the lowest point of waste disposal/storage to the highest seasonal level of the saturated zone of the aquifer of concern?**

   The highest recorded levels in 1990 for groundwater in the Brunswick Shale aquifer under the MSP piles occurred in well MSP 4A. The water level was 46.25 feet above mean sea level. This corresponds to an elevation that is approximately 4 feet below the lowest elevation of the ground surface prior to construction of the storage piles at MSP.

   Ref. Nos. 12, p. 28; 14, p. E-4

4. **What is the distance to and depth of the nearest well that is currently used for drinking purposes?**

   The nearest active wells currently used for drinking water purposes are two wells owned by the Elizabethtown Water Company in Bound Brook, New Jersey; they are the Mountain Station wells 1 and 2 which are located approximately 2 miles west of the site and have depths of 366 and 404 feet, respectively.

   Ref. Nos. 2; 10

5. **If a release to groundwater is observed or suspected, determine the number of people that obtain drinking water from wells that are documented or suspected to be located within the contamination boundary of the release.**

There is an observed release to the groundwater at this site. However, the majority of the drinking water in the site's vicinity is obtained from surface water. The nearest active wells to MSP are two wells in Bound Brook, the Mountain Station wells, which are upgradient of the MSP site. Therefore, there are no people documented or suspected to be located within the contamination boundary of the release.

Ref. Nos. 2; 10

6. **Identify the population served by wells located within 4 miles of the site that draw from the aquifer of concern.**

The total estimated population using groundwater for drinking purposes near the site are as follows:

Distance	Population
0 - ¼ mi	0
>¼ - ½ mi	0
>½ - 1 mi	0
>1 - 2 mi	1,162
>2 - 3 mi	6,972
>3 - 4 mi	2,905

Ref. No. 2

State whether groundwater is blended with surface water, groundwater, or both before distribution.

The groundwater is blended with surface water prior to distribution.

Ref. No. 2

Is a designated well head protection area within 4 miles of the site?

The proximity of the site to a wellhead protection area cannot be determined, pending promulgation by the New Jersey Department of Environmental Protection and Energy (NJDEPE) of protected areas.

Ref. No. 3

Does a waste source overlie a designated or proposed wellhead protection area? If a release to groundwater is observed or suspected, does a designated or proposed wellhead protection area lie within the contaminant boundary of the release?

The proximity of the site to a wellhead protection area cannot be determined, pending promulgation by the NJDEPE of protected areas.

Ref. No. 3

7. **Identify uses of groundwater within 4 miles of the site (i.e. private drinking source, municipal source, commercial, irrigation, unusable).**

The groundwater within a 4-mile radius of the MSP site is utilized for both industrial and drinking water purposes.

Ref. No. 12, p. 33

SURFACE WATER ROUTE

8. **Describe the likelihood of a release of contaminant(s) to surface water as follows: observed release, suspected release, or none. Identify contaminants detected or suspected and provide a rationale for attributing them to the site. For observed release, define the supporting analytical evidence.**

   There is an observed release to the surface waters from MSP site based on surface water/sediment samples collected from the Main Stream. Contaminants which were detected include uranium, as total uranium (5.4 pCi/g, 2 pCi/L), radium-226 (1.7 pCi/g), and thorium-232 (3 pCi/g).

   Ref. Nos. 12, pp. 194 - 195; 14, pp. 40 - 48, 64 - 78

9. **Identify the nearest downslope surface water. If possible, include a description of possible surface drainage patterns from the site.**

   Surface runoff from the MSP site flows generally in a southern direction and is drained through an engineered drainage system to a drainage ditch south of the site. This drainage ditch discharges into a creek named Main Stream before emptying into Ambrose Brook. The Ambrose Brook joins the Green Brook before flowing into the Raritan River.

   Ref. Nos. 5; 10; 12, p. 39

10. **What is the distance in feet to the nearest downslope surface water? Measure the distance along a course that runoff can be expected to follow.**

    Surface runoff from the the site flows through a drainage ditch south of the site which approximately 600 feet south empties into the Main Stream. The Main Stream (<6.1 cubic feet per second (cfs)) joins Ambrose Brook (6.1 cfs) approximately 2,800 feet from the site, which flows into Green Brook (690 cfs) approximately 2.04 miles downstream. The Green Brook, approximately 2.24 miles downstream, then flows into the Raritan River (1,292 cfs). Neither Main Stream nor Ambrose Brook are used for water supplies.

    Ref. Nos. 4; 5; 10; 12, p. 39; 15, p. 2-1

11. **Determine the type of floodplain that the site is located within.**

    The site is in an area of minimal flood frequency.

    Ref. No. 12, pp. 41 - 42, 198

12. **Identify drinking water intakes in surface waters within 15 miles downstream of the point of surface water entry. For each intake identify: the name of the surface water body in which the intake is located, the distance in miles from the point of surface water entry, population served, and stream flow at the intake location.**

    There are no drinking water intakes from surface waters within 15 miles downstream of the point of surface water entry.

    Ref. Nos. 2; 11

13. **Identify fisheries that exist within 15 miles downstream of the point of surface water entry. For each fishery specify the following information:**

Fishery Name	Water Body Type	Flow (cfs)	Saline/Fresh/Brackish
Ambrose Brook	small to moderate stream	6.1	fresh
Green Brook	moderate to large stream	690	fresh
Raritan River	large stream to river	1,292	fresh

Ref. Nos. 4; 6

14. **Identify surface water sensitive environments that exist within 15 miles of the point of surface water entry.**

Environment	Water Body Type	Flow (cfs)	Wetland Frontage
Wetlands	River	1242	7.8 miles
State designated area for the protection of aquatic life and is a source of drinking water under the Clean Water Act	Stream/River	<6.1	N/A

Ref. Nos. 4, 11

15. **If a release to surface water is observed or suspected, identify any intakes, fisheries, and sensitive environments from question Nos. 12-14 that are or may be located within the contamination boundary of the release.**

Intake: None

Fishery: None

Sensitive Environment: State designated area for the protection of aquatic life and is a source of drinking water under the Clean Water Act.

Ref. Nos. 2; 4; 6; 11

SOIL EXPOSURE PATHWAY

16. **Determine the number of people that occupy residences or attend school or day care on or within 200 feet of the site property.**

There are approximately 23 people that occupy residences on or within 200 feet of observed contamination. There are no schools or daycare centers identified on or within 200 feet of observed contamination.

Ref. Nos. 9, 10

17. **Determine the number of people that regularly work on or within 200 feet of the site property.**

An estimated 20 people work on or within 200 feet of the MSP site property.

Ref. No. 12, p. 38

18. **Identify terrestrial sensitive environments on or within 200 feet of the site property.**

There are no known terrestrial sensitive environments on or within 200 feet of the MSP site.

Ref. No. 7

AIR ROUTE

19. **Describe the likelihood of release of contaminants to air as follows: observed release, suspected release, or none. Identify contaminants detected or suspected and provide a rationale for attributing them to the site. For observed release define the supporting analytical evidence.**

A release of contaminants is neither observed nor suspected.

Ref. No. 12, p. 209

20. **Determine populations that reside within 4 miles of the site.**

Distance	Population
0 - ¼ mi	358
>¼ - ½ mi	694
>½ - 1 mi	6,259
>1 - 2 mi	22,286
>2 - 3 mi	41,381
>3 - 4 mi	35,293

Ref. No. 8

21. **Identify sensitive environments, including wetlands and associated wetlands acreage, within ½ mile of site.**

Distance	Wetlands Acreage
0 - ¼ mi	14
>¼ - ½ mi	50
>½ - 1 mi	86
>1 - 2 mi	113
>2 - 3 mi	153
>3 - 4 mi	172

State designated area for the protection of aquatic life and is a source of drinking water under the Clean Water Act.

Ref. Nos. 7; 10; 11

22. If a release to air is observed or suspected, determine the number of people that reside or are suspected to reside within the area of air contamination from the release.

A release to the air is neither observed nor suspected.

Ref. No. 12, p. 209

23. If a release to air is observed or suspected, identify any sensitive environments, listed in question No. 21, that are or may be located within the area of air contamination from the release.

A release to the air is neither observed nor suspected.

Ref. No. 12, p. 209

ATTACHMENT 1

REFERENCES

1. U. S. Environmental Protection Agency (EPA), Superfund Program, Comprehensive Environmental Response Compensation Liability Information System (CERCLIS), List 8: Site/Event Listing, p. 159, August 31, 1992.

2. Project Note: to Middlesex Sampling Plant file; from David Kahlenberg, Malcolm Pirnie, Inc., Subject: Groundwater Usage, September 3, 1992.

3. Telecon Note: Conversation between Dan Van Abs, Bureau of Water Supply and Planning, New Jersey Department of Environmental Protection and Energy (NJDEPE), and K. Campbell, Halliburton NUS Environmental Corporation, February 14, 1992.

4. Project Note: To Middlesex Sampling Plant file; from David Kahlenberg, Malcolm Pirnie, Inc., Subject: Surface Water Resources, December 15, 1993.

5. Telecon Note: Conversation between Susan Kange, Department of Energy, and David Kahlenberg, Malcolm Pirnie, Inc., September 23, 1992.

6. Project Note: to Middlesex Sampling Plant file; from David Kahlenberg, Malcolm Pirnie, Inc., Subject: Fisheries, September 8, 1992.

7. Letter from Elena A. Williams, Natural Heritage Program, Division of Parks and Forestry, Office of Natural Lands Management, NJDEPE, to Andrew Clibanoff, Malcolm Pirnie, Inc., September 9, 1992.

8. Project Note: to Middlesex Sampling Plant file; from David Kahlenberg, Malcolm Pirnie, Inc., Subject: Population in 4-mile radius map, August 26, 1992.

9. Project Note: to Middlesex Sampling Plant file; from David Kahlenberg, Malcolm Pirnie, Inc., Subject: Residential Population, December 15, 1993.

10. Four-Mile Vicinity Map for Middlesex Sampling Plant based on U. S. Geological Survey Topographic Maps, 7.5 minute series, Quadrangles of "Boundbrook, NJ, 1955, photorevised 1970, photo inspection 1977", "Chatham, NJ, 1955, photorevised 1981", "Plainfield, NJ, 1955, photorevised 1981", "Bernardsville, NJ, 1954, photorevised 1981."

11. Fifteen-Mile Surface Water Pathway Map based on U.S. Department of the Interior, Fish, Game and Wildlife Service, Atlas of National Wetlands Inventory (NWI) Maps for New Jersey, 1984, NWI Maps used "Plainfield, NJ", "Boundbrook, NJ", "New Brunswick, NJ", "South Amboy, NJ."

12. Letter from David G. Adler, Former Sites Restoration Division, Department of Energy, to Helen Shannon, Region II Docket Coordinator, EPA, March 2, 1992.

13. Bechtel National Inc. (BNI), Middlesex Sampling Plant, Environmental Report for Calendar Year 1989, Middlesex, NJ, Formerly Utilized Remedial Action Program (FUSRAP), DOE/OR/ 20722-285, Oak Ridge, Tennessee, May 1990.

14. BNI, Middlesex Sampling Plant Annual Environmental Report for Calendar Year 1990, Middlesex, NJ, FUSRAP, DOE/OR/21949-285, Oak Ridge, Tennessee, September 1991.

15. Ford, Bacon & Davis Utah, Inc. (FBDU), Environmental Analysis of the Former Middlesex Sampling Plant and Associated Properties, Middlesex, New Jersey, Formerly Utilized MEP/AEC Sites Remedial Action Program, FBDU 230-005, Final Report, July 1979.

16. FBDU, Environmental Assessment of the Properties Adjacent to and Nearby the Former Middlesex Sampling Plant, Middlesex, New Jersey, UC-342, October 1980.

17. BNI, Post Remedial Action Report for The Middlesex Municipal Landfill Site, Middlesex, New Jersey, FUSRAP, DOE/OR/20722-135, February 1987.

18. BNI, Characterization Report for the Interim Storage piles at the Middlesex Sampling Plant, Middlesex New Jersey, FUSRAP, DOE/OR/21949-297, Volume I, December 1991.

19. BNI, Characterization Report for the Interim Storage piles at the Middlesex Sampling Plant, Middlesex New Jersey, FUSRAP, DOE/OR/21949-297, Volume II, December 1991.

20. Project Note: to Middlesex Sampling Plant file; from David Kahlenberg, Malcolm Pirnie, Inc., Subject: Vicinity Property Waste Pile, December 9, 1993.

21. Project Note: to Middlesex Sampling Plant file; from David Kahlenberg, Malcolm Pirnie, Inc., Subject: Radiological Background Conditions, December 9, 1993.

22. USDOE, Radiological Survey of the Middlesex Sampling Plant, Middlesex, New Jersey, Formerly Utilized MED/AEC Sites Remedial Action Program, November 1977.

23. Oak Ridge National Laboratory, Radiological Surveys of Properties in the Middlesex, New Jersey, Area, prepared for the USDOE, DOE/EV-005/1, March 1981.

24. NLO, Inc., Phase I Remedial Action of Properties Associated with the Former Middlesex Sampling Plant Site, prepared for the USDOE, NLCO-006 EV, April 1982.

25. Project Note: to Middlesex Sampling Plant file; from David Kahlenberg, Malcolm Pirnie, Inc., Subject: Remedial Action Descriptions, December 9, 1993.

26. BNI, Final Report on Phase II Remedial Action at the Former Middlesex Sampling Plant and Associated Properties, Middlesex, New Jersey, FUSRAP Contract No. DE-AC05-810R20722, Volume I, April 1985.

27. BNI, Final Report on Phase II Remedial Action at the Former Middlesex Sampling Plant and Associated Properties, Middlesex, New Jersey, FUSRAP Contract No. DE-AC05-810R20722, Volume II, April 1985.

REFERENCE NO. 1

SELECTION:
SEQUENCE: REGION, STATE, SITE NAME

EVENTS: ALL

EPA ID NO.	SITE NAME / STREET / CITY / COUNTY CODE AND NAME	STATE ZIP / CONG DIST.	OPRBLE UNIT	EVENT TYPE	EVENT GOAL	ACTUAL START DATE	ACTUAL COMPL DATE	CURRENT EVENT LEAD
NJD002195303	METZ METALLURGICAL CORP.		00	DS1			06/06/89	EPA (FUND)
	3900 SOUTH CLINTON AVE.			PA1	DEFERRED TO RCRA OR NRC		07/20/89	EPA (FUND)
	SOUTH PLAINFIELD	NJ 07080		SI1	LOWER PRIORITY	07/01/91	09/24/91	STATE(FUND)
	023 MIDDLESEX	NJ-06						
NJD980595015	MICHAEL CERVINO		00	DS1			10/01/90	EPA (FUND)
	REAR OF 179 GODWIN AVE			PA1	LOWER PRIORITY	10/01/90	12/31/90	EPA (FUND)
	WYCKOFF	NJ 07481		SI1	NO FURTHER REMDL ACT PLND	07/01/91	09/25/91	EPA (FUND)
	003 BERGEN	NJ-05						
NJD981490287	MICHAEL DESKOVICK LANDFILL		00	DS1			06/27/86	STATE(FUND)
	KLINGER ROAD			PA1	LOWER PRIORITY	06/27/86	06/30/86	STATE(FUND)
	EAST HANOVER	NJ 07936						
	027 MORRIS	NJ-11						
NJD053101129	MIDDLESEX INDUSTRIAL CENTER		00	DS1			06/01/81	EPA (FUND)
	MOUNTAIN AV & LEHIGH VALLEY RR			PA1	LOWER PRIORITY	09/28/87	09/29/87	STATE(FUND)
	MIDDLESEX	NJ 08846		SI1	HIGHER PRIORITY	04/01/91	06/27/91	STATE(FUND)
	023 MIDDLESEX	NJ-05						
NJD980505499	MIDDLESEX LANDFILL		00	DS1			06/01/81	EPA (FUND)
	MOUTAIN AVE			PA1	LOWER PRIORITY		09/01/84	EPA (FUND)
	MIDDLESEX	NJ 08846		SI1	HIGHER PRIORITY	06/27/86	06/30/86	STATE(FUND)
	023 MIDDLESEX	NJ-05						
NJD001734733	MIDDLESEX QUALITY CONTAINER & DRUM		00	DS1			07/01/80	EPA (FUND)
	909 SOMERSET STREET			PA1	NO FURTHER REMDL ACT PLND	06/01/84	06/01/84	EPA (FUND)
	SOMERSET	NJ 08873						
	035 SOMERSET	NJ-05						
NJD690090012	MIDDLESEX SAMPLING PLANT		00	DS1			02/07/86	FED. FAC.
	239 MOUNTAIN AVENUE			PA1	LOWER PRIORITY		03/10/86	FED. FAC.
	MIDDLESEX BOROUGH	NJ 08846		SI1	HIGHER PRIORITY	06/23/88	06/30/88	FED. FAC.
	023 MIDDLESEX	NJ-07						

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REFERENCE NO. 2

MALCOLM PIRNIE, INC. PROJECT NOTES

To: File
From: David Kellenberg
Subject: Groundwater Usage

Date: September 3, 1992
Project Number: 8003-093
Site Name: Middlesex Sampling Plant

It was determined that the Elizabethtown Water Company is the principle supplier of drinking water within a 4 mile radius of the site. There are a total of 19 wells that Elizabeth Town owns in the 4 mile vicinity and are distributed as follows:

Ring	number of wells
0-1/4 mile	0
1/4-1/2 mile	0
1/2-1 mile	0
1-2 mile	2
2-3 mile	12
3-4 mile	5

Elizabethtown Water Company blends its water (potable) so that approximately 85% of the water is from surface water and 15% is from groundwater. Elizabethtown Water Company serves a total population of 507410 people and maintains 131 groundwater wells.

Assuming that 15% of the water supplied is from the groundwater there are 76112 people served by the groundwater (15% of 507410 people). Since there are 131 wells each well services 581 people (76112/131).

Therefore, the groundwater population served within a 4 mile vicinity of the Middlesex Sampling Plant is:

Ring	Population	Ring	Population
0-1/4 mile	0 mile	1-2 miles	1162
1/4-1/2	0 mile	2-3 miles	6972
1/2-1	0 mile	3-4 miles	2905

ARCS II CONTRACT 68-W9-0051
MALCOLM PIRNIE, INC.
RECORD OF TELEPHONE CONVERSATION/AGREEMENT

File No. _____

Date: 8/26/92 Time: 1:40 [ ] AM [✓] PM

[ ] Incoming Call From: _____
Telephone No.
Affiliation: _____

[✓] Outgoing Call To: Richard Sadowski 1-800-272-1325
Telephone No.
Affiliation: Elizabethtown Water Company

Malcolm Pirnie Staff: DAVID KAHCENBERG 1-609-860-0100
(Receiving or Calling) Name Telephone No.

Summary of [✓] Conversation [ ] Agreement:

I spoke with Mr Sadowski to confirm that the Hebring Mill Well fields were closed due to volatile organic chemical (VOC) contamination and he agreed. He confirmed that Elizabethtown blends these surface water with their groundwater in a mixture of approximately 85 % + 15 % (50):6. He said that all three of their surface water intakes are located near the confluence of the Raritan + Millstone rivers, either on the Delaware-Raritan Canal, Millstone or Raritan rivers. He also told me that system wide as of December 31, 1992 the water company serviced an estimated permanent population of 507,410 people.

f:\rectele.jan(1)

ARCS II CONTRACT 68-W9-0051
MALCOLM PIRNIE, INC.
RECORD OF TELEPHONE CONVERSATION/AGREEMENT

File No. _____

Date: 8/26/92 Time: 2:57 [ ] AM [✓] PM

[ ] Incoming Call From: _____ Telephone No.

Affiliation: _____

[✓] Outgoing Call To: Steve Naglich 1 908 634 1500 Telephone No.

Affiliation: Middlesex Water Co.

Malcolm Pirnie Staff: DAVID KAHLENBERG 1 609 860 0100
(Receiving or Calling) Name Telephone No.

Summary of [✓] Conversation [ ] Agreement:

I spoke with Mr Naglich of the water co. had any surface water intakes — he said that they had one intake to his knowledge in New Brunswick off of Hamilton Street that draws from the Delaware-Raritan Canal. The total population served is 207,000 people.

f:\rectele.jan(1)

ARCS II CONTRACT 68-W9-0051
MALCOLM PIRNIE, INC.
RECORD OF TELEPHONE CONVERSATION/AGREEMENT

File No. 9002-078

Date: 3-23-92 Time: 11 30 [X] AM [ ] PM

[ ] Incoming Call From: _____ Telephone No.

Affiliation: _____

[X] Outgoing Call To: Mr. Richard Sadowski 908-654-1234 Telephone No.

Affiliation: Elizabethtown Water Co.

Malcolm Pirnie Staff: Todd G Tenek 609-860-0100
(Receiving or Calling) Name Telephone No.

Summary of [X] Conversation [ ] Agreement:

Mr. Sadowski mentioned that Elizabethtown water Co has a total of 131 wells and serves approximately 500,000 people

Todd G Tenek

f:\rectele.jan(1)

ELIZABETHTOWN WATER COMPANY

WELL LIST

Town	County	Facility Name	Well Depth	Well Permit Number	Effective Date	Formation	Pump Cap. (GPM)	Motor HP	Type
Bound Brook	Somerset	Mountain Sta. #1	366				750	60	Turbine
Bound Brook	Somerset	Mountain Sta. #2	404				356	40	Turbine
Bridgewater	Somerset	Papen Road	225	25-13435	7/12/83	Basalt	220	40	Turbine
Bridgewater	Somerset	Wells Road #1	130	25-5803	7/12/83	Basalt	75	10	Turbine
Bridgewater	Somerset	Wells Road #2	130	25-11512	7/12/83	Basalt	75	10	Turbine
Clark	Union	Elks Well	59	26-4751	7/12/83	Brunswick	300	30	Turbine
Green Brook	Somerset	Green Brook #1	451	45-23	6/7/83	Brunswick	310	25	Turbine
Green Brook	Somerset	Green Brook #2	376	45-24	6/7/83	Brunswick	650	50	Turbine
Green Brook	Somerset	Green Brook #3	550	45-25	6/7/83	Brunswick	60	7.5	Submersible
Green Brook	Somerset	Green Brook #4	400	45-26	6/7/83	Brunswick	350	30	Turbine
Green Brook	Somerset	Green Brook #5	373	25-572	6/7/83	Brunswick	315	25	Turbine
Green Brook	Somerset	Green Brook #6	373	25-632	6/7/83	Brunswick	278	25	Turbine
Green Brook	Somerset	Green Brook #7	238	25-633	6/7/83	Brunswick	179	15	Turbine
Green Brook	Somerset	Green Brook #8	445	25-2715	6/7/83	Brunswick	495	40	Turbine
Green Brook	Somerset	Green Brook #9	507	25-2716	6/7/83	Brunswick	500	50	Turbine
Green Brook	Somerset	Green Brook #11	510	25-2718	6/7/83	Brunswick	340	25	Submersible
Green Brook	Somerset	Rock Avenue	350	25-12665	6/7/83	Brunswick	330	40	Submersible
Kenilworth	Union	Quinton Avenue	502	46-14	7/31/83	Brunswick	185	40	Turbine
Kenilworth	Union	Richfield Avenue	401	46-15	7/31/83	Brunswick	250	30	Turbine
Middlesex	Middlesex	Sebrings Mill #4	300	25-11582	8/17/84	Brunswick	200	25	Submersible
Middlesex	Middlesex	Sebrings Mill #6	412	45-43	8/17/84	Brunswick	400	40	Submersible
Middlesex	Middlesex	Sebrings Mill #7	285	25-11367	8/17/84	Brunswick	300	30	Submersible
Middlesex	Middlesex	Sebrings Mill #8	430	25-13397	8/17/84	Brunswick	200	25	Submersible
Montgomery	Somerset	Montgomery #1	305	28-5407	6/7/83	Stockton	450		Submersible
Montgomery	Somerset	Montgomery #2	335	28-5511	6/7/83	Stockton	450		Submersible
Mountainside	Union	Bristol Road	315	25-9206	6/7/83	Brunswick	330	40	Submersible
Mountainside	Union	Central Avenue	300	25-9083	6/7/83	Brunswick	475	60	Submersible
Mountainside	Union	Charles Street #1	454	25-872	6/7/83	Brunswick	300	40	Submersible
Mountainside	Union	Charles Street #2	572	45-4	6/7/83	Brunswick	150	25	Submersible
N. Plainfield	Somerset	Board of Education	311	45-22	6/7/83	Brunswick	400	50	Turbine
N. Plainfield	Somerset	Rockview Avenue	400	25-13898	6/7/83	Brunswick	300		Submersible
N. Plainfield	Somerset	Rockview Terrace	400	25-13106	6/7/83	Brunswick	200	25	Submersible
Piscataway	Middlesex	Rock Avenue	350	25-13248	6/7/83	Brunswick	150	20	Submersible
Plainfield	Union	Fifth Street	350	25-12961	6/7/83	Brunswick	300	40	Submersible
Plainfield	Union	George Street	89	45-21	6/7/83	Brunswick	125	20	Turbine
Plainfield	Union	Netherwood #1	350	45-9	6/7/83	Brunswick	225	20	Turbine
Plainfield	Union	Netherwood #2	500	45-10	6/7/83	Brunswick	225	20	Turbine
Plainfield	Union	Netherwood #3	350	45-11	6/7/83	Brunswick	600	25	Submersible
Plainfield	Union	Netherwood #4	400	45-12	6/7/83	Brunswick	400	15	Turbine
Plainfield	Union	Netherwood #5	350	45-13	6/7/83	Brunswick	300	15	Submersible
Plainfield	Union	Netherwood #6	300	45-14	6/7/83	Brunswick	325	20	Turbine
Plainfield	Union	Netherwood #7	350	45-15	6/7/83	Brunswick	350	25	Submersible
Plainfield	Union	Netherwood #8	304	45-16	6/7/83	Brunswick	300	25	Submersible
Plainfield	Union	Netherwood #9	350	45-17	6/7/83	Brunswick	300	30	Submersible
Plainfield	Union	Netherwood #10	350	45-18	6/7/83	Brunswick	300	25	Submersible
Plainfield	Union	Netherwood #11	350	45-19	6/7/83	Brunswick	250	20	submersible
Plainfield	Union	Netherwood #12	352	45-20	6/7/83	Brunswick	250		Turbine
Plainfield	Union	City of Plainfield	300	45-27	6/7/83	Brunswick	400	50	Turbine
Plainfield	Union	Prospect Avenue	350	25-9037	6/7/83	Brunswick	300	60	Submersible
Plainfield	Union	Watchung Avenue	605	25-8185	6/7/83	Brunswick	280	30	Submersible
Plainsboro	Middlesex	Plainsboro #1	120	28-9278	7/12/83	Raritan	350		Turbine
Plainsboro	Middlesex	Plainsboro #2	208	28-11477	7/12/83	Raritan	295		Turbine
Princeton	Mercer	Edgerstoune		28-5000	7/12/83	Stockton	125		Turbine

5 of 13

Town	County	Facility Name	Well Depth	Well Permit Number	Effective Date	Formation	Pump Cap. (GPM)	Motor HP	Type
Princeton	Mercer	Grover Avenue	439	28-2607	7/12/83	Raritan	100		Turbine
Princeton	Mercer	Harrison Street #1	503	48-5	7/12/83	Stockton	100	20	Submersible
Princeton	Mercer	Harrison Street #3	301	28-4371	7/12/83	Stockton	100	65	Turbine
Princeton	Mercer	Harrison Street #4	302	48-6	7/12/83	Stockton	110	20	Turbine
Princeton	Mercer	Harrison Street #5	320	48-7	7/12/83	Stockton	150	20	Turbine
Princeton	Mercer	Harrison Street #6	335	28-1886	7/12/83	Stockton	400	50	Turbine
Princeton	Mercer	Harrison Street #7	300	28-4999	7/12/83	Stockton	200	15	Submersible
Princeton	Mercer	Harrison Street #8	347	28-5073	7/12/83	Stockton	400	40	Submersible
Princeton	Mercer	Stony Brook #2	279	48-8	7/12/83	Stockton	300	40	Turbine
Princeton	Mercer	Stony Brook #3	353	48-9	7/12/83	Stockton	500	30	Turbine
Princeton	Mercer	Stony Brook #4	382	48-10	7/12/83	Stockton	300	15	Submersible
Princeton	Mercer	Stony Brook #6	304	48-11	7/12/83	Stockton	450	40	Turbine
Princeton	Mercer	Stony Brook #7	350	48-12	7/12/83	Stockton	600	25	Submersible
Princeton	Mercer	Stony Brook #8	302	48-13	7/12/83	Stockton	600	40	Turbine
Raritan Township	Hunterdon	Maple Glen	355				250	15	Submersible
Roselle	Union	Chandler Avenue	350	26-2393	7/31/83	Brunswick	300	30	Submersible
Roselle	Union	First Avenue	509	26-1696	7/31/83	Brunswick	450	50	Turbine
Roselle	Union	Walburga #1	350	26-2302	7/31/83	Brunswick	200	40	Submersible
Roselle	Union	Walburga #2	348	26-2360	7/31/83	Brunswick	200	60	Submersible
Roselle	Union	Walburga #3	321	26-2412	7/31/83	Brunswick	350	40	Submersible
Roselle	Union	Walburga #4	321	26-2463	7/31/83	Brunswick	300	50	Submersible
Scotch Plains	Union	3 - Aberdeen Road	350	25-12631	6/7/83	Brunswick	250	30	Submersible
Scotch Plains	Union	Glenside Avenue	540	25-7173	7/12/83	Brunswick	150	20	Turbine
Scotch Plains	Union	Jerusalem Road #1	650	25-130	7/12/83	Brunswick	275	30	Turbine
Scotch Plains	Union	Jerusalem Road #2	665	25-649	7/12/83	Brunswick	350	30	Turbine
Scotch Plains	Union	Jerusalem Road #3	708	25-800	7/12/83	Brunswick	150	15	Turbine
Scotch Plains	Union	6 - Morse Avenue	400	25-9281	7/12/83	Brunswick	295	30	Submersible
South Plainfield	Middlesex	Clinton Avenue	350	25-13354	6/7/83	Brunswick	475	50	Submersible
South Plainfield	Middlesex	Eighth Street	350	25-12632	6/7/83	Brunswick	450	50	Submersible
Springfield	Union	Springfield #1		46-39	7/12/83	Brunswick	50	3	Submersible
Springfield	Union	Springfield #1A		46-40	7/12/83	Brunswick	100	7.5	Turbine
Springfield	Union	Springfield #2					150	7.5	Submersible
Springfield	Union	Springfield #2A		46-41	7/12/83	Brunswick	100	7.5	Turbine
Springfield	Union	Springfield #3		26-4082	7/12/89	Brunswick	300	7.5	Turbine
Springfield	Union	Springfield #4						10	Turbine
Springfield	Union	Springfield #5						10	Turbine
Springfield	Union	Springfield #5A		46-42	7/12/83	Brunswick	75	5	Turbine
Springfield	Union	Springfield #6		26-4082	7/12/83	Brunswick	160	7.5	Submersible
Springfield	Union	Springfield #6A		46-43	7/12/83	Brunswick	300	7.5	
Springfield	Union	Springfield #7		46-44	7/12/83	Brunwsick	100		
Springfield	Union	Springfield #7A		46-45	7/12/83	Brunswick	75	7.5	Turbine
Springfield	Union	Springfield #8R		46-46	7/12/83	Brunswick	100	10	Submersible
Springfield	Union	Springfield #9R		46-47	7/12/83	Brunswick	200	7.5	Turbine
Springfield	Union	Springfield #11		46-48	7/12/83	Brunswick	125	7.5	Submersible
Springfield	Union	Springfield #12R							
Springfield	Union	Springfield #17							
Springfield	Union	Springfield #21R		46-50	7/12/83	Brunswick	150	5	Turbine
Springfield	Union	Springfield #23					50	5	Turbine
Springfield	Union	Springfield #24		46-51	7/12/83	Brunswick	60	3	Submersible
Springfield	Union	Springfield #25					100	10	Turbine
Springfield	Union	Springfield #29					100	5	Submersible
Springfield	Union	Springfield #32							
Springfield	Union	Springfield #36		46-52	7/12/83	Brunswick	125	5	Submersible
Springfield	Union	Springfield #41					75	7.5	Submersible
Springfield	Union	Springfield #42		46-53	7/12/83	Brunswick	100	5	Submersible
Springfield	Union	Springfield #43							

Town	County	Facility Name	Well Depth	Well Permit Number	Effective Date	Formation	Pump Cap. (GPM)	Motor HP	Type
Springfield	Union	Springfield #47		46-54	7/12/83	Brunswick	125	5	Submersible
Springfield	Union	Springfield #48		46-55	7/12/83	Brunswick	75	5	Submersible
Springfield	Union	Springfield #50		46-56	7/12/83	Brunswick	50	5	Turbine
Springfield	Union	Springfield #53		46-57	7/12/83	Brunswick	175	7.5	Turbine
Springfield	Union	Springfield #54		46-58	7/12/83	Brunswick	150	7.5	Turbine
Springfield	Union	Springfield #55		46-59	7/12/83	Brunswick	175	7.5	Turbine
Tewksbury	Somerset	Pottersville	400	25-15051	6/7/83	Pre-Cambrian	100	30	Submersible
Union	Union	Hummocks #1	326	46-16	7/12/83	Brunswick	100		
Union	Union	Hummocks #1A	143	46-17	7/12/83	Brunswick	200		
Union	Union	Hummocks #2A	122	46-18	7/12/83	Brunswick	150		
Union	Union	Hummocks #3	91	46-19	7/12/83	Brunswick	200		
Union	Union	Hummocks #3A	126	46-20	7/12/83	Brunnwick	100		
Union	Union	Hummocks #4A*	117.5	46-21	7/12/83	Brunswick	70	5	Submersible
Union	Union	Hummocks #5	92	46-22	7/12/83	Brunswick	200		
Union	Union	Hummocks #5A*	128	46-23	7/12/83	Brunswick	100	7.5	Submersible
Union	Union	Hummocks #6AR*	130	46-24	7/12/83	Brunswick	300	20	Turbine
Union	Union	Hummocks #7A*	233	46-25	7/12/83	Brunswick	85	5	Submersible
Union	Union	Hummocks #8A*	114	46-26	7/1/83	Brunswick	200	10	Turbine
Union	Union	Hummocks #9A	126	46-27	7/12/83	Brunswick	150		
Union	Union	Hummocks #10	84	46-27	7/12/83	Brunswick	100		
Union	Union	Hummocks #10A	118	46-29	7/12/83	Brunswick	150		
Union	Union	Hummocks #11A	125	46-30	7/12/83	Brunswick	100		
Union	Union	Hummocks #12A	120	46-31	7/12/83	Brunswick	200		
Union	Union	Hummocks #17*	99.6	46-32	7/12/83	Brunswick	250	15	Submersible
Union	Union	Hummocks #19	455	46-33	7/12/83	Brunswick	100		
Union	Union	Hummocks #23	120	46-34	7/12/83	Brunswick	100		
Union	Union	Hummocks #26		46-35	7/12/83	Brunswick	100		
Union	Union	Hummocks #28	96	46-36	7/12/83	Brunswick	100		
Union	Union	Hummocks #29	92	46-37	7/12/83	Brunswick	100		
Union	Union	Hummocks #41	83	46-38	7/12/83	Brunswick	150		
Union	Union	Hummocks #H2*		26-4830	7/12/83	Brunswick	150		Turbine
Union	Union	Hummocks #H5		26-4926	7/12/83	Brunswick	220		
Union	Union	Hummocks #TB2		26-4808	7/12/83	Brunswick	200		
Union	Union	Hummocks #TB2A		26-4829	7/12/83	Brunswick	400		
Watchung	Somerset	Two Guys #1	325	25-8131	6/7/83	Brunswick	400	40	Submersible
Watchung	Somerset	Two Guys #2	350	25-8132	6/7/83	Brunswick	60	20	Submersible
Westfield	Union	Elm Street	525	25-8087	7/12/83	Brunswick	350	40	Submersible
Westfield	Union	Prospect Street	500	25-12960	7/12/83	Brunswick	150	20	Submersible
Westfield	Union	Westfield Office #1	523	25-873	7/12/83	Brunswick	500	50	Turbine
Westfield	Union	Westfield Office #2	502	45-5	7/12/83	Brunswick	350	40	Turbine
Westfield	Union	Wittke #1	506	25-4639	7/12/83	Brunswick	425	50	Turbine
Westfield	Union	Wittke #2	511	25-5083	7/12/83	Brunswick	525	75	Turbine
West Windsor	Mercer	Jefferson Park #1	121	28-5368	6/7/83	Raritan	600		Turbine
West Windsor	Mercer	Jefferson Park #2	126	28-6455	6/7/83	Raritan	600		Turbine

*Only wells in service with new V.O.C. facility

Elizabethtown Water Company

Netherwood Operations Center: 1-41 [illegible] Avenue, Plainfield, NJ 07062 (908) 561-1231
Mailing Address: P.O. Box 111, Plainfield, NJ 07061-0201

March 9, 1992

Mr. Todd Teryek
Malcolm Pirnie, Inc.
104 Interchange Plaza
Cranbury, NJ 08512-9543

Dear Mr. Teryek:

In accordance with your request, I am returning your maps for the two CERCLIS sites, Pack Tech Services and Standard Plastic Products, Inc. I've indicated the Elizabethtown wells that are within a 4 mile radius of the sites. Well depth and formation are also included. To determine the population served by these wells is extremely difficult due to the fact that these wells supplement the area; most of the water serving the area is surface water supplied by our main treatment plant in Bridgewater, the Raritan Millstone Plant.

Should you have any questions or require additional information please feel free to call me.

Very truly yours,

Richard A. Sadowski
Superintendent
Wells and Stations

RAS/cll

ELIZABETHTOWN WATER COMPANY WELLS INDICATED ON FOUR MILE VICINITY MAP

FOR

PACK TECH SERVICES

PISCATAWAY, NJ

	NAME	TOWN	SCREEN DEPTH (ft)	FORMATION
1.	Sebring Mills Well Field	Middlesex		
	Well # 4		300	Brunswick
	Well # 6		412	Brunswick
	Well # 7		285	Brunswick
	Well # 8		430	Brunswick
2.	Green Brook Well Field	Green Brook		
	Well # 1		451	Brunswick
	Well # 2		376	Brunswick
	Well # 3		550	Brunswick
	Well # 4		400	Brunswick
	Well # 5		373	Brunswick
	Well # 6		373	Brunswick
	Well # 7		238	Brunswick
	Well # 8		445	Brunswick
	Well # 9		507	Brunswick
	Well # 11		510	Brunswick
3.	Rock Avenue Well	Green Brook	350	Brunswick
4.	City of Plainfield Well	Plainfield	300	Brunswick
5.	Board of Education Well	No. Plainfield	311	Brunswick
6.	Rock Avenue Well	Piscataway	350	Brunswick
7.	Rockview Avenue Well	No. Plainfield	400	Brunswick
8.	Fifth Street Well	Plainfield	350	Brunswick
9.	Eighth Street Well	So. Plainfield	350	Brunswick
10.	Clinton Avenue Well	So. Plainfield	350	Brunswick

SURFACE WATER INTAKE LOCATIONS
BUREAU OF SAFE DRINKING WATER

Prepared by: Michael Mariano

STATE OF NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF SAFE DRINKING WATER
MARCH 1992

PWSID#	PURVEYOR NAME	PHONE NUMBER	INTAKE MUNICIPALITY	INTAKE LOCATION
0102001	ATLANTIC CITY WATER DEPARTMENT	609-345-3315	ABSECON	DOUGHTY POND - South tip - Mays Landing Rd. & Mill Rd.
0238001	HACKENSACK WATER DEPARTMENT	201-767-9300	PARAMUS	SADDLE RIVER - South of intersection of Paramus Rd. & Midland Ave.
			ORADELL	HACKENSACK RIVER - At Martin Ave.
			NORTHVALE	SPARK HILL CREEK - Northwest of intersection of Pegasus Ave. & Hill Terr.
			ORADELL	LONG SWAMP BROOK - At Martin Ave.
0305001	BURLINGTON CITY WATER DEPARTMENT	609-386-0307	EAST BURLINGTON	DELAWARE RIVER - 1/4 mile north of Assiscunk Creek
			BURLINGTON ISLAND	BURLINGTON ISLAND LAKE
0325001	FORT DIX	609-542-5040		RANCOCAS CREEK
1613001	NJDWSC	201-575-0225	POMPTON LAKES	RAMAPO RIVER - At Pompton Lake (pump to Wanaque Res.)
			WANAQUE	WANAQUE RESERVOIR - Ringwood Ave & Oricchio Ave
0717001	CITY OF ORANGE	201-762-6000	SOUTH ORANGE	ORANGE RESERVOIR - On West branch of Rahway River 40 ft upstream from dam

STATE OF NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF SAFE DRINKING WATER
MARCH 1992

PWSID#	PURVEYOR NAME	PHONE NUMBER	INTAKE MUNICIPALITY	INTAKE LOCATION
0712001	NJ AMERICAN NORTHERN DISTRICT	201-376-8800	MILLBURN	PASSAIC RIVER - At Kennedy Parkway
			SHORT HILLS	CANOE BROOK - North of Route 24
			CALDWELL	POMPTON RIVER - At Bridges Rd.
0714001	NEWARK WATER DEPT	201-256-4965		PEQUANNOCK WATER SHED
0906001	JERSEY CITY WATER DEPARTMENT	201-547-4390	BOONTON	BOONTON RESERVOIR - 200 yds northwest of Washington St Bridge
			ROCKAWAY	SPLIT ROCK RESERVOIR - Empties into Boonton Res. via Rockaway River
1017001	LAMBERTVILLE WATER DEPARTMENT	609-397-0526	LAMBERTVILLE	SWAN CREEK RESERVOIR EAST
			LAMBERTVILLE	SWAN CREEK RESERVOIR WEST
			LAMBERTVILLE	DELAWARE-RARITAN CANAL - At Swan St. (Emergency)
1111001	CITY OF TRENTON	609-989-3208	TRENTON	DELAWARE RIVER - At Rt 29 north of Calhoun St. Bridge
1216001	PERTH AMBOY	908-826-0290	OLD BRIDGE	TENNENTS POND - At Waterworks Rd.
1225001	MIDDLESEX WATER CO	908-634-1500	? EDISON	DELAWARE-RARITAN CANAL & MILLSTONE RIVER - At Rt 18

STATE OF NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF SAFE DRINKING WATER
MARCH 1992

PWSID#	PURVEYOR NAME	PHONE NUMBER	INTAKE MUNICIPALITY	INTAKE LOCATION
1214001	NEW BRUNSWICK WATER DEPARTMENT	908-745-5060	NEW BRUNSWICK	LAWRENCE BROOK - At Burnet St St.
			NEW BRUNSWICK	DELAWARE-RARITAN CANAL - At George St & College Ave
1214001	NORTH BRUNSWICK	908-247-0922	FRANKLIN TWP	DELAWARE-RARITAN CANAL - At Suydan Ave.
1219001	SAYERVILLE	908-390-7000	OLD BRIDGE	SOUTH RIVER - At Main St North of Rt 18
1352005	NEW JERSEY WATER SUPPLY AUTH.		WALL TWP	MANASQUAN RIVER - Hospital Rd. North of Garden State Parkway (Pump to Manasquan Resevior)
1345001	NJ AMERICAN - MONMOUTH		WALL TWP	MANASQUAN RIVER - Hospital Rd. North of GSP (Pump to Glendola Reservoir)
			NEPTUNE TWP	SHARK RIVER - Off Corlies Ave. 2000' North of GSP
			NEPTUNE TWP	JUMPING BROOK - At Greensgrove & Corlies Aves
			LINCROFT	SWIMMING RIVER RESERVOIR - 1000' West of Swimming Riv.
1326004	MATCHAPONIX		MANALAPAN	MATCHAPONIX BROOK - At Wilson Ave.
1401001	TOWN OF BOONTON	201-299-7740	MONTVILLE	TAYLORTOWN RESERVOIR - At Taylortown Rd.

STATE OF NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF SAFE DRINKING WATER
MARCH 1992

PWSID#	PURVEYOR NAME	PHONE NUMBER	INTAKE MUNICIPALITY	INTAKE LOCATION
1403001	BUTLER WATER DEPT	201-838-7200	BUTLER	KIKEOUT RESERVOIR - At Resevior Rd.
1424001	SOUTH EAST MORRIS COUNTY	201-538-5600	MENDHAM	CLYDE POTTS RESERVOIR - Cold Hill Rd & Woodland Rd
1506001	BRICK TWP	908-458-7000		METEDECONK RIVER
1603001	HALEDON WATER DEPT		HALEDON	HALEDON RESERVOIR - Lower Basin pump station at Belmont Ave.
1605002	PASSAIC VALLEY WATER COMMISSION	201-256-1566	WAYNE	POMPTON RIVER - At Confluence of Ramapo & Pequannock Rivers
			TOTOWA	PASSAIC RIVER - At Union Blvd.
1708300	E.I. DUPONT PENNSVILLE	609-299-5000		SALEM CANAL
1712001	SALEM WATER DEPT	609-935-0350	CLINTON TWP	LAUREL LAKE - At Waterworks Rd & Lake Ave.
			ALLOWAY TWP	ELKINTON MILL POND - Waterworks Rd. 3 miles east of Laurel Lake (Seasonal)
1903001	BRANCHVILLE WATER DEPARTMENT	201-948-6463	FRANKFORD TWP	BRANCHVILLE RESERVOIR - 7300' northeast of Mattison Ave & Mattison School Rd.
1906002	FRANKLIN WATER DEPT	201-827-7060	FRANKLIN BOROUGH	FRANKLIN POND - Franklin Ave. Across from plant
1915001	NEWTON WATER DEPT	201-383-3521	SPARTA TWP	MORRIS LAKE

STATE OF NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF SAFE DRINKING WATER
MARCH 1992

PWSID#	PURVEYOR NAME	PHONE NUMBER	INTAKE MUNICIPALITY	INTAKE LOCATION
1921001	SUSSEX WATER DEPT	201-967-5622	WANTAGE TWP	COLESVILLE RESERVOIR - At Brink Rd. 400' west of Rt. 23
2013001	RAHWAY WATER DEPT	201-388-0086	RAHWAY	RAHWAY RIVER - At pump station off Valley Rd & Lambert St.
2004002	ELIZABETHTOWN WATER COMPANY	~~201-345-4444~~	BRIDGEWATER TWP	RARITAN & MILLSTONE RIVERS - At confluence
2108001	HACKETTSTOWN MUA	201-852-3622	DRAKESTOWN	MINE HILL RESERVOIR - Off Mine Hill Rd.
			DRAKESTOWN	BURD RESERVOIR - Off Reservoir Rd. Southeast of

REFERENCE NO. 3

NUS CORPORATION AND SUBSIDIARIES

TELECON NOTE

CONTROL NO.:	DATE:	TIME:
9061	02/14/92	11:30

DISTRIBUTION:
- Tooley's Garage
- Staff

BETWEEN:	OF:	PHONE:
Don Van Abs	NJDEPE, Bureau of Water Supply Planning	(609) 633-1179

AND: K. Campbell (NUS)

DISCUSSION:

Mr. Van Abs returned my call of 02/13/92, and provided the following information on Wellhead Protection Area (WHPA) delineation for the State of New Jersey:

- WHPAs are not yet delineated for the state. The Bureau of Water Supply Planning is working on a draft delineation (a multi-year process).

Mr. Van Abs will put HNEC on their mailing list to receive updates on WHPA regulations.

ACTION ITEMS:

K. Campbell 02/14/92

REFERENCE NO. 4

MALCOLM PIRNIE, INC.	PROJECT NOTES

To: File	Date: December 15, 1993
From: David Kahlenberg	Project #: 8003-093
Subject: Surface Water Resources	Site Name: Middlesex Sampling Plant

The Ambrose Brook has a flow of 6.1 cubic feet per second (cfs) and has a surface water classification of FW2-NT which stands for fresh water, non-trout waters under NJAC 7:9-4.1 et seq. In addition, all FW2 waters are designated for the use of maintenance, migration, and propagation of the natural and established biota; and is a source of drinking water.

The Main Stream has an unknown flow, but it is assumed to be less than 6.1 cfs.
This stream is also classified as FW2-NT as it is stated on p. 52-53 of NJAC 7:9-4.1 et seq.

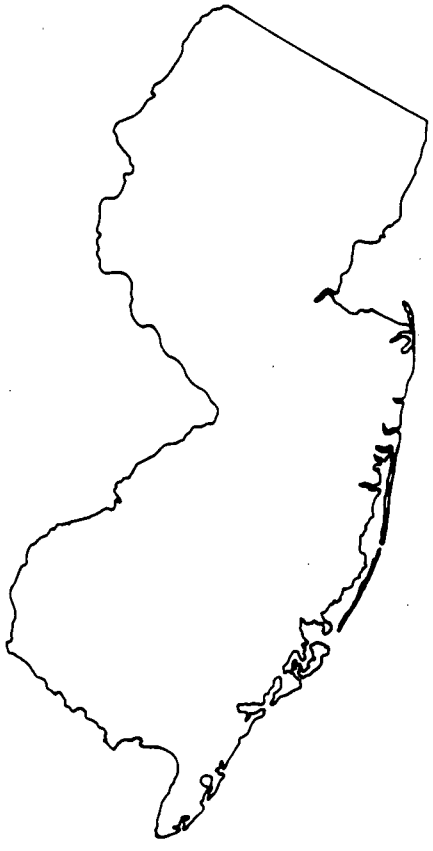
The Green Brook has a flow of 690 cfs and is also classified under NJAC 7:9-4.1 et seq. as FW2-NT.

The Raritan River has a flow of 1292 cfs and is also classified under NJAC 7:9-4.1 et seq. as FW2-NT.

Water Resources Data
New Jersey
Water Year 1990

Volume 1. Surface-Water Data

by W.R. Bauersfeld, E.W. Moshinsky, and E.A. Pustay



U.S. GEOLOGICAL SURVEY WATER-DATA REPORT NJ-90-1
Prepared in cooperation with the New Jersey
Department of Environmental Protection
and with other agencies

2814

01403060 RARITAN RIVER BELOW CALCO DAM, AT BOUND BROOK, NJ

LOCATION.--Lat 40°33'05", long 74°32'54", Somerset County, Hydrologic Unit 02030105, on right bank 1,000 ft downstream from Calco Dam and Cuckold Brook, 1,400 ft upstream of bridge on Interstate 287, 1.2 mi downstream from Millstone River, and 1.2 mi southwest of Bound Brook.

DRAINAGE AREA.--785 mi^2 (includes 11 mi^2 which drains into the Delaware and Raritan Canal).

PERIOD OF RECORD.--September 1903 to March 1909, October 1944 to current year. Monthly discharge only for some periods, published in WSP 1302. Prior to October 1966 published as "Raritan River at Bound Brook" (station 01403000).

REVISED RECORDS.--WSP 1552: 1903-07, 1946(M), 1949, 1952(P).

GAGE.--Water-stage recorder. Datum of gage is National Geodetic Vertical Datum of 1929. Sept. 12, 1903 to Mar. 31, 1909, nonrecording gages at highway bridge, 1.2 mi downstream at different datum. October 1944 to Sept. 30, 1966, water-stage recorder and concrete control at site 1,000 ft upstream at datum 18.06 ft higher.

REMARKS.--No estimated daily discharges. Records good. Water diverted 1.2 mi above station by Elizabethtown Water Co. for municipal supply (see Raritan River basin, diversions). Flow regulated by Spruce Run and Round Valley Reservoirs (see Raritan River basin, reservoirs in). Diversions to and releases from Round Valley Reservoir (see Raritan River basin, diversions and station 01399690). Slight diurnal fluctuations at low flow. Several measurements of water temperature were made during the year. New Jersey Water Supply Authority gage-height telemeter at station.

DISCHARGE, CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1989 TO SEPTEMBER 1990, DAILY-MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	955	1680	736	2080	2490	778	1200	569	2390	474	545	462
2	1830	1230	616	1340	1960	742	1050	506	1440	741	424	420
3	2230	1060	575	824	1680	749	3090	442	1160	507	278	394
4	1410	992	365	680	2150	725	3040	424	1030	412	240	350
5	1150	960	551	634	2560	635	2010	3210	914	338	246	315
6	1000	734	523	576	1710	617	1400	1930	755	388	1870	298
7	918	670	516	475	1440	572	1360	1070	742	547	7540	293
8	839	686	420	458	1250	551	1350	778	695	398	3700	288
9	790	2260	337	727	1120	574	1110	638	3740	352	1730	260
10	743	2730	376	1780	2090	590	953	1400	1750	887	1520	253
11	767	1580	381	2680	2770	609	1280	7730	1110	573	9100	252
12	638	1240	404	1520	1780	601	1160	3130	829	503	4300	239
13	656	954	393	904	1540	568	923	2680	664	2010	2240	263
14	660	844	354	623	1340	542	818	3670	614	1320	2560	274
15	665	835	471	608	1190	502	3140	1880	2140	858	1310	279
16	651	958	389	563	1210	485	2720	1600	1420	721	929	307
17	1120	1130	429	630	1140	560	1780	10600	879	559	717	512
18	2240	917	422	852	930	1810	1440	4890	1380	422	589	354
19	2890	750	393	958	875	1300	1110	2620	5300	316	547	268
20	9000	701	416	771	820	2080	930	1810	2670	311	519	280
21	13000	646	372	1620	724	2690	919	1500	1480	446	444	271
22	5300	534	310	2170	729	1590	1010	1340	1110	547	566	636
23	2980	561	333	1460	1070	1180	850	1150	939	541	499	829
24	2110	541	368	1120	1950	959	740	1020	823	756	3090	477
25	1730	515	394	2830	1390	861	674	893	684	585	2130	361
26	1520	608	416	7780	926	794	666	909	581	476	1110	290
27	1350	723	386	4360	833	717	612	1040	514	430	835	274
28	1240	1120	297	2330	834	635	563	861	463	412	773	252
29	1170	1180	303	1910	---	591	548	2500	432	401	775	233
30	1070	858	288	10800	---	852	617	9110	536	378	815	221
31	1140	---	360	4710	---	1400	---	4770	---	383	562	---
MEAN	2057	1007	416	1960	1446	899	1302	2473	1306	580	1694	340
MAX	13000	2730	736	10800	2770	2690	3140	10600	5300	2010	9100	829
MIN	638	515	288	458	724	485	548	424	432	311	240	221

STATISTICS OF MONTHLY FLOW DATA FOR PERIOD OF RECORD, BY WATER YEAR (WY)

MEAN	663	1076	1451	1587	1754	2112	1786	1319	790	701	694	691
MAX	2953	3684	4172	5825	3232	3858	5326	3862	3883	4624	3576	3158
(WY)	1904	1973	1974	1979	1971	1978	1983	1989	1972	1975	1955	1975
MIN	113	138	178	179	485	454	230	339	117	84.7	69.9	76.1
(WY)	1958	1966	1966	1981	1980	1985	1985	1965	1965	1955	1957	1957

SUMMARY STATISTICS	FOR 1990 WATER YEAR		FOR PERIOD OF RECORD	
AVERAGE FLOW	1292		1215	Unadjusted
HIGHEST ANNUAL MEAN			2046	1975
LOWEST ANNUAL MEAN			480	1985
HIGHEST DAILY MEAN	13000	Oct 21	34100	Aug 28 1971
LOWEST DAILY MEAN	221	Sep 30	37	Sep 6 1964
INSTANTANEOUS PEAK FLOW	17900	Oct 21	46100	Aug 28 1971
INSTANTANEOUS PEAK STAGE	28.13	Oct 21	37.47a	Aug 28 1971
10 PERCENTILE	2570		2620	
50 PERCENTILE	818		642	
95 PERCENTILE	287		133	

a From floodmark.

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Annual maximum discharge at crest-stage partial-record stations during water year 1990--Continued

Station No.	Station name	Location	Drainage area (mi^2)	Period of record	Annual Maximum Date	Annual Maximum Gage height (ft)	Annual Maximum Discharge (ft^3/s)
		Raritan River basin--Continued					
01401595	Rock Brook near Blawenburg, NJ	Lat 40°25'47", long 74°41'05", Somerset County, Hydrologic Unit 02030105, at bridge on Burnt Hill Road, 0.7 mi upstream from mouth, 1.0 mi northeast of Blawenburg, and 2.8 mi northwest of Rocky Hill. Datum of gage is 63.45 ft above National Geodetic Vertical Datum of 1929.	9.03	1967-90	8-11-90	b6.34	2,020
01401600	Beden Brook near Rocky Hill, NJ	Lat 40°24'52", long 74°39'02", Somerset County, Hydrologic Unit 02030105, at bridge on U.S. Route 206, 0.7 mi upstream from Pike Run, 1.2 mi northwest of Rocky Hill, and 4.6 mi north of Princeton. Datum of gage is 38.09 ft above National Geodetic Vertical Datum of 1929.	27.6	1967-90	8-11-90	9.23	3,300
01401870	Six Mile Run near Middlebush, NJ	Lat 40°28'12", long 74°32'42", Somerset County, Hydrologic Unit, 02030105, at bridge on South Middlebush Road, 1.6 mi upstream from mouth, and 2.1 mi south of Middlebush. Datum of gage is 39.91 ft above National Geodetic Vertical Datum of 1929.	10.7	1966-90	5-17-90	6.97	1,190
01403395	Blue Brook at Seeleys Pond Dam, near Berkeley Heights, NJ	Lat 40°40'02", long 74°24'13", Union County, Hydrologic Unit 02030105, on wall on right bank, upstream from Seeleys Pond spillway, 300 ft north of Scotch Plains, 1.0 mi west of Mountainside, and 4.5 mi southeast of Berkeley Heights. Datum of gage is 202.05 ft National Geodetic Vertical Datum of 1929.	3.59	1973, 1981-90	10-20-89	4.57	173
01403500	Green Brook at Plainfield, NJ	Lat 40°36'53", Long 74°25'55", Union County, Hydrologic Unit 02030105, on left bank 20 ft downstream from bridge on Sycamore Avenue in Plainfield and 1.0 mi upstream from Stony Brook. Datum of gage is 70.37 ft above National Geodetic Vertical Datum of 1929.	9.75	1938-84†, 1985-90	10-20-89	b3.20	690
		Navesink River basin					
01407290	Big Brook near Marlboro, NJ	Lat 40°19'10", long 74°12'52", Monmouth County, Hydrologic Unit 02030104, downstream side of bridge on Hillsdale Road, 1.7 mi east of Marlboro, and 3.0 mi northwest of Colts Neck.	6.42	1980-90	8-06-90	b9.24	1,200
		Manasquan River basin					
*01407830	Manasquan River near Georgia, NJ	Lat 40°12'36", long 74°16'41", Monmouth County, Hydrologic Unit 02040301, at culvert on Jacksons Mill Road near Georgia, and 0.5 mi upstream from Debois Creek. Datum of gage is 70.47 ft above National Geodetic Vertical Datum of 1929. Revised Records--WDR NJ-87-1.	10.6	1969-90	8-06-90	11.60	780
*01408015	Mingamahone Brook at Farmingdale, NJ	Lat 40°11'38", long 74°09'42", Monmouth County, Hydrologic Unit 02040301, at bridge on Belmar Road in Farmingdale, and 3.0 mi upstream from mouth. Datum of gage is 48.64 ft above National Geodetic Vertical Datum of 1929.	6.20	1969-90	10-20-89	5.16	176

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Discharge measurements made at low-flow partial-record stations during water year 1990--Continued

Station No.	Station Name	Location	Drainage area (mi^2)	Period of record	Measurements Date	Measurements Discharge (ft^3/s)
		Raritan River basin--Continued				
01399280	Lamington River near Chester, NJ	Lat 40°48'09", long 74°41'52", Morris County, Hydrologic Unit 02030105, at bridge on Pleasant Hill Road, 1.2 mi north of Chester, and 1.7 mi upstream from Tanners Brook.	17.3	1963-64, 1973, 1990	4-30-90 8-16-90	24 31
01399300	Lamington River at Milltown, NJ	Lat 40°47'13", long 74°43'13", Morris County, Hydrologic Unit 02030105, at bridge on New Furnace Road, 0.1 mi downstream from Tanners Brook, and 0.6 mi north of Milltown.	23.2	1988-90	3-14-90 6-14-90 8-17-90	38 57 38
*01399700	Rockaway Creek at Whitehouse, NJ	Lat 40°37'49", long 74°44'11", Hunterdon County, Hydrologic Unit 02030105, at bridge on Lamington Road, 1.4 mi northeast of Whitehouse, and 1.8 mi upstream from mouth.	37.1	1959-62, 1964-65, 1973, 1977-84c, 1986-90	9-19-90	20
d01400540	Millstone River near Manalapan, NJ	Lat 40°15'44", long 74°25'13", Monmouth County, Hydrologic Unit 02030105, at bridge on State Route 33, 1.3 mi west of Manalapan, 5.5 mi east of Hightstown, and 8.4 mi upstream of Rocky Brook.	7.37	1960-62, 1964, 1971-72, 1985, 1987-90	9-14-90	10
*01400947	Stony Brook at Pennington, NJ	Lat 40°19'50", long 74°46'05", Mercer County, Hydrologic Unit 02030105, 25 ft upstream from dam on Stony Brook at Old Mill Road, 1.3 mi east of Pennington, and 1.4 mi downstream from Baldwin Creek.	26.7	1965-69, 1971-72, 1985-88	b4-13-88	13
01400970	Honey Branch near Rosedale, NJ	Lat 40°20'26", long 74°44'39", Mercer County, Hydrologic Unit 02030105, at bridge on Elm Ridge Road, 0.2 mi above mouth, and 1.2 mi west of Rosedale.	3.83	1957-59, 1968-73, 1975, 1983-88	b4-12-88	1.5
01404060	Ambrose Brook at Middlesex, NJ	Lat 40°34'03", long 74°31'02", Middlesex County, Hydrologic Unit 02030105, at dam, 900 ft upstream from bridge on State Route 18 in Middlesex, and 0.7 mi upstream from mouth.	13.9	1979-90	6-14-90 9-07-90	6.1 4.1
01405170	Milford Brook at Englishtown, NJ	Lat 40°18'02", long 74°20'07", Monmouth County, Hydrologic Unit 02030105, at bridge on Conmack Road, 0.6 mi upstream from McGellairds Brook, 1.2 mi east of Englishtown, and 2.0 mi southwest of Gordons Corner.	4.86	1982, 1984-90	6-14-90 9-07-90	4.1 3.8
01405180	McGellairds Brook at Englishtown, NJ	Lat 40°18'06", long 74°21'26", Monmouth County, Hydrologic Unit 02030105, at bridge on Wilson Avenue in Englishtown, 0.8 mi downstream from Milford Brook, 1.0 mi southeast of Monmouth-Middlesex County line, and 5.5 mi northwest of Freehold.	14.9	1982, 1984-90	6-14-90 9-07-90	14 9.6
01405210	Pine Brook at Clarks Mills, NJ	Lat 40°18'58", long 74°19'51", Monmouth County, Hydrologic Unit 02030105, at bridge on Winthrop Drive, 1.3 mi east of Clarks Mills, 1.9 mi upstream of Matchaponix Brook, and 4.8 mi northwest of Freehold.	4.66	1982, 1984-90	6-14-90 9-07-90	4.9 3.4
01405440	Manalapan Brook at Bridge Street, at Spotswood, NJ	Lat 40°23'26", long 74°23'26", Middlesex County, Hydrologic Unit 02030105, at bridge on Bridge Street in Spotswood, 400 ft below DeVoe Lake Dam.	43.9	1973-76, 1989-90	9-27-90	40

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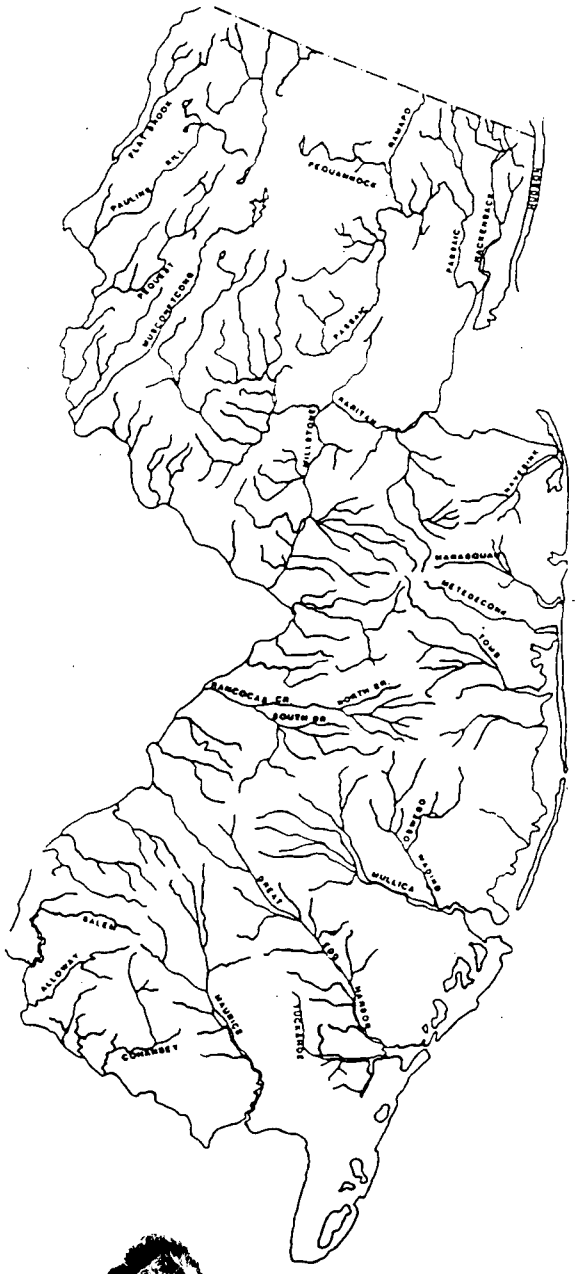
Let's protect our earth

Surface Water Quality Standards

N.J.A.C. 7:9-4.1 et seq.



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New Jersey Department of Environmental Protection

Division of Water Resources

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1. It is demonstrated to the satisfaction of the Department that the waters should be set aside to represent the natural aquatic environment and its associated biota; or

2. It is demonstrated to the satisfaction of the Department that a more restrictive use is necessary to protect a unique ecological system or threatened/endangered species.

(g) In those cases in which a thermal discharge is involved, the procedures for reclassifying segments for more restrictive uses shall be consistent with section 316 of the Federal Clean Water Act.

7:9-4.12 Designated uses of FW1, PL, FW2, SE1, SE2, SE3, and SC Waters

(a) In all FW1 waters the designated uses are:

1. Set aside for posterity to represent the natural aquatic environment and its associated biota;

2. Primary and secondary contact recreation;

3. Maintenance, migration and propagation of the natural and established aquatic biota; and

4. Any other reasonable uses.

(b) In all PL waters the designated uses are:

1. Cranberry bog water supply and other agricultural uses;

2. Maintenance, migration and propagation of the natural and established biota indigenous to this unique ecological system;

3. Public potable water supply after such treatment as required by law or regulations;

4. Primary and secondary contact recreation; and

5. Any other reasonable uses.

(c) In all FW2 waters the designated uses are:

1. Maintenance, migration and propagation of the natural and established biota;

2. Primary and secondary contact recreation;

3. Industrial and agricultural water supply;

4. Public potable water supply after such treatment as required by law or regulation; and

5. Any other reasonable uses.

(d) In all SE1 waters the designated uses are:

1. Shellfish harvesting in accordance with N.J.A.C. 7:12;

2. Maintenance, migration and propagation of the natural and established biota;

3. Primary and secondary contact recreation; and

4. Any other reasonable uses.

(e) In all SE2 waters the designated uses are:

1. Maintenance, migration and propagation of the natural and established biota;

2. Migration of diadromous fish;

3. Maintenance of wildlife;

4. Secondary contact recreation; and

5. Any other reasonable uses.

(f) In all SE3 waters the designated uses are:

1. Secondary contact recreation;

2. Maintenance and migration of fish populations;

3. Migration of diadromous fish;

4. Maintenance of wildlife; and

5. Any other reasonable uses.

(g) In all SC waters the designated uses are:

1. Shellfish harvesting in accordance with N.J.A.C. 7:12;

2. Primary and secondary contact recreation;

3. Maintenance, migration and propagation of the natural and established biota; and

4. Any other reasonable uses.

7:9-4.15 Surface water classifications for the waters of the State of New Jersey

(a) This section contains the surface water classifications for the waters of the State of New Jersey. Surface water classifications are presented in tabular form. Subsections (c) through (g) contain surface water classifications by major drainage basin. Subsection (h) lists FW1 waters by tract within basins and subsection (i) identifies the outstanding national resource waters of the State.

(b) The following are instructions for the use of Tables 1 through 5 found in N.J.A.C. 7:9-4.15(c) through (g) respectively:

1. The surface water classification tables give the surface water classifications for waters of the State. Surface waters of the State and their classification are listed in the Table covering the major drainage basin in which they are located. The major drainage basins are:

i. The Atlantic Coastal drainage basin which contains the surface waters listed in Table 1 in (c) below;

ii. The Delaware River drainage basin which contains the surface waters listed in Table 2 in (d) below;

iii. The Passaic River, Hudson River and New York Harbor Complex drainage basin which contains the surface waters listed in Table 3 in (e) below;

iv. The Raritan River and Raritan Bay drainage basin which contains the surface waters listed in Table 4 in (f) below; and

v. The Wallkill River drainage basin which contains the surface waters listed in Table 5 in (g) below.

2. Within each basin the waters are listed alphabetically and segment descriptions begin at the headwaters and proceed downstream.

3. To find a stream:

i. Determine which major drainage basin the stream is in;

ii. Look for the name of the stream in the appropriate Table and find the classification;

iii. For unnamed or unlisted streams, find the stream or other waterbody that the stream of interest flows into and look for the classification of that stream or waterbody. The classification of the stream of interest may then be determined by referring to (b)5 below. If the second stream or waterbody is also unlisted, repeat the process until a listed stream or waterbody is found. Use (b)5iv below to classify streams entering unlisted lakes.

4. To find a lake or other non-stream waterbody:

i. Determine which major drainage basin the waterbody is in;

ii. Look for the waterbody name in the appropriate Table;

iii. If the waterbody is not listed, use (b)5ii, 5iii, 5vi, and 5vii below to determine the appropriate classification.

5. To find unnamed waterways or waterbodies or named waterways or waterbodies which do not appear in the listing, use the following instructions:

i. Unnamed or unlisted freshwater streams that flow into streams classified as FW2-TP, FW2-TM, or FW2-NT take the classification of the classified stream they enter, unless the unlisted stream is a PL water which is covered in (b)5vii below. If the stream could be a C1 water, see (b)5vi below.

ii. All freshwater lakes, ponds and reservoirs that are five or more acres in surface area, that are not located entirely within the Pinelands Area boundaries (see (b)5vii below) and that are not specifically listed as FW2-TM are classified as FW2-NT. This includes lakes, ponds and reservoirs on segments of streams which are classified as FW2-TM or FW2-TP such as Saxton Lake on the Musconetcong River. If the waterbody could be a C1 water, also check (b)5vi below.

iii. All freshwater lakes, ponds and reservoirs, that are less than five acres in surface area, upstream of and contiguous with FW2-TP or FW2-TM streams, and which are not located entirely within the Pinelands Area boundaries (see(b)5vii below) are classified as FW2-TM. All other freshwater lakes, ponds and reservoirs that are not otherwise classified in this subsection or the following Tables are classified as FW2-NT. If the waterbody could be a C1 water, also check (b)5vi below.

iv. Unnamed or unlisted streams that enter FW2 lakes, ponds and reservoirs take the classification of either the listed tributary stream flowing into the lake with the highest classification or the listed tributary stream leaving the lake with the highest classification, whichever has the highest classification, or, if there are no listed tributary or outlet streams to the lake, the first listed stream downstream of the lake. If the stream is located within the boundaries of the Pinelands Area, see (b)5vii below; if it could be a C1 water, also see (b)5vi below.

v. Unnamed or unlisted saline waterways and waterbodies are classified as SE1 in the Atlantic Coastal Basin. Unnamed or unlisted saline waterways which enter SE2 or SE3 waters in the Passaic, Hackensack and New York Harbor Complex basin are classified as SE2 unless otherwise classified within Table 3 in (e) below. Freshwater portions of unnamed or unlisted streams entering SE1, SE2, or SE3 waters are classified as FW2-NT. This only applies to waters that are not PL waters (see (b)5vii below). If the waterbody or waterway could be a C1 water, also see (b)5vi below.

vi. If the waterway or waterbody of interest flows through or is entirely located within State parks, forests or fish and game lands, Federal wildlife refuges, other special holdings, or is a State shellfish water as defined in N.J.A.C. 7:9-4, the Department's maps should be checked to determine if the waterbody of interest is mapped as a C1 water. If the waterway or waterbody does not appear on the United States Geological Survey quadrangle that the Department used as a base map in its designation of the C1 waters, the Department will determine on a case-by-case basis whether the waterway or waterbody should be designated as C1.

vii. All waterways or waterbodies, or portions of waterways or waterbodies, that are located within the boundaries of the

Pinelands Area established at N.J.S.A. 13:18A-11a are classified as PL unless they are listed as FW1 waters in Table 6 in (h) below. A tributary entering a PL stream is classified as PL only for these portions of the tributary that are within the Pinelands Area. Lakes are classified as PL only if they are located entirely within the Pinelands Area.

6. The following 10 classifications are used for the sole purpose of identifying the water quality classification of the waters listed in the Tables in (c) through (h) below:

i. "FW1" means freshwaters wholly within Federal or State lands or special holdings that are preserved for posterity and are not subject to manmade wastewater discharges.

ii. "FW2-TP" means FW2 Trout Production.

iii. "FW2-TM" means FW2 Trout Maintenance.

iv. "FW2-NT" means FW2 Non Trout.

v. "PL" means Pinelands Waters.

vi. "SE1" means saline estuarine waters whose designated uses are listed in N.J.A.C. 7:9-4.12(d).

vii. "SE2" means saline estuarine waters whose designated uses are listed in N.J.A.C. 7:9-4.12(e).

viii. "SE3" means saline estuarine waters whose designated uses are listed in N.J.A.C. 7:9-4.12(f).

ix. "SC" means the general surface water classification applied to saline coastal waters.

x. FW2-NT/SE1 (or a similar designation that combines two classifications) means a waterway in which there may be a salt water/fresh water interface. The exact point of demarcation between the fresh and saline waters must be determined by salinity measurements and is that point where the salinity reaches 3.5 parts per thousand at mean high tide. The stream is classified as FW2-NT in the fresh portions (salinity less than or equal to 3.5 parts per thousand at mean high tide) and SE1 in the saline portions.

7. The following water quality designations are used in Tables 1 through 5 in (c) through (g), respectively, below:

i. "(C1)" means Category 1 waters;

ii. "(tp)" indicates trout production in waters which are classified as FW1. This is for information only and does not affect the water quality criteria for those waters;

iii. "(tm)" indicates trout maintenance in waters which are classified as PL or FW1. For FW1 waters this is for information only and does not affect the water quality criteria for those waters.

(f) The surface water classifications in Table 4 are for waters of the Raritan River and Raritan Bay Basin:

Alin Stream is a tributary to the Ambose Brook

TABLE 4

WATERBODY	CLASSIFICATION
ALLERTON CREEK (Allerton) - Entire length	FW2-NT
AMBROSE BROOK (Piscataway) - Entire length	FW2-NT
AMWELL LAKE (Syndertown)	FW2-NT(C1)
ASSISCONG CREEK (Flemington) - Entire length	FW2-NT
BACK BROOK (Vanliew's Corners) - Entire length	FW2-NT
BALDWINS CREEK	
(Pennington) - Entire length, except segment described separately below	FW2-NT
(Baldwin) - Segment within the boundaries of Baldwin Lake Wildlife Management Area	FW2-NT(C1)
BARCLAY BROOK (Redshaw Corners) - Entire length	FW2-NT
BEAVER BROOK	
(Cokesbury) - Source to Reformatory Road bridge	FW2-TP(C1)
(Annandale) - Reformatory Rd. bridge to Raritan River, South Branch	FW2-TM
BEDEN BROOK (Montgomery) - Entire length	FW2-NT
BIG BEAR BROOK (West Windsor) - Entire length	FW2-NT
BIG BROOK (Vanderberg) - Entire length	FW2-NT
BLACK BROOK (Polktown) - Entire length	FW2-TP(C1)
BLACK RIVER - See LAMINGTON RIVER	
BLACKBERRY CREEK	
(Oceanport) - Source to a line beginning on the easternmost extent of Gooseneck Point and bearing approximately 162 degrees True North to its terminus on the westernmost extent of an unnamed point of land in the vicinity of the western extent of Cayuga Ave. in Oceanport.	SE1
(Oceanport) - Creek below the line described above	SE1
BLUE BROOK (Mountainside) - Entire length	FW2-NT
BOULDER HILL BROOK (Tewksbury) - Entire length	FW2-TP(C1)
BOUND BROOK (Dunellen) - Entire length	FW2-NT
BRANCHPORT CREEK	
(Long Branch) - Source to a line beginning on the northernmost extent of an unnamed point of land lying north of Pocano Ave. in Oceanport and bearing approximately 055 degrees True North to its terminus on the westernmost extent of the northern bulkhead at the lagoon located between France Rd. and	FW2-NT/SE1

Oceanport	
(Oceanport) - Creek downstream of line described above	SE1(C1)
PARKERS CREEK	
(Fort Monmouth) - Source to a line beginning on the easternmost extent of Horseneck Point and bearing approximately 000 degrees T (True North) to its terminus on Breezy Point on the Little Silver side (north) side of the creek.	FW2-NT/SE1
(Fort Monmouth) - Creek downstream of line described above	SE1(C1)
PEAPACK BROOK (Gladstone) - Entire length	FW2-TP(C1)
PETERS BROOK (Somerville) - Entire length	FW2-NT
PIGEON SWAMP (S. Brunswick) - All waters within the boundaries of Pigeon Swamp State Park	FW2-NT(C1)
PIKE RUN (Belle Meade) - Entire length	FW2-NT
PINE BROOK (Clarks Mills) - Entire length	FW2-NT
PINE BROOK (Cooks Mill) - Entire length	FW2-TM
PLEASANT RUN (Readington) - Entire length	FW2-NT
PRESCOTT BROOK (Stanton Station) - Entire length	FW2-TM
RAMANESSIN (HOP) BROOK (Holmdel) - Entire length	FW2-TM
RARITAN BAY - Entire drainage	FW2-NT/SE1
RARITAN RIVER	
NORTH BRANCH (Also see INDIA BROOK)	
(Pleasant Valley) - Source to, but not including, Ravine Lake	FW2-TP(C1)
(Far Hills) - Ravine Lake dam to Rt. 512 bridge	FW2-TM
(Bedminister) - Rt. 512 bridge to confluence with South Branch, Raritan River	FW2-NT
SOUTH BRANCH RARITAN RIVER	
(Mt. Olive) - Source to the dam that is 390 feet upstream of the Flanders-Drakestown Road bridge	FW2-NT(C1)
(Mt. Olive) - Dam to confluence with Turkey Brook	FW2-TM(C1)
(Naughright) - Confluence with Turkey Brook to confluence with Electric Brook	FW2-TP(C1)
(Clinton) - Confluence with Electric Brook to downstream end of Packers Island, except segment described separately, below	FW2-TM
(Ken Lockwood Gorge) - River and tributaries within Ken Lockwood Gorge Wildlife Management Area	FW2-TM(C1)
(Neshanic Sta.) - Downstream end of Packers Island to confluence with North Branch, Raritan River	FW2-NT
MAIN STEM RARITAN RIVER	
(Bound Brook) - From confluence of North	FW2-NT

and South Branches to Landing Lane bridge in New Brunswick and all freshwater tributaries downstream of Landing Lane bridge.	
(Sayreville) - Landing Lane bridge to Raritan Bay and all saline water tributaries	SE1
RINEHART BROOK (Hacklebarney) - Entire length	FW2-TP(C1)
ROCK BROOK (Montgomery) - Entire length	FW2-NT
ROCKAWAY CREEK	
NORTH BRANCH	
(Mountainville) - Source to Rt. 523 bridge	FW2-TP(C1)
(Whitehouse) - Rt. 523 bridge to confluence with South Branch	FW2-TM
SOUTH BRANCH (Whitehouse) - Entire length	FW2-TM
MAIN STEM (Whitehouse) - Confluence of North and South Branches to Lamington River	FW2-NT
ROUND VALLEY RESERVOIR (Clinton)	FW2-TM
ROYCE BROOK (Manville) - Entire length	FW2-NT
SHREWSBURY RIVER	
(Little Silver) - Source to Rt. 36 highway bridge	SE1(C1)
(Highlands) - Rt. 36 bridge to Sandy Hook bay	SE1
SIMONSON BROOK (Griggstown) - Entire length	FW2-NT
SIX MILE RUN	
(Franklin Church) - Entire length, except segment described below	FW2-NT
(Hillsborough) - Segment within the boundaries of Six Mile Run State Park	FW2-NT(C1)
SOUTH RIVER	
(Old Bridge) - Duhernal Lake to intake of the Sayreville Water Department	FW2-NT
(Sayreville) - Below the intake of the Sayreville Water Department	SE1
SPOOKY BROOK (Bound Brook)	FW2-NT
SPRUCE RUN	
(Glen Gardner) - Source to, but not including, Spruce Run Reservoir	FW2-TP(C1)
(Clinton) - Spruce Run Reservoir dam to Raritan River, South Branch	FW2-TM
SPRUCE RUN RESERVOIR (Union) - Reservoir and tributaries	FW2-TM(C1)
STONY BROOK (Washington) - Entire length	FW2-TP(C1)
STONY BROOK	
(Hopewell) - Entire length, except that segment described below	FW2-NT
(Syndertown) - Brook and tributaries within Amwell Lake Wildlife Management Area	FW2-NT(C1)
STONY BROOK (Watchung) - Entire length	FW2-NT
SUN VALLEY BROOK (Mt Olive) - Entire length	FW2-TP(C1)
SWIMMING RIVER	
(Red Bank) - Source to the intake of the	FW2-NT

REFERENCE NO. 5

ARCS II CONTRACT 68-W9-0051
MALCOLM PIRNIE, INC.
RECORD OF TELEPHONE CONVERSATION/AGREEMENT

File No. 8003-093

Date: 9/23/92 Time: 2:22 [ ] AM [✓] PM

[✓] Incoming Call From: SUSAN KANSE 615-576-5724
Telephone No.

Affiliation: Dept. of Energy

[ ] Outgoing Call To:
Telephone No.

Affiliation:

Malcolm Pirnie Staff: DAVID KAHCENBERG 609-860-0100
(Receiving or Calling) Name Telephone No.

Summary of [✓] Conversation [ ] Agreement:

Ms. Kanse returned my call to her about the Main Stream - as to whether or not it was a perennially flowing water body. She said that she spoke both her co-workers who work at the site and they said that the Main Stream is a perennially flowing water body. I asked her if there was any documentation for this; and she said that the only documentation was the verbal observations of her co-workers that she reported to me.

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REFERENCE NO. 6

MALCOLM PIRNIE, INC. PROJECT NOTES

To: FILE
From: DAVID KAHLENBERG
Subject: FISHERIES

Date: September 8, 1992
Project Number: 8003093
Site Name: Middlesex Sampling Plan

The Ambrose and Green Brooks serve as areas for low to moderate fishing, while the Raritan River is a more heavily fished water body.

Reference the attached telecons dated July 10, 1992 and September 8, 1992

ARCS II CONTRACT 68-W9-0051
MALCOLM PIRNIE, INC.
RECORD OF TELEPHONE CONVERSATION/AGREEMENT

File No. _____

Date: 9/8/92 Time: 9:32 [✓] AM [ ] PM

[✓] Incoming Call From: Arthur Lipine 908-236-2118
Telephone No.

Affiliation: NJDEP Fish, Game, Wildlife

[ ] Outgoing Call To: _____
Telephone No.

Affiliation: _____

Malcolm Pirnie Staff: DAVID KAHLENBERG 609 360 0100
(Receiving or Calling) Name Telephone No.

Summary of [✓] Conversation [ ] Agreement:

I spoke with Arthur Lipine to determine if there were fisheries in the Ambrose and Green Brooks. He said that both of the brooks have low to moderate fishing and assumed there was consumption of the fish.

Fish in AMBROSE BROOK: white suckers, brown bullhead, red breast sunfish, spot tail shiner, Tessellated darter, pumpkin seed sunfish, Blue gill sunfish, banded killy fish, cream chip pickerel, american eel, carp, pumpkin seed bass, large mouth bass
- it is classified as non-trout waters

Fish in the Green Brook: brown trout, pumpkin seed, brown bullhead, common shiner, long nose aces, black head aces, fat head minnow, silvery minnow, banded killy fish
- is classified for trout maintenance

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ARCS II CONTRACT 68-W9-0051
MALCOLM PIRNIE, INC.
RECORD OF TELEPHONE CONVERSATION/AGREEMENT

File No. _____

Date: 7/10/92 Time: 1:05 [ ] AM [✓] PM

[✓] Incoming Call From: Arthur Lipine 908-236-2118
Telephone No.

Affiliation: NJDEP - Div. Fish, Game, Wildlife

[ ] Outgoing Call To: _____
Telephone No.

Affiliation: _____

Malcolm Pirnie Staff: DAVID KAHLENBERG 609 860 0100
(Receiving or Calling) Name Telephone No.

Summary of [✓] Conversation [ ] Agreement:

Mr Lipine returned my phone call and I asked him about the fisheries that exist from Chambers Brook to the North Branch of the Raritan River to the Main stream of the Raritan River ~~to~~ to Bound Brook.

He said that there are no fisheries along Chamber's Brook and nobody really fishes there. Also he said that the ~~stream~~ brook cannot handle effluents and that the brook is fairly small with a width varying in 2 to 3 ft to 6 ft wide.

He said that the North Branch of the Raritan River has many fish including small mouth bass, some large mouth bass, blue gill, red breast, suckers, carp, and it is stocked with trout.

He said that the Raritan River has American shad, river herring, striped bass, Tiger Muskellunge, Northern Pike as well as others.

He said that the region is very heavily fished during trout season.

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REFERENCE NO. 7

State of New Jersey
Department of Environmental Protection and Energy
Division of Parks and Forestry
Office of Natural Lands Management
CN 404 Trenton New Jersey 08625-0404
(609) 984-1339
FAX (609) 984-1427

Scott A. Weiner
Commissioner

Thomas F. Hampton
Administrator

September 9, 1992

Andrew Clibanoff
Malcom Pirnie, Inc.
104 Interchange Plaza
Cranbury, NJ 08512

Re: Middlesex Sampling Plant and Associated Waterways

Dear Mr. Clibanoff:

Thank you for your data request regarding rare species information for the above referenced project site in Middlesex and Somerset Counties.

The Natural Heritage Data Base does not have any records for rare plants, animals, or natural communities on the Middlesex Sampling Plant site. However, there are records for a number of occurrences for rare species which may be on, or in the immediate vicinity of the waterways that you have associated with this site. The attached list provides additional information about these occurrences. Also attached is a list of rare species from records in the general vicinity of the project site (within approximately 4 miles).

Also attached are lists of rare vertebrates of Middlesex and Somerset Counties together with descriptions of their habitats. If suitable habitat is present at the project site, these species would have potential to be present. If you have questions concerning the wildlife records or wildlife species mentioned in this response, we recommend you contact the Division of Fish, Game and Wildlife Endangered and Nongame Species Program.

In order to red flag the general locations of documented occurrences of rare and endangered species and natural communities, in 1988 we prepared computer generated Natural Heritage Index Maps. Enclosed please find these maps for the Bound Brook, New Brunswick, Plainfield, and South Amboy USGS quadrangles.

PLEASE SEE THE ATTACHED 'CAUTIONS AND RESTRICTIONS ON NHP DATA'.

Thank you for consulting the Natural Heritage Program. The fee to cover the cost of processing this data request is $40.00. Payment should be made payable to Treasurer, State of New Jersey and mailed to Office of Natural Lands Management, DEPE Div. of Parks and Forestry, CN404, Trenton, NJ 08625-0404. To ensure that your payment is properly credited, please provide a copy of this

letter with your remittance. Feel free to contact us again regarding any future data requests.

Sincerely,

Elena A. Williams

Elena A. Williams
Senior Planner
Natural Heritage Program

cc: JoAnn Frier-Murza
Thomas Hampton

REFERENCE NO. 8

MALCOLM PIRNIE, INC.

PROJECT NOTES

To: FILE

From: DAVID KAHCENBERG

Subject: Population in 4 mile RADIUS MAP

Date: August 26, 1992

Project Number: P003093

Site Name: Middlesex Sampling Plant

A house count was performed in the 0-1/4 mile and 1/4-1/2 mile rings to supplement the data obtained from RCBEMS. The house count was performed on the four mile vicinity map made from USGS Topography maps for the Middlesex Sampling Plant.

Houses Counted	Distance
132	0-1/4 mile
256	1/4-1/2 mile

AVG. number of people per household in Middlesex County = 2.71

Distance	number of people
0-1/4	(132) 2.71 = 358 people
1/4-1/2	(256) 2.71 = 694 people

Total Population for 4 miles vicinity to the Middlesex Sampling Plant is:

Distance	number of People
0-1/4 mile	358
1/4-1/2	694
1/2-1	6259
1-2	22286
2-3	41381
3-4	35293
	106271 = Total

Table 6. Household, Family, and Group Quarters Characteristics: 1990

[For definitions of terms and meanings of symbols, see text]

State / County / Place and (In Selected States) County Subdivision	Persons in households	All households	Family households: Total	Family households: Married-couple family	Family households: Female householder, no husband present	Nonfamily households: Total	Nonfamily households: Householder living alone: Total	Nonfamily households: Householder living alone: 65 years and over: Total	Nonfamily households: Householder living alone: 65 years and over: Female	Persons per— Household	Persons per— Family	Persons in group quarters: Total	Persons in group quarters: Institutionalized persons	Persons in group quarters: Other persons in group quarters
The State	7 558 820	2 794 711	2 021 346	1 578 702	338 455	773 365	646 171	273 736	213 511	2.70	3.21	171 368	92 670	78 698
COUNTY														
Atlantic County	218 321	85 123	56 576	41 202	11 647	28 547	22 666	9 598	7 302	2.56	3.13	6 006	3 014	2 992
Bergen County	816 230	308 880	225 188	186 258	29 139	83 692	71 606	30 959	24 491	2.64	3.14	9 150	5 485	3 665
Burlington County	380 910	136 554	104 190	85 741	14 015	32 364	26 746	9 309	7 303	2.79	3.23	14 156	7 068	7 088
Camden County	493 933	178 758	129 568	96 405	26 205	49 190	41 328	16 352	12 633	2.76	3.28	8 891	6 812	2 079
Cape May County	92 414	37 856	25 667	20 592	3 882	12 189	10 406	5 510	4 206	2.44	2.98	2 675	1 839	836
Cumberland County	131 455	47 118	34 966	25 318	7 429	12 152	10 191	5 060	3 961	2.79	3.24	6 598	6 047	551
Essex County	759 590	278 752	191 363	124 659	53 401	87 389	75 440	30 077	23 011	2.72	3.32	18 616	8 353	10 263
Gloucester County	225 971	78 845	60 808	49 629	8 453	18 037	14 875	5 940	4 586	2.87	3.30	4 111	1 712	2 399
Hudson County	546 160	208 739	136 143	90 508	34 343	72 596	59 931	22 921	17 406	2.62	3.26	6 939	3 561	3 378
Hunterdon County	104 438	37 906	29 295	25 953	2 371	8 611	6 770	2 349	1 842	2.76	3.16	3 338	3 260	78
Mercer County	309 804	116 941	82 447	62 715	15 448	34 494	28 277	11 589	8 976	2.65	3.16	16 020	5 803	10 217
Middlesex County	648 111	238 833	175 451	143 344	23 886	63 382	50 903	19 029	14 955	2.71	3.18	23 669	7 926	15 743
Monmouth County	541 950	197 570	145 892	120 609	19 442	51 678	43 434	19 373	15 332	2.74	3.24	11 174	5 904	5 270
Morris County	413 680	148 751	113 074	96 850	11 923	35 677	28 312	9 742	7 749	2.78	3.21	7 673	4 164	3 509
Ocean County	426 852	168 147	120 783	102 028	14 443	47 364	41 879	27 121	21 674	2.54	3.04	6 351	4 529	1 822
Passaic County	442 797	155 269	115 135	84 917	22 753	40 134	33 677	15 585	12 133	2.85	3.33	10 263	5 321	4 942
Salem County	63 765	23 794	17 645	13 780	3 017	6 149	5 329	2 579	1 924	2.68	3.15	1 529	1 337	192
Somerset County	235 585	88 346	65 368	55 575	7 231	22 978	18 182	5 351	4 165	2.67	3.11	4 694	4 204	490
Sussex County	129 218	44 456	35 516	30 810	3 379	8 940	7 193	2 768	2 167	2.91	3.28	1 725	1 643	82
Union County	487 238	180 076	131 200	101 002	22 958	48 816	41 475	19 046	14 963	2.71	3.19	6 581	3 884	2 697
Warren County	90 398	33 997	25 011	20 807	3 090	8 986	7 551	3 478	2 732	2.66	3.14	1 209	784	425
PLACE AND COUNTY SUBDIVISION														
Aberdeen township, Monmouth County	16 896	5 905	4 617	3 873	555	1 288	1 038	250	185	2.86	3.27	142	129	13
Absecon city, Atlantic County	7 144	2 579	2 009	1 659	262	570	454	209	167	2.77	3.14	154	140	14
Alexandria township, Hunterdon County	3 531	1 203	1 016	922	65	187	146	55	35	2.94	3.21	63	63	-
Allamuchy township, Warren County	3 448	1 471	1 033	904	99	438	371	97	77	2.34	2.81	36	-	36
Allamuchy-Panther Valley CDP, Warren County	2 728	1 232	843	750	72	389	332	82	65	2.21	2.69	36	-	36
Allendale borough, Bergen County	5 709	1 859	1 603	1 439	128	256	197	69	59	3.07	3.31	191	191	-
Allenhurst borough, Monmouth County	759	298	208	174	27	90	79	38	28	2.55	3.11	-	-	-
Allentown borough, Monmouth County	1 828	655	519	427	73	136	107	26	21	2.79	3.13	-	-	-
Alloway CDP, Salem County	1 335	473	382	329	37	91	86	46	33	2.82	3.18	36	36	-
Alloway township, Salem County	2 759	956	774	664	80	182	162	81	51	2.89	3.24	36	36	-
Alpha borough, Warren County	2 530	967	729	590	110	238	199	104	87	2.62	3.03	-	-	-
Alpine borough, Bergen County	1 716	534	482	442	27	52	39	17	15	3.21	3.33	-	-	-
Andover borough, Sussex County	700	261	181	149	24	80	61	15	15	2.68	3.23	-	-	-
Andover township, Sussex County	4 747	1 695	1 337	1 162	126	358	280	81	64	2.80	3.16	691	679	12
Annandale CDP, Hunterdon County	1 074	390	300	262	27	90	74	36	28	2.75	3.16	-	-	-
Asbury Park city, Monmouth County	16 277	6 871	3 584	1 662	1 611	3 287	2 836	1 357	1 075	2.37	3.28	522	28	494
Atlantic City city, Atlantic County	36 225	15 731	8 183	3 713	3 584	7 548	6 391	3 022	2 201	2.30	3.13	1 761	934	827
Atlantic Highlands borough, Monmouth County	4 629	1 774	1 267	1 021	181	507	415	186	142	2.61	3.11	-	-	-
Audubon borough, Camden County	9 205	3 622	2 433	1 952	373	1 189	1 031	521	421	2.54	3.17	-	-	-
Audubon Park borough, Camden County	1 150	498	346	237	92	152	143	97	81	2.31	2.83	-	-	-
Avalon borough, Cape May County	1 809	838	545	468	61	293	253	135	111	2.16	2.68	-	-	-
Avenel CDP, Middlesex County	12 212	4 854	3 420	2 719	524	1 434	1 200	400	280	2.52	3.02	3 292	3 261	31
Avon-by-the-Sea borough, Monmouth County	2 141	989	555	447	90	434	384	200	159	2.16	2.94	24	-	24
Barnegat CDP, Ocean County	1 160	424	311	248	47	113	90	48	34	2.74	3.22	-	-	-
Barnegat township, Ocean County	12 120	4 163	3 343	2 838	389	820	695	372	277	2.91	3.29	115	115	-
Barnegat Light borough, Ocean County	657	330	198	173	19	132	121	56	37	1.99	2.55	18	-	18
Barrington borough, Camden County	6 774	2 688	1 863	1 499	295	825	709	235	172	2.52	3.08	-	-	-
Bass River township, Burlington County	1 580	554	435	361	56	119	98	44	38	2.85	3.25	-	-	-
Bay Head borough, Ocean County	1 226	530	364	293	59	166	147	73	51	2.31	2.81	-	-	-
Bayonne city, Hudson County	61 191	25 309	16 528	11 956	3 475	8 781	7 955	3 958	3 084	2.42	3.06	253	-	253
Beach Haven borough, Ocean County	1 460	659	421	344	61	238	206	112	90	2.22	2.78	15	-	15
Beach Haven West CDP, Ocean County	4 237	1 832	1 286	1 090	154	546	475	193	129	2.31	2.76	-	-	-
Beachwood borough, Ocean County	9 324	3 047	2 476	2 035	339	571	461	207	162	3.06	3.42	-	-	-
Beattystown CDP, Warren County	3 966	1 679	1 077	880	148	602	467	81	61	2.36	2.94	-	-	-
Beckett CDP, Gloucester County	3 815	1 188	1 046	950	65	142	107	7	5	3.21	3.46	-	-	-
Bedminster township, Somerset County	7 086	3 447	1 991	1 654	272	1 456	1 225	118	94	2.06	2.66	-	-	-
Belleville CDP, Essex County	34 123	13 374	9 193	6 964	1 637	4 181	3 575	1 245	951	2.55	3.13	90	13	77
Belleville township, Essex County	34 123	13 374	9 193	6 964	1 637	4 181	3 575	1 245	951	2.55	3.13	90	13	77
Bellmawr borough, Camden County	12 603	4 679	3 531	2 732	610	1 148	968	404	307	2.69	3.13	-	-	-
Belmar borough, Monmouth County	5 851	2 718	1 381	1 009	265	1 337	1 084	404	314	2.15	2.94	26	-	26
Belvidere town, Warren County	2 663	1 027	728	596	100	299	247	113	96	2.59	3.09	6	-	6
Bergenfield borough, Bergen County	24 417	8 799	6 733	5 462	932	2 066	1 741	919	729	2.77	3.21	41	-	41
Berkeley township, Ocean County	36 794	17 614	12 394	11 076	997	5 220	4 928	4 023	3 227	2.09	2.50	525	518	7
Berkeley Heights township, Union County	11 540	3 860	3 325	3 017	220	535	414	181	129	2.99	3.22	440	402	38
Berkeley Heights CDP, Union County	11 540	3 860	3 325	3 017	220	535	414	181	129	2.99	3.22	440	402	38
Berlin borough, Camden County	5 672	1 950	1 502	1 265	179	448	373	167	130	2.91	3.35	-	-	-
Berlin township, Camden County	5 453	1 777	1 432	1 151	202	345	275	97	72	3.07	3.42	13	-	13
Bernards township, Somerset County	16 146	6 345	4 608	4 160	327	1 737	1 432	425	356	2.54	3.02	1 053	1 007	46
Bernardsville borough, Somerset County	6 546	2 449	1 843	1 617	164	606	496	202	163	2.67	3.07	51	51	-
Bethlehem township, Hunterdon County	3 104	1 033	882	803	51	151	115	34	29	3.00	3.26	-	-	-
Beverly city, Burlington County	2 973	1 011	753	510	197	258	207	89	68	2.94	3.42	-	-	-
Blackwood CDP, Camden County	5 101	1 835	1 380	1 098	211	455	374	157	104	2.78	3.22	19	-	19
Blairstown township, Warren County	5 331	1 773	1 474	1 328	112	299	251	128	90	3.01	3.33	-	-	-
Bloomfield CDP, Essex County	44 633	18 455	11 857	9 258	1 970	6 598	5 675	2 490	1 993	2.42	3.07	428	164	264
Bloomfield township, Essex County	44 633	18 455	11 857	9 258	1 970	6 598	5 675	2 490	1 993	2.42	3.07	428	164	264
Bloomingdale borough, Passaic County	7 530	2 747	2 094	1 763	248	653	507	169	128	2.74	3.15	-	-	-
Bloomsbury borough, Hunterdon County	890	330	255	227	18	75	62	23	18	2.70	3.11	-	-	-
Bogota borough, Bergen County	7 811	2 777	2 079	1 674	312	698	582	213	169	2.81	3.31	13	11	2
Boonton town, Morris County	8 198	3 121	2 127	1 665	356	994	737	315	250	2.63	3.15	145	97	48
Boonton township, Morris County	3 440	1 241	1 006	893	82	235	185	82	57	2.77	3.10	126	126	-
Bordentown city, Burlington County	4 297	1 784	1 148	809	258	636	543	205	149	2.41	3.02	44	-	44
Bordentown township, Burlington County	7 334	2 857	2 024	1 683	256	833	678	207	154	2.57	3.08	349	115	234
Bound Brook borough, Somerset County	9 475	3 675	2 490	1 913	422	1 185	945	369	293	2.58	3.10	12	-	12
Bradley Beach borough, Monmouth County	4 465	2 009	1 086	778	230	923	731	248	198	2.22	2.96	10	-	10
Branchburg township, Somerset County	10 885	3 744	3 080	2 799	193	664	522	151	115	2.91	3.23	3	-	3
Branchville borough, Sussex County	851	354	241	193	34	113	97	52	40	2.40	2.90	-	-	-
Brass Castle CDP, Warren County	1 419	477	403	374	17	74	67	44	31	2.97	3.28	-	-	-
Brick township, Ocean County	66 170	24 965	18 729	15 810	2 259	6 236	5 338	2 855	2 274	2.65	3.10	303	286	17
Brick Township CDP, Ocean County	66 170	24 965	18 729	15 810	2 259	6 236	5 338	2 855	2 274	2.65	3.10	303	286	17
Bridgeton city, Cumberland County	18 288	6 725	4 640	2 674	1 621	2 085	1 802	937	738	2.72	3.30	654	625	29

3 of 4

GSC-TR-32-90-008

DRAFT

PCGEMS
USER'S GUIDE
RELEASE 1.0

Prepared for

U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF PESTICIDES AND TOXIC SUBSTANCES
EXPOSURE EVALUATION DIVISION

Under
Contract No. 68024281
Task No. 2-28
Project Officer: Lynn Delpire
Task Manager: Patricia Harrigan

Prepared by

GENERAL SCIENCES CORPORATION
6100 Chevy Chase Drive
Laurel, Maryland 20707

April 1990

MIDDLESEX SAMPLING PLANT

LATITUDE 40:33:43 LONGITUDE 74:29:32 1980 POPULATION

KM	0.00- 0.4	0.4- 0.8	0.8- 1.6	1.6- 3.2	3.2- 4.8	4.8- 6.4	SECTOR TOTALS
S 1	0	0	6259	22286	41381	35293	105219
RING TOTALS	0	0	6259	22286	41381	35293	105219

REFERENCE NO. 9

MALCOLM PIRNIE, INC.	PROJECT NOTES

To: File	Date: December 15, 1993
From: David Kahlenberg	Project #: 8003-093
Subject: Residential Population Threat	Site Name: Middlesex Sampling Plant (MSP)

The following residential properties are located on or within 200 feet of observed contamination from the MSP site:

650 Harris Avenue: Ref. Nos. 20; 21; 23, pp. 3-38; 24, pp. 2-6, 3-10, 4-4, 6-16, 6-34 - 6-34A, 6-39, 6-45, 6-49, A-8 - A-9, A-11 - A-13, A-19 - A-20; 25, pp. 138-152

432 Williams Street: Ref. Nos. 20; 21; 23, pp. 49-60; 24, pp. 2-6, 3-11, 4-4, 6-17, 6-36, 6-41, 6-46, A14 - A20; 25, pp. 122-137

217 Mountain Avenue: Ref. Nos. 20 - 22, pp. 15-16, 46, 51, 62-63, 66, 80; 25, pp. 45-64, 26, pp. 39, 86; 27, pp. 44 - 51

223 Mountain Avenue: Ref. Nos. 20 - 22, pp. 15-16, 46, 51, 66, 80; 25, pp. 27 - 44; 26, pp. 39, 86; 27, pp. 26 - 35

233 Mountain Avenue: Ref. Nos. 20 - 22, pp. 15-16, 46, 51, 62, 66, 80; 25, pp. 9 - 27; 26, pp. 39, 86; 27, pp. 12-25

312 Mountain Avenue: Ref. Nos. 20; 21; 24, pp. 3-2, 3-13, 3-19, 4-4, 6-38, 6-43, 6-48, A-22 - A23

611 Williams Street (Parcel 17): Ref. Nos. 25, pp. 105-121; 26, pp. 88; 27, pp. 142-149

203 Mountain Avenue (Parcel 6): Ref. Nos. 25, pp. 86-104; 26, pp. 39, 86; 27, pp. 61-69

215 Mountain Avenue (Parcel 5): Ref. Nos. 25, pp. 65-85; 26, pp. 39, 86; 27, pp. 52-60

The Middlesex County 1990 Census average number of persons per household of 2.71 was used to determine populations.

According to reference 23, page 49, one person resides at 432 Williams Street.

Residential Population = 8 x 2.71 = 21.68
432 Williams Street Population = + 1
Total Population = 22.68 or approximately 23 people

Table 6. **Household, Family, and Group Quarters Characteristics: 1990**

[For definitions of terms and meanings of symbols, see text]

State / County / Place and (In Selected States) County Subdivision	Persons in households	All households	Family households: Total	Family households: Married-couple family	Family households: Female householder, no husband present	Nonfamily households: Total	Nonfamily households: Householder living alone: Total	Nonfamily households: Householder living alone: 65 years and over: Total	Nonfamily households: Householder living alone: 65 years and over: Female	Persons per— Household	Persons per— Family	Persons in group quarters: Total	Persons in group quarters: Institutionalized persons	Persons in group quarters: Other persons in group quarters
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COUNTY														
Atlantic County	218 321	85 123	56 576	41 202	11 647	28 547	22 666	9 598	7 302	2.56	3.13	6 006	3 014	2 992
Bergen County	816 230	308 880	225 188	186 258	29 139	83 692	71 606	30 959	24 491	2.64	3.14	9 150	5 485	3 665
Burlington County	380 910	136 554	104 190	85 741	14 015	32 364	26 746	9 309	7 303	2.79	3.23	14 156	7 068	7 088
Camden County	493 933	178 758	129 568	96 405	26 205	49 190	41 328	16 352	12 633	2.76	3.28	8 891	6 812	2 079
Cape May County	92 414	37 856	25 667	20 592	3 882	12 189	10 406	5 510	4 206	2.44	2.98	2 675	1 839	836
Cumberland County	131 455	47 118	34 966	25 318	7 429	12 152	10 191	5 060	3 961	2.79	3.24	6 598	6 047	551
Essex County	759 590	278 752	191 363	124 659	53 401	87 389	75 440	30 077	23 011	2.72	3.32	18 616	8 353	10 263
Gloucester County	225 971	78 845	60 808	49 629	8 453	18 037	14 875	5 940	4 586	2.87	3.30	4 111	1 712	2 399
Hudson County	546 160	208 739	136 143	90 508	34 343	72 596	59 931	22 921	17 406	2.62	3.26	6 939	3 561	3 378
Hunterdon County	104 438	37 906	29 295	25 953	2 371	8 611	6 770	2 349	1 842	2.76	3.16	3 338	3 260	78
Mercer County	309 804	116 941	82 447	62 715	15 448	34 494	28 277	11 589	8 976	2.65	3.16	16 020	5 803	10 217
Middlesex County	648 111	238 833	175 451	143 344	23 886	63 382	50 903	19 029	14 955	2.71	3.18	23 669	7 926	15 743
Monmouth County	541 950	197 570	145 892	120 609	19 442	51 678	43 434	19 373	15 332	2.74	3.24	11 174	5 904	5 270
Morris County	413 680	148 751	113 074	96 850	11 923	35 677	28 312	9 742	7 749	2.78	3.21	7 673	4 164	3 509
Ocean County	426 852	168 147	120 783	102 028	14 443	47 364	41 879	27 121	21 674	2.54	3.04	6 351	4 529	1 822
Passaic County	442 797	155 269	115 135	84 917	22 753	40 134	33 677	15 585	12 133	2.85	3.33	10 263	5 321	4 942
Salem County	63 765	23 794	17 645	13 780	3 017	6 149	5 329	2 579	1 924	2.68	3.15	1 529	1 337	192
Somerset County	235 585	88 346	65 368	55 575	7 231	22 978	18 182	5 351	4 165	2.67	3.11	4 694	4 204	490
Sussex County	129 218	44 456	35 516	30 810	3 379	8 940	7 193	2 768	2 167	2.91	3.28	[illegible]	[illegible]	[illegible]
Union County	487 238	[illegible]	131 200	101 002	22 958	48 816	41 475	19 046	14 963	2.71	3.19	6 581	3 884	2 697
Warren County	90 398	33 997	25 011	20 807	3 090	8 986	7 551	3 478	2 732	2.66	3.14	1 209	784	425
PLACE AND COUNTY SUBDIVISION														
Aberdeen township, Monmouth County	16 896	5 905	4 617	3 873	555	1 288	1 038	250	185	2.36	3.27	142	129	13
Absecon city, Atlantic County	7 144	2 579	2 009	1 659	262	570	454	209	167	2.77	3.14	154	140	14
Alexandria township, Hunterdon County	3 531	1 203	1 016	922	55	187	146	55	35	2.94	3.21	63	63	-
Allamuchy township, Warren County	3 448	1 471	1 033	904	99	438	371	97	77	2.34	2.81	36	-	36
Allamuchy-Panther Valley CDP, Warren County	2 728	1 232	843	750	72	389	332	82	65	2.21	2.69	36	-	36
Allendale borough, Bergen County	5 709	1 859	1 603	1 439	128	256	197	69	59	3.07	3.31	191	191	-
Allenhurst borough, Monmouth County	759	298	208	174	27	90	79	38	28	2.55	3.11	-	-	-
Allentown borough, Monmouth County	1 828	655	519	427	73	136	107	26	21	2.79	3.13	-	-	-
Alloway CDP, Salem County	1 335	473	382	329	37	91	86	46	33	2.82	3.18	36	36	-
Alloway township, Salem County	2 759	956	774	664	80	182	162	81	51	2.89	3.24	36	36	-
Alpha borough, Warren County	2 530	967	729	590	110	238	199	104	87	2.62	3.03	-	-	-
Alpine borough, Bergen County	1 716	534	482	442	27	52	39	17	15	3.21	3.33	-	-	-
Andover borough, Sussex County	700	261	181	149	24	80	61	15	15	2.68	3.23	-	-	-
Andover township, Sussex County	4 747	1 695	1 337	1 162	126	358	280	81	64	2.80	3.16	691	679	12
Annandale CDP, Hunterdon County	1 074	390	300	262	27	90	74	36	28	2.75	3.16	-	-	-
Asbury Park city, Monmouth County	16 277	6 871	3 584	1 662	1 611	3 287	2 836	1 357	1 075	2.37	3.28	522	28	494
Atlantic City city, Atlantic County	36 225	15 731	8 183	3 713	3 584	7 548	6 391	3 022	2 201	2.30	3.13	1 761	934	827
Atlantic Highlands borough, Monmouth County	4 629	1 774	1 267	1 021	181	507	415	186	142	2.61	3.11	-	-	-
Audubon borough, Camden County	9 205	3 622	2 433	1 952	373	1 189	1 031	521	421	2.54	3.17	-	-	-
Audubon Park borough, Camden County	1 150	498	346	237	92	152	143	97	81	2.31	2.83	-	-	-
Avalon borough, Cape May County	1 809	838	545	468	61	293	253	135	111	2.16	2.68	-	-	-
Avenel CDP, Middlesex County	12 212	4 854	3 420	2 719	524	1 434	1 200	400	280	2.52	3.02	3 292	3 261	31
Avon-by-the-Sea borough, Monmouth County	2 141	989	555	447	90	434	384	200	159	2.16	2.94	24	-	24
Barnegat CDP, Ocean County	1 160	424	311	248	47	113	90	48	34	2.74	3.22	-	-	-
Barnegat township, Ocean County	12 120	4 163	3 343	2 838	389	820	695	372	277	2.91	3.29	115	115	-
Barnegat Light borough, Ocean County	657	330	198	173	19	132	121	56	37	1.99	2.55	18	-	18
Barrington borough, Camden County	6 774	2 688	1 863	1 499	295	825	709	235	172	2.52	3.08	-	-	-
Bass River township, Burlington County	1 580	554	435	361	56	119	98	44	38	2.85	3.25	-	-	-
Bay Head borough, Ocean County	1 226	530	364	293	59	166	147	73	51	2.31	2.81	-	-	-
Bayonne city, Hudson County	61 191	25 309	16 528	11 956	3 475	8 781	7 955	3 958	3 084	2.42	3.06	253	-	253
Beach Haven borough, Ocean County	1 460	659	421	344	61	238	206	112	90	2.22	2.78	15	-	15
Beach Haven West CDP, Ocean County	4 237	1 832	1 286	1 090	154	546	475	193	129	2.31	2.76	-	-	-
Beachwood borough, Ocean County	9 324	3 047	2 476	2 035	339	571	461	207	162	3.06	3.42	-	-	-
Beattystown CDP, Warren County	3 966	1 679	1 077	880	148	602	467	81	61	2.36	2.94	-	-	-
Beckett CDP, Gloucester County	3 815	1 188	1 046	950	65	142	107	7	5	3.21	3.46	-	-	-
Bedminster township, Somerset County	7 086	3 447	1 991	1 654	272	1 456	1 225	118	94	2.06	2.66	-	-	-
Belleville CDP, Essex County	34 123	13 374	9 193	6 964	1 637	4 181	3 575	1 245	951	2.55	3.13	90	13	77
Belleville township, Essex County	34 123	13 374	9 193	6 964	1 637	4 181	3 575	1 245	951	2.55	3.13	90	13	77
Bellmawr borough, Camden County	12 603	4 679	3 531	2 732	610	1 148	968	404	307	2.69	3.13	-	-	-
Belmar borough, Monmouth County	5 851	2 718	1 381	1 009	265	1 337	1 084	404	314	2.15	2.94	26	-	26
Belvidere town, Warren County	2 663	1 027	728	596	100	299	247	113	96	2.59	3.09	6	-	6
Bergenfield borough, Bergen County	24 417	8 799	6 733	5 462	932	2 066	1 741	919	729	2.77	3.21	41	-	41
Berkeley township, Ocean County	36 794	17 614	12 394	11 076	997	5 220	4 928	4 023	3 227	2.09	2.50	525	518	7
Berkeley Heights township, Union County	11 540	3 860	3 325	3 017	220	535	414	181	129	2.99	3.22	440	402	38
Berkeley Heights CDP, Union County	11 540	3 860	3 325	3 017	220	535	414	181	129	2.99	3.22	440	402	38
Berlin borough, Camden County	5 672	1 950	1 502	1 265	179	448	373	167	130	2.91	3.35	-	-	-
Berlin township, Camden County	5 453	1 777	1 432	1 151	202	345	275	97	72	3.07	3.42	13	-	13
Bernards township, Somerset County	16 146	6 345	4 608	4 160	327	1 737	1 432	425	356	2.54	3.02	1 053	1 007	46
Bernardsville borough, Somerset County	6 546	2 449	1 843	1 617	164	606	496	202	163	2.67	3.07	51	51	-
Bethlehem township, Hunterdon County	3 104	1 033	882	803	51	151	115	34	29	3.00	3.26	-	-	-
Beverly city, Burlington County	2 973	1 011	753	510	197	258	207	89	68	2.94	3.42	-	-	-
Blackwood CDP, Camden County	5 101	1 835	1 380	1 098	211	455	374	157	104	2.78	3.22	19	-	19
Blairstown township, Warren County	5 331	1 773	1 474	1 328	112	299	251	128	90	3.01	3.33	-	-	-
Bloomfield CDP, Essex County	44 633	18 455	11 857	9 258	1 970	6 598	5 675	2 490	1 993	2.42	3.07	428	164	264
Bloomfield township, Essex County	44 633	18 455	11 857	9 258	1 970	6 598	5 675	2 490	1 993	2.42	3.07	428	164	264
Bloomingdale borough, Passaic County	7 530	2 747	2 094	1 763	248	653	507	169	128	2.74	3.15	-	-	-
Bloomsbury borough, Hunterdon County	890	330	255	227	18	75	62	23	18	2.70	3.11	-	-	-
Bogota borough, Bergen County	7 811	2 777	2 079	1 674	312	698	582	213	169	2.81	3.31	13	11	2
Boonton town, Morris County	8 198	3 121	2 127	1 665	356	994	737	315	250	2.63	3.15	145	97	48
Boonton township, Morris County	3 440	1 241	1 006	893	82	235	185	82	57	2.77	3.10	126	126	-
Bordentown city, Burlington County	4 297	1 784	1 148	809	258	636	543	205	149	2.41	3.02	44	-	44
Bordentown township, Burlington County	7 334	2 857	2 024	1 683	256	833	678	207	154	2.57	3.08	349	115	234
Bound Brook borough, Somerset County	9 475	3 675	2 490	1 913	422	1 185	945	369	293	2.58	3.10	12	-	12
Bradley Beach borough, Monmouth County	4 465	2 009	1 086	778	230	923	731	248	198	2.22	2.96	10	-	10
Branchburg township, Somerset County	10 885	3 744	3 080	2 799	193	664	522	151	115	2.91	3.23	3	-	3
Branchville borough, Sussex County	851	354	241	193	34	113	97	52	40	2.40	2.90	-	-	-
Brass Castle CDP, Warren County	1 419	477	403	374	17	74	67	44	31	2.97	3.28	-	-	-
Brick township, Ocean County	66 170	24 965	18 729	15 810	2 259	6 236	5 338	2 855	2 274	2.65	3.10	303	286	17
Brick Township CDP, Ocean County	66 170	24 965	18 729	15 810	2 259	6 236	5 338	2 855	2 274	2.65	3.10	303	286	17
Bridgeton city, Cumberland County	18 288	6 725	4 640	2 674	1 621	2 085	1 802	937	738	2.72	3.30	654	625	29

REFERENCE NO. 10

SITE LOCATION
ELIZABETHTOWN WATER COMPANY
WELL LEGEND
1. SEBRING MILLS WELL FIELD
2. GREEN BROOK WELL FIELD
3. ROCK AVENUE WELL
4. CITY OF PLAINFIELD WELL
5. BOARD OF EDUCATION WELL
6. ROCK AVENUE WELL
8. FIFTH STREET WELL
9. EIGHTH STREET WELL
10. CLINTON AVENUE WELL
11. MOUNTAIN STATION WELLS
SCALE 1:24000
CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
TITLE: FOUR-MILE VICINITY MAP
SITE NAME: MIDDLESEX SAMPLING PLANT
MIDDLESEX, MIDDLESEX COUNTY, N.J.
DATE: SEPTEMBER 30, 1992
SCALE: 1" = 2000'
REPORT NUMBER: 8003-09-3
USGS TOPO NAME: PLAINFIELD, NEW JERSEY

ATLAS OF

NATIONAL WETLANDS INVENTORY MAPS

FOR NEW JERSEY

Ralph W. Tiner, Jr.
Regional Wetland Coordinator
U.S. Fish and Wildlife Service
Region 5
1 Gateway Center, Suite 700
Newton Corner, MA 02158

February 1984

HOW TO USE THIS ATLAS

The Atlas contains reductions of all 1:24,000 National Wetlands Inventory maps. Maps appear in alphabetical order. Map names can be located on the index map (Figure 2). Each map shows the configuration, location and type of wetlands and deepwater habitats found within a given area.

WETLAND LEGEND

Wetland data are displayed on maps by a series of letters and numbers (alpha-numerics). Mixing of classes and subclasses are represented by a diagonal line. The more common symbols are shown below; less common symbols have been omitted for simplicity. For identifying these latter symbols, the reader should refer to an actual NWI map legend.

Examples of Alpha-numerics:

E2EMN6	=	Estuarine (E), Intertidal(2), Emergent Wetland(EM), Regularly Flooded(N), Oligohaline(6)
E2FL	=	Estuarine(E), Intertidal(2), Flat(FL)
PF01	=	Palustrine(P), Forested Wetland(FO), Broad-leaved Deciduous(1)
PEM/OW	=	Palustrine(P), Emergent Wetland/Open Water(EM/OW)
PFO/SS1	=	Palustrine(P), Forested Wetland/Scrub-Shrub Wetland(FO/SS), Broad-leaved Deceduous(1)

SYMBOLOGY

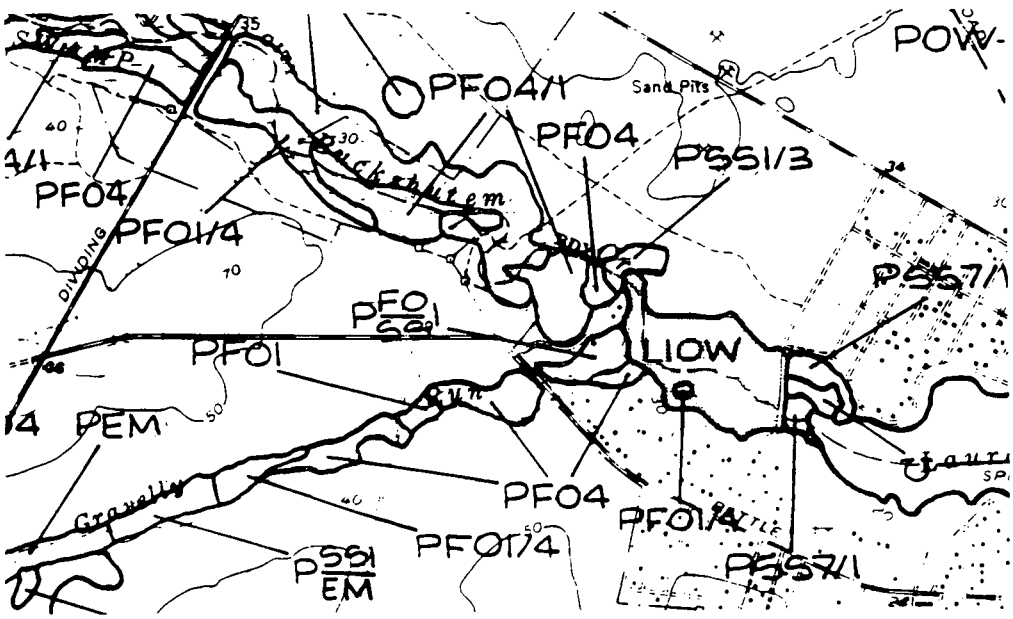
Systems and Subsystems:

M 1	=	Marine Subtidal	R 3	=	Riverine Upper Perennial
M 2	=	Marine Intertidal	R 4	=	Riverine Intermittent
E 1	=	Estuarine Subtidal	L 1	=	Lacustrine Limnetic
E 2	=	Estuarine Intertidal	L 2	=	Lacustrine Littoral
R 1	=	Riverine Tidal	P	=	Palustrine
R 2	=	Riverine Lower Perennial	U	=	Upland

Classes (subclasses and modifers designated where appropriate):

AB	=	Aquatic Bed
BB	=	Beach/Bar
EM	=	Emergent Wetland
EMN6	=	Emergent Wetland, Regularly Flooded, Oligohaline
EMP6	=	Emergent Wetland, Irregularly Flooded, Oligohaline
EMR	=	Emergent Wetland, Seasonally Flooded-Tidal
FL	=	Flat
FO1	=	Forested Wetland, Broad-leaved Deciduous
FO2	=	Forested Wetland, Needle-leaved Deciduous
FO4	=	Forested Wetland, Needle-leaved Evergreen
OW	=	Open Water/Unknown Bottom
SS1	=	Scrub=Shrub Wetland, Broad-leaved Deciduous
SS3	=	Scrub-Shrub Wetland, Broad-leaved Evergreen
SS4	=	Scrub-Shrub Wetland, Needle-leaved Evergreen
SS5	=	Scrub-Shrub Wetland, Dead
SS7	=	Scrub-Shrub Wetland, Evergreen

ATLAS
OF
NATIONAL WETLANDS INVENTORY MAPS
FOR
NEW JERSEY



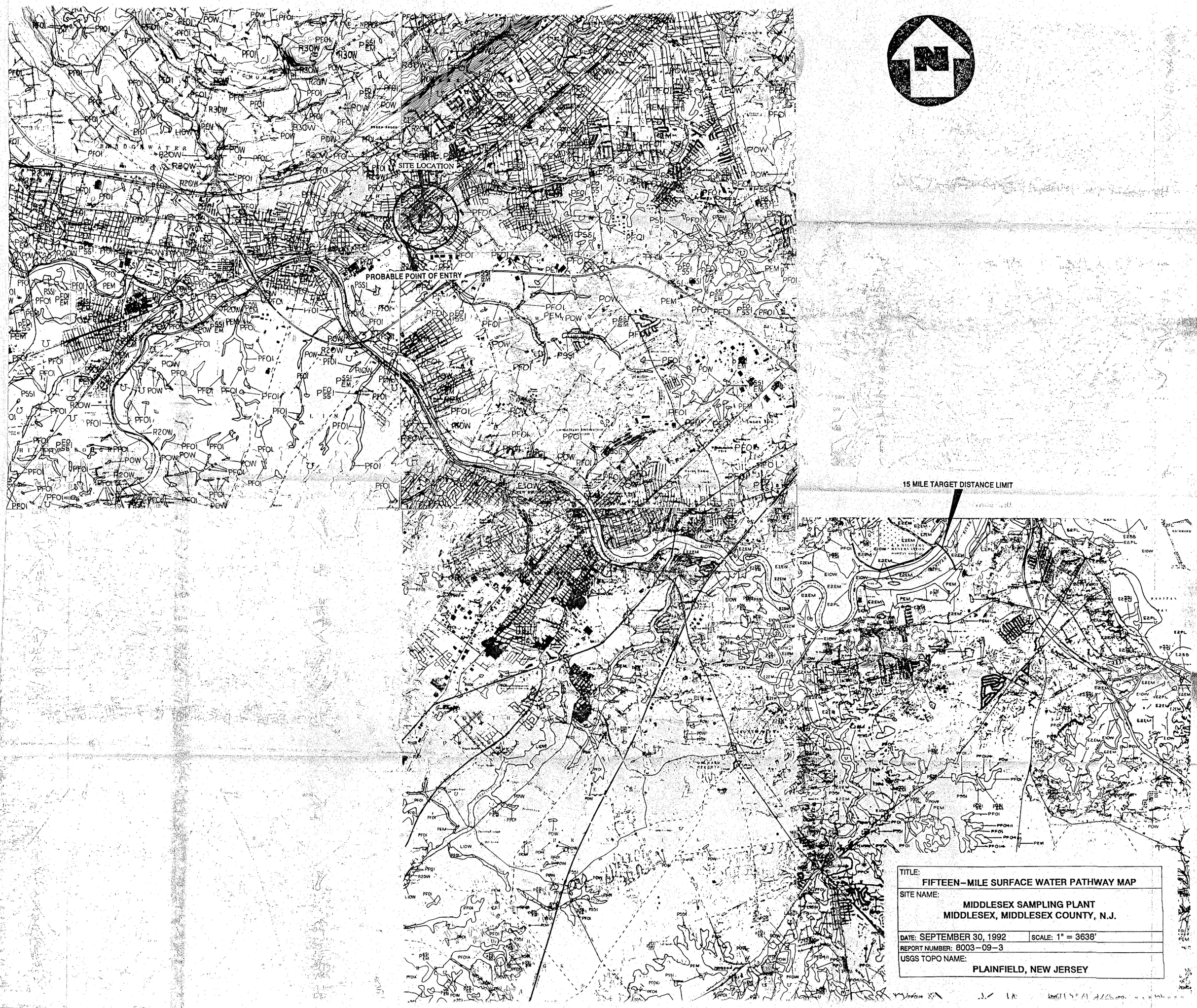
PORTION OF DIVIDING CREEK MAP

SCALE: 1:24,000

UNITED STATES
DEPARTMENT OF THE INTERIOR
Fish and Wildlife Service
Region Five
Habitat Resources
One Gateway Center, Suite 700
Newton Corner, Massachusetts

1984

REFERENCE NO. 11



TITLE:
FIFTEEN–MILE SURFACE WATER PATHWAY MAP

SITE NAME:
MIDDLESEX SAMPLING PLANT
MIDDLESEX, MIDDLESEX COUNTY, N.J.

DATE: SEPTEMBER 30, 1992 | SCALE: 1" = 3638'

REPORT NUMBER: 8003–09–3

USGS TOPO NAME:
PLAINFIELD, NEW JERSEY

REFERENCE NO. 12

085775

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

March 2, 1992

Ms. Helen Shannon
Region II Docket Coordinator
U.S. Environmental Protection Agency
26 Federal Plaza, Room 2930
New York, New York 10278

Dear Ms. Shannon:

SUBMITTAL OF REVISED PRELIMINARY ASSESSMENT SCORESHEETS AND SITE INVESTIGATION REPORTS FOR THE MIDDLESEX SAMPLING PLANT (MSP)

Please find enclosed the revised Preliminary Assessment (PA) Scoresheets and Site Investigation (SI) Reports for the MSP in New Jersey.

The only information added to these reports is the inclusion of data indicating the presence of RCRA-regulated material in one of the two storage piles at MSP. This data was analyzed and evaluated after the submission of a PA/SI package to your office in August 1991. Also included in this revised package is information clarifying the presence of contamination above cleanup guidelines in an off-site drainage ditch.

The additional data has been inserted as an addendum to the pertinent sections of the PA/SI package submitted in August 1991. An index to the pages that have been changed is attached.

If you have any questions, please contact me at (615) 576-9634.

Sincerely,

David G. Adler, Site Manager
Former Sites Restoration Division

Enclosure

cc: S. D. Liedle, BNI

185775

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

March 2, 1992

Ms. Helen Shannon
Region II Docket Coordinator
U.S. Environmental Protection Agency
26 Federal Plaza, Room 2930
New York, New York 10278

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Sincerely,

David G. Adler, Site Manager
Former Sites Restoration Division

Enclosure

cc: S. D. Liedle, BNI

ATTACHMENT: INDEX TO SUPPLEMENTAL INFORMATION

Addendum 1: Hazardous Substances/Physical State

Addendum 2: Reference for the MSP Characterization

Addendum 3: Groundwater Route, Supplemental Information on Off-Site Contamination

Addendum 4: Surface Water Route, Supplemental Information on Off-Site Contamination

Addendum 5: Information on Sediment Contamination

Addendum 6: Information on Chemical Characterization

Addendum 7: Waste Characteristic Score

Addendum 8: Reference for the MSP Characterization

Addendum 9: Surface Water Pathway, Supplemental Information on Off-Site Contamination

085775 080528

Bechtel

Oak Ridge Corporate Center
151 Lafayette Drive
P.O. Box 350
Oak Ridge, Tennessee 37831-0350

Facsimile: (615) 220-2100

Job No. 14501, FUSRAP Project
DOE Contract No. DE-AC05-91OR21949
Code: 7440/WBS: 118

AUG 26 1991

U.S. Department of Energy
DOE Field Office, Oak Ridge
P.O. Box 2001
Oak Ridge, TN 37831-8723

Attention: David G. Adler, Site Manager
Former Sites Restoration Division

Subject: Transmittal of Site Inspection Reports and Preliminary Assessment Scoresheets for the Middlesex Sampling Plant (MSP)

Dear Mr. Adler:

Enclosed for your submittal to Ms. Helen Shannon, Region II Docket Coordinator, U.S. Environmental Protection Agency, are the completed Site Inspection Reports and Preliminary Assessment Scoresheets for the Middlesex Sampling Plant.

EPA recognized, as reflected in the instruction pages to both the PA Scoresheets and the Site Inspection Reports, that not all the information requested would be available during the PA/SI process. As much information as possible was gathered in the time available, and where informed assumptions were made, the most conservative estimate was chosen.

I certify that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. To the best of my knowledge and belief the information submitted is true, accurate, and complete.

If you have any questions, please contact me at 576-5207.

Very truly yours,

M. E. Redmon

M. E. Redmon
Project Manager - FUSRAP

RKA:jlm1403e
Enclosure: Transmittal to EPA, Program Support Branch

Concurrence: R. K. Atwood @ RKA
T. C. Adler TCA
W. Osburn, Analysas WLO
J. S. Novick JSN
N. C. Ring NCR

3

Bechtel National, Inc.

080528

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

Ms. Helen Shannon
Region II Docket Coordinator
U. S. Environmental Protection Agency
26 Federal Plaza, Room 2930
New York, New York 10278

Dear Ms. Shannon:

SUBMITTAL OF COMPLETED SITE INVESTIGATION REPORTS AND PRELIMINARY ASSESSMENT SCORESHEETS FOR THE MIDDLESEX SAMPLING PLANT (MSP)

Please find enclosed the Site Investigation (SI) Reports and Preliminary Assessment (PA) Scoresheets for the MSP site in New Jersey.

EPA recognized, as reflected in the instruction pages to both the PA Scoresheets and the Site Inspection Reports, that not all the information requested would be available during the PA/SI process. As much information as possible was gathered in the time available, and where informed assumptions were made, the most conservative estimate was chosen.

These reports have been completed on the forms provided by your office. If you have any questions, please contact me at (615) 576-9634 or (FTS) 626-9634.

Sincerely,

David G. Adler, Site Manager
Former Sites Restoration Division

Enclosure
cc: M. E. Redmon, BNI

4

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085706 0528

RECEIVE
OCT 2 199
S & M BRANC

SITE INSPECTION REPORT

5

SITE SUMMARY AND RECOMMENDATION

Site History

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

The Middlesex Sampling Plant facility was established in 1943 by the Manhattan Engineer District (MED) to sample, store, and/or ship uranium, thorium, and beryllium ores. In 1955, the Atomic Energy Commission (AEC), successor to MED, terminated the operation and later used the site for storage and limited sampling of thorium residues. In 1967, AEC activities ceased, onsite structures were decontaminated, and the site was certified for unrestricted use under criteria applicable at that time.

Between 1968 and 1980, the site changed hands, first to the General Services Administration, and then to the Department of the Navy for use as a U.S. Marine Corps reserve training center. In 1980, custody of MSP was returned to DOE, which then initiated remedial action to clean up vicinity properties. The Middlesex Municipal Landfill (MML), a vicinity property established in the mid-1940's, began to receive soil contaminated with pitchblende (high-grade uranium ore) in 1948, which resulted in contaminated soil being placed over existing fill at MML. By 1974, solid waste disposal ceased at MML. Early radiological surveys indicated that 0.2 ha (0.5 acre) of MML required remediation; in 1984, approximately 12,000 m^3 (16,000 yd^3) of contaminated soil was returned to MSP for interim storage. Later investigations showed the contaminated area to be 1.2 ha (3.0 acres). By 1986, remediation at MML was essentially complete; 23,900 m^3 (31,200 yd^3) of contaminated soil was returned to MSP for interim storage. In 1987, MML was turned over to the Borough of Middlesex.

Site Description

MSP occupies approximately 3.9 ha (9.6 acres) in north-central New Jersey within the Borough of Middlesex (Middlesex County) (Figure 1-1). The MSP property includes four buildings and two storage piles that total 50,748 m^3 (66,372 yd^3) of waste (Figure 1-2). More than 70 percent of the MSP site is paved with asphalt. The site, currently being used for interim storage of radioactively contaminated soil, is entirely fenced and public access is restricted. Figure 1-3 is an aerial photograph of the site.

Recommendation

MSP is currently subject to an environmental monitoring program. Ground water, surface water and sediments, air monitoring (radon), and soil samples are monitored to detect the presence of any contaminants migrating off-site.

Environmental monitoring activities, site maintenance activities, and site characterization should continue until remedial action at MSP is complete.

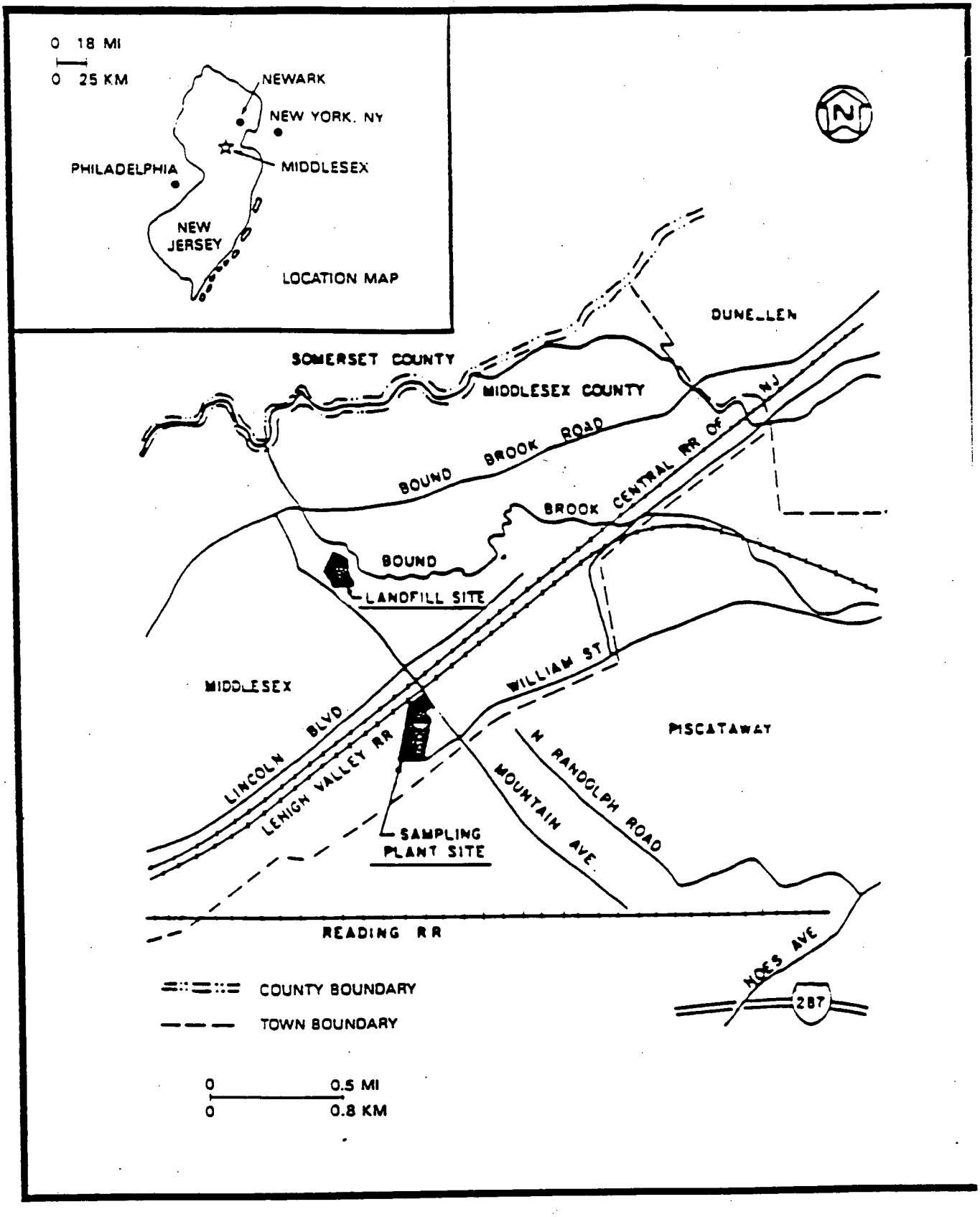

Figure 1-1 Location of MSP

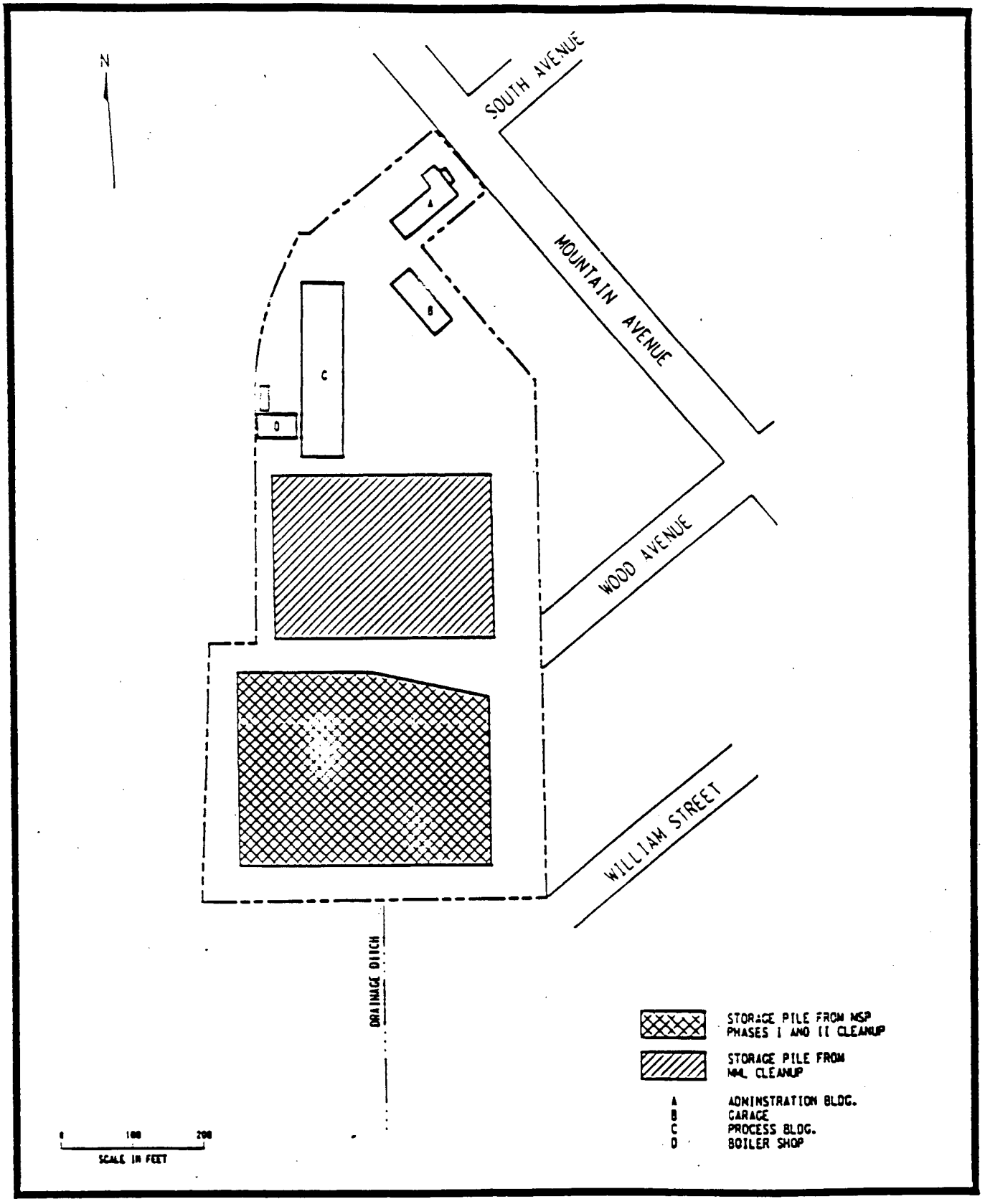

Figure 1-2 Map of the MSP Site

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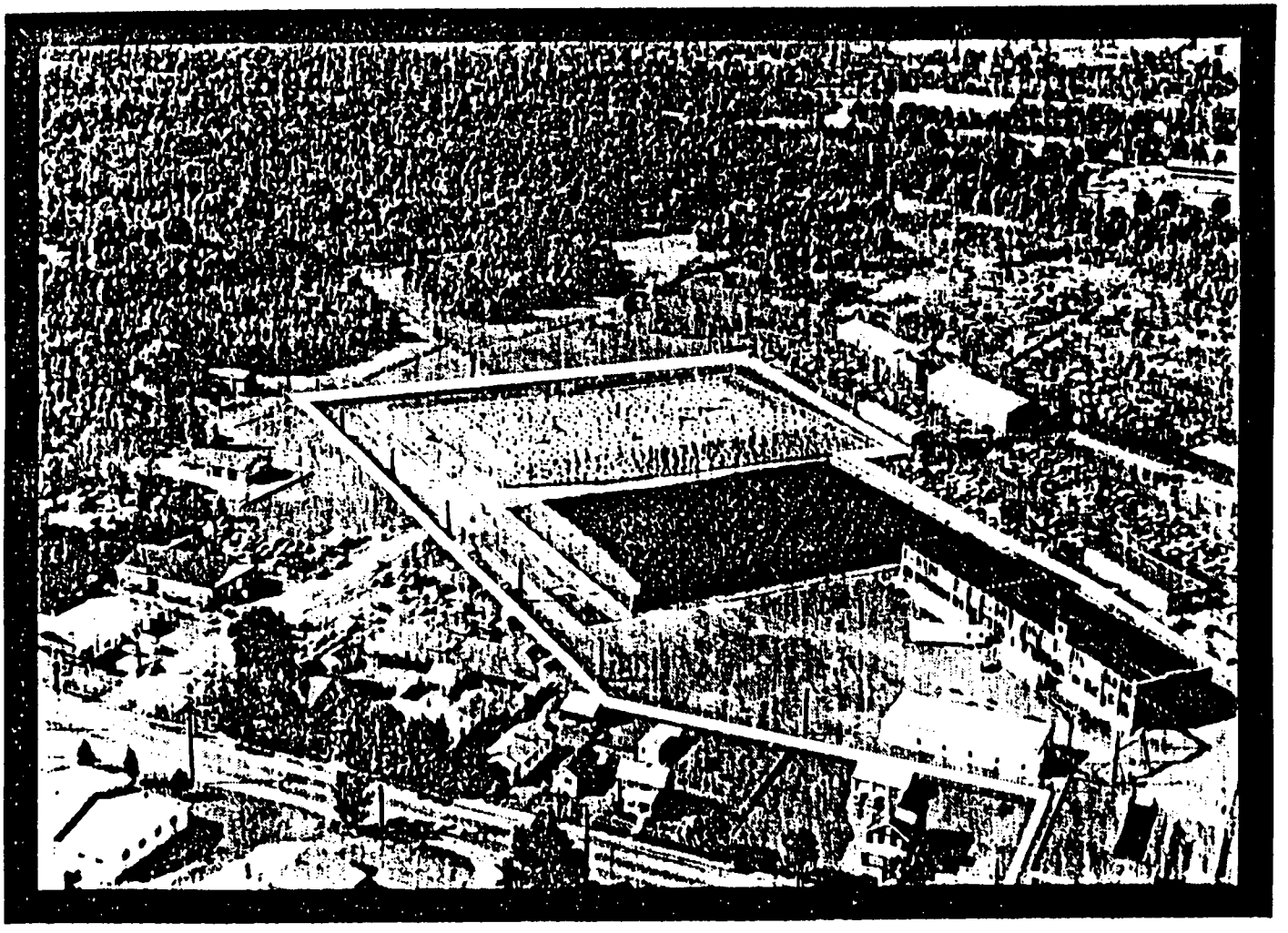

Figure 1-3 Aerial View of MSP

08 05 28

PART I: SITE INFORMATION

080528

1. Site Name/Alias Middlesex Sampling Plant

Street 239 Mountain Avenue

City Middlesex State NJ Zip 08846

2. County Middlesex County Code 23 Cong. Dist. ___

3 EPA ID No. NJ 0890090012

4. Block No. ___ Lot No. ___

5. Latitude --40 34-N Longitude ---74 29-W

USGS Quad. Plainfield, New Jersey Quadrangle

6. Owner Dept. of Energy, OR Operations Tel. No. (615) 576-0948

Street P.O. Box 2001

City Oak Ridge State TN Zip 37831

7. Operator DOE Tel. No. ___

Street ___

City ___ State ___ Zip ___

8. Type of Ownership

☐ Private ☒ Federal ☐ State

☐ County ☐ Municipal ☐ Unknown ☐ Other ___

9. Owner/Operator Notification on File

☐ RCRA 3001 Date ___ ☐ CERCLA 103c Date ___

☒ None ☐ Unknown

10. Permit Information

Permit	Permit No.	Date Issued	Expiration Date	Comments

11. Site Status

☐ Active ☒ Inactive ☐ Unknown

12. Years of Operation 1943 to 1967

11

13. Identify the types of waste sources (e.g., landfill, surface impoundment, piles, stained so above- or below-ground tanks or containers, land treatment, etc.) on site. Initiate as man waste unit numbers as needed to identify all waste sources on site.

(a) Waste Sources

Waste Unit No.	Waste Source Type	Facility Name for Unit
1	Contaminated Soil Pile	Vicinity Property Waste
2	Contaminated Soil Pile	Middlesex Municipal Lanc
etc.		(MML) Waste Pile

(b) Other Areas of Concern

Identify any miscellaneous spills, dumping, etc. on site; describe the materials and identif their locations on site.

14. Information available from

Contact Amy Brochu Agency U.S. EPA Tel. No. (201) 906-6802

Preparer _____ Agency NUS Corp Region 2 FIT Date _____

PART II: WASTE SOURCE INFORMATION

For each of the waste units identified in Part I, complete the following items.

Waste Unit (No.) 1 - (Facility Name for Unit) Vicinity Property Waste Pile

Source Type

____	Landfill	____	Contaminated Soil
____	Surface Impoundment	X	Pile
____	Drums	____	Land Treatment
____	Tanks/Containers	____	Other

Description: In 1980, DOE initiated remedial action to clean up properties in the vicinity of MSP, with the cleanup continuing in 1981. Contaminated soil from this remedial action was transporte to MSP where an asphalt pad was constructed as a base for an interim storage pile. The pile is enclosed with concrete curbing to prevent migration of the stored materials. Synthetic geomembra fabric is attached to the curbing to cover the stored materials. The design of the interim storage pile includes a leachate collect system to preclude the uncontrolled release of contaminants.

Hazardous Waste Quantity

Approximately 26,848 m^3 (35,172 yd^3) of material was placed into the pile.

Hazardous Substances/Physical State

The pile consists primarily of soil contaminated with uranium, radium-226, and thorium-232.

Ref. No.

- Middlesex Sampling Plant Annual Environmental Report for Calendar Year 1990, Middlesex, New Jersey (BNI, June 1991)
- Preliminary Assessment for Middlesex Sampling Plant, Middlesex, New Jersey (BNI, July 1989).

For each of the waste units identified in Part I, complete the following items.

Waste Unit (No.) 2 (Facility Name for Unit) Middlesex Municipal Landfill (MML Waste Pile

Source Type

____	Landfill	____	Contaminated Soil
____	Surface Impoundment	X	Pile
____	Drums	____	Land Treatment
____	Tanks/Containers	____	Other

Description: MML, a vicinity property established in the 1940s, bega to receive contaminated soil in 1948, which resulted in contamina soil being placed over existing fill at MML. By 1974, solid wast disposal ceased at MML. Early radiological surveys indicated MML required remediation and contaminated soil was returned to MSP fc interim storage in 1984. Later investigations showed additional contamination and by 1986, remediation at MML was essentially com The MML Waste Pile is constructed similarly to the Vicinity Prope Pile (No. 1) and includes a leachate collection system.

Hazardous Waste Quantity

The MML Waste Pile ocntains approximately 23,900m³ (31,200 yd³) of contaminated material.

Hazardous Substances/Physical State

The pile contains primarily soil contaminated with pitchblende, a high-grade uranium ore. In addition to uranium, radium-226, and thorium-232 have been detected.

Ref. No. Middlesex Sampling Plant Annual Environmental Report for calendar year 1990, Middlesex, New Jersey, (BNI, June 1991). Preliminary Assessment for Middlesex Sampling Plant, Middlesex, New Jersey, (BNI, July 1989).

SEE ATTACHED TEXT LABELED "PART III: SAMPLING RESULTS"

ADDENDUM 1

Hazardous Substances/Physical State

The pile contains primarily soil contaminated with pitchblende, a high-grade uranium ore. In addition to uranium, radium-226, and thorium-232 have been detected.

In December 1991, a characterization report for the piles at MSP was published. As part of the chemical characterization of the site, soil samples were tested using the Toxicity Characteristic Leaching Procedure (TCLP). Analysis indicates that the MML pile contains lead in concentrations exceeding the TC regulatory guidelines.

Reference: Characterization Report for the Interim Storage Piles at the Middlesex Sampling Plant, Middlesex, New Jersey, DOE/OR/21949-297, December 1991.

(NOTE: This report shall be cited MSP Characterization, December 1991. This report was transmitted to the New Jersey Department of Environmental Protection and Energy, and is available upon request.)

PART III: SAMPLING RESULTS

EXISTING ANALYTICAL DATA
SITE INSPECTION RESULTS

The following list of references contains sampling results and analytical data in various forms.

(1) Middlesex Sampling Plant Annual Environmental Report for Calendar Year 1990. Bechtel National, Inc. (BNI), June 1991, DOE/OR/21949-285 (Draft).
A great deal of environmental monitoring data exists in the form of these Annual Environmental Reports. These reports have been provided to EPA on an yearly basis.

(2) Preliminary Assessment and Site Inspection for Middlesex Sampling Plant, Middlesex, New Jersey. BNI, July 1989, Prepared for Department of Energy, Oak Ridge Operations.

(3) Hazard Ranking System Scoring for Middlesex Sampling Plant, Middlesex, New Jersey, BNI. July 1989, Prepared for Department of Energy, Oak Ridge Operations.

All of these published documents contain information that provides background and summaries of analytical data that will support this Site Inspection Report. The Annual Environmental Monitoring Reports in particular will provide the rationale for the determination of whether there has been a release from the facility, information on surface and ground flow, as well as information about the environmental monitoring program.

ADDENDUM 2

The MSP Characterization, December 1991, should be refered to for information on levels of chemical contamination in the storage piles.

GROUNDWATER ROUTE

1. Describe the likelihood of a release of contaminant(s) to the groundwater as follo observed release, suspected release, or none. Identify contaminants detected or suspec and provide a rationale for attributing them to the site. For observed release, define t supporting analytical evidence.

   Ref. No. Insert MSP 1

2. Describe the aquifer of concern; include information such as depth, thickness, geolog composition, areas of karst terrain, permeability, overlying strata, confining laye interconnections, discontinuities, depth to water table, groundwater flow direction.

   Ref. No. Insert MSP 2

3. Is a designated well head protection area within 4 miles of the site?

   Ref. No. Insert MSP 3

4. What is the depth from the lowest point of waste disposal/storage to the highest seasonal level of the saturated zone of the aquifer of concern?

   Ref. No. Insert MSP 4

5. What is the permeability value of the least permeable continuous intervening stratum between the ground surface and the aquifer of concern?

   Ref. No. Insert MSP 5

6. What is the net precipitation for the area?

   Net precipitation is 5 to 15 inches/year

   Ref. No. Hazard Ranking System Scoring for Middlesex Sampling Plant, Middlesex, NJ, BNI, July 1989

7. What is the distance to and depth of the nearest well that is currently used for drinking purposes?

   Ref. No. Insert MSP 7

8. If a release to groundwater is observed or suspected, determine the number of people tha obtain drinking water from wells that are documented or suspected to be located within th contamination boundary of the release.

Ref. No. Insert MSP 8

9. Identify the population served by wells located within 4 miles of the site that draw from th aquifer of concern.

Distance	Population
0 - ¼ mi	
> ¼ - ½ mi	
> ½ - 1 mi	Insert MSP 9
> 1 - 2 mi	
> 2 - 3 mi	
> 3 - 4 mi	

Ref. No.

10. Identify uses of groundwater within 4 miles of the site (i.e. private drinking source, municipa source, commercial, irrigation, unuseable).

Ref. No. Insert MSP 10

SURFACE WATER ROUTE

11. Describe the likelihood of a release of contaminant(s) to surface water as follows: observe release, suspected release, or none. Identify contaminants detected or suspected and provid a rationale for attributing them to the site. For observed release, define the supportin analytical evidence.

Ref. No. Insert MSP 11

12. Identify the nearest downslope surface water. If possible, include a description of possibl surface drainage patterns from the site.

Ref. No. Insert MSP 12

PART IV: HAZARD ASSESSMENT

GROUNDWATER ROUTE

Insert MSP 1.

Analysis of the groundwater occuring under MSP shows that groundwater in several wells contains concentrations of radionuclides significantly above background. Background, measured at the Middlesex Municipal Landfill, 0.5 mi northwest of the site, averages 3.2×10^{-9} Ci/l for uranium and 0.3×10^{-6} Ci/l for radium-226. Groundwater in seven of eighteen wells had average concentrations of uranium that were greater than two times background levels. Six wells contained groundwater with radium-226 levels that were greater than two times background (BNI, 1991a). The entry of surface water into monitoring wells is believed to be introducing contamination to groundwater at MSP. This condition has been reported in BNI (1991b) and is presently being corrected.

References:

Bechtel National, Inc. (1991a). Middlesex Sampling Plant Annual Environmental Report for Calendar Year 1990. DOE/OR/21949-285, Draft, Oak Ridge, TN.

Bechtel National, Inc. (1991b). Results of New Jersey Sites Monitoring Well Inspection. Draft Internal Report, Oak Ridge, TN.

ADDENDUM 3

GROUNDWATER ROUTE

Insert MSP 1.

Analysis of groundwater data from off-site wells indicates elevated levels of contaminants. Groundwater exceeds the New Jersey Department of Environmental Protection and Energy (NJDEPE) standards in calendar year 1990 for chromium, radium-226, and trichloroethane. See MSP Annual Environmental Report for Calendar Year 1990.

Insert MSP 2

Describe the aquifer of concern; include information such as depth, thickness, geologic composition, areas of karst terrain, permeability, overlying strata, confining layers, interconnections, discontinuities, depth to water table, groundwater flow direction?

The uppermost aquifer of concern at MSP is the Brunswick Shale. The Brunswick Shale was the uppermost bedrock unit that was encountered during drilling activities at MSP. At MSP, the Brunswick Formation is a red shale with interbedded siltstone and occasional layers of sandstone. The unit is relatively impermeable except along numerous fractures and cracks that occur at high angles to bedding, and do not show any preferred orientation. There is no indication that zones of fracturing and fissility are pervasive, open fractures capable of transmitting water away from the site, however two boreholes did have zones of highly fissile shale in them. The depth to the Brunswick Formation at MSP ranges from 0.45 to 2.4 m (1.5 to 8.0 ft). Material overlying the Brunswick Shale consists of unconsolidated silty to sandy loams with poor to moderate drainage and low to moderate permeability. A 0.3 m (1 ft) thick zone of weathered bedrock directly overlies the unit (FBDU, 1979, BNI, 1989). The thickness of the Brunswick Shale underlying NBL also is not know, however, regionally the unit may be greater than 1524 m (5000 ft) in thickness (Geraghty and Miller, 1976).

Regionally, the Brunswick Formation is an important source of ground water supplying water for both industrial and drinking water purposes. Ground water occurs in fractures and cracks. The specific yield of the Brunswick Shale is relatively low compared to other ground water bearing units in the area. Specific yield decreases with depth corresponding to a decrease in the occurrence of fractures. The thickness of the water-bearing zone of the Brunswick Shale is only 12.2 to 13.7 m (40 to 45 ft) thick (MCPB, 1979). At MSP, the depth to ground water in the Brunswick Shale ranges from 2.4 to 9.1 m (8 to 30 ft). Ground water moves towards the center of the site with flow from the southern end of the site draining to the north, and flow from the northern end of the site draining to the south (BNI, 1991). Transmissivity values have been measured in slug tests at MSP. Values range from 0.86 to 1.4 m^2/day (69 to 115 gpd/ft)(Weston, 1980). A figure showing the configuration of the water table in the bedrock aquifer is attached.

Although no confining layers were encountered during the subsurface investigation of MSP, a zone of ground water occurs in the unconsolidated overburden. It is not known to what extent ground water in the unconsolidated sediments and in the Brunswick Formation are interconnected, however, differences between the hydraulic characteristics of each unit suggests that the two units are not connected. The water table in the unconsolidated sediments occurs from 0.6 to 3.0 m (2 to 10 ft) which is closer to the surface than in the bedrock aquifer. Ground water flow in the upper unit is to the southwest (BNI, 1990). Transmissivity values, measured by slug tests in the upper unit are reported to

be 0.087 to 0.27 m^2/day (7 to 22 gpd/ft) which is slightly lower than in the Brunswick Shale. Both units reported have low ground water flow velocities (Weston, 1980). Ground water in the unconsolidated sediments is not used for drinking water. A figure showing the configuration of the water table in the unconsolidated sediments is attached.

References

Middlesex County Planning Board (MCPB)(1979). Policies and Practices for Managing Middlesex County's Groundwater Resources. New Brunswick, NJ

Bechtel National, Inc. (BNI)(1989). Site Inspection for Middlesex Sampling Plant. Oak Ridge, TN

Geraghty and Miller, Inc. (1976). Lower Raritan/Middlesex County 208 Water Quality Management Planning Program; Task 8 Groundwater Analysis. Port Washington, NY

Ford, Bacon and Davis Utah, Inc. (FBDU)(1979). Environmental Analysis of the Former Middlesex Sampling Plant and Associated Properties. Salt Lake City, UT

Bechtel National, Inc. (1991). Middlesex Sampling Plant Annual Site Environmental Report for Calendar Year 1990. DOE/OR/21949-285 (Draft). Oak Ridge, TN

Roy F. Weston, Inc. (1980). Hydrogeology of the Former Middlesex Sampling Plant Site, Middlesex, New Jersey. West Chester, PA

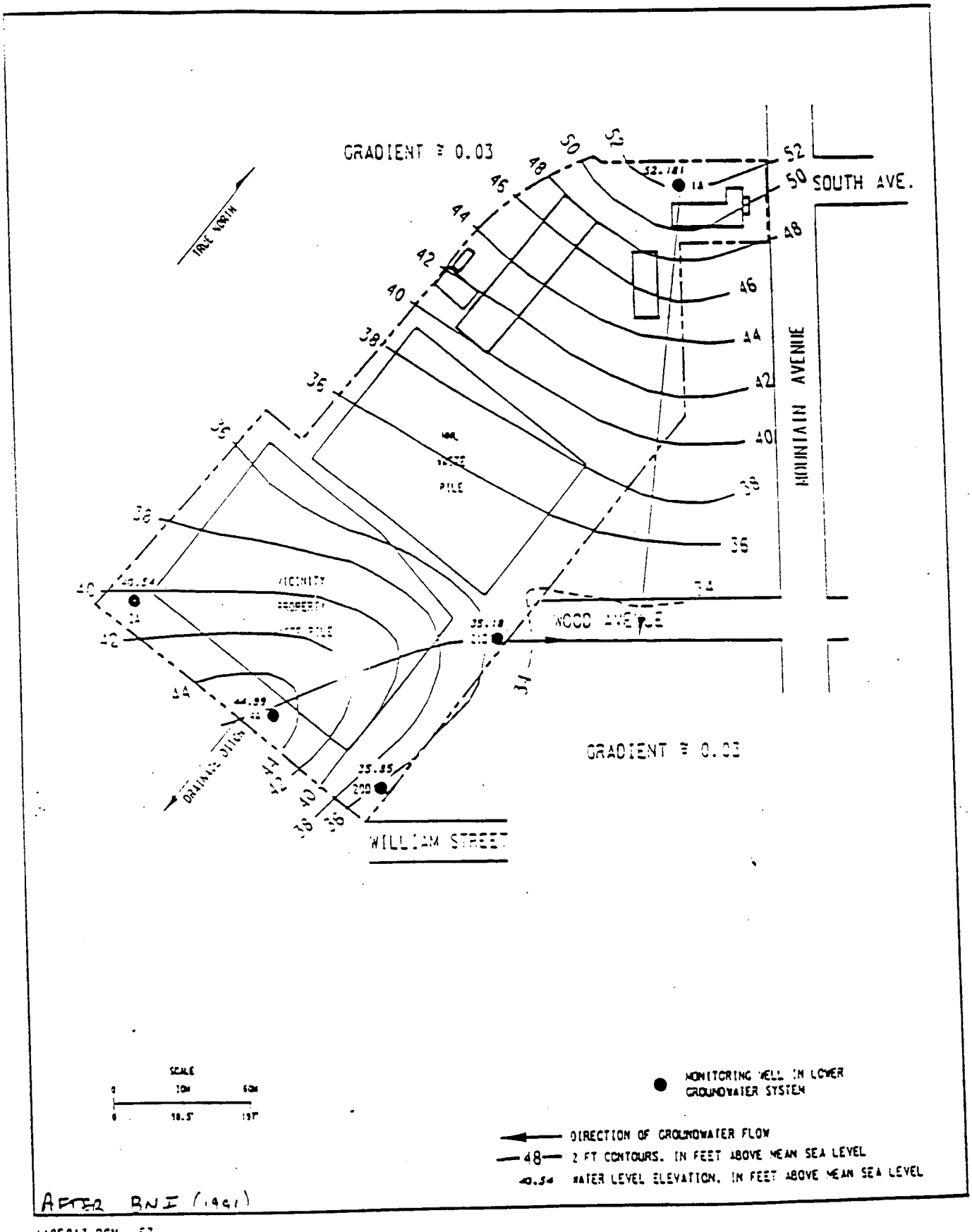

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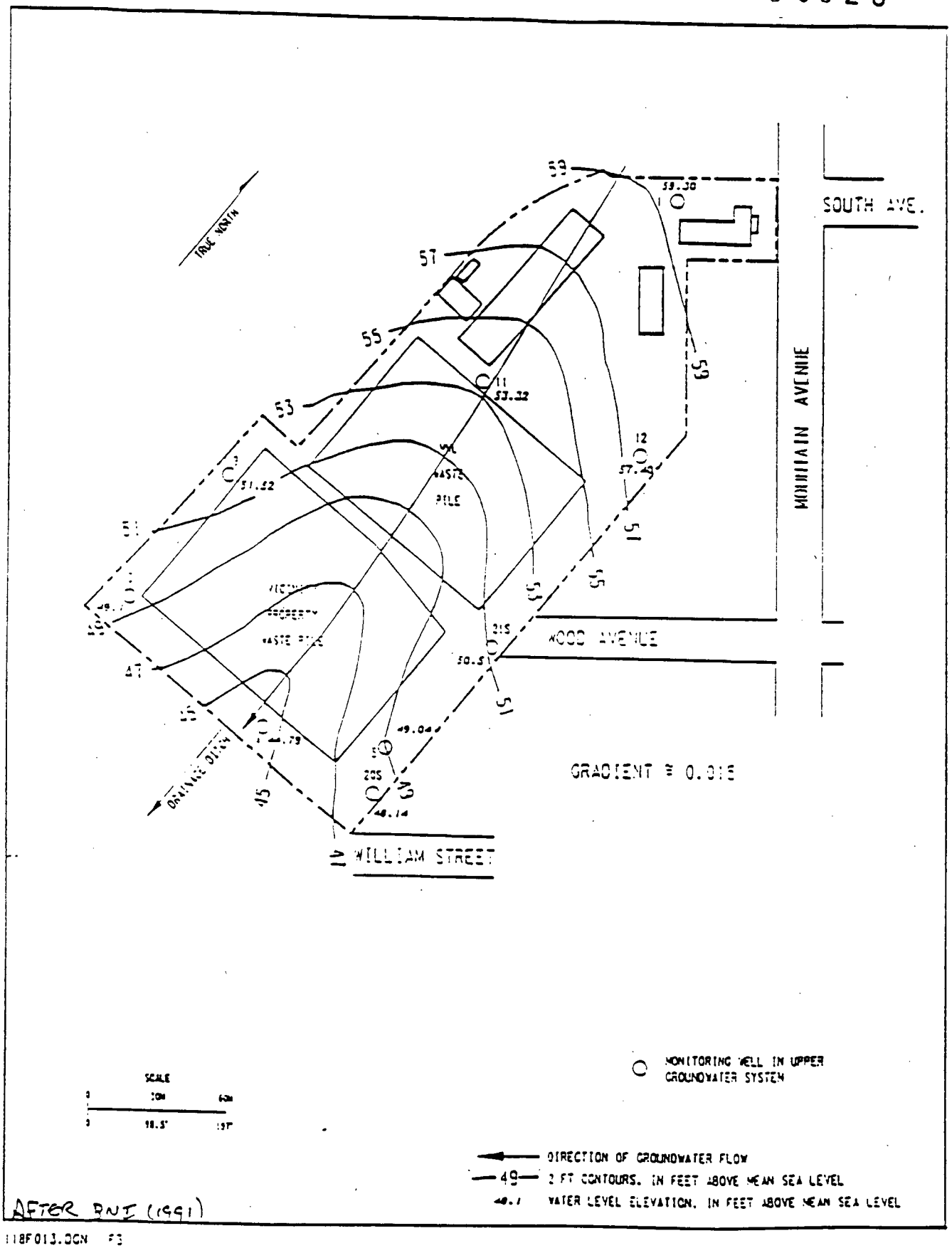
Figure 1

Potentiometric Surface Map of BEDROCK Groundwater System at MSP (6/15/90)



AFTER RNI (1991)

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Potentiometric Surface Map of Upper Groundwater System at MSP (6/15/90)

Insert MSP 3.

There are no well head protection areas in Middlesex County. One inactive public well field, the Sebrings Mill Well Field, is located 2 km (1.25 mi) northwest of Middlesex Sampling Plant. Sebrings Mill Well Field is owned by the Elizabethtown Water Company. It was closed due to the presence of VOC contamination in groundwater.

Reference:

Elizabethtown Water Company, Mr. Sedowski, Personal communication with Jon Novick, FUSRAP, 8-15-91.

Insert MSP 4.

The highest recorded levels in 1990 for ground water in the Brunswick Shale aquifer under the MSP piles occurred in well MSP 4A. The water level was 46.25 feet above mean sea level (BNI, 1991). This corresponds to an elevation that is approximately 4 feet below the lowest elevation of the ground surface prior to construction of the storage piles at MSP.

Reference: Bechtel National, Inc. (1991). Middlesex Sampling Plant Annual Site Environmental Report for Calendar Year 1990. DOE/OR/21949-285 (Draft). Oak Ridge, TN.

Insert MSP 5.

The least permeable unit between the aquifer and the ground surface is the weathered bedrock zone. Transmissivities in this unit ranged from 0.087 to 0.27 m^2/day (7 to 22 gpd/ft) as measured in slug tests (Weston 1980).

Reference: Roy F Weston, Inc. (1980). Hydrogeology of the Former Middlesex Sampling Plant Site, Middlesex, New Jersey. West Chester, PA.

Insert MSP 7.

Sebrings Mill Well Field, an inactive well field is located about 1 1/4 mile northwest of MSP. Sebrings Mill Well Field is a municipal well field that is owned by the Elizabethtown Water Company. The well field is reportedly no longer used due to the presence of organic contamination in groundwater. It is not expected to be used as a source of groundwater in the future. There are no other wells that are known to be used for drinking water in the area.

Reference: Elizabethtown Water Company, Mr. Sedowski, Personal Communication with John Novick, FUSRAP, 8-15-91.

INSERT 8

Middlesex Municipal Water Company estimates that 80% of the population in the Middlesex area obtains drinking water from public water supplies. Calculations determining the number of people who obtain drinking water from groundwater are presented in "INSERT D" of the Preliminary Assessment for MSP.

Reference: Middlesex Water Company, Mr. Sedowski, Personnal Communication with Jon Novick, FUSRAP, 8-15-91.

Insert MSP 9.

A well canvas conducted in 1988 revealed there to be 74 privately owned wells within 3 miles of MSP. Data on wells located between 3 and 4 miles from the site is not presently available. Although information on the aquifers from which these wells draw water is not known, the intervals from which water is obtained range from 19 to 520 feet which implies that some, if not all of the wells obtain water from the Brunswick Shale aquifer. The locations of wells relative to MSP and the population using each well is not presently available. The Middlesex Municipal Water Company estimates that 20% of the population in the Middlesex area get their drinking water from groundwater. Calculations showing the total number of people in the Middlesex area, and the number obtaining drinking water from groundwater are presented in "INSERT D" of the Preliminary Assessment for MSP.

Reference: Classification of Ground Water Resources for Site Areas in the Formerly Utilized Sites Remedial Action Program, (BNI, Draft, 1989).

Middlesex Water Company, Mr. Sedowski, Personnal Communication to Jon Novick, 8-15-91.

Insert MSP 10.

A well canvas conducted in 1988 revealed there to be 74 privately owned wells within 3 miles of MSP. Data on wells located between 3 and 4 miles from the site is not presently available. The results of the canvas revealed that 69 of the wells are used for domestic purposes, 3 are used for industrial purposes, 1 is used by a car wash, and 1 is used by a church. None of the privately owned wells are listed for use as drinking water, however a conservative approach would assume that domestic wells are used for drinking water. If each household is assumed to have 4 residents, than a total of 276 people must be assumed to recieve drinking water from these wells.

The inactive Sebrings Mill Well Field (Well Field) is located 1 1/4 miles northwest of the MSP, and is owned by the Elizabethtown Water Company. Because of organic contamination of the Well Field, it is not likely to be used as a source of drinking water in the future.

Reference: Classification of Ground Water Resources for Site Areas in the Formerly Utilized Sites Remedial Action Program, (BNI, Draft 1989).

INSERT MSP 11

Sampling has been conducted quarterly since 1982 to monitor the movement of uranium and radium-226 from MSP in surface water. Average uranium and radium-226 concentrations in the drainage ditch to the south of MSP are consistently higher than the background levels. The average annual concentration of uranium in surface water at the site outfall ranges from 34 to 103 pCi/l during the years 1982 through 1990. During that same period, the average annual concentrations of radium-226 in surface water ranged from 1.7 to 3.8 pCi/l. The background concentrations ranged from 3 to 5 pCi/l for uranium and from 0.1 to 1.2 pCi/l for radium-226. Average concentrations of uranium and radium-226 in surface water decrease with distance downstream from the site. Surface water samples were collected at the confluence of the drainage ditch and Ambrose Brook approximately 0.25 mi downstream of MSP. Samples collected at this location between 1987 and 1990 yielded average concentrations of uranium from 3 to 5 pCi/l and 0.3 to 0.7 pCi/l for radium-226 (BNI, 1991).

Sediment samples also have been collected from the drainage ditch. Sampling has been conducted at the same locations as surface water samples. Between 1986 and 1990, average annual concentrations of uranium in sediments at the MSP outfall ranged from 7.1 to 20.0 pCi/g. During the same period, average annual concentration ranged from 6.0 to 12.8 pCi/g for radium-226. Background concentrations ranged from 0.7 to 7.8 pCi/g for uranium and from 0.7 to 2.0 pCi/g for radium-226. Average annual concentrations of uranium and radium-226 in sediments were elevated above background levels in all downstream sediment sampling locations (BNI, 1991).

Prior to the fall of 1990, information on the method of contaminant transport off-site in surface water did not exist. Begining in fall of 1990, both filtered and unfiltered surface water samples were collected. Data from analyses of these samples are still preliminary, however, persistently high levels of contaminants in sediments, and the low solubility of uranium and radium-226 in water would suggest that radioisotopes are not being transported off-site in the dissolved phase. More likely, transport of contaminants is occuring through particulate movement, or by chealation or complexation with naturally occuring organic material.

Reference:

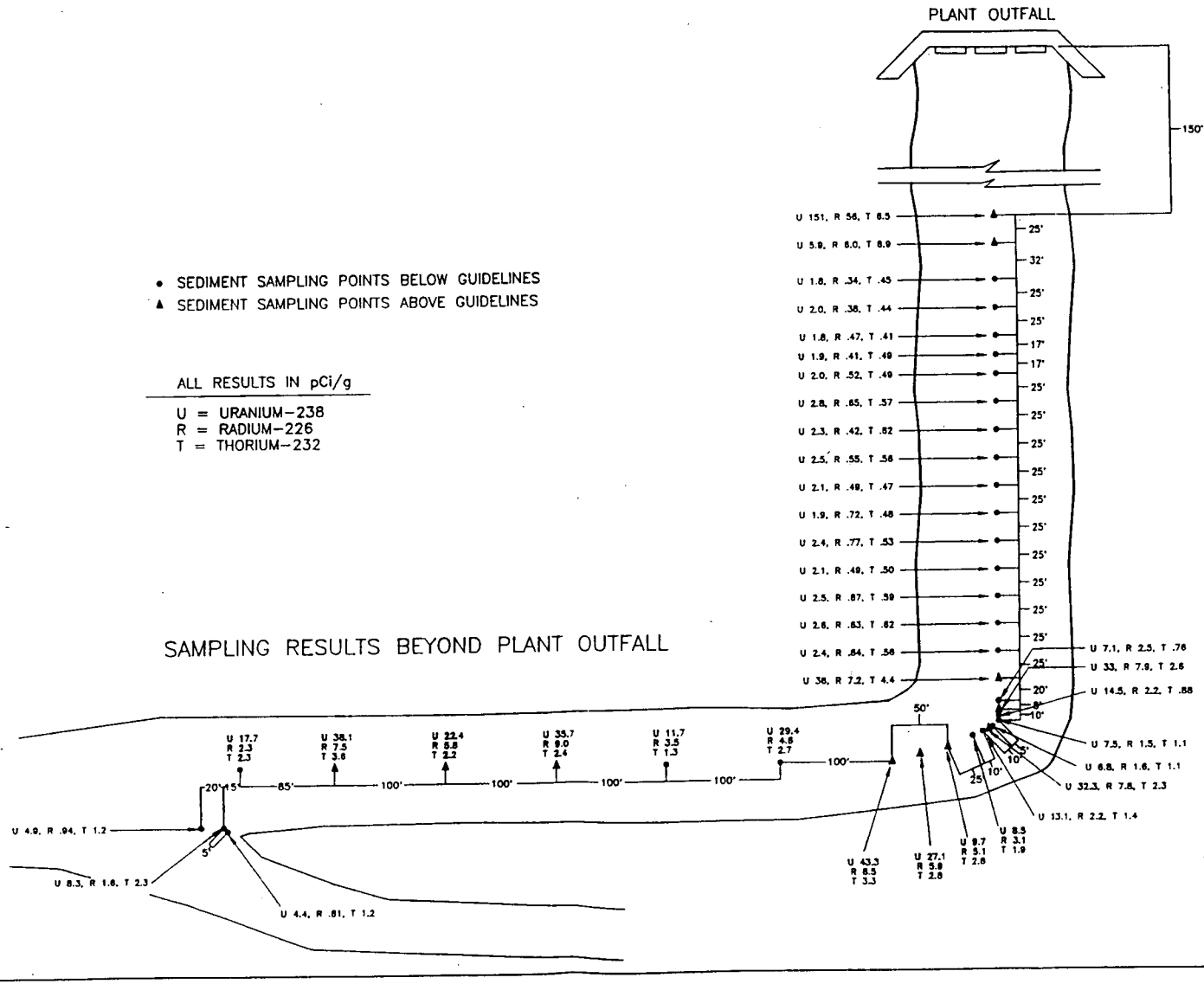
Bechtel National, Inc. (1991). Middlesex Sampling Plant Annual Environmental Report for Calendar Year 1990. DOE/OR/21949-285, Draft, Oak Ride, TN.

ADDENDUM 4

SURFACE WATER ROUTE

Insert MSP 11.

Attached as supplemental information are two drawings which show levels of contamination in the drainage ditch south of the MSP. The first drawing is labeled Figure 1 Sampling Results from Plant Outfall which represents contaminant levels from sampling locations at the outfall and extending 125 feet down the drainage ditch. The second drawing is labeled Sampling Results Beyond Plant Outfall, and represents contaminant levels from 150 feet beyond the outfall to the confluence with the Ambrose Brook.


PLANT OUTFALL
150'
• SEDIMENT SAMPLING POINTS BELOW GUIDELINES
▲ SEDIMENT SAMPLING POINTS ABOVE GUIDELINES
ALL RESULTS IN pCi/g
U = URANIUM-238
R = RADIUM-226
T = THORIUM-232
SAMPLING RESULTS BEYOND PLANT OUTFALL
U 151, R 56, T 8.5
U 5.9, R 6.0, T 8.9
U 1.8, R .34, T .45
U 2.0, R .38, T .44
U 1.8, R .47, T .41
U 1.9, R .41, T .49
U 2.0, R .52, T .49
U 2.8, R .65, T .57
U 2.3, R .42, T .82
U 2.5, R .55, T .56
U 2.1, R .49, T .47
U 1.9, R .72, T .48
U 2.4, R .77, T .53
U 2.1, R .49, T .50
U 2.5, R .87, T .59
U 2.6, R .63, T .62
U 2.4, R .64, T .56
U 38, R 7.2, T 4.4
25'
32'
17'
20'
8'
10'
5'
U 7.1, R 2.5, T .76
U 33, R 7.9, T 2.6
U 14.5, R 2.2, T .88
U 7.5, R 1.5, T 1.1
U 6.8, R 1.6, T 1.1
U 32.3, R 7.8, T 2.3
U 13.1, R 2.2, T 1.4
U 8.5 R 3.1 T 1.9
U 9.7 R 5.1 T 2.6
U 27.1 R 5.9 T 2.8
U 43.3 R 8.5 T 3.3
50'
U 17.7 R 2.3 T 2.3
U 38.1 R 7.5 T 3.6
U 22.4 R 5.8 T 2.2
U 35.7 R 9.0 T 2.4
U 11.7 R 3.5 T 1.3
U 29.4 R 4.6 T 2.7
100'
85'
15'
20'
U 4.9, R .94, T 1.2
U 8.3, R 1.6, T 2.3
U 4.4, R .81, T 1.2

85:TRENCH:V1

13. What is the distance to the nearest downslope surface water? Measure the distance along course that runoff can be expected to follow.

080528

Ref. No Insert MSP 13

14. Determine the floodplain that the site is located within.

Ref. No. Insert MSP 14

15. What is the 2-year 24-hour rainfall?

Approximately 3.3 inches for Middlesex County.

Ref. No. Technical Paper No. 40, Rainfall Frequency Atlas of the United States, December 1982.

16. Identify drinking water intakes in surface waters within 15 miles downstream of the site. For each intake identify: the distance from the point of surface water entry, population served, and stream flow at the intake location.

Intake	Distance	Population Served	Flow (cfs)

Ref. No. Insert MSP 16

17. Identify fisheries that exist within 15 miles downstream of the point of surface water entry. For each fishery specify the following information:

Fishery	Water Body Type	Flow (cfs)

Information to identify potential fisheries that exist within 15 mi of surface water entry is presently unavailable.

Ref. No.

18. Identify sensitive environments that exist within 15 miles of the point of surface water entry. For each sensitive environment specify the following:

Environment	Water Body Type	Flow (cfs)

No rare or endangered species of flora or fauna are known to exist within the environs of the site.

Ref. No. SI Page 31

19. If a release to surface water is observed or suspected, identify any intakes, fisheries, and sensitive environments from question Nos. 16-18 that are or may be located within the contamination boundary of the release.

Intake	Fishery	Environment

Ref. No. Insert MSP 19

SOIL EXPOSURE PATHWAY

20. Determine the number of people that occupy residences or attend school or day care on or within 200 feet of the site property.

No schools or day care centers and located within 200 ft of the si property. Three homes are located near MSP. These residences to an estimated 15 people.

Ref. No.

21. Determine the number of people that work on or within 200 feet of the site property.

A salvage yard (estimated 10 employees) and a machine shop (estima 5 employees) border the MSP fenceline. Including site workers, a estimated total of 20 people wor within 200 feet of the site prop

Ref. No.

22. Identify terrestrial sensitive environments on or within 200 feet of the site property.

Ref. No. Insert MSP 22

AIR ROUTE

23. Describe the likelihood of release of contaminants to air as follows: observed release, suspected release, or none. Identify contaminants detected or suspected and provide a rationale for attributing them to the site. For observed release define the supporting analytical evidence.

Ref. No. Insert MSP 23

24. Determine populations that reside within 4 miles of the site.

Distance	Population
0 - ¼ mi	
> ¼ - ½ mi	
> ½ - 1 mi	
> 1 - 2 mi	
> 2 - 3 mi	
> 3 - 4 mi	

Ref. No. Insert MSP 24

25. Identify sensitive environments and wetlands acreage within ½ mile of the site.

Sensitive Environment Type	Distance

Ref. No. Insert MSP 25

Insert MSP 12.

Surface runoff from MSP flows generally in a southern direction. Runoff from the asphalt pad is collected in several drains that empty into a large settling basin through an underground drainage system. This drainage system empties into a drainage ditch south of the site which flows into a creek named Main Stream. Main Stream empties into Ambrose Brook and Ambrose Brook flows into Green Brook near the confluence with the Raritan River.

Reference: Environmental Analysis of the Former Middlesex Sampling Plant and Associated Properties, Middlesex, New Jersey; Ford, Bacon, and Davis Utah, Inc. (FBDU) July, 1979, Pages 230-235.

Insert MSP 13.

Surface runoff from the two storage piles at MSP is collected in several drains that empty into a large settling basin located on the site through an underground drainage system and then into a drainage easement ditch south of the site which runs 0.3 miles south to Main Stream. Main Stream empties into Ambrose Brook, and Ambrose Brook flows into Green Brook near the confluence with the Raritan River. Neither Main Stream nor Ambrose Brook are used for water supplies.

Reference: Certification Docket for Remedial Action Performed at the Middlesex Municipal Landfill in Middlesex, New Jersey in 1984 and 1986, (BNI, May 1989), Prepared for U.S. DOE, Oak Ridge Operations.

Insert MSP 14.

The Middlesex Sampling Plant site is not located within any floodplain. The closest floodplain is from Ambrose Brook, located approximately 600 m (2,000 ft) southwest of the site.

Reference: Site Inspection Report, Page 45.

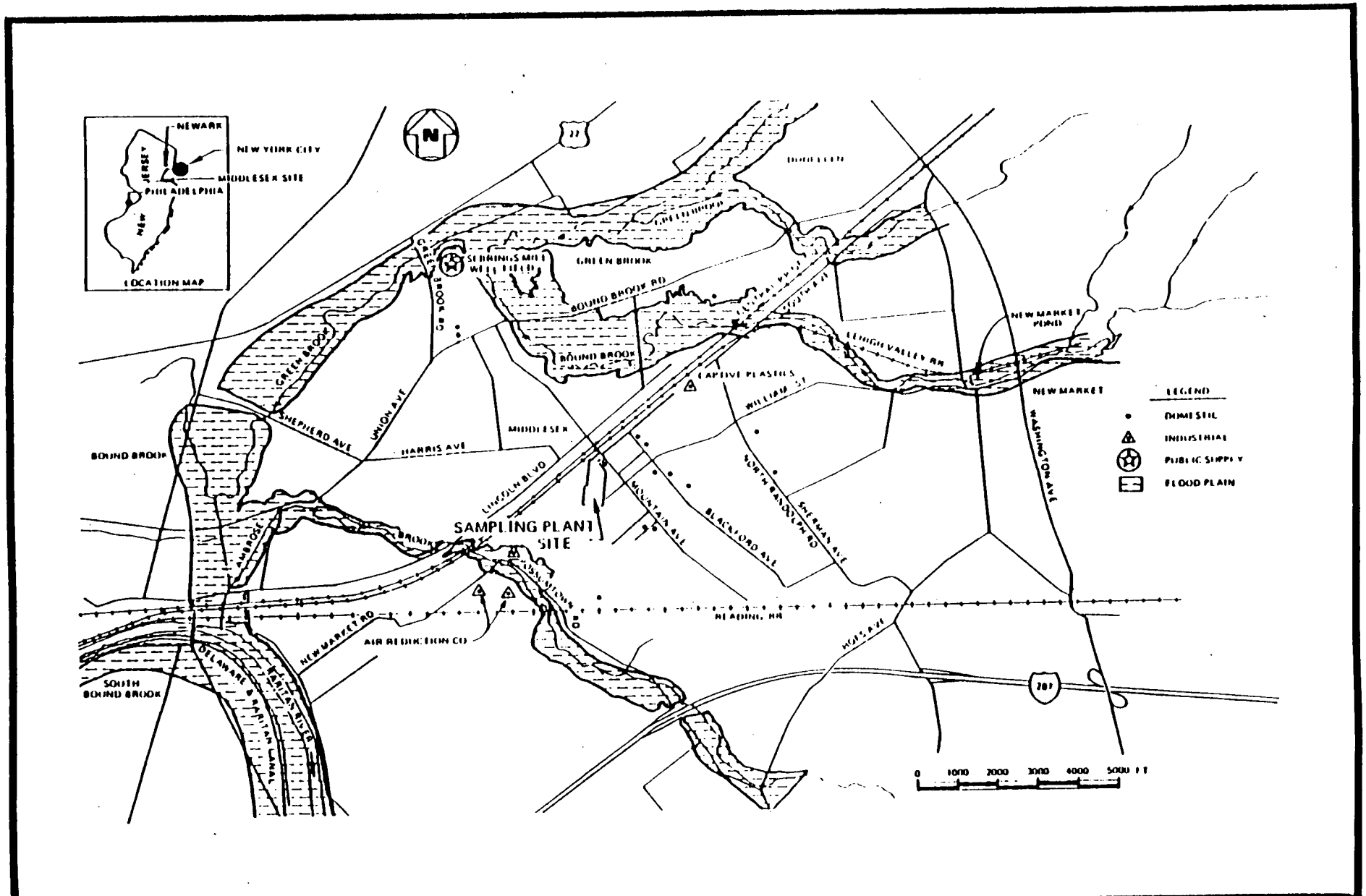


FIGURE 6-3 FLOODPLAINS AND APPROXIMATE LOCATION OF WELLS IN VICINITY OF MSP

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The quality of surface water in Middlesex County varies, but the major streams still serve as drinking water sources for a large percentage of the population of the Middlesex area. The Elizabethtown water company has an intake on the Rariton river at its confluence with the Millstone river. This location is upstream of the confluence of the Rariton river and Ambrose brook. A second intake is located on the Rariton river downstream of its confluence with Ambrose brook. This intake is owned and operated by the town of Middlesex and is located approximately 3.3 miles downstream of the site. The Middlesex Water Company also owns an intake on the Delaware and Rariton Canal about 5.3 miles downstream from MSP. The population served by these sources is not known, however it is assumed to be greater than 1,000,000. The flow of the Rariton river is 1320 cfs.

Reference:

Elizabethtown Water Company, Mr. Sedowski, Personnal Communication with Jon Novick, FUSRAP, 8-15-91.

Insert MSP 19.

The drainage ditch located south of the site received most of the site drainage. This area appears to have been impacted by the deposition of contaminated soil that had been transported as suspended particles via surface water runoff and lateral transport through the parking lot subbase.

There are no critical habitats, sensitive environments, fisheries, or surface water intakes within 1 mile of the site.

References: Site Inspection Report for MSP, Page 65.
Hazard Ranking System Scoring for Middlesex Sampling Plant, Middlesex, New Jersey, (BNI, July 1989).

ADDENDUM 5

Insert MSP 19.

Please see Addendum 4 for locations and data on contamination of sediment in the drainage ditch beyond the outfall south of the MSP.

INSERT MSP 22

Minimal biotic resources occur on the Middlesex Sampling Plant site because most of the site is paved. Pigeons, sparrows, rats, and mice may occur on the site, and some aquatic insects (mostly dipterans) and frogs may occur in the sedimentation basin.

Because the ecosystem on the Sampling Plant has been disturbed, the occurence of any rare or endangered species on the site is extremely unlikely.

There are no known sensitive environments within one mile of the site.

Reference:

Certification Docket II-171.

AIR ROUTE

Insert MSP 23

The only suspected air contaminants emitted from the site are radon and thoron. Radon emissions are present due to the radium and thorium contaminated soil stored in the piles.

No release of radon is suspected, as defined in the Guidance Manual. The Annual Average Concentration of radon in 1990 was just above background. No values as high as two to three times background were obtained.

Radon flux monitoring has been performed for MSP by sampling the two piles. Results of sampling performed in May 1991 indicate a radon flux range on the pile designated the MML cleanup pile range from 0.03-0.04 pCi/m^2/sec and an average of 0.038 pCi/m^2/sec; the storage pile designated the Phases I and II pile had a range of radon flux rates from 0.03-0.52 pCi/m^2/sec and an average of 0.157 pCi/m^2/sec. The radon flux standard for DOE sites is 20.0 pCi/m^2/sec, per the National Emission Standards for Hazardous Air Pollutants (NESHAPs), 40 CFR Part 61.

Reference:

Middlesex Sampling Plant Annual Environmental Report for Calendar Year 1990, June 1991, BNI, Inc., (DOE/OR/21949-285).

Letter from David G. Adler, Site Manager, Former Sites Restoration Division, DOE, to Paul A. Giardina, Radiation Branch Manager, USEPA Region II, July 16, 1991, (CCN 079488).

INSERT MSP 24

Population calculations were performed in "Insert D" of the Preliminary Assessment for MSP. Totals calculated are:

Distance	Population
0 - 1/4 mi.	423
>1/4 - 1/2 mi.	1267
>1/2 - 1 mi.	8038
>1 - 2 mi.	32,136
>2 - 3 mi.	53,594
>3 - 4 mi.	75017

INSERT MSP 25

There are no State or Federally designated sensitive environments within 15 miles downstream of MSP.

26. If a release to air is observed or suspected, determine the number of people that reside or suspected to reside within the area of air contamination from the release.

Ref. No. Insert MSP 26

27. If a release to air is observed or suspected, identify any sensitive environments, listed question No. 25, that are or may be located within the area of air contamination from t release.

Ref. No. Insert MSP 27

AIR ROUTE

Insert MSP 26.

No migration of contaminants through the air has been observed or suspected from the site. However, the site is monitored for radon and thoron, as described in Question 23. Site contamination is generally limited to the two storage piles on site, which are covered with an impervious liner.

In addition to radon monitoring discussed above, radionuclide emission rates for non-radon emitters were calculated using the EPA-approved dose model AIRDOS-PC, as directed in 40 CFR Section 61.93, to comply with NESHAPs requirements.

Reference:

Middlesex Annual Environmental Report, Pages 25-30.

Letter from William M. Seay, Deputy Director, Former Sites Restoration Division, DOE, to Paul A. Giardina, Radiation Branch Manger, USEPA Region II, June 28, 1991, (CCN 079116).

AIR ROUTE

Insert MSP 27.

No releases to air have been observed or suspected. Radon emissions are monitored as part of an environmental monitoring program, and are below EPA guidelines, as expressed in NESHAPs Subpart Q, 40 CFR Part 61. (See the answer to Question 23).

Reference: Middlesex Annual Environmental Report, Pages 25-30.

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PA Scoresheets

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INSTRUCTIONS FOR SCORESHEETS

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Introduction

These scoresheets require you to record information collected during the PA, indicate references used, select values ("scores") for factors, calculate pathway scores and a site score, and conclude with a site recommendation. You are encouraged to write notes on the scoresheets and especially on the Criteria Lists. On pages with a reference column, indicate a number corresponding to attached sources of information or pages containing rationale for hypotheses; attach to the scoresheets a numbered list of these references. Evaluate all four pathways. Complete and submit all Criteria Lists, scoresheets, and tables. Show calculations, as appropriate. Do not enter values or scores in shaded areas of the scoresheets.

General Information

Site Description and Operational History: Provide a brief description of the site and its operating history. State the site name, owner/operator, type of facility and operations, size of property, active or nonactive status, and years of waste generation. Summarize waste treatment, storage, or disposal activities that have or may have occurred at the site, note also if these activities are documented or alleged. Identify probable source types and prior spills. Summarize highlights of previous investigations.

Probable Contaminants of Concern: List hazardous substances you think may have been stored, handled, or disposed of at this site, based on your knowledge of site operations. The purpose of identifying probable substances of concern is to consider the mobility of wastes to hypothesize whether a release has occurred. Identify the sources to which the substances may be related. Summarize any analytical data that may exist concerning contamination detected on site or impacting targets as a result of previous investigations performed on the site.

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STATE	SITE NUMBER
NJ	0890090012

SITE LOCATION

SITE NAME Legal, common or descriptive name of site
Middlesex Sampling Plant

STREET ADDRESS ROUTE or SPECIFIC LOCATION IDENTIFIER
239 Mountain Avenue

CITY
Middlesex

STATE	ZIP CODE	TELEPHONE
NJ	08846	(201) 469-21

COORDINATES LATITUDE and LONGITUDE
--40 34-N ---74 29-W

TOWNSHIP, RANGE, and SECTION
Middlesex County

OWNER/OPERATOR IDENTIFICATION

OWNER: Dept. of Energy, OR Operations	OPERATOR:
OWNER ADDRESS: P.O. Box 2001	OPERATOR ADDRESS:
CITY: Oak Ridge	CITY:
STATE: TN; ZIP CODE: 37831; TELEPHONE: (615) 576-0948	STATE; ZIP CODE; TELEPHONE: ( )

TYPE OF OWNERSHIP

- [ ] PRIVATE
- [X] FEDERAL Agency name DOE
- [ ] STATE
- [ ] COUNTY
- [ ] MUNICIPAL
- [ ] OTHER
- [ ] NOT SPECIFIED

OWNER/OPERATOR NOTIFICATION ON FILE

- [X] NONE
- [ ] CERCLA 103 C. UNCONTROLLED WASTE SITE DATE
- [ ] RCRA 3001 DATE

SITE STATUS

- [ ] ACTIVE
- [X] INACTIVE
- [ ] UNKNOWN

YEARS OF OPERATION

BEGINNING YEAR 1943

ENDING YEAR 1967

[ ] UNKNOWN

APPROXIMATE SIZE OF SITE

SITE EVALUATION

AGENCY / ORGANIZATION

INVESTIGATOR

CONTACT

ADDRESS

TELEPHONE ( )

DATE

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Site Sketch: Prepare a sketch of the site. Indicate all pertinent features of the site and nearby environs, including: sources of wastes, areas of visible and buried wastes, buildings, residences, access roads, parking areas, drainage patterns, water bodies, vegetation, wells, sensitive environments, etc.

Site Description and Operational History:

SEE ATTACHED TEXT LABELED "INSERT A"

Probable Contaminants of Concern:
(Previous investigations: analytical data)

SEE ATTACHED TEXT LABELED "INSERT B"

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Source Descriptions: Identify and describe all sources (for example, surface impoundments, landfills, underground tanks, drums, piles, areas of contaminated soil, etc.) at the site. Provide source dimensions and the best available waste quantity information. Indicate if there are any containment structures present (are the sources poorly contained?).

SOURCE TYPE DEFINITIONS

Landfill: a man-made (by excavation or construction) or natural hole in the ground into which wastes have come to be disposed by backfilling, or by contemporaneous soil deposition with waste disposal.

Surface Impoundment: a natural topographic depression, man-made excavation, or diked area primarily formed from earthen materials (lined or unlined) which was designed to hold an accumulation of liquid wastes, wastes containing free liquids, or sludges that were not backfilled or otherwise covered; depression may be wet with exposed liquid or dry if deposited liquid has evaporated, volatilized or leached; structures that may be more specifically described as lagoon pond, aeration pit, settling pond, tailings pond, sludge pit, etc. A surface impoundment that has been covered with soil after the final deposition of waste materials (i.e., buried or backfilled) is also considered a surface impoundment.

Drums: a portable container, designed to hold a standard 55-gallon volume of wastes.

Tanks and Non-Drum Containers: any device other than drums designed to contain an accumulation of waste that provides structural support and is constructed primarily of fabricated materials (such as wood, concrete, steel or plastic); any portable or mobile device in which waste is stored or otherwise handled.

Contaminated Soil: an area or volume of soil onto which hazardous substances are suspected to have been spilled, disposed, or deposited.

Pile: any non-containerized accumulation above the ground surface of solid, non-flowing wastes; includes open dumps. Some types of waste piles are: Chemical Waste Pile: a pile consisting primarily of discarded chemical products, by-products, radioactive wastes, or used or unused feedstocks; Scrap Metal or Junk Pile: a pile consisting primarily of scrap metal or discarded durable goods such as appliances, automobiles, auto parts, batteries, etc., composed of materials suspected to contain or have contained hazardous substances; Tailings Pile: a pile consisting primarily of any combination of overburden from a mining operation and tailings from a mineral mining, benefication, or processing operation; and Trash Pile: a pile consisting primarily of paper, garbage or discarded non-durable goods which are suspected to contain or have contained hazardous substances.

Land Treatment: landfarming or other land treatment, method of waste management in which liquid wastes or sludges are spread over land and tilled, or liquids are injected at shallow depths into soils.

Waste Characteristics: Evaluate hazardous waste quantity for all sources at the site to determine the Waste Characteristics factor category score (WC).

Use PA Table 1a (page 5) to determine the WC score for sites with only one source. If more than one source is present, you will need to calculate an intermediate waste quantity value (WQ) for each source using a divisor, then sum the WQ values to determine the total WQ for the site (see instructions opposite Table 1, page 5). Use PA Table 1b (page 5) to determine the WC score.

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Site Sketch:

(Show all pertinent features: indicate sources and closest targets)

PLEASE SEE FIGURES ATTACHED TO INSERTS A AND B

PA SCORESHEET

INSERT A

Site Description

MSP occupies approximately 3.9 ha (9.6 acres) in north-central New Jersey within the Borough of Middlesex (Middlesex County) (Figure 1-1). The MSP property includes four buildings and two storage piles that total 50,748 m^3 (66,372 yd^3) of waste (Figure 1-2). More than 70 percent of the MSP site is paved with asphalt. The site, currently being used for interim storage of radioactively contaminated soil, is entirely fenced and public access is restricted. Figure 1-3 is an aerial photograph of the site.

Site History

The Middlesex Sampling Plant (MSP) facility was established in 1943 by the Manhattan Engineer District (MED) to sample, store, and/or ship uranium, thorium, and beryllium ores. In 1955, the Atomic Energy Commission (AEC), successor to MED, terminated the operation and later used the site for storage and limited sampling of thorium residues. In 1967, AEC activities ceased, onsite structures were decontaminated, and the site was certified for unrestricted use under criteria applicable at that time.

Between 1968 and 1980, the site changed hands, first to the General Services Administration, and then to the Department of the Navy for use as a U.S. Marine Corps reserve training center. In 1980, custody of MSP was returned to DOE, which then initiated remedial action to clean up vicinity properties. The Middlesex Municipal Landfill (MML), a vicinity property established in the mid-1940s, began to receive soil contaminated with pitchblende (high-grade uranium ore) in 1948, which resulted in contaminated soil being placed over existing fill at MML. By 1974, solid waste disposal ceased at MML. Early radiological surveys indicated that 0.2 ha (0.5 acre) of MML required remediation; in 1984,

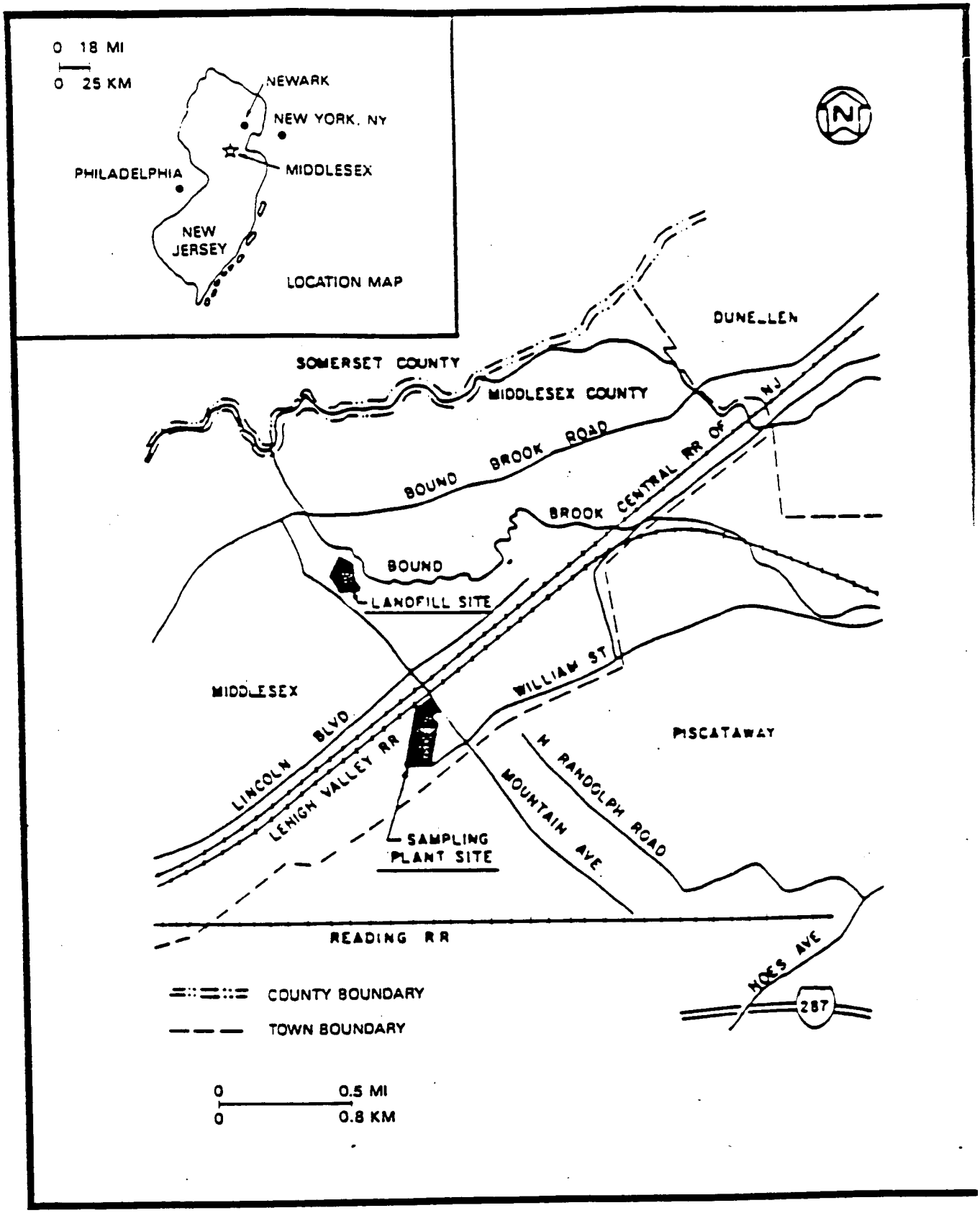

Figure 1-1 Location of MSP

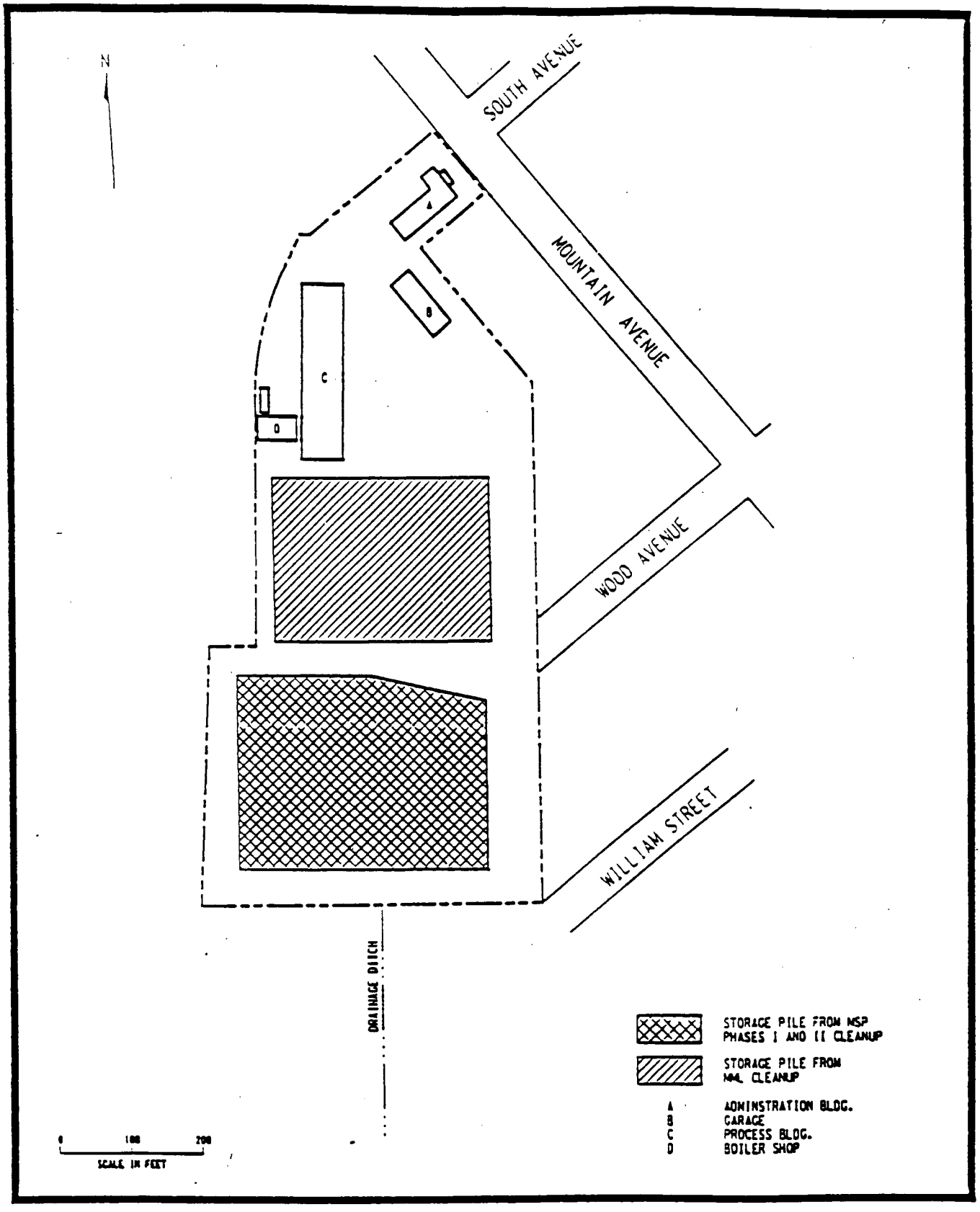

Figure 1-2 Map of the MSP Site

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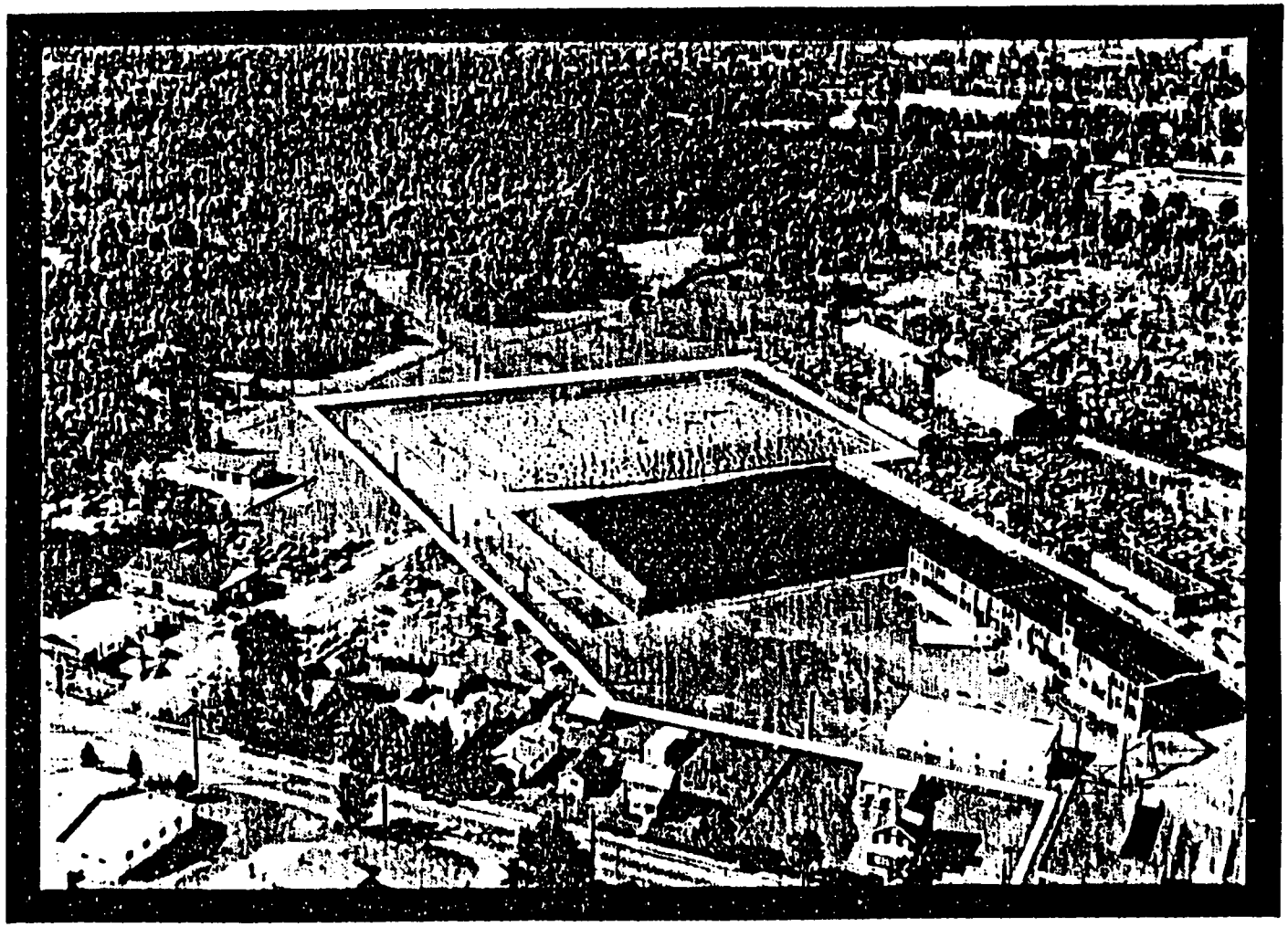

Figure 1-3 Aerial View of MSP

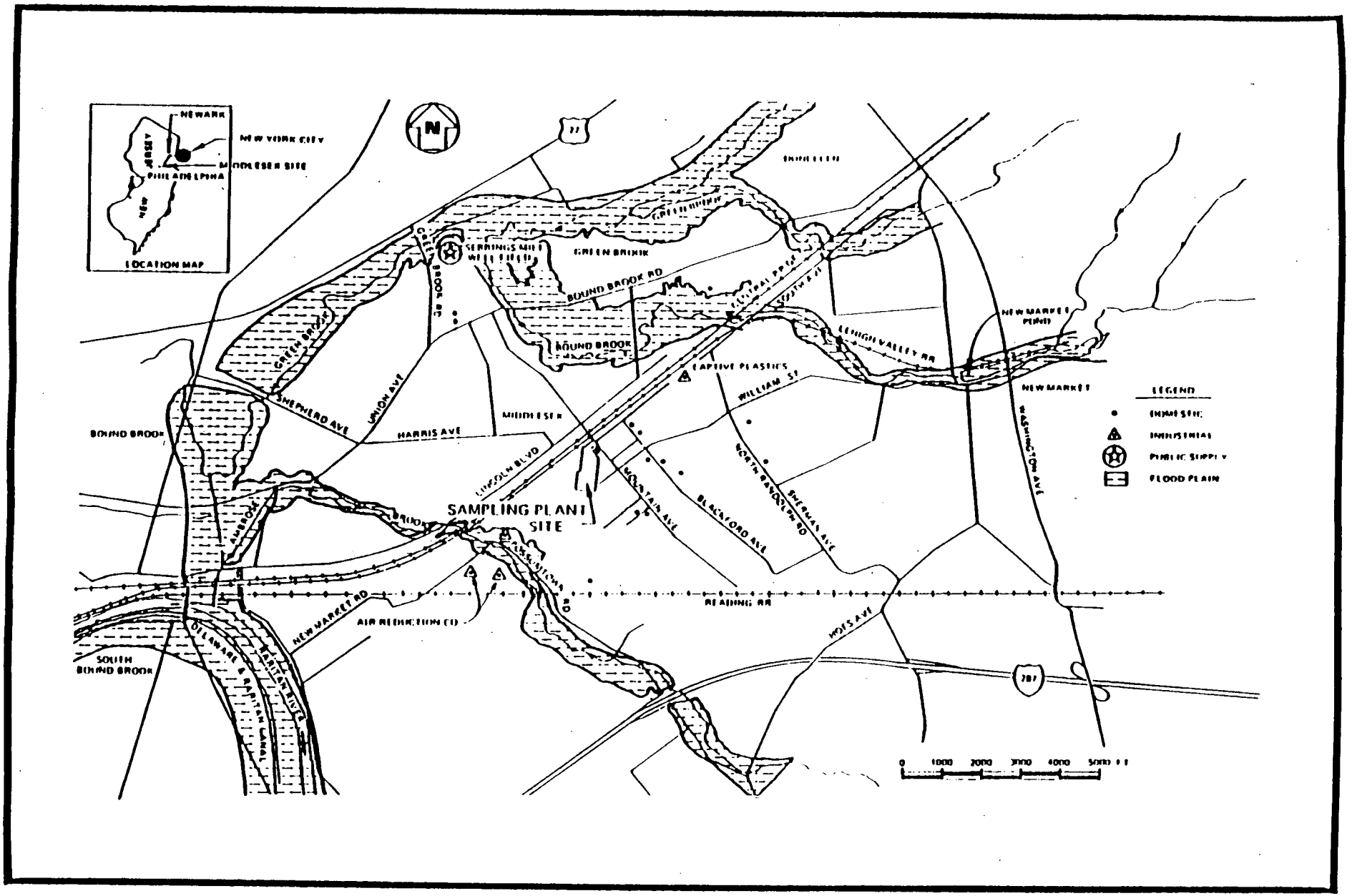

FIGURE 6-3 FLOODPLAINS AND APPROXIMATE LOCATION OF WELLS IN VICINITY OF MSP

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approximately 12,000 m^3 (16,000 yd^3) of contaminated soil was returned to MSP for interim storage. Later investigations showed the contaminated area to be 1.2 ha (3.0 acres). By 1986, remediation at MML was essentially complete; 23,900 m^3 (31,200 yd^3) of contaminated soil was returned to MSP for interim storage. In 1987, MML was turned over to the Borough of Middlesex.

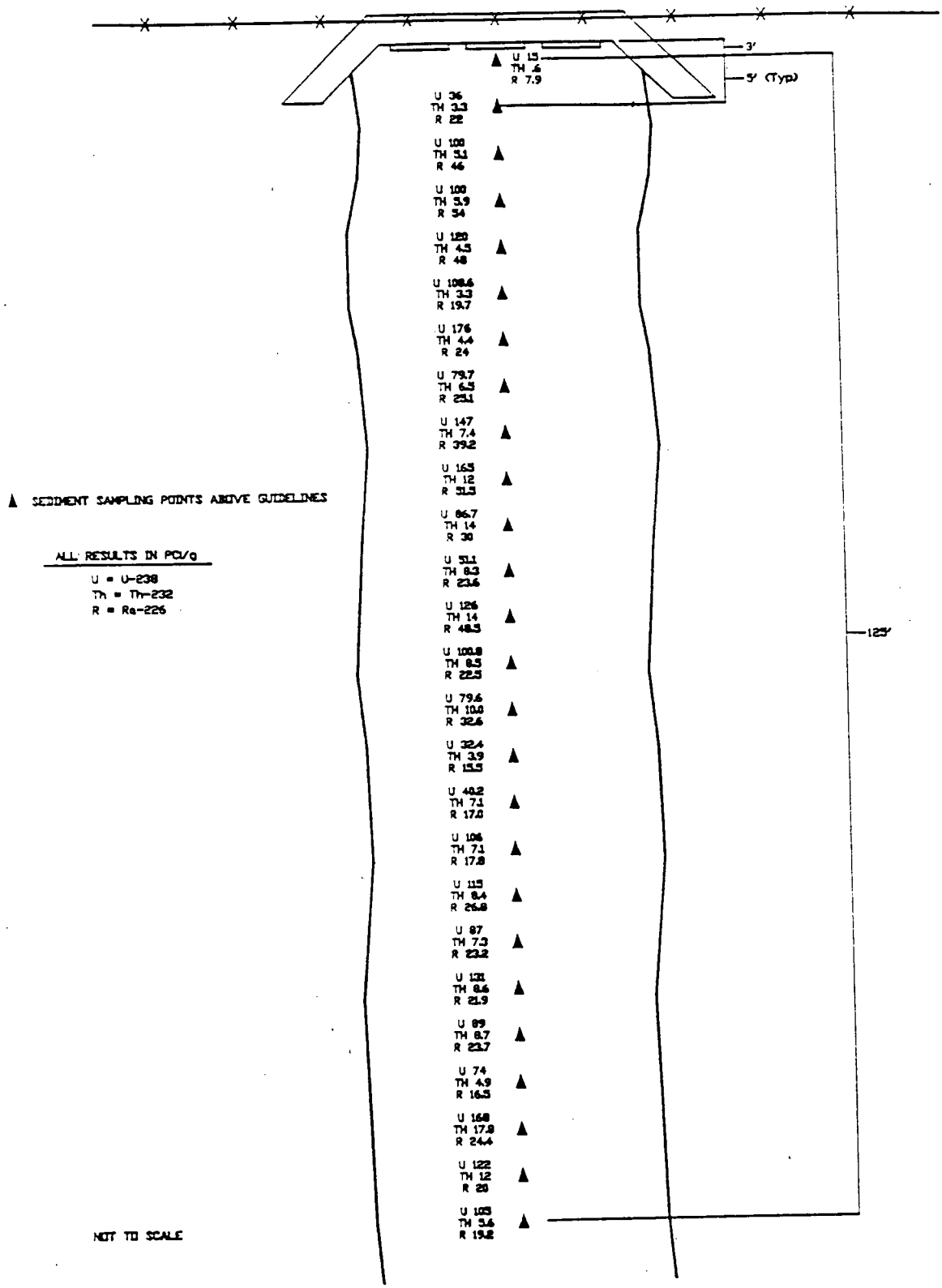

FIGURE 1 SAMPLING RESULTS FROM PLANT OUTFALL

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ADDENDUM 6

The piles at MSP have been characterized for chemical contamination, and the results of the characterization were published in December 1991. Analysis has revealed the presence of lead in the MML pile, as determined by the Toxicity Characteristic Leaching Procedure (TCLP). 46 of 54 samples taken from the MML pile failed the TC for lead.

Reference: MSP Characterization, December 1991.

INSERT B

Summary of Environmental Monitoring Data

The following subsections summarize environmental monitoring results for MSP for calendar year 1990.

Radon

Annual average radon concentrations at the site boundary ranged from 0.4E-9 to 1E-9 μCi/ml (0.02 to 0.04 Bq/L), including an average background level of 0.8E-9 μCi/L (0.03 Bq/L). Radon concentrations at all monitoring locations along the site boundary were below the DOE guideline of 3E-9 μCi/ml (0.1 Bq/L) for interim storage sites and remained close to background levels throughout the year. The only concentrations exceeding DOE guidelines were at stations located in the process building on site. Thoron monitoring was not conducted at MSP during 1990; however, it will be added to the environmental monitoring program in 1991.

Radon flux measurements were collected to demonstrate that the site was in compliance with the radon flux limit of 20E-9 $\mu Ci/m^2/s$ set forth in 40 CFR Part 61, Subpart Q. Both piles had average radon flux rates of 0.09E-9 $\mu Ci/m^2/s$ (3E-3 $\mu Ci/m^2/s$).

External Gamma Radiation Exposure

The annual average external gamma radiation exposure level was 76 mR/yr onsite and 55 mR/yr at the property line, excluding an average background of 64 mR/yr. Detailed information on gamma radiation exposure monitoring can be found in Subsection 4.1.2.

Surface Water

Surface water sampling was performed quarterly to determine concentrations of total uranium, radium-226, and thorium-232 and to assess any impact of site discharges to surface waters in the

vicinity. Concentrations of radionuclides at downstream and upstream (background) sampling locations were essentially the same except for one total uranium value. Annual average concentrations ranged from 0.4E-9 to 2.8E-9 μCi/ml (0.02 to 0.1 Bq/L) for radium-226 and from 3E-9 to 60E-9 μCi/ml (0.1 to 2.2 Bq/L) for total uranium. Thorium-232 concentrations averaged 0.1E-9 μCi/ml (4E-3 Bq/L). All radionuclide concentrations were below the DCGs of 100E-9 μCi/ml (3.7 Bq/L) for radium, 50E-9 μCi/ml (1.9 Bq/L) for thorium-232, and 600E-9 μCi/ml (22 Bq/L) for total uranium.

Sediment

Sediment samples were collected in conjunction with surface water samples as a check for deposition of the contaminants of interest (total uranium, radium-226, and thorium-232). Average annual concentrations in sediment ranged from 0.7 to 6 pCi/g (0.03 to 0.2 Bq/g) for radium-226, 0.5 to 2 pCi/g (0.02 to 0.07 Bq/g) for thorium-232, and 0.7 to 11 pCi/g (0.03 to 0.4 Bq/g) for total uranium. Concentrations in downstream sediment were elevated compared with those found in upstream (background) samples. There are currently no guidelines in effect for radionuclide concentrations in sediment; however, some of the radium-226 and thorium-232 values were greater than the 5 pCi/g (0.2 Bq/g) FUSRAP guideline for the top 15-cm (6-in.) layer of soil. Radionuclide concentrations were comparable to the concentrations typically found in phosphate fertilizers.

Groundwater

Groundwater results were in general agreement with previous data. Quarterly groundwater samples were analyzed for total uranium, radium-226, thorium-232, and chemical indicator parameters [specific conductance, pH, total organic carbon (TOC), and total organic halides (TOX)], and metals. In addition, volatile and semivolatile organic compounds were analyzed for during the third quarter. Average annual concentrations in groundwater ranged from 0.3E-9 to 2.4E-9, 0.1E-9 to 1E-9, and 3E-9 to 123E-9 μCi/ml (0.01

to 0.09, 0.004 to 0.04, and 0.1 to 4.6 Bq/L) for radium-226, thorium-232, and total uranium, respectively. Radionuclide concentration levels in all samples were below the DCGs of 100E-9, 50E-9, and 600E-9 μCi/ml (3.7, 1.9, and 22 Bq/L) for radium-226, thorium-232, and total uranium, respectively. The groundwater quality is poor, but this is typical for an industrialized urban area.

Source Descriptions:

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SEE ATTACHED INSERT LABELED " SOURCE DESCRIPTIONS"

Waste Characteristics (WC) Calculations:
(See PA Table 1, page 5)

SEE ATTACHED INSERT LABELED "WASTE CHARACTERISTICS (WC) CALCULATIONS"

W.C = 100

Determining the Waste Characteristics (WC) Score: WC, based on waste quantity, may be determined by one or all of four measures called "tiers": constituent quantity, wastestream quantity, source volume, and source area. PA Table 1a (page 5) is structured according to these tiers. The amount and level of detail of information available to you determine which tier(s) you can use for each source. For each source, evaluate waste quantity for as many of the tiers as you have information to support, and select the result that gives you the highest WC score. For any one source or for all sources at a site, if no information is available regarding waste quantity assign a WC score of 18 (minimum).

PA Table 1a has 6 columns: column 1 indicates the quantity tier; column 2 lists source types for the four tiers; columns 3, 4, and 5 provide ranges of waste amount for sites with only one source, which correspond to WC scores at the tops of the columns (18, 32, or 100); column 6 provides formulas to obtain source waste quantity (WQ) values at sites with multiple sources.

To determine WC for sites with only one source

1. *Identify source type (see definitions).*
2. *Examine all waste quantity data available.*
3. *Estimate the mass and/or dimensions of each source.*
4. *Determine which quantity tiers you can use based on available source information.*
5. *Convert source measurements to appropriate units for each tier you can evaluate for the source.*
6. *Identify the range into which the total quantity falls for each tier evaluated (PA Table 1a.*
7. *Determine the highest WC score obtained for any tier (18, 32, or 100, at top of PA Table 1a columns 3, 4, & 5, respectively).*
8. *Use this WC score for all pathways.**

To determine WC for sites with multiple sources

1. *Identify each source type (see definitions).*
2. *Examine all waste quantity data available for each source.*
3. *Estimate the mass and/or dimensions of each source.*
4. *Determine which quantity tiers you can use for each source based on the available information.*
5. *Convert the measurements to the appropriate units for each tier you can evaluate for each source.*
6. *For each source, use the formulas in column 6 of PA Table 1a to determine the WQ value for each tier that be evaluated. The highest WQ value obtained for any tier is the WQ value for the source.*
7. *Sum the WQ values for all sources to get the site WQ total.*
8. *Use the site WQ total from step 7 to assign the WC score from PA Table 1b.*
9. *Use this WC score for all pathways.**

---

* The WC score is considered in all four pathways. However, if there are primary targets for ground water, surface water, or air migration pathways, assign the determined WC or a score of 32, whichever is greater, as the WC score for that pathway.

SOURCE DESCRIPTIONS:

The MSP property includes four buildings and two engineered storage piles that contain 50,748 m^3 (66,372 yd^3) of contaminated soil. More than 70 percent of the MSP site is paved with asphalt. The site is currently being used for interim storage of radioactively contaminated soil. The site is entirely fenced and public access is restricted.

The two storage piles are engineered, bermed, and covered with an impermeable (Hypalon) covers. Both piles were constructed on an asphalt pad; in addition, one pile has a liner and leachate collection system. Run-on and run-off controls have been installed.

WASTE CHARACTERISTICS (WC) CALCULATIONS

From the definitions of waste sources provided, it appears that the waste sources can be evaluated under 3 of the 4 tiers described:

- Constituent
- Volume (pile)
- Area

Volume estimates for both Middlesex piles are well established. As a result, area calculations will not be performed.

There are two piles, one from the clean-up of the Middlesex Municipal Landfill (MML), and one from remediation of MSP vicinity properties. Each will be treated separately in the calculations which follow:

I) CONSTITUENTS

MML Pile:

Average Contaminant Activity (A_{Ave}) (BNI, 1991a)

U-238 = 20 pCi/g
Ra-226 = 19 pCi/g
Th-232 = 2 pCi/g

The average bulk density of the soil in the MML pile is assumed to be

$$\rho = 1.8 \text{ g/cm}^3$$

The volume of the MML pile is (BNI, 1991b): $V_{MML} = 31{,}209 \text{ yd}^3$

The total activity of each contaminant in the MML pile:

$$A_{Tot} = A_{Ave}\ \rho\ V_{MML}$$

$$A_{U\text{-}238} = (20 \times 10^{-12} \text{ Ci/g})(1.8 \text{ g/cm}^3)(31{,}209 \text{ yd}^3)(7.645 \times 10^5 \text{ cm}^3/\text{yd}^3) = 0.86 \text{ Ci}$$

$$A_{Ra\text{-}226} = (19 \times 10^{-12} \text{ Ci/g})(1.8 \text{ g/cm}^3)(31{,}209 \text{ yd}^3)(7.645 \times 10^5 \text{ cm}^3/\text{yd}^3) = 0.82 \text{ Ci}$$

$$A_{Th\text{-}232} = (2 \times 10^{-12} \text{ Ci/g})(1.8 \text{ g/cm}^3)(31{,}209 \text{ yd}^3)(7.645 \times 10^5 \text{ cm}^3/\text{yd}^3) = 0.086 \text{ Ci}$$

The Specific Activity for each radioisotope:
(U.S. Department of Health, Education, and Welfare, 1970)

Ra-226: $A_{sp} = 0.988$ Ci/g
Th-232: $A_{sp} = 1.09 \times 10^{-7}$ Ci/g

The Specific Activity of U-238 must be calculated using the method described in U.S. Department of Health, Education, and Welfare (1970)

$$A_{sp} = \frac{3.578 x 10^5}{(T_{1/2} M_{Atomic})}$$

Where: $T_{1/2}$ = Half Life of U-238 = 4.51×10^9 yrs
M_{Atomic} = The Atomic Mass of U-238 = 238 g

A_{sp} = $(3.578 \times 10^5$ Ci yr$)/(4.51 \times 10^9$ yrs$)(238$ g$)$
= 3.33×10^{-7} Ci/g

So the total mass of contaminants in the MML pile:

$M_{U\text{-}238} = A_{U\text{-}238}/A_{sp}$

= $(0.86$ Ci$)/(3.33 \times 10^{-7}$ Ci/g$)(453.5$ g/lb$)$
$M_{U\text{-}238}$ = 5695 lbs

$M_{Ra\text{-}226}$ = $(0.82$ Ci$)/(0.988$ Ci/g$)(453.5$ g/lb$)$
= 1.8×10^{-3} lbs

$M_{Th\text{-}232}$ = $(0.086$ Ci$)/(1.09 \times 10^{-7}$ Ci/g$)(453.5$ g/lb$)$
= 1740 lbs

M_{MML} = 1595 lbs + 1.8×10^{-3} lbs + 1740 lbs
M_{MML} = 7435 lbs for MML Pile

<u>Middlesex Vicinity Properties (MVP) Pile</u>:

Average Contaminant Activity (A_{Ave}) (BNI, 1991a)

U-238 = 19 pCi/g
Ra-226 = 12 pCi/g
Th-232 = 2 pCi/g

The volume of the MVP pile is (BNI, 1991b): V_{MVP} = 35,163 yd^3

The total activity of each contaminant in the MML pile:

$A_{Tot} = A_{Ave}\ \rho\ V_{MVP}$

$A_{U\text{-}238}$ = $(19 \times 10^{-12}$ Ci/g$)(1.8$ g/cm$^3)(35{,}163$ yd$^3)(7.645 \times 10^5$ cm^3/yd$^3)$
= 0.92 Ci

$A_{Ra\text{-}226}$ = $(12 \times 10^{-12}$ Ci/g$)(1.8$ g/cm$^3)(35{,}163$ yd$^3)(7.645 \times 10^5$ cm^3/yd$^3)$
= 0.58 Ci

$A_{Th\text{-}232}$ = $(2 \times 10^{-12}$ Ci/g$)(1.8$ g/cm$^3)(35{,}163$ yd$^3)(7.645 \times 10^5$ cm^3/yd$^3)$
= 0.097 Ci

So the total mass of contaminants in the MSP Vicinity Properties Pile is:

$M_{U\text{-}238} = A_{U\text{-}238}/A_{sp}$

$= (0.92\ Ci)/(3.33 \times 10^{-7}\ Ci/g)(453.5\ g/lb)$

$M_{U\text{-}238} = 6092$ lbs

$M_{Ra\text{-}226} = (0.58\ Ci)/(0.988\ Ci/g)(453.5\ g/lb)$
$= 1.3 \times 10^{-3}$ lbs

$M_{Th\text{-}232} = (0.097\ Ci)/(1.09 \times 10^{-7}\ Ci/g)(453.5\ g/lb)$
$= 1962$ lbs

$M_{MVP} = 6092$ lbs $+ 1.3 \times 10^{-3}$ lbs $+ 1962$ lbs
$M_{MVP} = 8054$ lbs for MVP Pile

The waste constituents are divided by 1. So,

$M_{Tot} = 7435$ lbs $+ 8054$ lbs
$= 15{,}489$ lbs

THE ASSIGNED WASTE CONSTITUENT SCORE IS:

WC = 100

II) PILES

Pile Volumes (BNI, 1991b)

MML: 31,209 yd^3
MVP: 35,163 yd^3

For multiple source sites, the volume in cubic yards is divided by 2.5

MML: $\frac{31{,}209\ yd^3}{2.5} = 12{,}483.6\ yd^3$

MVP: $\frac{35{,}163\ yd^3}{2.5} = 14{,}065.2\ yd^3$

Total Volume: $12{,}483.6\ yd^3 + 14{,}065.2\ yd^3 = 26{,}548.8\ yd^3$

THIS RECEIVES A SCORE OF:

WC = 100

ADDENDUM 7

WASTE CHARACTERISTICS (WC) CALCULATIONS

As noted in earlier addendum pages in this revised package, the MML pile at MSP contains lead in excess of the RCRA characteristic level. The presence of this consitituent does not affect the WC calculation, as the maximum value of 100 has already been reached due to the volume of waste at the MSP. Therefore, no new calculation has been performed as this value will remain unchanged.

REFERENCES

Bechtel National, Inc. (1991a). Characterization Report for the Interim Storage Piles at the Middlesex Sampling Plant, Middlesex, New Jersey. DOE/OR/21949-297, Draft Report, Oak Ridge, Tennessee.

Bechtel National, Inc. (1991b). Volume Register for FUSRAP and SFMP Sites. 14501 VR-001, Rev. 5, Oak Ridge, Tennessee.

U.S. Department of Health, Education, and Welfare (1970). Radiological Health Handbook. Washington, D.C.

Calculations prepared by: _____

Calculations checked by: _____

ADDENDUM 8

References: MSP Characterization, December 1991.

PA Table 1a: WC Scores for Single Source Sites and Formulas for Multiple Source Sites

TIER	SOURCE TYPE	SINGLE SOURCE SITES (assigned WC scores)			MULTIP
		WC = 18	WC = 32	WC = 100	For Assign WC
CONSTITUENT	N/A	≤ 100 lbs	> 100 to 10,000 lbs	> 10,000 lbs	lb:
WASTESTREAM	N/A	≤ 500,000 lbs	> 500,000 to 50 million lbs	> 50 million lbs	lbs -
VOLUME	Landfill	≤ 6.75 million ft³ ≤ 250,000 yd³	> 6.75 million ft³ to 675 million ft³ > 250,000 to 25 million yd³	> 675 million ft³ > 25 million yd³	ft³ - yd³ -
	Surface impoundment	≤ 6,750 ft³ ≤ 250 yd³	> 6,750 ft³ to 675,000 ft³ > 250 to 25,000 yd³	> 675,000 ft³ > 25,000 yd³	ft³ - yd³
	Drums	≤ 1,000 drums	> 1,000 to 100,000 drums	> 100,000 drums	drums
	Tanks and non-drum containers	≤ 50,000 gallons	> 50,000 to 5 million gallons	> 5 million gallons	gallons
	Contaminated soil	≤ 6.75 million ft³ ≤ 250,000 yd³	> 6.75 million ft³ to 675 million ft³ > 250,000 to 25 million yd³	> 675 million ft³ > 25 million yd³	ft³ → yd³ →
	Pile	≤ 6,750 ft³ ≤ 250 yd³	> 6,750 ft³ to 675,000 ft³ > 250 to 25,000 yd³	> 675,000 ft³ > 25,000 yd³	ft³ → yd³ -
AREA	Landfill	≤ 340,000 ft² ≤ 7.8 acres	> 340,000 to 34 million ft² > 7.8 to 780 acres	> 34 million ft² > 780 acres	ft² → acres →
	Surface impoundment	≤ 1,300 ft² ≤ 0.029 acres	> 1,300 to 130,000 ft² > 0.029 to 2.9 acres	> 130,000 ft² > 2.9 acres	ft² → acres -
	Contaminated soil	≤ 3.4 million ft² ≤ 78 acres	> 3.4 million to 340 million ft² > 78 to 7,800 acres	> 340 million ft² > 7,800 acres	ft² → 3 acres →
	Pile*	≤ 1,300 ft² ≤ 0.029 acres	> 1,300 to 130,000 ft² > 0.029 to 2.9 acres	> 130,000 ft² > 2.9 acres	ft² → acres → 0
	Land treatment	≤ 27,000 ft² ≤ 0.62 acres	> 27,000 to 2.7 million ft² > 0.62 to 62 acres	> 2.7 million ft² > 62 acres	ft² → acres →

1 ton = 2,000 lbs = 1 yd³ = 4 drums = 200 gallons

* Use area of land surface under pile, not surface area of pile.

PA Table 1b: WC Scores for Multiple Source Sites

WC Total	WC Score
> 0 to 100	18
> 100 to 10,000	32
> 10,000	100

80

Describe Ground Water Use Within 4-miles of the Site:
(Provide generalized stratigraphy; information on aquifers, municipal, and or private wells:

SEE ATTACHED TEXT LABELED "INSERT C"

Show calculations of ground water drinking water populations:

SEE ATTACHED TEXT LABELED "INSERT D"

Insert C

Data on groundwater use in the vicinity of MSP is provided in a guidance manual titled: Policies and Practices for Managing Middlesex County's Groundwater, which is provided as an attachment to the PA, per instructions contained in the PA Scoresheets.

Regional stratigraphy is presented in Table 1, also attached (Geraghty and Miller (1976)).

GROUND WATER USE DESCRIPTION

The uppermost aquifer of concern at MSP is the Brunswick Shale. The Brunswick Shale was the uppermost bedrock unit that was encountered during drilling activities at MSP. At MSP, the Brunswick Formation is a red shale with interbedded siltstone and occasional layers of sandstone. The unit is relatively impermeable, except along numerous fractures and cracks that occur at high angles to bedding. There is no indication that zones of fracturing and fissility are pervasive, open fractures capable of transmitting water away from the site, however, two boreholes did have zones of highly fissile shale in them. The depth to the Brunswick Formation at MSP ranges from 0.45 to 2.4 m (1.5 to 8.0 ft). Material overlying the Brunswick Shale consists of unconsolidated silty to sandy loams with poor to moderate drainage and low to moderate permeability. A 0.3 m (1 ft) thick zone of weathered bedrock directly overlies the unit (FBDU, 1979, BNI, 1989). The thickness of the Brunswick Shale underlying MSP is not known, however, regionally the unit may be greater than 1524 m (5000 ft) in thickness (Geraghty and Miller, 1976).

Regionally, the Brunswick Formation is an important source of groundwater supplying water for industrial and, to a lesser extent, drinking water purposes. Groundwater occurs in fractures and cracks. The specific yield for the Brundwick Shale is relatively low compared to other groundwater bearing units in the area. Specific yield decreases with depth corresponding to a decrease in the occurrence of fractures. The thickness of the water-bearing zone of the Brunswick Shale is only 12.2 to 13.7 m (40 to 45 ft) thick (MCPB, 1979). At MSP, the depth to groundwater in the Brunswick Shale ranges from 2.4 to 9.1 m (8 to 30 ft). Groundwater moves towards the center of the site with flow from the southern end of the site draining to the north, and flow from the northern end of the site draining to the south (BNI, 1991). Transmissivity values have been measured in slug tests at MSP. Values range from 0.86 to 1.4 m^2/day (69 to 115 gpd/ft)(Weston, 1980). A figure showing the configuration of the water table in the bedrock aquifer is attached.

Although no confining layers were encountered during the subsurface investigation of MSP, a zone of groundwater occurs in the unconsolidated overburden. It is not known to what extent groundwater in the unconsolidated sediments and in the Brunswick Formation are interconnected, however, differences between the

hydraulic characteristics of each unit suggests that the two units are not connected. The water table in the unconsolidated sediments occurs from 0.6 to 3.0 m (2 to 10 ft) which is closer to the surface than in the bedrock aquifer. Groundwater flow in the upper unit is to the southwest (BNI, 1990). Transmissivity values, measured by slug tests in the upper unit are reported to be 0.087 to 0.27 m^2/day (7 to 22 gpd/ft) which is slightly lower than in the Brunswick Shale. Both units reportedly have low groundwater flow velocities (Weston, 1980). Groundwater in the unconsolidated sediments is not used for drinking water. A figure showing the configuration of the water table in the unconsolidated sediments is attached.

Sebrings Mill Well Field is located about 1 1/4 mile northwest of MSP. Sebrings Mill Well Field is an inactive municipal well field that is owned by the Elizabethtown Water Company. The depth of wells located in the well field is not known. The well field was closed due to the presence of volatile organic contaminants in the groundwater, and is not expected to be used for drinking water in the future.

A well canvas conducted in 1988 revealed there to be 74 privately owned wells within 3 miles of MSP. Data on wells located between 3 and 4 miles from the site are not presently available. The results of the canvas revealed that 69 of the wells are used for domestic purposes, 3 are used for industrial purposes, 1 is used by a car wash, and 1 is used by a church. None of the privately owned wells is specifically designated for drinking water. Although information on the aquifers from which these wells draw water is not known, the intervals from which water is obtained range from 19 to 520 ft which implied that some, if not all of the wells obtain water from the Brunswick Shale. The locations of wells relative to MSP, and the population using each well is not presently available, however, the name, address, and well depth for each well is provided in an attachment to this PA.

References:

Middlesex County Planning Board (MCPB) (1979). Policies and Practices for Managing Middleses County's Groundwater Resources. New Brunswick, N.J.

Bechtel National, Inc. (BNI) (1989). Site Inspection for Middlesex Sampling Plant. Oak Ridge, TN.

Geraghty and Miller, Inc. (1976). Lower Raritan/Middlesex County 208 Water Quality Management Planning Program; Task 8 Groundwater Analysis. Port Washington, NY.

Ford, Bacon and Davis Utah, Inc. (FBDU) (1979). Environmental Analysis of the Former Middlesex Sampling Plant and Associated Properties. Salt Lake City, UT.

Bechtel National, Inc. (1991). Middlesex Sampling Plant

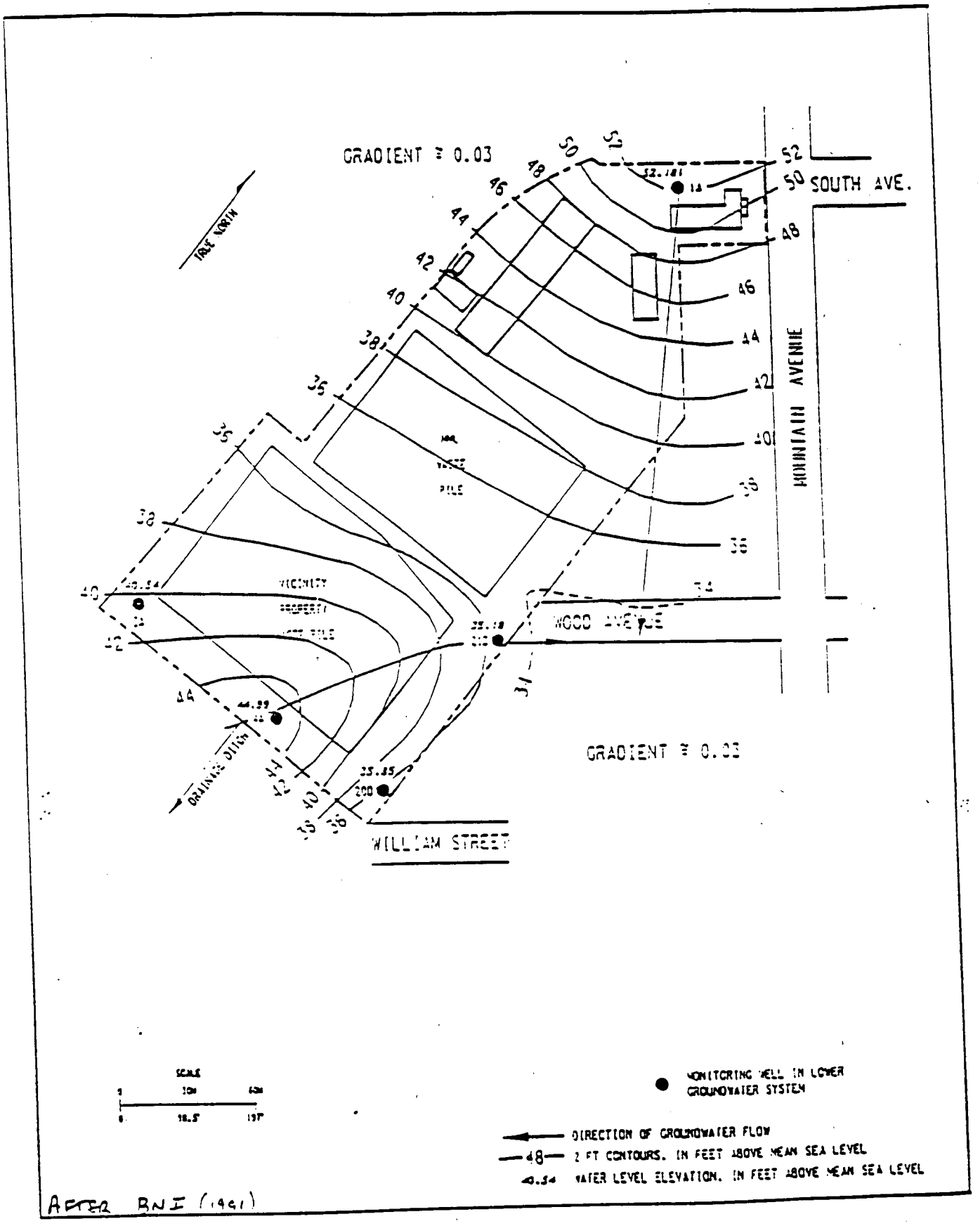
Annual Site Environmental Report for Calendar Year 1990. DOE/OR/21949-285 (Draft). Oak Ridge, TN.

Roy F. Weston, Inc. (1980). Hydrogeology of the Former Middlesex Sampling Plant Site, Middlesex, New Jersey. West Chester, PA.

Table 1 - Geologic Units and Their Ground-Water Potential in the Middlesex 208 Area.

System	Unit	Lithologic description	Thickness (feet)
Quaternary	Alluvium	Silt, sand and mud	0 - 50
	Eolian deposits	Sand dunes	0 - 40
	Stratified drift	Sand, gravel	0 - 60
	Non-stratified drift (till)	Clay, boulders, gravel, sand, silt	0 - 150
	Cape May Formation	Fine- to medium-grained quartz sand and some fine gravel	0 - 50
	Pensauken Formation	Clayey sand and gravel	0 - 70
Cretaceous	Mount Laurel and Wenonah Sands	Micaceous sand	50
	Marshalltown Formation	Micaceous, sandy clay	40
	Englishtown Sand	Micaceous, fine- to medium-grained sand, some clay lenses	100
	Woodbury Clay	Black, micaceous clay	50
	Merchantville Clay	Black, micaceous clay with glauconite	50 - 60

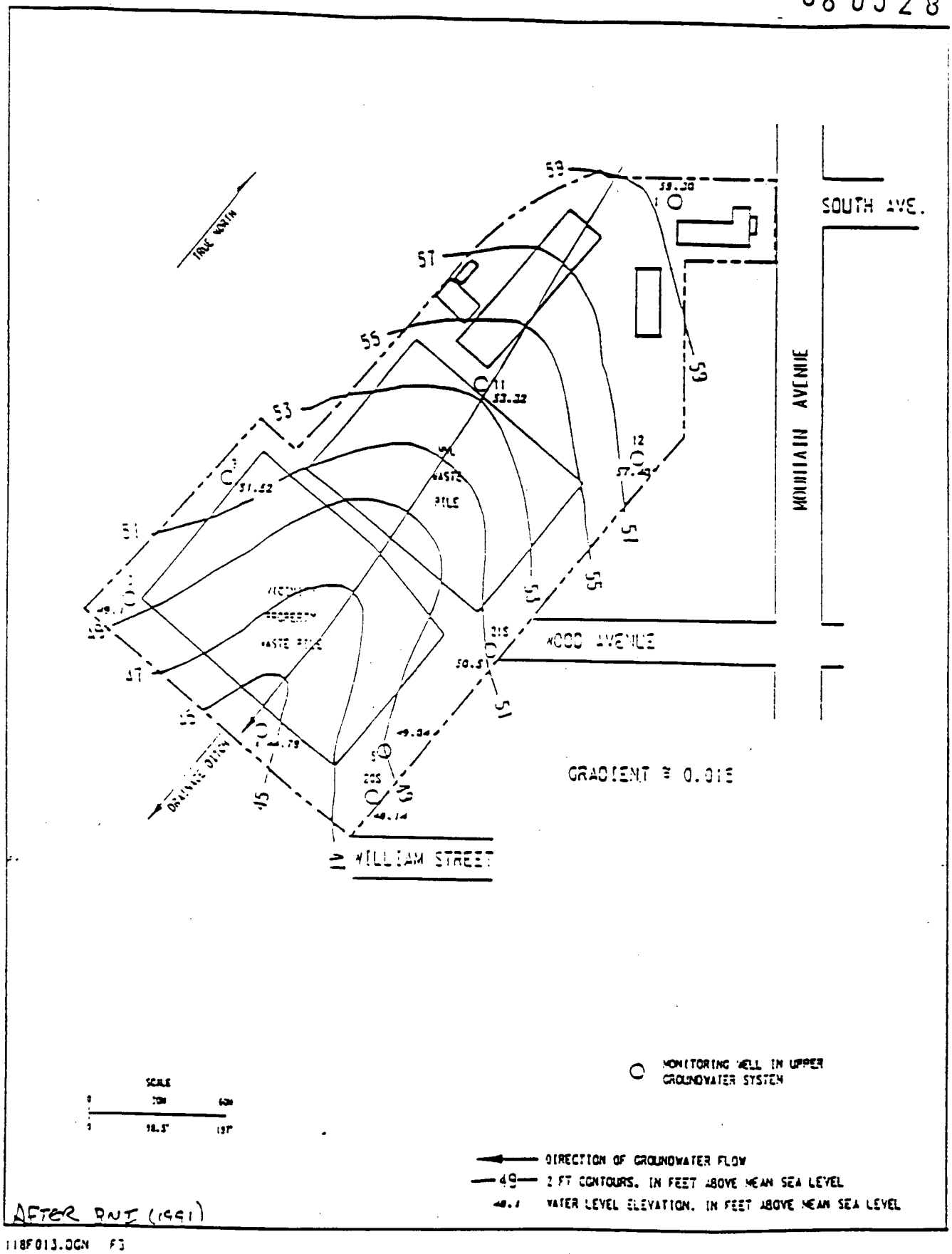
System	Unit		Lithologic description	Thickness (feet)
Cretaceous	Magothy Formation		Fine lignitic sand and black clay	90 - 130
	Amboy Stoneware Clay		Gray to black clay with carbonaceous material	0 - 30
	Old Bridge Sand		Fine- to coarse-grained white to yellow sand	20 - 110
	South Amboy Fire Clay		Varicolored clay	0 - 35
	Sayreville Sand		Fine, white micaceous sand	0 - 40
	Woodbridge Clay		Gray clay and clayey sand	50 - 100
	Farrington Sand		Gray to yellow fine- to medium-grained sand. Contains some clay layers.	30 - 150
	Raritan Fire Clay		Varicolored basal clay	0 - 90
Triassic	Brunswick Formation	Newark Group	Red shale interbedded with siltstone and sandstone	5,000+
	Lockatong Formation		Hard shale and argillite	1,000+
	Stockton Formation		Conglomerate and sandstone	1,000+
Triassic	Diabase and basalt		Dense crystalline rock	500
Precambrian	Gneiss and schist		Metamorphic crystalline rocks	5,000+



118F013.DGN FT

Figure 1

Potentiometric Surface Map of BEDROCK Groundwater System at MSP (6/15/90)



AFTER RNT (1991)

118F013.DGN F3

Potentiometric Surface Map of Upper Groundwater System at MSP (6/15/90)

ATTACHMENT:

RESULTS OF MIDDLESEX WELL CANVAS

TABLE _____

GROUNDWATER WELLS INCLUDED IN WELL CANVASS OF THE MIDDLESEX SAMPLING PLANT ~~SITE~~, NEW JERSEY

Permit Number	Owner/Address	Use*	Date Drilled	Depth (Open Interval)	Yield ~~(gpm)~~ (gpm) ~~(gpd)~~
25-17060	KNICKERBOCKER TOWY CO. 207 POND AVE. MIDDLESEX, NJ.	N	1973	213(40-213)	150 ~~gpm~~
25-15273	MAXWELL BORDW 378 UNION AVE. MIDDLESEX, NJ.	D	1969	380(60-380)	25 ~~gpm~~
25-10586	FRED SPADAFARN 16 WILLOW AVE. PLAINFIELDS, NJ.	D	1962	115(40-115)	~~300~~ 10 gpm
25-10889	THEODORE MARSHALL NEW MARKET, NJ.	D	1962	107(45-107)	~~200~~ 10 gpm
25-17669	MICHAEL MINCER 290 RIVER RD. PISCATAWAY, NJ.	D	1975	150(50-150)	25 gpm
25-13075	MAY HOMES, INC. 602 ASHLAND PONDS MIDDLESEX, NJ.	D	1965	140(---)	~~250~~ 20 gpm
25-13078	MIDDLESEX PRESB. CHURCH 14 STARLET DR. MIDDLESEX, NJ.	O	1965	150(---)	~~250~~ 40 gpm
25-13264	GEORGE OSTERMAN 545 BOUND BROOK MIDDLESEX, NJ.	O	1965	145(31.6-145)	120 gpm
25-20058	PHIL LOPA JR. 342 GRANT AVE. MIDDLESEX, NJ.	D	1978	150(50-150)	~~400~~ 20 gpm
25-11543	ANDREW HELTON 5 GARDEN PL. MIDDLESEX, NJ.	D	1963	100(49-100)	~~200~~ 10 gpm
25-11261	ANDREW HUZZY 48 GREENBROOK RD. MIDDLESEX, NJ.	D	1963	102(46-102)	~~300~~ 35 gpm
25-22556	RAY REEFER 616 WILLIAMS ST. MIDDLESEX, NJ.	D	1982	125(50-125)	10 gpm

* D = domestic; N = industrial; R = irrigation; P = public water supply; O = other

keep this gpm

delete all other gpm

08 05 28

68

TABLE _____

GROUNDWATER WELLS INCLUDED IN WELL CANVASS OF THE MIDDLESEX SITE, NEW JERSEY

Permit Number	Owner/Address	Use*	Date Drilled	Depth (Open Interval)	Yield ~~(gpm)~~ (gpm)
25-22179	AQAZIO & THERESA USSIA 24 STRATTON RD. PISCATAWAY, NJ.	D	1981	200(50-200)	10 gpm
25-14479	PHILLIPS LENS 700 CEDAR AVE. MIDDLESEX, NJ.	D	1972	195(52-195)	50 gpm
25-13167	PHILLIP GRIFFE 405 HIGH ST. DUNELLEN, NJ.	D	1965	110(81-110)	~~300~~ 40 gpm
25-17797	THOMAS O'LEARY 205 WASHINGTON ROCK RD. MIDDLESEX, NJ	D	1975	150(50-150)	30 gpm
25-10840	CHARLES KOESTNEV S. PLAINFIELD MIDDLESEX, NJ.	D	1962	107(43-107)	~~200~~ 10 gpm
25-11765	GEORGE HAAS 300 EVERGREEN AVE. S. BOUNDBROOK, NJ.	D	1964	125 (---)	~~250~~ 20 gpm
25-17728	MARIO LOMBARDI 315 EVERGREEN ST. BOUNDBROOK, NJ.	D	1974	170(42-170)	10 gpm
25-4430	R. H. LOEWE 39 PROSPECT ST. S. BOUNDBROOK, NJ.	D	1955	130(24-130)	20 gpm
25-22111	VISA INC. 3939 WADE ST. PISCATAWAY, NJ.	D	1981	150(50-150)	~~450~~ 20 gpm
25-22113	VISA INC. KENT ST. PISCATAWAY, NJ.	D	1981	125(50-125)	~~450~~ 20 gpm
25-19470	308 MAPLE AVE. S. BLVD. PISCATAWAY, NJ.	D	1977	110(50-110)	~~500~~ 20 gpm
25-21697	JOSEPH AMOTO 5 BAY ST. PISCATAWAY, NJ.	D	1980	150(50-150)	~~450~~ 20 gpm

* D = domestic; N = industrial; R = irrigation; P = public water supply; O = other

90

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TABLE _____

GROUNDWATER WELLS INCLUDED IN WELL CANVASS OF THE MIDDLESEX SITE, NEW JERSEY

Permit Number	Owner/Address	Use*	Date Drilled	Depth (Open Interval)	Yield (gpm)
25-15958	VINCENT DILORENZO 454 W. UNION AVE. BOUNDBROOK, NJ.	P	1971	140(60-140)	20 gpm
25-20868	T.B.I. BUILDERS 127 JEFFERSON AVE. MIDDLESEX, NJ.	D	1979	130(50-130)	~~300~~ 25 gpm
25-11545	JAMES DURI 9 GARDEN PL. MIDDLESEX, NJ.	D	1963	96(47-96)	~~200~~ 10 gpm
25-22566	T.C. & D BUILDERS 122 LINCOLN ST. BERKLEY HTS., NJ.	D	1982	275(100-275)	100 gpm
25-20155	T.B.I. BUILDERS 127 JEFFERSON AVE. MIDDLESEX, NJ.	D	1978	120(50-120)	~~400~~ 20 gpm
25-16416	HAROLD PEERY 212 MTN. BLVD. DUNELLEN, NJ.	D	1963	200(50-200)	~~500~~ 8 gpm
25-11288	ROSE BEAVERS BOX # 233 DUNELLEN, NJ.	D	1963	110(50-110)	~~500~~ 50 gpm
25-11265	EUGENE FUCHA 216 FAIRFIELD AVE. MIDDLESEX, NJ.	D	1963	110(42-110)	~~500~~ 15 gpm
25-15076	VWE JENSON 136 FRONT ST. DUNELLEN, NJ.	D	1969	120(50-120)	40 gpm
25-11918	JOSEPH DOREN MIDDLESEX, NJ.	D	1964	92(50-92)	~~200~~ 10 gpm
25-18103	GREGORY DOBUSZ 127 MTN. SIDE LN. SOMERVILLE, NJ.	D	1975	150(51-150)	20 gpm
25-17199	WILLIAM & MARGARET REILLEY 90 DESNA ST. PISCATAWAY, NJ.	D	1973	180(52-180)	15 gpm

* D = domestic; N = industrial; R = irrigation; P = public water supply; O = other

TABLE _____

GROUNDWATER WELLS INCLUDED IN WELL CANVASS OF THE MIDDLESEX SITE, NEW JERSEY

Permit Number	Owner/Address	Use*	Date Drilled	Depth (Open Interval)	Yield (gpm)
25-23516	JOHN SWAEM 357 S. MADISON AVE. DUNELLEN, NJ.	D	1983	75(50-75)	15 gpm
25-18766	GREGORY DOBUSZ 127 MTN. SIDE LN. SOMERVILLE, NJ.	D	1976	150(50-150)	12 gpm
25-21575	ROBERT BYBEL P.O. BOX 292 HAYFORD ST. PISCATAWAY	D	1980	100(50-100)	60 gpm
25-36088	THOMAS BIONDI RT. 28 MIDDLESEX, NJ.	D	1954	110(33-110)	200 gpm
25-20865	ELAINE BRESLIN 90 JACKSON ST. PISCATAWAY, NJ.	D	1979	130(50-130)	~~400~~ 25 gpm
25-8904	HOLLIS OSBORN NO. RANDOLPH RD. NEW MARKET, NJ.	D	---	130(27-130)	~~300~~ 10 gpm
25-10706	OLIVER 6TH ST. & DUNN AVE. PISCATAWAY, NJ.	D	1962	100(35-100)	~~250~~ 15 gpm
25-20801	D.H.S. CONST. CO. QUARRY LN. MARTINSVILLE, NJ.	D	1979	130(60-130)	26 gpm
25-13403	HOFFMAN HOMES 1262 CORNELL DR. SOMERVILLE, NJ.	D	1965	110(61-110)	~~200~~ 14 gpm
25-33418	BRINKERHOFF & ROYER R.D. 2, BOX 229 NESHANIC STAT., NJ.	D	1969	320(60-320)	20 gpm
---	RALPH V. LYNG STAR RT. MARTINSVILLE, NJ.	D	---	190(23-190)	~~300~~ 5 gpm
25-9654	ALBERT COBETTA R.F.D. MARTINSVILLE, NJ.	D	---	250(22-250)	300 15 gpm

* D = domestic; N = industrial; R = irrigation; P = public water supply; O = other

TABLE _____

GROUNDWATER WELLS INCLUDED IN WELL CANVASS OF THE MIDDLESEX SITE, NEW JERSEY

Permit Number	Owner/Address	Use*	Date Drilled	Depth (Open Interval)	Yield (gpm)
---	BRINKERHOFF & ROYER R.D. 2 BOX 229 NESHANIC STATION, NJ.	D	1969	380(60-380)	20 gpm
25-9681	NICK LIWONCHUK R.F.D. #1 MARTINSVILLE, NJ.	D	---	175(36-175)	~~300~~ 12 gpm
---	A. ENGELBRECHT WASHINGTON VALLEY RD. MARTINSVILLE, NJ.	D	1966	250(60-250)	8 gpm
---	BRINKERHOFF & ROYER R.D. 2, BOX 229 NESHANIC STATION, NJ.	D	1968	320(60-320)	8 gpm
---	JOHN J. CASE JR. RD #1 MARTINSVILLE, NJ.	D	1955	96(45-96)	~~200~~ 12 gpm
25-19185	ANTHONY R. PLOSHOY RD. NO. VOSSELLER AVE. MARTINSVILLE, NJ.	D	1977	175(60-175)	10 gpm
25-15521	JOHN PERRINE VOSSELLER AVE. MARTINSVILLE, NJ.	D	1970	130(60-130)	15 gpm
25-20776	STANLEY LEVITT KENVIL, NJ.	D	1980	300(60-300)	25 gpm
25-12192	HOFFMAN HOMES, INC. 2720 CORNELL DR. SOMERVILLE, NJ.	D	1964	122(31-122)	~~200~~ 9 gpm
---	JOHN MAYER R.D. #1 MARTINSVILLE, NJ.	D	1954	122(40-122)	~~300~~ 12 gpm
25-9570	NICK LIWONCHUK EAST BROOK RD. MARTINSVILLE, NJ.	D	---	115(33-115)	~~300~~ 20 gpm
25-9375	NICK LIWONCHUK EAST BROOK RD. MARTINSVILLE, NJ.	D	---	120(28-120)	~~300~~ 20 gpm

* D = domestic; N = industrial; R = irrigation; P = public water supply; O = other

TABLE _____

GROUNDWATER WELLS INCLUDED IN WELL CANVASS OF THE MIDDLESEX SITE, NEW JERSEY

Permit Number	Owner/Address	Use*	Date Drilled	Depth (Open Interval)	Yield ~~(gpm)~~ ~~(gpd)~~ (gpm)
25-17,992	CHARLES M. CARR 85 N. POCONO RD. MOUNTAIN LAKES, NJ	D	1975	125 (50-125)	7 gpm
25-17,898	NORTHOVER CAMPS VOSSELLER AVE. BRIDGEWATER, NJ	O	1975	200 (60-200)	35 gpm
25-21,921	MARTIN H. CORNICK 846 WASHINGTON AVE. MARTINSVILLE, NJ	D	1981	225 (140-225)	20 gpm
25-14,710	MYRON LIEBERMAN 75 LIVINGSTON AVE. NEW BRUNSWICK, NJ	D	1968	380 (135-380)	25 gpm
25-14,031	JEROME HARRIS P.O. BOX 127 PLAINFIELD, NJ	D	1966	405 (60-405)	30 gpm
25-10,495	EDMAR CORP. RT. 22 BOUND BROOK, NJ	N	1962	248 (63'8"-248)	40 gpm
25-21,106	WYCHWOOD ASSOC. BOX 6282 BRIDGEWATER, NJ	D	1979	175 (60-175)	~~400~~ 20 gpm
25-21,105	WYCHWOOD ASSOC. BOX 6282 BRIDGEWATER, NJ	D	1979	130 (60-130)	~~400~~ 40 gpm
25-23,566	LEONARD SALVATORE 57 ASH ST. BRIDGEWATER, NJ	D	1983	125 (60-125)	30 gpm
25-21,109	WYCHWOOD ASSOC. BOX 6282 BRIDGEWATER, NJ	D	1979	190 (60-190)	~~400~~ 25 gpm
25-21,408	MIKE GAMPODELLA DRAKE ST. BOUND BROOK, NJ	D	1981	150 (50-150)	~~400~~ 25 gpm
25-19,696	ROBERT E. AGANS 105 BAKER AVE. SO. PLAINFIELD, NJ	D	1978	250 (50-250)	20 gpm

* D = domestic; N = industrial; R = irrigation; P = public water supply; O = other

TABLE _____

GROUNDWATER WELLS INCLUDED IN WELL CANVASS OF THE MIDDLESEX SITE, NEW JERSEY

Permit Number	Owner/Address	Use*	Date Drilled	Depth (Open Interval)	Yield ~~(gpm)~~ ~~(gpd)~~ (gpm)
25-18670	ROGER SPINDLER 818 BROOKSIDE DR. MARTINSVILLE, NJ.	D	1976	225(608"-225)	5 gpm
25-18438	AL GRIFFITH WASHINGTON VALLEY RD. MARTINSVILLE, NJ.	D	1976	220(80-220)	18 gpm
25-20778	ROBERT MORELLA 70 WASHINGTON VALLEY RD MARTINSVILLE, NJ.	D	1979	125(50-125)	50 gpm
25-20944	BROOKSIDE DR. BRIDGEWATER, NJ.	D	1979	225(61-225)	20 gpm
25-15124	BRINKERHOFF & ROYER R.D. 2, BOX 229 NESHANIC STATION, NJ.	D	1969	320(60-320)	30 gpm
25-15652	FRANK CONSALVO BOX 201, MARTINSVILLE, NJ.	D	1971	145(63'6"-145)	20 gpm
25-12969	HOUDAILLE CONST. 10 PARK PL. MORRISTOWN, NJ.	D	1965	242(60-242)	---
25-104916	CHANDLER REALTY CO. INC. RT. 22 BOUNDBROOK, NJ.	-	1962	240(64-240)	35 gpm
25-96666	PAULEEN LESTER RT. 22 SOMERVILLE, NJ.	-	1960	250(30'6"-250)	30 gpm
25-15033	BRINKERHOFF & ROYER R.D. 2 BOX 229 NESHANIC, NJ.	D	1968	325(60-325)	25 gpm
25-21641	R. CHALAK 41 MINE BROOK RD.	D	1981	605(52-605)	10 gpm
25-9653	FARREL REILLY RFD. #1 MARTINSVILLE, NJ	D	---	200(23-200)	~~100~~ 20 gpm

* D = domestic; N = industrial; R = irrigation; P = public water supply; O = other

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TABLE _____

GROUNDWATER WELLS INCLUDED IN WELL CANVASS OF THE MIDDLESEX SITE, NEW JERSEY

Permit Number	Owner/Address	Use*	Date Drilled	Depth (Open Interval)	Yield ~~(gpm)~~ ~~(gpm)~~ (gpm)
25-10,713	BETTY ANN PETRACCO RANDOLPHVILLE RD, NEW MARKET, NJ	D	1962	110 (40-110)	~~500~~ 15 gpm
25-8433	BORIS SULIBTIC WASHINGTON VALLEY RD. SPRINGDALE, NJ	D	---	115 (31-115)	~~300~~ 15 gpm
25-6879	THOMAS GIBSON, BOX 4512 MORNING GLORY RD. BOUNDBROOK, NJ	D	1957	389 (---)	10 gpm
25-4136	REDWOOD CONST. CO. 2075 RT. 22 UNION, NJ	D	1960	175 (19'6"-175)	~~90~~ 16 gpm
25-15,389	MICHAEL DERELANKO HILLCREST RD. BRIDGEWATER, NJ	D	1969	420 (64-420)	30 gpm
25-19,886	ANTHONY KIM 123 NO MOUNTAIN RD. BOUND BROOK, NJ	D	1978	355 (115-355)	15 gpm
25-14,944	BRINKERHOFF & ROYER R.D. 2 BOX 229 NESHANIC STATION	D	1968	325 (63-325)	30 gpm
25-15,215	BRINKERHOFF & ROYER R.D. 2 BOX 229 NESHANIC STATION	D	1969	320 (60-320)	15 gpm
25-15,216	BRINKERHOFF & ROYER R.D. 2 BOX 229 NESHANIC STATION	D	1969	360 (60-360)	15 gpm
25-4370	RICHARD BARNET RT 22	D	1963	92 (49-92)	~~200~~ 20 gpm
25-15,077	SEBASTIAND FAILLA 315 HIGHWAY 22	D	1969	150 (50-150)	40 gpm
25-13,397	ELIZABETHTOWN WATER CO. N. AVE. PLAINFIELD, NJ	P	1965	480 (51-480)	350 gpm

* D = domestic; N = industrial; R = irrigation; P = public water supply; O = other

Out of Boundaries

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TABLE _____

GROUNDWATER WELLS INCLUDED IN WELL CANVASS OF THE MIDDLESEX SITE, NEW JERSEY

Permit Number	Owner/Address	Use*	Date Drilled	Depth (Open Interval)	Yield (gpm) ~~(gpm)~~ (gpm)
25-19,846	LEE MILTS PETROLEUM INC. 67 BOND ST. WESTBURY, NY	D	1978	175 (82-175)	15 gpm
25-9519	RAYMOND BARRETT 443 STEELE AVE PLAINFIELD, NJ	D	1960	520 (23-520)	~~+200~~ 19 gpm
25-3879	CLYDE YOUNG RD #2 MTN. PARKWAY DUNELLEN, NJ	D	1954	140 (50-140)	~~300~~ 12 gpm
25-4066	ROBERT J. SAYE JR. RD #2 MTN. PARKWAY DUNELLEN, NJ	D	1954	165 (50-165)	~~300~~ 10 gpm
25-6681	CITIES SERVICE OIL CO. 390 HALSEY ST. NEWARK, NJ	D	1957	125 (60-125)	10 gpm
25-14,928	MICHAEL RONDA RONDA PL. GREEN BROOK, NJ	D	1968	120 (57-120)	25 gpm
25-16,319	RICHARD HAAS 9 RONDA PL. GREENBROOK, NJ	D	1972	120 (53-120)	40 gpm
25-9198	TOP BUILDERS GREENBROOK TWSP, NJ	D	1960	157 (66-157)	20 gpm
25-9197	TOP BUILDERS VITALE TRAIL GREENBROOK TWSP, NJ	D	1960	115 (35-115)	15 gpm
25-20,900	HENRY PATUILLO 321 KINGS COURT BOUND BROOK, NJ	D	1979	150 (50-150)	~~400~~ 30 gpm
25-20,901	HERBERT HEPTER 528 LONGWOOD AVE BOUND BROOK, NJ	D	1979	150 (50-150)	~~400~~ 30 gpm
25-20-973	HENRY KIRKLOWICZ 318 KINGS CT. BOUND BROOK, NJ	D	1979	175 (60-175)	40 gpm

* D = domestic; N = industrial; R = irrigation; P = public water supply; O = other

TABLE _____

GROUNDWATER WELLS INCLUDED IN WELL CANVASS OF THE MIDDLESEX SITE, NEW JERSEY

Permit Number	Owner/Address	Use*	Date Drilled	Depth (Open Interval)	Yield ~~(gpm)~~ ~~(gpd)~~ (gpm)
25-19,586	ANDREW CASELLO 47 BALL ST. BOUNDBROOK, NJ	D	1977	100 (50-100)	~~200~~ 20 gpm
25-15,935	WILLIAM R. BOETCHER 515 GARFIELD AVE. SOMERSET, NJ	D	1971	195 (50-195)	12 gpm
25-19,189	JAMES C. ESPOSITO 106 GRANT AVE. SO. BOUND BROOK, NJ	D	1978	125 (50-125)	~~400~~ 10 gpm
25-21,564	EDNA SCHMIDT 6 HALL ST. BOX 193 SOMERSET, NJ	D	1980	125 (50-125)	~~450~~ 80 gpm
25-15,688	HENRY A. PATULLO BOUND BROOK, NJ	D	1970	100 (50-100)	10 gpm
25-22,705	GEORGE CHANDLER RTE 22 BRIDGEWATER, NJ	D	1982	200 (50-200)	17 gpm
25-10,097	ANTHONY CERRATO 113 EDGEWOOD TERRACE BOUNDBROOK, NJ	D	---	130 (42-130)	~~300~~ 12 gpm
25-20,549	FRED GUDSIK & WAYNE GULICK 118 PROSPECT ST. SO. BOUNDBROOK, NJ	D	1979	175 (50-175)	10 gpm
25-16,266	ROBERT H. LOEWE 263 CANAL RD. SO. BOUNDBROOK, NJ	D	1972	140 (43-140)	50 gpm
25-16,857	RICHARD PRASTER 37 TEMPLE ST. SOMERSET, NJ	D	1973	140 (53-140)	25 gpm
25-18,787	LEONARD SALVATORE 311 TOP AVE. GREEN BROOK, NJ	D	1977	200 (60-200)	30 gpm
25-15,687	THOMAS G. REILLY, JR. MIDDLESEX, NJ.	D	1970	100 (50-100)	40 gpm

* D = domestic; N = industrial; R = irrigation; P = public water supply; O = other

TABLE _____

GROUNDWATER WELLS INCLUDED IN WELL CANVASS OF THE MIDDLESEX SITE, NEW JERSEY

Permit Number	Owner/Address	Use*	Date Drilled	Depth (Open Interval)	Yield ~~(gpm)~~ ~~(gpm)~~ (gpm)
25-11,425	MICHAEL GRASSI 104 WYNNEWOOD AVE. BOUND BROOK, NJ	D	1963	210 (50-210)	~~500~~ 40 gpm
25-17,037	GLOBAL DEVELOPMENT 349 WATCHUNG AVE. PLAINFIELD, NJ	D	1978	130 (50-130)	~~350~~ 20 gpm
25-20,988	G.D.A. BLDRS. INC. 738 ~~VOORHESS~~ VOORHESSE AVE. MIDDLESEX, NJ	D	1979	50 (50-50)	75 gpm
---	KELSEY 817 VOORHESSE AVE. MIDDLESEX, NJ	D	BEFORE 1959	---	---
---	GYESKI 821 VOORHESSE AVE. MIDDLESEX, NJ	D	BEFORE 1949	69 (20-69)	8 GPM
---	HANANIA 448 RUNYAN AVE. MIDDLESEX, NJ	N	EARLY 1960's	25 (---)	---
---	SOLDO 12 GARDEN PL. MIDDLESEX, NJ	D	≈ 1956	100 (40-100)	---
25-11,544	RAFFERTY 11 GARDEN PL. MIDDLESEX, NJ	D	1963	98 (49-98)	10 GPM
---	MCLEAN 160 BREWSTER PISCATAWAY, NJ	D	1976	130 (60-130)	---

* D = domestic; N = industrial; R = irrigation; P = public water supply; O = other

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ATTACHMENT:

POLICIES AND PRACTICES FOR MANAGING
MIDDLESEX COUNTY'S GROUNDWATER RESOURCES

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Policies and Practices for Managing Middlesex County Groundwater Resources

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POLICIES AND PRACTICES FOR MANAGING MIDDLESEX COUNTY'S GROUNDWATER RESOURCES

PREPARED BY THE
ENVIRONMENTAL SYSTEMS SECTION
MIDDLESEX COUNTY PLANNING BOARD
NEW BRUNSWICK, N.J.
SEPTEMBER 1974

TEXT REVISED AND REPRINTED
JANUARY 1979

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Thomas J. Molyneux, Director
Stephen J. Capestro
David B. Crabiel
Frank Pelly
John A. Phillips
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John A. Smith

Middlesex County
Board of Chosen Freeholders

Middlesex County
Planning Board

Hyman Center, Chairman
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John J. Reiser, County Engineer
Sidney Sewitch, Vice Chairman
Walter Wilson

Douglas S. Powell
Frank J. Rubin, Counsel
Patricia Lycosky, Secretary

ACKNOWLEDGEMENT

Many people have contributed their time and expertise during this study. The Middlesex County Water Supply Advisory Committee provided support and encouragement for the study and several members of the Committee provided data and information. Mr. Joseph Miller and Mr. Daniel Dombroski, Jr., of the N.J. Department of Environmental Protection - Bureau of Geology and Topography provided information on specific well locations and Mr. Raymond Webster of the NJ Bureau of Water Allocating provided data on groundwater withdrawals in the County. Mr. William Kann and Mr. George Farlekas of the United State Geologic Survey provided useful water quality data and geophysical logs during the earl stages of this study. We are thankful of these gentlemen for their cooperatic and assistance.

The members of the Middlesex County Water Supply Advisory Committee provided significant advice and assistance during the preparation of this study and reviewed the final report.

At its meeting of November 21, 1974 the Committee unanimously adopted a motion approving and accepting this study and directed that it be forwarded to the Middlesex County Planning Board for its consideration.

Middlesex County
Water Supply Advisory Committee

Mr. Elmer Dieker, Chairman
Mr. Edward Bastian -Middlesex Water Company
Mr. Thomas Cawley - Elizabethtown Water Company
Mr. Martin E. Langenohl - Perth Amboy Water Department
General William Whipple - Water Resources Research Institute - Rutgers Univ.
Mr. Alvin Zach - Newark Department of Engineering
Mr. Robert Frisch - Attorney
Mr. Russell Fleming - Attorney
Mr. John Marshall - Duhernal Water Company
Mr. Donald Carey - New Brunswick Water Department

PREFACE

Under county planning enabling legislation adopted by the State of New Jersey in 1935, the Middlesex County Planning Board has the responsibili for developing a County-wide comprehensive master planning program. Such a program must consider the patterns, relationships and impacts of land use development within the context of promoting the public health and welfare. This concern for public health and welfare requires that comprehensive land use planning consider the impacts of such development on Middlesex County's natural resources and features.

During recent years the Middlesex County Planning Board has been engage in identifying and assessing the environmental impact of land use developmen to such areas as air and water quality, natural resources, solid waste and water supply.

The preparation of this report has been carried out as a means to identify the availability of groundwater supplies in Middlesex County and the determination of how such supplies can best ben protected to insure the continued availability to the County.

This report represents a first step in the process of addressing the interrelationships of water supply and water quality and will become an integral component of the County's water supply and water quality planning programs which are being carried out in response to the need for greater understanding and awareness of the major water supply needs and problems facing State, regional and local decision-makers so that agreements can be reached to insure the future water supply needs of the County's residents, businesses and industries are properly and adequately met.

Over the period of time this report was prepared Middlesex County has been the recipient of federal funds under Section 208 of the Water Pollution Control Act Amendments (PL 92-500). Such funds have been used to develop Middlesex County's Water Resource Management Program of which groundwater management planning forms a significant element. This report has been revised and updated to account for study efforts undertaken since 1975.

The staff responsible for the preparation of this report included:

Douglas S. Powell, Director of County Planning
Dinesh Sharma, Principal Planner
William J. Kruse, Supervising Principal Planner
Emily May, Planning Intern
Edited by: Robert J. Nardi, Supervising Principal Planner
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I. INTRODUCTION

The Middlesex County Planning Board and the Middlesex County Water Supply Advisory Committee have long supported research in the area of water supply planning and management in Middlesex County. As part the the Board's comprehensive planning program specific plans for the provision of water suppl through the year 2000 have been prepared and adopted. In order to meet the needs of Middlesex County in the year 2000, under growth levels projected by the Planning Board Staff in 1978, the County would require a supp of 160 million gallons of water per day compared against 1975 estimated demands of 102 million gallons per day.

Table 1 below compares the estimated (1970) sources of water supply available to Middlesex County against those called for in the Middlesex County Planning Board's adopted water supply plan:

TABLE 1

Water Supply Resources - Raritan Basin
(million gallons/day)

	1970	2000
Delaware and Raritan Canal	36	36
Six Mile Run Reservoir	Programmed for Construction	14 of 38*
Allocated Raritan River Surface Diversion	24 of 80	50 of 80*
Spruce Run/Round Valley Reservoir System	190*	190*
Confluence Reservoir	Programmed for Construction	15 of 60*
Crab Island Reservoir	Feasibility Studies to be Completed	100**
Lawrence Brook System	6.5	6.5
Middlesex County Groundwater	63 of 130	130
	129.5	351.5

* No committment has been made to provide water from supply source to Middlese: County - Other areas in N.J. are in competition for this water.

** Should this project be found unfeasible for environmental or economic reasons, an alternative source of 100 mgd will need to be found.

Water supply sources for the year 2000, shown in Table 1, indicate that over half the water supplied to Middlesex County will be from surface and groundwater sources within the County's borders. The need for the County to insure its future water supply is underscored by the fact that Middlesex County lies at the lower end of the Raritan River Basin and furthest away from the major surface water supply reservoirs at the Spruce Run/Round Valley complex. The County presently relies on surface water supplies from the Delaware and Raritan Canal, the Lawrence Brook reservoir system and from the Raritan River in addition to groundwater sources within its borders. In addition the State of New Jersey has estimated that the urbanized northeastern region must rely more on the Raritan River Basin for water supplies for three reasons: surface supplies in the northern portion of the State are limited in capacity; new large-scale reservoir sites no longer remain in this area; the development of the proposed Tocks Island Dam and Reservoir project on the Delaware River as a major New Jersey water supply source appears, at the present time unlikely. This will mean that the major water supply facilities in the Raritan River Basin will need to serve not only the counties of Morris, Hunterdon, Somerset and Middlesex, but must provide some level of supply to Union, Essex, Hudson, and perhaps Passaic and Bergen Counties. This will in turn require Middlesex County to continue to rely heavily on water supply sources within or near its borders. In this light the Middlesex County Water Supply Master Plan recommends that the County undertake programs to encourage proper management and protection of water resources and to include the development of a water resource management plan to include recommendations for resource protection and areawide management of water supply sources and distribution systems.

A. Resource Inventory and Capacity Analysis

Following the completion of the Water Supply Master Plan the Middlesex County Planning Board recognized that additional research and evaluation of its environmental resource base were necessary in order to better understand the potential impacts of the growth projected by the Planning Board through the year 2000. Rather than merely planning for systems to provide resources to support a given level of growth it was instead proposed to develop a program of research and study to identify those resources available to Middlesex County, the degree to which they are presently utilized and the estimated capacity to support additional growth leading to a better balancing between projected growth and available resources. The Middlesex County Planning Board's Environmental Systems Staff prepared a work program for a Resource Inventory and Capacity Analysis (RICA) which would include the analysis of air, water and land resource capacities. An important element in the RICA's water resource analysis is the identification of the availability of groundwater supplies in Middlesex County and the determination of how such supplies can best be protected to insure their future availability

B. Goals and Objectives

This analysis of Middlesex County's groundwater supplies is designed to meet the following goals and objectives as established by the Middlesex County Planning Board's comprehensive planning program:

1. Provide Adequate Capacity

   - Identify the amount and location of groundwater supplies available to Middlesex County.

   - Identify the demand for groundwater supplies.

   - Identify areas persently providing recharge to the groundwater system. Estimate potential recharge capability under present development characteristics within recharge areas and identify appropriate developments which may be safely supported within such areas.

2. Insure Economy and Efficiency

   - Recommend methods of maintaining or augmenting groundwater recharge in a manner that insures availability of groundwater as a water supply in the face of the need to later compete for higher cost water supplies to meet needs.

3. Provide for Protection of Public Health and Safety

   - Insure that recharge area protection includes consideration of water pollution control.

4. Insure Equal Attention to Water Supply Needs in All Areas of the County

   - Identify, analyze and recommend groundwater management programs with application to areas throughout Middlesex County.

5. Provide for Citizen Participation and Intergovernmental Cooperation

   - Work closely with the Middlesex County Water Supply Advisory Committee.

   - Coordinate this study with work accomplished by other agencies including those of federal, State, local governments and authorities.

   - Recommend an approach to recharge area protection which can be presented to affected municipalities, neighboring counties, and State authorities.

6. Provide for Protection of the Natural Environment, Maintain Existing Amenities and Enhance Aesthetics

   - Maximize groundwater protection through measures which protect the natural environment.

   - Address the maintenance of open space as a groundwater recharge protection measure as well as a method of providing much needed recreation and aesthetic resources.

C. Scope of Study

The scope of this study covers the entire area of Middlesex County. Section II describes and evaluates the hydrogeologic characteristics of the aquifers along with their specific water carrying and water producing characteristics and safe yield. Natural and artificial recharge capacities of various aquifers is outlined along with estimated groundwater withdrawals for both 1966 a 1973. Section III serves to describe the extent of urbanization within the recharge areas and its impact on groundwater quality and quantity together with the need for protecting the County's aquifers. Section IV briefly describes methods that are available for the protection and preservation of critical resources of the County. Section V outlines specific recommendations for the preservation of various conservation areas which will serve to protect the County's groundwater resources. Section VI presents a recommended program of next steps which should be undertaken to carry forth the work begun by this study.

///

II. HYDROGEOLOGY OF MIDDLESEX COUNTY

A. Background

Middlesex County lies within two major physiographic provinces - the Atlantic Coastal Plain and the Piedmont Province. That portion of the County west of the Lawrence Brook and north of the Raritan River are generally within the Piedmont Province while the remainder of the County is within the Atlantic Plain. That portion within the Piedmont Province is generally characterized by clay and shale formations with relatively high surface runoff rates while the Coastal Plain is characterized by sand and gravel formations along with a higher infiltration rate. The topography of the County is generally level or rolling with maximum elevations of approximately 240 feet in the southwestern part of South Brunswick Township. The remainder of the County averages some 100 feet in elevation. The lowest elevations approach sea level at the tidal areas on Raritan Bay and at the mouth of the Raritan River. As a result of its natural topography and its proximity to Raritan Bay the County contains numerous natural drainage ways the majority of which drain to the mainstem of the Raritan River and into Raritan Bay. Several streams in the eastern area of the County drain directly to the Raritan Bay and several in the northeastern portion of the County are tributaries of the Rahway River or drain directly to the Arthur Kill (See Figure 1).

Middlesex County's climate is described as temperate with the average annual temperature between 50°F and 55°F. January and February are the coldest months having a mean temperature of 32°F with July the warmest month having a mean temperature of 75°F. Water temperatures follow a similar pattern, also ranging from 32°F to 75°F. Prevailing winds are from the northwest during the winter months and from south to southwest during the warmer months.

The average annual precipitation within the County is approximately 44 inches with February having the lowest monthly average and July the highest. The period from May to September has the highest average rainfall. Annual snowfall averages between 20 and 30 inches. Complete precipitation and temperature data for the New Brunswick meteorological station are shown in Table 2 on the following page.

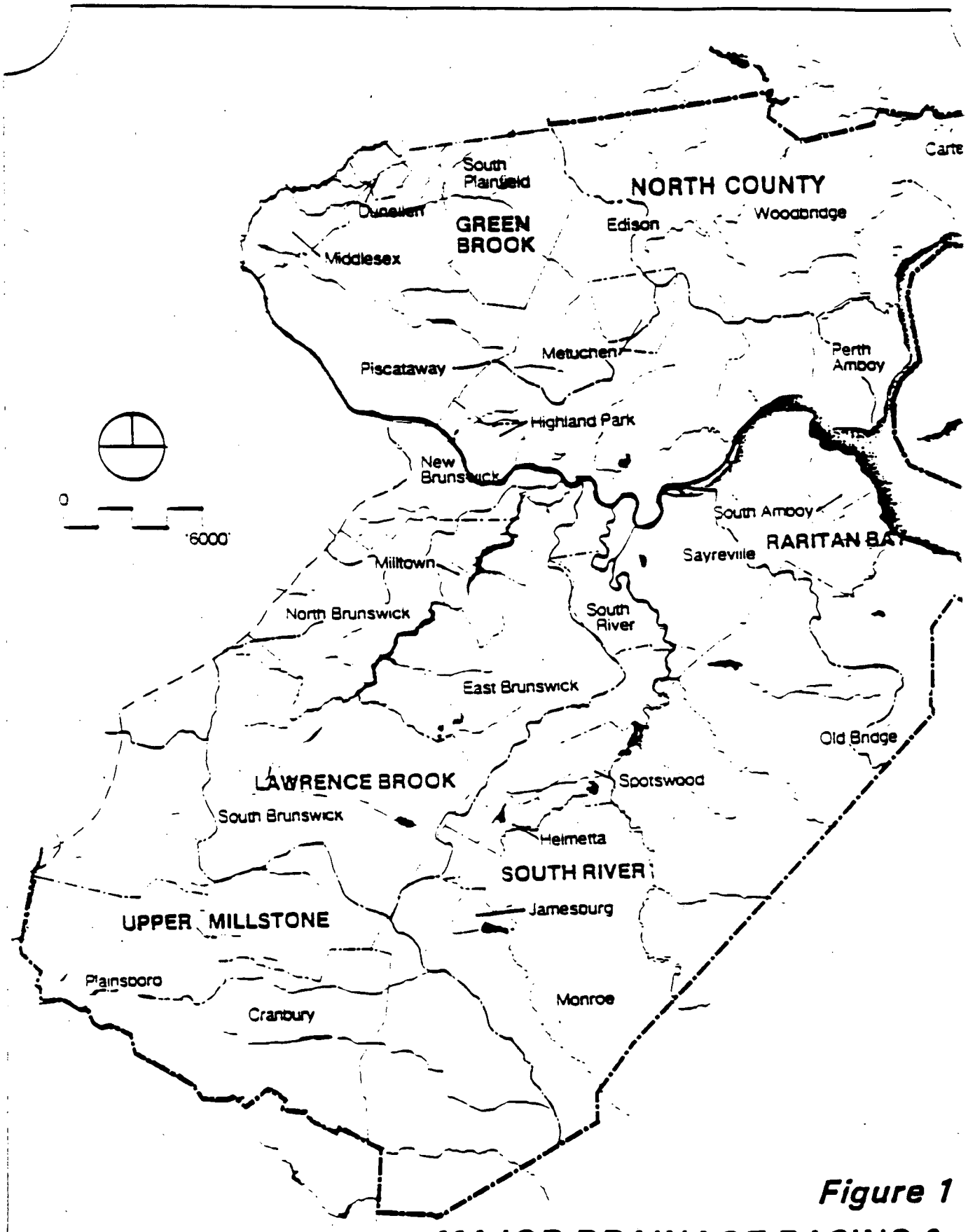

Figure 1

MAJOR DRAINAGE BASINS & STUDY AREA MUNICIPALITIES

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TABLE 2

Average Precipitation and Temperature
At New Brunswick, N.J.

Month	Precipitation[1] (inches)	Temperature[2] °F
January	3.25	31.2
February	2.96	32.8
March	3.59	40.6
April	3.47	51.6
May	3.77	61.4
June	3.67	70.2
July	4.89	74.9
August	4.73	73.1
September	3.68	66.7
October	3.22	56.5
November	3.16	45.6
December	3.26	33.9
Annual Average	43.65	53.2°

B. Hydrogeology

Geologic sequence in Middlesex County is listed in Table 3 with those formations which are both sufficiently thick and important County water supply sources highlighted. A generalized northwest-southeast cross section from the Stelton to Runyon areas shown in Figure 2.

The areal extent of major aquifer recharge areas in Middlesex County have been identified in Figure 3. These are the locations where water bearing geologic formations are at the surface or have a water permeable ground cover. These recharge or outcrop areas provide the majority of the water to the wells drilled to the aquifers. It is estimated that there are more than eight thousand wells tapping groundwater in Middlesex County. The largest majority of these wells are of low capacity and are used primarily for domestic purposes, however, 293 wells can each produce at least 100,000 gallons per day[3].

The two distinct aquifer formations that provide the largest portion of the groundwater in Middlesex County are the unconsolidated sand and gravel of Upper Cretaceous Age and the consolidated rocks of Triassic Age. The principal sources of groundwater in order of their importance are: the Old Bridge Sand and Farrington Sand aquifers of the Raritan Formation, the Brunswick shale of Newark Group (Triassic formation) and the Undifferentiated Sands of Upper Cretaceous Age. Although more water is drawn from the Newark Group than from the Undifferentiated Sands and Englishtown Sand, Newark Group rocks are not as uniformaly reliable as the Cretaceous Sand.

A detailed discussion of the geologic and hydrologic characteristics of each strata is provided in the report by Henry C. Barksdale et. al[4]. In

TABLE 3

Hydrostratigraphic Sequence in Middlesex County[5]

Cenozoic Sequence
- Quarternary System
  - Recent Series
    - Alluvium
    - Eolin deposits
  - Pleistocene series
    - Wisconsin drift
    - Cape May formation
    - Pensauken formation

Unconformity

Mesozoic Sequence
- Cretaceous System
  - Upper Cretaceous series
    - Mount Laurel and Wenonah Sands
    - Marshalltown formation
    - Englishtown sand
    - Woodbury clay
    - Merchantville clay
    - Magothy formation
    - Raritan formation
      - Amboy stoneware clay
      - Old Bridge sand
      - South Amboy fire-clay
      - Sayreville sand
      - Woodbridge clay
      - Farrington sand
      - Raritan fire-clay

Unconformity

Triassic System
- Upper Triassic series (Newark group)
  - Brunswick shale
  - Lockatong formation
  - Stockton formation

Unconformity

Proterozoic Sequence
- Pre-Cambrian
  - Wissahickon formation

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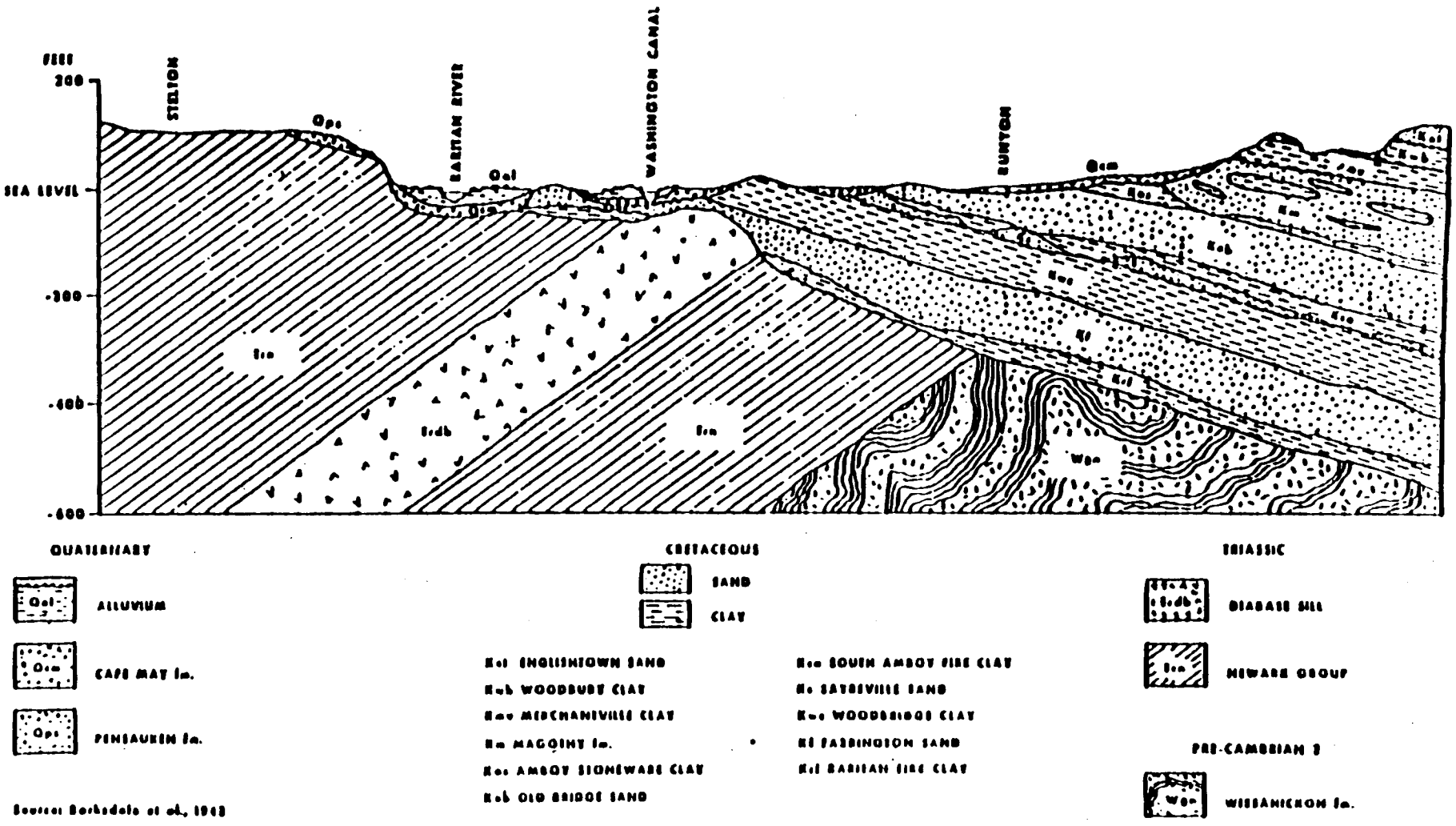
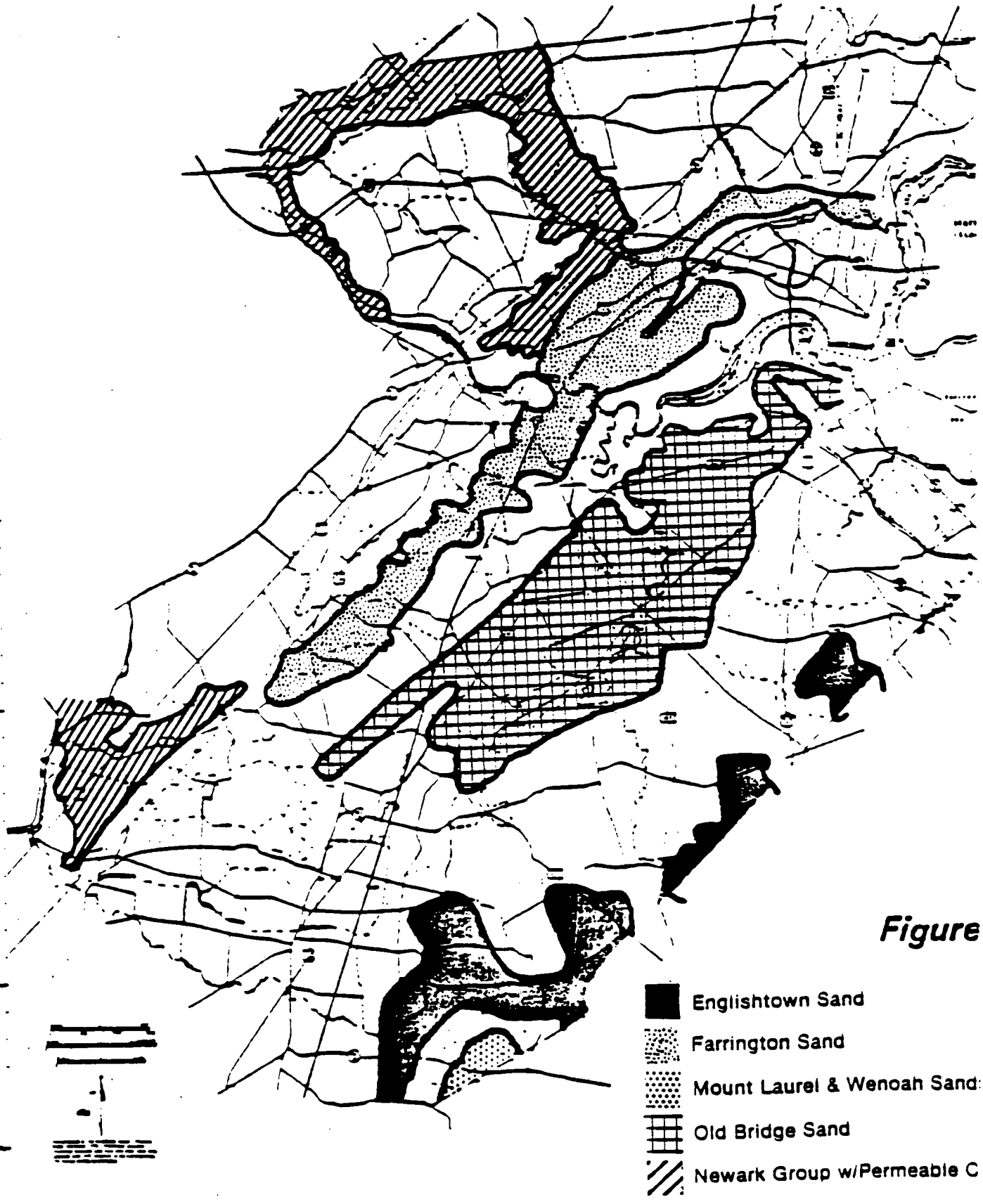


Source: Barksdale et al., 1943

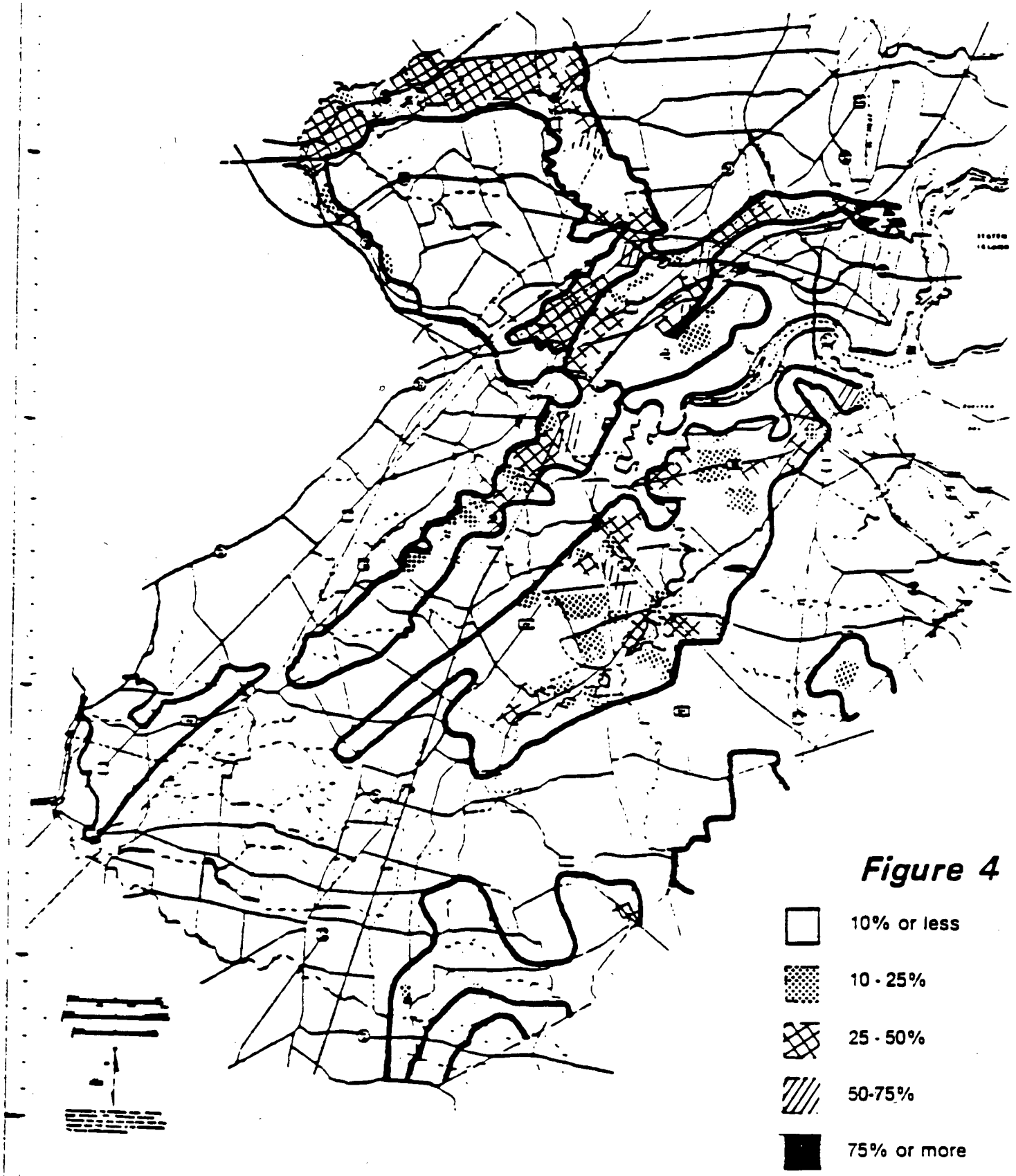
Figure 2

GENERALIZED GEOLOGIC SECTION - Middlesex County



Figure

AQUIFER RECHARGE ARE



DEVELOPMENT WITHIN AQUIFER RECHARGE AREAS
1973

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this study an attempt has been made to evaluate and summarize the geologic characteristics of the rocks as they relate to their water carrying and water producing capacity.

C. Quarternary System

1. Wisconsin Drift

The Wisconsin Drift was deposited by the last four continental ice sheets of the Pliestoncene Age which covered large portions of the northern United States. It forms a nearly continuous mantle over the underlying Triassic and Cretaceous rocks in the northeastern part of Middlesex County. The southern limit reached by the Wisconsin glacier in Middlesex County is roughly along a line from Plainfield to Metuchen and over to the mouth of the Raritan River at Perth Amboy.[3] The Wisconsin Drift is of importance from a water supply standpoint primarily because some portions are permeable enough to absorb water directly from precipitation and transmit it readily into underlying beds.

The outwash plain found between Metuchen, Plainfield and east Bound Brook covers an estimated 16 square miles and consists of layers of sand and gravel which together are called stratified drift. The stratified drift is approximately 10 to 60 feet thick on the eastern edge near the moraine. In general the stratified drift is quite permeable but it is too shallow and covers too small an area to be in itself an important water supply source. However, it holds water which percolates into the underlying Brunswick formatic and has increased the yield of many wells located on the drift.[9]

2. Cape May Formation

The Cape May formation is a pinkish-yellow fine to medium grained quartz sand forming a thin mantle 3 to 10 feet thick over the Cretaceous formation in the South River valley as well as along the south shore of the Raritan River

The average porosity of the Cape May formation is 43% and the average specific yield is 38%. The coefficient of permeability ranges between 180 to 900 with a weighted average of 450. A block of Cape May Sand one square mile in area and one foot thick is capable of storing approximately 80 million gallons of water.[10]

The important hydrologic feature of the Cape May formation is that it overlies the Old Bridge Sand aquifer and increases its recharge capacity. No major water supplies are drawn directly from the Cape May formation at the present time.

3. Pensauken Formation

In the southern portion of Middlesex County most of the hills and upland areas (above 60 feet elevation) are covered with a layer of yellow to brown, clayey sand and gravel known as the Pensauken formation. The largest

area is between the Lawrence Brook and South River extending southwest to Cranbury. The Pensauken formation in this area is of importance in that it covers the truncated sand members of the Raritan formation.

The Pensauken formation ranges in thickness to 70 feet with the average porosity and specific yield estimated to be 40% and 30% respectively. The coefficient of permeability is considerably less than the Cape May formation, ranging between 120 and 200 and averages approximately 170. A block of the Pensauken formation 1 square mile in area and 1 foot thick could store an estimated 64 million gallons of available water.

No large water supplies have been developed from the Pensauken formation however it does yield small supplies of water to a large number of wells for domestic and farm use. Its importance from an hydrologic standpoint is in that it readily absorbs water from precipitation and transmits it to underlying aquifers resulting in an increase in the effective recharge area. Much of the intake area of the Farrington Sand and a portion of the intake area of the Old Bridge Sand is overlain by the Pensauken formation.

D. Cretaceous System

1. Englishtown Sand

The Englishtown Sand occurs near the southeastern border of the County and is a fine to medium-grained white or yellow sand which is occasionally micaceous, lignitic and limonitic. The Englishtown Sand in Middlesex County is approximately 100 feet thick and is overlain by the relatively impermeable Marshalltown formation.

Physical properties of the formation vary widely. The weighted average coefficient of permeability is 525 with the average porosity 44% and specific yield 30%. On the basis of the physical properties and the performance of wells tapping this resource in Monmouth County, the Englishtown Sand is in all probability the third most productive Coastal Plain in Middlesex County. At the present time however, no large water supplies have been developed from this formation in Middlesex County because of its relatively remote location from population and industrial centers. It should be noted that the Englishtown Sand is the second major source of water supply to Monmouth County. A number of wells in this formation yield more than 0.5 mgd. It is possible to develop a water supply of approximately 5.0 million gallons per day from this source in the County.[11]

2. Magothy-Raritan Formations

Although the Magothy and Raritan formation are distinct geologic units, they are frequently in direct hydraulic contact and are considered part of the same aquifer system. Northeast of Jamesburg, the Raritan formation has been divided into seven members, three of which are water bearing. Even though it is possible to divide the Raritan formation into seven distinct

members, attempts to trace recognized units in the outcrop areas, both along the strike and downdip, have been only moderately successful.[12] Hydrogeologic characteristics of units in Raritan formation have been summarized in Table 4.

3. Magothy Formation

The Magothy formation lies immediately above the Raritan formation and is separated from the Old Bridge Sand member by the Amboy Stoneware Clay. Average porosity of the Magothy formation is 46% and specific yield is approximately 41%. The coefficient of permeability ranges between 60 and 925 with a weighted average of 296. A block of Magothy formation one square mile in area and one foot thick can store 85 million gallons of water.

While the Magothy formation is capable of storing large quantities of water it does not transmit it freely due to its low coefficient of permeability. At the present time no significant supply of water is drawn from this formation although numerous wells for domestic and agricultural uses draw water from this source. Due to its low permeability and transmissivity, successful development of large capacity wells in the Magothy formation would be difficult if not impossible to accomplish.

4. Old Bridge Sand

The Old Bridge Sand member of the Raritan formation is the most productive and intensely developed aquifer in Middlesex County. It outcrops or is exposed beneath permeable Pliestocene deposits in an irregular band that extends from Raritan Bay near South Amboy to and probably beyond Jamesburg. It has an intake area of approximately 25 square miles, a thickness of 80 to 110 feet and dips gently to the southeast at 40 to 45 feet per mile.

The Old Bridge Sand is well sorted and is composed of fairly fine to coarse sand or fine gravel. The average porosity of the Old Bridge Sand is estimated to be 42% and specific yield is 40%. The coefficient of permeability ranges between 1000 and 1500. The Old Bridge Sand is capable of storing and transmitting large quantities of water; for example, a block of Old Bridge Sand one square mile in area and one foot thick would store about 84 million gallons of available water. The sand can transmit approximately 1 mgd for each square mile of aquifer.[13]

5. Farrington Sand

The Farrington Sand outcrops in a contiguous band nearly a mile wide along the southeast edge of Farrington Lake in East Brunswick. It has a total outcrop area of approximately 22.3 square miles, of which 10.9 square miles lie south of the Raritan River and 11.4 square mile lie north. The effective recharge area of the Farrington Sand is 16.9 square miles and has an average thickness of 80 feet, dipping gently to the southeast at the rate of 45 to 55 feet per mile.

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The Farrington Sand is a medium to coarse grained sand with an average porosity estimated at 34% and specific yield 32%. The coefficient of permeability ranges between 210 and 3500 with a weighted average between 1,200 and 1,500. The Farrington Sand is also capable of storing and transmitting large quantities of water. A block of the Farrington Sand one square mile in area and 1 foot in thickness would be capable of storing almost 67 million gallons of available water. It can transmit more than 2.5 mgd for each square mile of aquifer.14

E. Triassic System

1. Newark Group

The rocks of the Newark Group are the third most important aquifer in the County (behind the Old Bridge Sand and Farrington Sand) because of their areal extent and large amount of water developed from them. The oldest is the Stockton formation consisting of conglomerate and sandstone interbedded with red shale. Next oldest is the Locatong formation consisting of hard shale and argullite. The two rocks are found in a small area near the southwestern border of the County. The Brunswick formation is a red shale interbedded with siltstone and occassional layers of sandstone and covers the entire area north of a line between Carteret and Plainsboro.

These formations are rather impermeable except along numerous cracks whic traverse the beds at high angles to the bedding. Some water may flow along the bedding planes but such movements are limited. These rocks dip to the northwest at angles ranging from 5o to 15o

The fact that these rocks are usually fine grained, relatively impermeabl and are water bearing by virtue of their cracks and crevices, introduces probl in any attempt to appraise their water bearing capacity. The permeability and specific yield of the Newark Group depends upon the degree of cracking. Since the degree of cracking decreases with the depth, the permeability and specific yield also decreases with the depth. The cracks in the rocks of the Newark Group intersect one another at many angles; the result being that water can move almost in any direction. Figure 3 shows the area of the Brunswick formation covered with permeable material to a thickness of 40 to 45 feet.

The coefficient of transmissibility of the Brunswick Shale is approximate 25,000 (as compared to 96,000 for the Farrington Sand and 108,000 for the Old Bridge Sand) and the storage coefficient is approximately 0.0044.15 This means that Farrington and Old Bridge Sands can transmit four times as much wat as the rocks of Newark Group under a given hydraulic head and through a given width of section. The difference in the capacity of the Newark Group to store water is even more striking. For one square mile area and 300 feet of saturat thickness Newark Group rocks would hold only 275 million gallons of water. By comparison 80 feet of the Farrington Sand would hold 5,360 million gallons of water for the same area. The low storage capacity explains the high rate of r off and low ground water flows observed in streams draining areas underlain by Newark Group formations where there is no permeable cover material.

TABLE 4

HYDROGEOLOGIC CHARACTERISTICS OF UNITS OF THE RARITAN FORMATION - MIDDLESEX COUNTY

Unit	Lithologic Description	Physical Properties: Average Porosity (percent by volume)	Physical Properties: Permeability[1]	Remarks
Amboy Stoneware Clay	Light-gray to nearly black clay; abundant carbonaceous materials; locally has mottled red appearance; in some places gray to black sandy clay; Lignitic. Thickness to 30 feet.	-	-	An aquiclude[2]
Old Bridge Sand	White to light-yellow, fine to medium grained, occasionally coarse grained, slightly micaceous sand; locally contains thin, irregular clay beds. Thickness 80 to 110 feet. Dips southeast 40 to 45 feet per mile.	40	1000 - 1500	Most productive aquifer in the Raritan Formation and the County. Effective intake area is 33 square miles.
South Amboy Fire Clay	Varicolored light-gray, white or brick-red clay; locally sandy. Thickness to 35 feet.	-	-	An aquiclude
Sayreville Sand	Layers of fine white micaceous sand, fine to coarse grained white sand, with or without clay and arkosic sand beds. Usually thin and lacks continuity. Thickness to 40 feet.	44	30 - 500	Owing to thinness and lack of continuity, this sand member is unimportant as an aquifer. So far as known, no wells in this area draw water entirely from this aquifer.
Woodbridge Clay	Dark-gray clay to sandy clay and clayey sands. The basal part is varicolored white, light-gray, and brick-red compact clay. Thickness 50 to 100 feet.	-	-	An aquiclude
Farrington Sand	Light-gray or light-yellow, fine to medium grained sand grading into coarse arkosic sand sprinkled with small pebbles and gravel in the lower part. This sand is commonly divided by clay layers into two or more parts. Thickness 35 to 135 feet. Dips southeast 55 feet per mile.	34	1200 - 1500	Second in importance as a productive aquifer to the Old Bridge Sand. Total intake area is 17 square miles.
Raritan Fire Clay	Varicolored blue, grown, gray or red clay. Basic component has brick-red color. Thickness to 90 feet.	-	-	An aquiclude

Note: Summarized from "The Groundwater Supplies of Middlesex County, N.J." Henry C. Barksdale, et. al., State Water Policy Commission, Special Report No. 8., 1943.

[1]Coefficient of permeability is the rate of flow of water in gallons per day through a cross sectional area of one square foot under a hydraulic gradient of 100% or the [illegible]

F. Groundwater Recharge

1. Natural Recharge

As was previously stated the Old Bridge Sand is the most productive aquifer in Middlesex County and may be the most productive in New Jersey. On the whole the intake area of the Old Bridge Sand is exceptionally well suited for absorbing water from precipitation and streamflow and transmitting it to the water table. It outcrops in an irregular band that extends from the Raritan Bay near South Amboy to and probably beyond Jamesburg. The intake area south of Jamesburg is deeply covered by the Cape May and Pensauken formations which themselves are quite porous and absorb and transmit water readily. Where it has been defined and mapped the intake area is approximately 25 square miles with the effective intake area estimated to be some 33 square miles.[16] Over much of the intake area the land surface is relative flat, hence water doesn't run off rapidly and instead has an opportunity to percolate into the ground. The sandy nature of the soil reduces the losses by direct evaporation from soil. The vegetation on the soil is not very rank so that evapo-transpiration losses are only moderate. The Farrington Sand is, for much of its area, overlain by permeable soils having excellent drainage which in turn allows for natural recharge.

Henry C. Barksdale estimated that 20 inches of precipitation are available annually for recharging the Old Bridge and Farrington Sands.[17] This is approximately 950,000 gallons/day/square mile. On this basis total natural recharge of the Old Bridge Sand would be 31.35 mgd for an effective intake area of 33 square miles. Natural recharge for the Farrington Sand, for an effective intake area of 17 square miles, would be approximately 16.2 mgd.

It is difficult to estimate natural recharge rate for the undifferentiat Magothy-Raritan formation due at this time to the lack of a detailed investigation. However, while the Magothy formation is capable of storing large quantities of water, it does not generally transmit it freely. This means that recharge rates would be much lower than has been estimated in Middlesex County's Comprehensive Master Plan.[18] Inference from hydrogeological properties leads us to believe that the natural rate of recharge for the Undifferentiated Magothy-Raritan formation is approximately half of the Old Bridge and Farrington Sands or about 0.5 mgd/square mile.

2. Artificial Recharge

As a means of increasing the supply of groundwater, attempts have been made to use man-made groundwater recharge basins. Artificial recharge is defined as augmenting the natural infiltration of precipitation or surface water into underground aquifers by artificially changing natural conditions to allow water to recharge. A variety of methods have been developed, including increasing the extent of water recharge ponds, recharging through pits excavations, wells and shafts and pumping to induce recharge from surfac water sources. The choice of a particular method is governed by local topographic, geologic and soils conditions, the quantity of water to be recharged and ultimate water use.

Recharge ponds are presently functioning to varying degrees of success within the Old Bridge Sand outcrop in the Old Bridge-Spotswood area. The Duhernal Water System along with the P.J. Schweitzer and Anheuser Busch Companies pump for wells adjacent to Duheranl Lake which was constructed in 1938 in order to enhance recharge to the Old Bridge Sand . Although the amount of water that is recharged varies, estimates made in 1969 identified that the average rate of recharge for the 173 acre Duhernal Lake is 67,000 gallons/day/acre or approximately 12 mgd is artificially recharged.[19] In recent years, the Duhernal Company has excavated additional recharge ponds adjacent to the lake increasing the recharge area to 221 acres. Total recharge now exceeds 15 mgd.

The Perth Amboy Water Department utilizes Tennent Pond within the Runyon Watershed for artificial recharge purposes. This 63 acre pond recharges the groundwater at a rate of 80,000 to 90,000 gallons/day/acre. A study conducte by Henry C. Barksdale in 1941 indicated that approximately 5 mgd, or virtuall the entire flow of Tennent Brook, was being used to recharge the Old Bridge Sand.[20] An additional 100 acre recharge pond on the Deep Run, now in the planning and design stage, is expected to increase the yield of the Perth Amboy wellfield by an additional 7 mgd.[21] The Sayreville Water Department ha recently constructed an artificial recharge pond having a total surface area of 66 acres. This pond has been designed to recharge the Old Bridge Sand and is estimated to increase the yield of the Bordentown wellfield by about 4 mgd.

In brief, the safe yield and natural recharge capacity of the Old Bridge Sand has been augmented by some 21.0 mgd, as shown in Table 5 below. Grounc water withdrawal from Old Bridge Sand in the County is within the natural safe yield of 31.0 mgd and total safe yield of 52 mgd.

At the present time artificial recharge is not taking place in Middlesex County to increase the productivity of the Farrington Sand. As noted earlier groundwater withdrawal from the Farrington Sand is in excess of 18.5 mgd whil the safe yield is only 16.2 mgd.[22] This strongly suggests that the safe yiel of the Farrington Sand is being exceeded evidenced by the decline in the wate table and resulting salt water intrusion in the Sayreville area. Due to the location of several wells near the Washington Canal and in the zone of

TABLE 5

Artificial Recharge Operations in Middlesex County - 1974

	Area of Recharge Pond (acres)	Safe Yie
Duhernal Water Company	221	15.0
Perth Amboy Water Dept.	63	5.0
Perth Amboy Water Dept. (Planned)	100 (est.)	7.0
Sayreville Water Dept.	66	4.0
Total	450	31.0

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tidal influence of the South River, the salt water interface has advanced some one to two miles inland. Several production wells between the lower Raritan and South River tidal reaches have had to be abandoned because of high chloride concentrations. In this area no more water can be pumped from the Farrington without further accentuating the salt water intrusion problem.

As a result of artificial recharge operations within the Old Bridge Sand and the similarity in hydrogeological characteristics of the Farrington and Old Bridge Sands it may be concluded that the productivity and safe yield of the Farrington can be augmented by artificial recharge. For example, the natural rate of recharge to Old Bridge and Farrington Sands is approximately 1,500 to 1,600 gallons/day/acre. The rate of artificial recharge to the Old Bridge Sands and Duhernal Lake and Tennent Pond ranges between 67,000 to 90,000 gallons/day/acre. By proper location, construction and operation of recharge ponds on the Farrington outcrop and by proper location of pumping wells, the safe yield of the Farrington Sand could be increased significantly. Specific recommendations for the protection of Farrington and Old Bridge aquifers are included in Section V.

The feasibility for artificially recharging the Brunswick Shale should be viewed from the perspective that the Brunswick Shale is not as uniform and as predictable an aquifer as the Old Bridge or Farrington Sands. Due to the nature of the rock openings it would not be as feasible to practice artificial recharge with the Brunswick Shale. It is recommended however that the natural recharge be protected through the provision of open space areas.

G. Groundwater Withdrawal

It is estimated that in 1975 93% of the County's population was served with public water supply systems. In the more urbanized areas of the County, namely the northern and eastern sections, public water system serves close to 100% of the developed area. In the southern portion of the study area, there is at present greater dependence on private water supply systems. However, numbers served by private systems are relatively small and are expected to be even less significant in the future.

Due to the lack of detailed reporting there is presently a problem in monitoring just how much water is being pumped from the County's aquifers. Many wells are accurately reported but many private wells and "grandfather" wells are not adequately monitored.[23] Through this study an attempt has been made to locate all wells pumping more than 70 gallons/minute or 100,000 gallons/day.

Groundwater withdrawal from the Raritan formation for the years 1966 and 1973 is shown in Table 6 . It should be noted that total groundwater withdrawal declined from 51.8 mgd in 1966 to 49.0 mgd in 1973. Groundwater withdrawal from the Old Bridge Sand amounted to 29.0 mgd in 1966 and 25.9 mgd in 1973. Groundwater production from Farrington Sand was 17.7 mgd in 1966 and 18.5 mgd in 1973. Withdrawal from the Undifferentiated Sands remained

TABLE 6

Average Groundwater Withdrawal
from the Raritan Formation - Middlesex County
(million gallons per day)

Purveyors	Old Bridge Sand 1966	Old Bridge Sand 1973	Farrington Sand 1966	Farrington Sand 1973	Undifferentiated Sands 1966	Undifferentiated Sands 1973	Total 1966	Total 1973
Cranbury	-	-	-	-	0.141	0.135	0.141	0.135
East Brunswick	-	-	2.550	2.393	-	-	2.550	2.393
Edison	-	-	4.250	-0-	-	-	4.25	-0-
Helmetta	-	-	-	-	0.021	0.023	0.021	0.023
Jamesburg	-	-	-	-	0.345	0.423	0.345	0.423
Old Bridge	1.179	1.130	0.745	2.780	-	-	1.924	3.910
Monroe	-	-	0.500	0.645	-	-	0.500	0.645
(Forsgate Water Co., Forsgate Farm, Reliable Water Co., NJ State Home for Boys)	-	-	-	-	0.620	0.784	0.620	0.784
Perth Amboy	6.588	4.669	2.793	3.000	-	-	9.381	7.669
Plainsboro	-	-	-	-	-	-	-	-
Sayreville	2.437	1.311	-0-	1.852	-	-	2.437	3.164
South Amboy	0.455	0.735	0.623	0.568	-	-	1.078	1.630
South Brunswick	-	-	0.910	1.630	-	-	0.910	1.630
South River	0.306	0.335	0.874	1.075	-	-	1.180	1.405
Spotswood	0.396	0.645	-	-	-	-	0.396	0.645
Unreported Private Wells	-	-	-	-	2.000	2.000	2.000	2.000
Subtotal	11.361	8.856	13.245	13.943	3.127	3.365	27.727	26.167
Industries								
Anheuser Busch, Inc.	0.505	0.961	0.963	1.001	-	-	1.468	1.962
Chevron Oil Co.	-	-	-	-	0.250	0.250	0.250	0.250
Duhernal Water Co.	13.959	13.000	0.828	0.048	-	-	14.785	13.048
E.I. DuPont Co.	0.324	0.144	0.052	0.014	-	-	0.376	0.158
Hercules Power Co.	-	-	0.044	0.004	-	-	0.044	0.004
National Lead Inc.	-	-	0.085	0.317	-	-	0.085	0.317
P.J. Schweitzer Inc.	2.884	2.959	2.401	2.595	-	-	5.286	5.554
BASF Products	-	-	-	0.467	-	-	-	0.467
Unreported Wells	-	-	-	-	1.000	1.000	1.000	1.000
Subtotal	17.672	17.072	4.373	4.446	0.250	0.250	23.950	22.768
Total	29.033	25.928	17.618	18.389	4.377	4.615	51.677	48.935

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relatively constant between 1966 and 1973 at approximately 4.5 mgd.

Reduction in groundwater withdrawal for public use can be attributed to decline in groundwater use by the City of Perth Amboy and Edison Township. Perth Amboy had to close a portion of its well-fields tapping the Old Bridge Sand due to industrial pollution in 1972-73. Total pumpage from Old Bridge Sand declined from 6.6 mgd to 4.7 mgd. The Borough of Sayreville was pumping 2.4 mgd from Old Bridge Sand in 1966 while it pumped only 1.3 mgd in 1973. These two major municipal withdrawals amount to a 3.0 mgd reduction over the 1966-1973 period.

Conversely, groundwater withdrawal for public supplies from the Farrington Sand increased from 13.4 mgd in 1966 to 14.0 mgd in 1973. Suring this period Edison Township switched to surface water supplied by the Elizabethtown Water Company thereby releasing 4.25 mgd in groundwater now available to other users. Major public water users of the Farrington Sand include Perth Amboy, Old Bridge, East Brunswick, Sayreville, South Brunswick, and South River. Old Bridge increased its groundwater withdrawal from the Farrington Sand from 0.75 mgd in 1966 to 2.78 mgd in 1973. Sayreville pumped 1.85 mgd in 1973 while in 1966 it pumped no water from the Farrington Sand. South Brunswick pumped 0.91 mgd in 1966 which rose to 1.63 mgd in 1973.

Industrial groundwater withdrawal from the Old Bridge and Farrington Sands has not changed significantly in recent years. The Duhernal Water Company and the P.J. Schweitzer and Anheuser Busch Companies pump approximately 17.5 mgd from the Old Bridge Sand and with Schweitzer and Anheuser Busch pumping approximately 4.25 mgd from the Farrington Sand.

Total groundwater withdrawal from the Undifferentiated Sands could not be accurately estimated due to a lack of complete data. In 1973 about 3.5 mgd of water was pumped for domestic and agricultural purposes and 1.25 mgd was pumped for industrial uses in southern Middlesex County. However, these estimates should be used with caution because even though a large number of private wells have been located, the groundwater withdrawal from these wells is not precisely known.

Information on groundwater withdrawals from the Newark Group also remains incomplete at this time. In order to estimate the total water withdrawal from these rocks, all wells pumping 70 gpm or 100,000 gpd were plotted from information provided by the N.J. Department of Environmental Protection. Owners of these wells were also contracted by telephone and through a written questionnaire. Most of the respondents replied that either the well is not in use at the present time or that records of pumpage are not kept.

The Middlesex, Kingston, and Elizabethtown Water Companies are the three important public water purveyors pumping the Newark Group within the County. The Middlesex Water Company pumped 13.45 mgd from the Brunswick Shale in 1969 and 4.96 mgd in 1973. The reason for the decline in pumpage is that the Middlesex Water Company started to utilize the Delaware and Raritan Canal

in 1970 as its primary supply source. However, it should be noted that groundwater withdrawal increased from 3.55 mgd in 1972 to 4.96 mgd in 1974. The Middlesex Water Company has been selling approximately 2.5 mgd to the Perth Amboy Water Department due to the closing of some Old Bridge wells in 1973 as noted earlier. The Elizabethtown Water Company pumped 12.83 mgd in 1969 and 15.02 mgd in 1974 from the wells in Middlesex County. The Kingston Water Company pumped 0.114 mgd for public water supply from the Lockatong and Stockton formations in the southwestern corner of the County in 1974. Total withdrawal for public supplies was approximately 19 mgd in 1974.

It is difficult to estimate the groundwater withdrawal for industrial use due to the reasons cited earlier. There are approximately 60 industrial wells which supply cooling water to industrial plants. The information gathered from telephone interviews revealed that a least half of these wells are not currently in operation or operate only during emergencies. The groundwater withdrawal from 13 wells was accounted for and averages approximately 0.857 mgd as shown in Table 7. Groundwater withdrawal from the remaining unreported industrial wells is estimated at approximately 3.0 mgd.

It should be pointed out that many industrial wells which are not in full use at this time should not be considered permanently inactive. These wells represent important potential water supply sources and should be carefully protected from any pollution which might make them unsuitable for future use.

Additional details regarding groundwater withdrawals during the period 1950-1975 can be found in Appendix C.

H. Diversion Rights for the Withdrawal of Groundwater

By law the State of New Jersey, through the Water Policy and Supply Council, regulates all groundwater withdrawals. Some domestic well users are generally exempt from State statutes, however, permits are required for the withdrawal of groundwater in excess of 100,000 gallons per day (roughly equivalent to a continous pumping rate of 70 gallons per minute). Users of groun water prior to 1947 (the time of promulgation of the water law) were granted "grandfather rights" which were based largely on the pump capacity of the wel system in operation at that time. Those granted "grandfather rights" were no required to file for authorization in order to continue to withdraw groundwat and maintain withdrawal rights.

Information on present groundwater diversion rights to the Farrington and Old Bridge aquifers, compiled from the NJDEP-Bureau of Water Supply Plann and Management, is presented in Table 8. This table lists well owners in addition to the authorized and grandfathered diversion rights of each owner as of 1975. As shown, authorized diversion rights for the Farrington Sand were 44 mgd and grandfather rights amount to another 24.5 mgd, for a total of 68.5 mgd. The quantity of permitted diversions was approximately four times greater than the amount of water actually pumped from the Farrington in 1974.

TABLE 7

Average Groundwater Withdrawal
from the Newark Group - Middlesex County
(millions gallons per day)

Public Supplies	1969	1970*	1973*	1974	1975*
Elizabethtown Water Company	12.827	N.A.	N.A.	15.018	N.A.
Middlesex Water Company	13.447	7.910	4.960	3.944	3.328
Kingston Water Company	0.121	0.102	0.116	0.114	0.116
Subtotal	26.395	8.012	5.076	19.076	3.444

Industrial Supplies	1969*	1970*	1973*	1974*	1975*
Am Col (Edison)			0.042		
Dreyfus Co. (S. Plain.)			0.250		
Holophane (Edison)			0.007		
Kentile Inc. (S. Plain.)			0.350		
Parkway Plastics (Piscat.)			0.200		
Rhodia Inc. (New Bruns.)			0.008		
Other industrial supplies (Estimated)			3.000		
Subtotal			3.857		

* The data for these years remains incomplete
N.A. - Not Available

In the case of the Old Bridge aquifer, authorized diversions amount to 34.7 mgd and grandfather rights were an additional 19.6 mgd, for a total of 54.3 mgd. This total contrasts with 30 mgd withdrawn from the Old Bridge aquifer in 1974.

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TABLE 8

1975 Authorized and Grandfather Diversion Rights from the Farrington and Old Bridge Sands in Middlesex County

Farrington Sand (south of the Raritan River)

Well Owner	Diversion - MGD Authorized	Diversion - MGD Grandfather
Anheuser-Busch Co.	1.044	0.778
P.J. Schweitzer, Inc.	(1.000)	3.460 (a)
Sunshine Laundry	-	0.070
Hercules Powder Co.	-	7.488
Thomas & Chadwick	-	0.215
Milltown Industrial Sites		
W.R. & C.W. Dey	-	0.288
Mustephla Ahmed	-	0.865
Charles H. Holster, Jr.	-	0.865
Badische Products Co. - BASF (Formally United Cork Co.)	-	0.710
	-	0.288
Phelps Dodge Copper Co. (former owner)	-	0.864
Joseph Guerriero	0.360	-
Duhernal Water System	-	4.610
Joseph Konuk	0.140	-
Charles Bonkoski	0.500	-
Edward Collins	0.100	-
Marvin Hallick	0.360	-
Arthur Perrine	0.300	-
Lawrence J. Smith	0.400	-
Great Bay Chemical Co.	0.576	-
Cranbury Township	0.400 (a)	0.149
South River Borough	1.500	-
East Brunswick Township	3.000	-
N.J. State Home for Boys	1.080	-
Old Bridge Township M.U.A.	5.375	-
South Brunswick Township	2.750	-
South Amboy	0.650	-
Forsgate Water Co. (purchased by Monroe M.U.A.)	4.570	-
Forsgate Farms	0.540	-
National Lead, Inc.	5.000	-
Perth Amboy City	10.000	-
E.I. Dupont deNemours Co.	-	5.000
Sayreville Water Department	2.940	-
Spotswood Water Department	0.382	-
	44.467	26.650

(a) Total Diversion Limit

TABLE 8 CONT.

Old Bridge Sand

Well Owner	Diversion - MGD Authorized	Grandfather
Duhernal Water System	10.622	23.872 (a)
W.R. & C.W. Dey	-	0.086
Mustepha Ahmed	-	0.086
J.F. Abeel	-	0.144
E.I. DuPont deNemours Co.	-	0.800
H.H. Monteath	-	0.288
Anheuser-Busch Co.	1.670	-
P.J. Schweitzer, Inc.	2.160	6.540 (a)
Forsgate Water Company (purchased by Monroe M.U.A.)	0.540	-
Perth Amboy City	10.000	-
Sayreville Borough	2.500	-
Spotswood Borough	1.500	-
George W. Helme Co.	-	0.111
N.J. Water Co. - Jamesburg District	0.850	-
Old Bridge Township M.U.A.	2.375	-
South River Borough	0.500	-
South Amboy	2.000	-
Kerr Glass Co. (formally Armstrong Cork Co.)	-	0.288
Cranbury Township	-	0.149
Monroe Township M.U.A.	-	-
	34.717	32.364

(a) Total Diversion Limit

1974	Farrington Sand	Old Bridge Sand
Authorized Diversion by Water Policy and Supply Council and predecessors	44.085 mgd	34.717 mgd
Grandfather Rights (in addition to authorized diversion)	24.501 mgd	19.582 mgd
TOTAL:	68.586 mgd	54.299 mgd

III. EFFECTS OF URBANIZATION ON GROUNDWATER RESOURCES

The capacity of a watershed to provide surface and groundwater depends upon many factors, including the amount and duration of precipitation, the geological characteristics of underlying rocks, the structure and condition of the soil, ground topography, the nature of forest cover, infiltration, surface detention and the land use pattern. A greater amount of surface runoff is genera on consolidated rocks than on sandy soils. Infiltration occurs more readil on natural (pervious) surfaces. While the infiltration on sandy soils and rock is great, infiltration in areas which are covered or paved with buildings, parking lots, roads and sidewalks is very low. At the same time runoff in these areas is great.

Surface detention is the process by which rainwater and surface runoff is collected and held in depressions and are not allowed to enter a natural or man-made drainage system. Natural detention is greater on natural ground than on urbanized surfaces. The land use pattern and slope significantly affect run off, infiltration and surface detention. The greater the surface slope, be it grass, roads or roof tops, the greater the runoff and the lower the infiltratio and surface detention. A significant reduction to infiltration results in a reduction of groundwater supply available to aquifers.

A. Urbanization of Recharge Areas

The following discussion serves to briefly describe the extent and impact of urban development on the groundwater resources of Middlesex County. Under traditional residential development practices, 40 to 70 percent of the land area is paved for buildings, roads, utilities, parking areas, etc., depending upon the density of development. In industrial and commercial developments, approximately 60 to 100 percent of the land area is paved for access roads, buildings, parking lots, etc. Figure 4 shows the extent of urban development on the groundwater recharge areas. The area was measured using a point area measuremen technique utilizing U.S. Geological Survey topographic quadrangles and 1973 aerial photographs (See Appendix A). Table 9 shows the total recharge area and developed and paved areas on each of the major aquifers in the Raritan formatior

It should be noted that the Farrington and Old Bridge Sands are the most urbanized outcrops of the Raritan formation. Of the Farrington Sand's 14,286 acre (22.3 sq. miles) effective recharge area 3,472 acres (5.4 sq. miles) have already been developed and 1,947 acres (3.04 sq. miles) has been completely pave Fully 24.3 % of the Farrington Sand recharge area has been urbanized and 13.6% has been completely paved. Of the 21,530 acres (33.6 sq. miles) of effective recharge area of the Old Bridge Sand, 4,295 acres (6.7 sq. miles) has becom urbanized and 2,260 acres (3.53 sq. miles) have been completely paved. This is 19.9% and 10.5% of the total recharge area of the Old Bridge Sands. Urbanization of the Englishtown and Mt. Laurel-Wenonah Sands is somewhat less severe.

Urban development on the Brunswick shale is more intensive than on the Raritan formation. In this study, the Brunswick shale with permeable cover (sand and gravel) has been identified covering 10,225 acres (15.98 sq. miles) and over 5,860 acres (9.2 sq. miles) have been developed. This constitutes 57.3% of the mapped area. Total paved area has not been estimated but if we use a conservative figure of 60% paved surface for the developed area, it would result in approximately 3,510 acres (5.48 sq. miles)

During the conversion of land from open space and agriculture use to urban/suburban development, the natural characteristics of the recharge area are significantly altered due to the removal of vegetation, the compaction of soils resulting from movement of construction equipment, and the placement of cover resulting from the construction of buildings, parking lots, roads, etc.. Although some 30% to 60% of the area within a typical residential development remains in open space, this open space is adversely affected for the purposes of groundwater recharge. Athough these areas provide much needed open space fo pleasant living environment, the infiltration capability of the area is significantly reduced due to soil compaction. For the purposes of groundwater manag ment only 50% of the remaining open space area in residential development should be considered as effectively recharging the groundwater system.

3. Impact on Groundwater Quality and Quantity

The impact of urban development on groundwater recharge is also reflected in a reduction in the quality and quantity of water. The placement of impervious surfaces increases water runoff and reduces the opportunity for water to infiltrate and recharge the groundwater system. At the same time, urban runoff carries with it greater amounts of toxic pollutants to the surface water body rendering it unsuitable for many desired uses. Studies have shown that significant amounts of chemicals, metals and organic materials are flushed from develop areas into streams and rivers by surface runoff. Where natural or man-made stormwater detention facilities or natural water courses provide for groundwater recharge the potential for groundwater pollution as a result of urba runoff is greatly increased. The nature of this pollution is not precisely known at the present time, but it is considered to be more toxic than common sewage pollution.

Due to the reduction is the recharge area of the Farrington Sand the safe yield of the aquifer has been reduced while the intrusion of salt water has increased. While the effective recharge area of the Farrington aquifer is estimated to be 20.6 square miles, 5.4 square miles has already been urbanized leaving only 15.2 square miles available for recharge. At the rate of 950,000 gallons/day/square mile, 1973 safe yield of the Farrington is estimated to be 14.44 mgd. Due to a decrease in natural recharge and the increase in pumping, the groundwater table in the Farrington Sand near the tidal zone of the Raritan and South Rivers has declined allowing the salt water front to proceed further inland. The severity of the salt water intrusion problem was first noted by Barksdale in 1943.[24] Barksdale estimated that no more than 10 mgd should be pumped from the Farrington Sand in Middlesex County.[25] Since 1943, the salt water interface has advanced inland approximately 2 miles.[26] Several large wells in the Sayreville area were abandoned due to high chloride concentrations during the past 30 years, while groundwater pumpage increased to 18.5 mgd.

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TABLE 9

Groundwater Recharge Area and the Extent of Urbanization - 1973

Formation	Total Area (Acres)	Developed Area (Acres)	Percent of Total	Paved Area (Acres)	Pe of
Mt. Laurel-Wenonah Sand	543	42	7.7%	28	5.
Englishtown Sand	7,808	350	4.5%	270	3.
Old Bridge Sand	21,530	4,295	19.9%	2,260	10.
Farrington Sand	14,286	3,472	24.3%	1,947	13.
TOTAL	43,130	8,159	18.9%	4,348	10.

In addition to the salt water intrusion problem in the Farrington Sand, unsewered urban development within the intake area of the Lawrence Brook threatens ground as well as surface water resources. It is estimated that 25 to 30% of the septic tanks in the Lawrence Brook Basin are adversely affecting groundwater quality. This pollution is a major threat to the groundwater derived from the Farrington Sand aquifer. Since large areas of the Farrington Sand in the Lawrence Brook Basin remain undeveloped and in order to protect the valuable ground and surface water resources of the County, sewerage service should be provided to the presently unsewered development while insuring that all new developments that do occur do not result in adverse impacts to water supplies.

Disposal of industrial waste has been another manifestation of the effect of urban development on water supply sources. Industrial pollution of groundwater adjacent to Prickett Brook, (near Perth Amboy's Runyon wellfield) resulted in the closing of wells in the northern section of the watershed. Chemical pollutants consisting of lead, zinc, cadmium and other heavy metals polluted wells and surface waters of Tennant Pond. One portion of the wellfield, pumping approximately 2.5 mgd, had to be abandoned because the groundwater aquifer has been contaminated. This wellfield area will not be productive again for several years.[27]

The utilization of swamps wetlands, or low-lying lands for the disposal of waste material has been common practice in New Jersey for many years and has come to be a major source of groundwater and surface water pollution. Improperly located and poorly operated sanitary landfills have had significant adverse impacts on ground and surface water quality where runoff and rainfall have been allowed to flush toxic materials from santiary landfills sites into rivers and streams and to percolate into groundwater supplies. Three major sanitary landfill operations are presently underway in the Edison and East Brunswick areas immediately adjacent to the Raritan River and within the Farrington Sand outcrop. A fourth major landfill is in operation in Sayreville, along the South River and within the Old Bridge Sand outcrop. The impact of these operations on groundwater quality has not been monitored in the past. Such monitoring should be instituted as soon as possible.

A major water quality problem results from the open dumping of wastes. Such operations have been banned by the N.J. Department of Environmental Protection. A major industrial dump located within the upper reaches of Deep Run (within Burnt Fly Bog and over the Englishtown Sand outcrop) was closed by NJDEP several years ago, however, pollution from the site may still be affecting the Deep Run and nearby area groundwater.[28]

The groundwater pollution problem affecting the Newark group is more complicated due to the nature of the formation. Since the pore spaces in these rocks consist of cracks and crevices of secondary origin interconnected at all angles, water in these rocks moves at relatively rapid velocity. Once a pollutant has entered these rocks it moves quickly and has relatively little opportunity to be filtered out. In order to protect the groundwater resources of the Brunswick shale, disposal of wastes in or on these rocks should be prohibited. In the absence of such measures existing and potential groundwater resources could be permanently lost.

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C. Need to Protect Water Resources

It should be pointed out that as local municipalities and private industries are directed to eliminate pollutant discharges under requirements of the Federal Water Pollution Control Act (1972) and Clean Air Act (1970), they will look towards alternative waste disposal methods and sites. Underground disposal of wastes offers an attractive alternative, however, the 1972 Federal Water Pollution Control Act Amendments prohibits underground disposal of waste materials if it threatens the quality of ground or surface water resources. The problem of groundwater pollution is more severe and complicated than that of surface water pollution because the nature of groundwater movement is not fully known. While some effects of surface water pollution can be ameliorated through natural aeration, sedimentation and bacteriological metbolism; once a pollutant enters the groundwater system it may never be eliminated or only over a long period of time. Many wells and wellfields may be rendered useless due to careless, and at times intentional waste discharges which affect the quality of groundwater resources.

As the population of the County rises and water resources become more limited in the future, the protection of the County's surface and groundwaters from polluton becomes increasingly urgent. At the same time in order to provide for water supply requirements, the productivity of watersheds and groundwater aquifers needs to be maintained and enhanced. Groundwater resources would assume a greater importance as a source of water supply in the County as surface water sources are utilized to capacity. In order to have a continuous supply of water it is essential that the amount and type of urban development on the groundwater recharge area be carefully planned, directed and controlled. If these valuable resources are allowed to be depleted while searching for short term gains (such as tax ratables), the County and its people would stand to lose much over the long term.

Addressing the problems of protecting groundwater quality and quantity in Middlesex County requires detailed analysis and evaluation of the specific problems facing each drainage basin in the County to identify precisely existing problems and potential solutions. This element of water planning has recently been addressed under the 208 Water Quality Management Planning Program which provides Federal funds for planning in areas such as Middlesex County with water quality problems resulting from point (industrial and municipal effluent discharges) and non-point (runoff borne pollution from urbanization, agriculture, mining,) sources.

IV. MEASURES TO PROTECT CRITICAL ENVIRONMENTAL RESOURCES

The major issue in any discussion concerning preserving and protecting critical environmental resources is how can a growing urban population be accomodated without sacrificing those resources within its borders? It is becoming increasingly apparent that the County must undertake a comprehensive evaluation of its capacity for growth at the same time while meeting the Federal and State environmental quality standards. It is clear that at the present time the County's air and water quality is well below the Federal and State standards.

Many believe that the technology exists to correct the ills of urban development and that this technology will provide the means to achieve environmental goals and standards. In recent years, however, it has been recognized that technology will solve only part of the problem because technological controls are largely capital intensive and at present are not available to deal with all problems. Part of the answer to the environmental problems will have to come from preventive measures. This would require a basic change in perceptions and attitudes in order to recognize that planning and the protection of critical environmental resources is essential for the long-term survival and ecomonic well-being of a community, that resources are limited and their conservation, protection and reuse is also essential and that governmental regulations are meant to protect the health and welfare of the people at large.

The following section serves to review available methods to protect and preserve open space and conservation areas. It should be stressed that the protection of groundwater recharge areas should be considered part of any program to protect other critical resources including prime agricultural land, wetlands, marshlands, woodlands and floodplains. This review of measures should not be viewed as exhaustive and complete, but rather is intended to provide the reader with some perspective on available approaches.

A. Land Regulation

Police power regulation is based upon the principal that in a society governed by law, everyone must submit to reasonable regulation of their liberty and property to prevent the abuses of others by careless and unscrupulous action. The police power is exercised to protect and promote the public health, safety, morals, comfort and general welfare. Based upon this power, the authority for land use regulations in New Jersey is delegated to local governments. Regulatory tools available to the municipalities include zoning, official mapping, subdivision and site plan regulations and the provision of utility services.

B. Zoning Ordinance

In the past zoning has been of limited utility in protecting critical environmental resources and in providing for open space, particularly if it was "cumulative" zoning. "Cumulative" ordinances are not restricted to one use,

but allow other uses in the same district. For example, agricultural zoning of this type would also allow residential uses within the same district. If, as in Middlesex County, the rate of urbanization is high, this type of district will succumb to economic pressures for rezoning to higher, more intensive uses. "Exclusive" zoning allows only the type of use specified or a use directly related to the primary use and would probably be more effective than cumulative zoning for the preservation of groundwater aquifers. It is, however, more likely to be subject to legal challenge if it prevents land owners from obtaining a reasonable economic return.

Despite these problems, recent trends in zoning laws hold some promise as a means of encouraging the preservation of open space and other critical natur resources. New Jersey has adopted as law the Flood Hazard Area Act (1972), th Wetlands Act (1970) and the Coastal Area Facilities Review Act (CAFRA, 1972), each of which authorize land use controls for the purpose of protecting critic natural resources and regulating development. At this time, however, there is no comprehensive land use legislation which would provide for the protection of other critical natural resources such as groundwater recharge areas, watershed lands, woodlands, prime agricultural land or unique geologic, biologic or historic sites. Such legislation is urgently needed to protect New Jersey's rapidly vanishing resources. New Jersey's Wetlands Act only covers tidal wetlands within a specific area and does not protect inland freshwater marshes. In addition, CAFRA only covers a small area in Old Bridge Township in the County.

In spite of the shortcomings in State government authority to act to protect New Jersey's resources, significant resources can be protected through application of existing laws. New Jersey has adopted enabling legislation permitting municipalities to include special provisions for Planned Unit Developments (PUD) in their zoning ordinances. This concept permits flexibility in the density and physical design of single or multi-use land development projects which can be used to provide protection to environmentally critical or significant portions of a municipality which would otherwise be developed in a traditional and potentially harmful manner. Under PUD regulations, structu and related facilities can be clustered in certain areas with protection to other areas through designation as open space.

At the present time the authority for resource protection rests in the local power to regulate land use. However, for economic and political reason land use control has been loosely applied at the municipal level, for the most part merely to protect existing land uses, maintain property values and foster development that will increase the community tax base. Furthermore, there is doubt that the zoning approach can, in the long run, provide the degree of environmental protection needed without constituting a taking of property without just compensation.

C. Official Map

In New Jersey, cities, villages and towns can designate parks and playgrounds as well as streets, highways and parkways on an official map. Howeve maintaining the integrity of an official map requires the municipality to be

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empowered to deny building permits for structures located in the designated area. In New Jersey, municipalities do not have such power.[29] Nevertheless, setting out proposed open space and conservation areas as part of the official map is useful if only to put developers on notice as to the municipalities' intentions. As a first step, each municipality should map their critical environmental resources and develop policy guidelines to direct development away from these areas.

D. Subdivision and Site Plan Regulations

On a limited scale, subdivision and site plan regulations could provide a basis for protecting and preserving critical environmental resources in the County. The regulation can serve to encourage clustering and other site and building design arrangements to provide for additional open space. More important, land developers can be required to dedicate specified portions of their land (up to 60%) as open space within outcrop/recharge areas to allow for groundwater recharge as well as to meet open space requirements.

In addition to these aspects of subdivision regulations, there is a broader issue of prohibiting subdivision plotting for development purposes entirely. This prohibition would be based not on a technical infraction but rather on a duly adopted master plan which indicates that the area in question was more suitable for conservation of natural resources (including watershed lands, floodplains, prime agricultural lands and recharge areas). In most cases, plat approvals require compliance with local master plans or official maps. If local governments have adopted one or both of these and if they have already identified open space and conservation areas, there will then be an additional rationale for withholding approvals within the delineated areas.

In order to maintain groundwater quality and maximum recharge capacities it is strongly encouraged and recommended that subdivision regulations require construction of multi-purpose detention ponds as a condition for granting approval. These ponds can serve several vital purposes; they would retain runoff from the development and thereby reduce off-site flooding; provide for groundwater recharge; serve as a natural filter to reduce the amount of pollutants reaching the surface and groundwater bodies; and would enhance the recreational opportunities for the residents of the development. However, these ponds, while relatively inexpensive to build, will require careful maintenance and management to protect them from eutrophication. The application of fertilizers on land surrounding the ponds will have to be minimized and the pond bed would have to be periodically dredged to allow for the continuation of recharge to the aquifers and to maintain overall pond capacity.

E. Provisions of Utility Services

In the recent past, various municipalities faced with the economic burdens resulting from rapid growth have not been able to keep abreast of the responsibility to provide the necessary public utilities, including sewer and water services. The N.J. Department of Environmental Protection at one time had imposed construction bans on three municipalities in Middlesex County due

to a lack of adequate sewer services. While the courts are generally sympath to the public interests, and while the provision of public services is within the police power regulation, they are still faced with the constitutional ques tion of confiscation. The State ban has not been tested in the courts and it may not be upheld due to the above reason. Traditionally, a reasonable econom return must be allowed to the land owner and the assumption made was that services, if not presently available, could be provided within a reasonable time period.

It has now been recognized that land development in areas which do not have adequate utility services, particularly sewerage facilities, may present a hazard to the general public health and welfare. In a landmark decision, the New York State Court of Appeals in Golden vs. Ramapo (285 NE, 2d 291, 1972) upheld a Ramapo, New York ordinance which regulates development on the basis of the availability of public services. The ordinance is directed at the phasing of development in that it limits development in areas without basic services until such services are available. This ordinance operates on the assumption that land areas will eventually be developed, however, it allows (indirectly) for the limiting of development to those areas suitable for development if future provision of facilities and services is provided according to plans reflecting resource and environmental constraints. A plan for utilities and other services which clearly identifies areas which should/should not be developed, and regulated by the provision of services to those areas with the fewest critical natural resources requiring protection, must be adopted and enforced. In the past the Courts have held invalid zoning ordina restricting land use to flood storage, parking lots, schools, recreational use and open space (greenbelts) and park purposes. Similarly, subdivision regulations have been held invalid, inspite of substantial public interest, where the owner is denied reasonable use of his property.[30] Therefore, a mechanism which coordinates development with adopted plans and provides a means for justly compensating those who cannot develop their lands under those plans must also be developed. The Ramapo ordinance establishes a mechanism for tax abatement on properties affected by the ordinance until such time as they are to be provided basic services. More permanent methods of equitable compensation need to be developed and implemented.

F. Compensable Regulation

To overcome the constitutional objections to development controls which deprive an owner the use of his property, conservation and open space objectives could be achieved by compensating owners for a portion of their loss. With compensable regulations a land owner is compensated for the reduction or loss of the property's development value involved at the time the controls are imposed.[31] For example, an owner of land in an agricultural district and having a market value of $2,000/acre would be entitled to a compensation of $1,200/acre if the market value of his land is reduced to only $800/acre when restricted to only agriculture or some similar open space use. The $1,200 in compensation represents the development value of the property "taken" from the owner by (police power) regulating the use of the property. The owner would not be entitled to the compensation until the property is sold because it is only until the sale that the owner would have incurred any "los

Under this approach the high cost of public acquisition (under eminent domain) is reduced by limiting public cost to the development value at the time of regu lation.

Inspite of the above advantages compensable regulation has not been utiliz as a tool for the preservation of public open space for a number of reasons: the general public does not seem prepared to accept a program that denies land owners the speculative value of their property; the public and legal profession are uncomfortable with the concept of development rights and are fearful of unknown consequences on the real estate market; it requires a relatively complex system of government admimistration consequently, the effectiveness of compensable regulation as a method of conserving and preserving critical enviro mental resources has not been tested. There is a further practical problem in that each time land covered by this regulation is sold a public expense will be involved if it is found that each owner is entitled to the difference in the market versus the "agricultural" value of the property, despite what has been paid originally for the property. However, this approach is worthy of closer review and evaluation than it has received in the past and may prove a valuable regulatory tool in the future.

G. Public Acquisition

The power of governments to acquire property for park and recreational areas is well established. The State, through its Green Acres Program, provides funds to County and local government to acquire lands for conservation, recreation or open space purposes. Public acquisition offers the opportunity for both effective control of land uses as well as the provision of public recreation needs.

A number of authors, including Marion Clawson, suggest that the government go into the "land banking" business as a means of controlling land use development and protecting critical environmental resources. The proposal is for the government to buy land in prime development and critical environmental areas through the use of a revolving fund. By selectively disposing or leasing parcels of land the process of development could be guided. Certain lands could be retained for permanent open space while specific restrictions could be attached to lands sold or leased. Funds received from such sales or leases would replenish the revolving fund.

Such a system has been successfully implemented both in Stockholm, Sweden and Regina, Saskachewan, Canada. Currently, the City of Boulder, Colorado is in the process of acquiring a large area of land around the City as a means to control development. It is then leasing back the land to farmers with use restrictions and retaining some portions for open space and municipal parks. In this manner the City plans to retain substantial control over the course of future development while protecting important environmental and scenic resources from the effects of urban sprawl.[32]

Theoretically, the "land banking" process could have a major role in timir and guiding development as well as managing the size of U.S. cities. However, segments of the American public frown upon such a move on the grounds that it flies in the face of the free enterprise system and again deprives land owners of the future speculative value of their land.

There is little doubt as to the effectiveness of these techniques to preserve critical environmental resources and open space. The primary impediment to the use of public acquisition is the lack of funds available for this purpose. While the New Jersey Green Acres Program has helped Middlesex County acquire open space there remains a need for additional funding to support further acquisitions. In addition to the restrictions and limitations on financial resources there are other objections to the acquisition of land for conservation and open space purposes. When land is transferred from private to public ownership the property is no longer taxable and the remaining property owners in the jurisdiction pay a proportionately higher share of the overall tax burden. There is strong political opposition to government ownership and management of land with many landowners reluctant to relinquish possession of their land even for fair compensation. Although the preservation of critical environmental resources is a commendable objective, the high cost of land acquisition also diverts public funds from other priority items.

H. Conservation Easement

In principal, public acquisition of (partial) rights to land in the form of an easement can economize on the acquisition budget. Under this approach the government acquires the owner's right to development the land, leaving him with all other rights to ownership including the right of continued possession. This is known as a conservation easement since the purpose of its acquisition is to conserve the environmental amenities of land, air, water, vegetation, wildlife and unique areas. Such an easement runs with the land and binds all subsequent owners.

Public acquisition of conservation easements rather than fee simple ownership has a number of advantages. The cost of a conservation easement is typically less than the cost of fee simple ownership. Outside the influence of urban development, the conservation easement could be acquired at a lower cost. There would be less opposition from farmowners to the acquisition of such easements because easements for purposes such as groundwater protection would protect prime agricultural land, thus allowing continued possession and use of their land for farming purposes. The land would continue to be taxed and at the time of public acquisition would not impose any appreciable burden on other property owners. The property tax should be imposed upon the open space and agricultural use value of the land. Property taxes on the easement land would not increase as the development values of surrounding lands rise and would not be too costly to maintain for farm or open space use. As the demand for developable property in the area increases, the owners of the developable land will reap the benefit of increased land value and would also pay taxes on higher assessment values of their land.

Inspite of these advantages, the acquisition of conservation easements has not yet proved an effective tool in preserving open space or critical environmental resources. The usefulness of conservation easements to protect agricultural land, groundwater recharge areas, watershed and marshlands, however, should continue to be explored.

I. Transfer of Development Rights

The Transfer of Development Rights (TDR) concept is an extension of existi planning and zoning procedures which make exclusive agricultural or other open space zoning possible. Special zoning districts are established and all develc ment therein other than farming, conservation or open space are prohibited. For each unit of development prohibited in such districts, a substituted unit of development is provided within the zoning which allows growth in the develop sections of the community.[33]

A development right is created for each eliminated unit and is given as compensation to the owners of land where development is prohibited (e.g., housing unit). In order to build the substituted unit in the developable section of the community, a development right is required along with the appropriate zoning and land ownership. Therefore, a builder must purchase development rights from a landowner in the preserved district in order to build at a higher density in the developable zones of the town. The value of the right is the sale price arrived at between the builder and the holder of the right. While new to the United States, the concept is well known in several nations with high population densities including Belgium, Holland and Switzerland. These nations have been able to preserve their character by regulating land use and the nature and location of homes, shopping centers and industrial sites

The concept can be applied to Middlesex County where according to the Blue print Commission Report there are 43,000 acres of class I, II and III agricultural land. The agricultural value of the average farm is $310/acre while the market value is $2,886/acre. The Development Right value is $2,576/acre or 89% of the market value.[34] This means that for each acre of preserved area in the County developers will have to pay $2,576 for building on the "developab land.

The net effect of TDR is the preservation of environmentally significant areas with equitable government compensation to owners. The TDR concept has merit for use in a number of municipalities in the County and should be considered one alternative to preserve and protect watershed land and groundwater recharge areas. The economic implications of such transfer needs further investigation and is already under active consideration by New Jersey's Legislatu:

J. Land Taxation

Although the tax on land in the United States has been consistently applie as a tax on current market value, nineteen States have enacted some form of modified property tax for application to agricultural lands. Some fourteen

States have an alternative tax for forest land. In some of these States the modified tax applies to all kinds of open space land, including farms, forest wetlands and other similar wild lands.

The undesirable effect of ad valorem property tax is that it tends to force premature subdivision and a change in land use. Use value taxation is a device which can prolong the life of privately owned conservation areas and open space. This method taxes property at the actual value in its presen use such as farmland or woodlands and not on its higher zone value (the speculative value). The owner is less likely then to be taxed into selling the land prematurely. The New Jersey Farmland Assessment Act of 1964 has helped to halt the conversion of agricultural land for speculative purposes.[3] The Blueprint Commission has recommended that 70% of the class I, II and III agricultural land in the County should be permanently set aside and protected from urban sprawl.

The validity of assessing other open space and conservation land on the use value may be questionable under existing legislation and practices. The wider implications of the Farmland Assessment Act to protect watersheds and recharge areas in conjunction with protecting prime agricultural land needs further investigation. It is recommended that in order to protect important critical resources such as groundwater recharge/outcrop areas, floodplains, watershed lands, marshlands, wetlands, unique cultural and educational sites, such land should be taxed on the basis of their use value rather than speculative value. Where a municipality is heavily burdened by such taxation, the State and County should identify the opportunity to provide some payment in lieu of taxes.

K. Technological Controls

As was previously mentioned, the safe yield of the County's aquifers could be increased by artificial recharge. Artificial recharge could be accomplished by infiltration or injection. The primary difference between these methods is the driving force behind recharge. With infiltration the driving force is gravity, whereas with injection, it is mechanical (pumped). The choice of a particular method is governed by local topography, geology, soil conditions, the quantity of water to be recharged and the ultimate use of water.

Artificial recharge through infiltration has been practiced in the Sayreville/Old Bridge area for some time and has increased the yield of the Old Bridge Sands aquifer by 21 MGD. At the present time no other formation is being artificially recharged. The source of recharge water in all cases is runoff water stored behind a small dam. No injection wells are used to recharge the aquifers at the present time but the utility of a series of injection wells to control the intrusion of saltwater into the Farrington Sand needs to be considered.

In many localities across the United States secondary and tertiary treate wastewaters are being used to recharge groundwater as well as for agricultural and industrial uses. When other sources of freshwater are exhausted the reuse of reclaimed wastewaters would offer an additional source of recharge water in the County. At the present time the use of reclaimed wastewater for potable supply purposes is not encouraged due to the many unresolved questions with respect to quality of the water and effect of toxic substances that may be present. If reclaimed wastewater is recharged for drinking purposes it must meet the U.S. Public Health Drinking Water Standards, The quality of recharge water must then be equal or better than the native water in the aquifer. Use of highly treated effluent from the Middlesex County Sewerage Authority treatment plant for injection wells recharging the Farrington Sand in the Sayreville area as a means to control saltwater intrusion offers a challenge. However, it should be noted that technical difficulties remain in the use of injection wells and still require careful planning, design, construction, operation and maintenance.

At this time, recharging reclaimed wastewater on agricultural lands remains a distinct possibility in the County and one which deserves further attention and investigation. Wastewater treatment facilities and agricultural lands are located within reasonable proximity and the recharging of such effluent may prove a safe and cost effective means of disposing of treated effluent.

In the recent years there have been several promising experiments with porous pavements. In order to reduce the impact of urbanization within recharge outcrop areas it is possible to construct porous parking lots to serve residential, commercial and industrial developments. Compared to conventional pavements, porous pavements reduce runoff and allow for greater infiltration of precipitation to the groundwater system. This would also result in the reduction in the amount of runoff reaching surface water bodies and may contribute to a reduction in flooding. This option should be further investigated to more fully assess its application in Middlesex County.

Artificial recharge, through any of the above measures requires safeguards to insure that pollutants are prevented from entering groundwater supplies. Where adequate filtration is present before recharge water reaches an aquifer some pollutants will be removed. However, periodic monitoring will be required to insure that toxic pollutants, including organic chemicals or metals, do not enter the County's water supply. It is evident that the control of artificial recharge facilities is required and protection must be provided to prevent developments to affect their water quality. The prevention of groundwater pollution also entails consideration of pipeline and sewer locations. The potential for leakage from pipelines or sewers into aquifers exists unless precautions are taken in the construction and operation of such facilities to minimize such leakage and monitor for breaks or exfiltration. Such facilities should be carefully located to avoid aquifers wherever possible.

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L. Water Conservation

Water conversation methods could increase the effective safe yield of the County's water resources. By reducing leakage in the conveyance system substantial amounts of water could be saved. Installing water conservation devices such as low-flow toilets (which use only two gallons of water as compared to the present five gallons) would decrease overall water supply requirements as well. Excessive lawn watering should be reduced by permitting watering only on certain days. More equitable rates for industrial water users could indirectly serve to enhance or protect water resources and their impact on safe yield should not be overlooked. By requiring water conservation devices and measures in plumbing codes, conservation could be made more effective to conserve and prolong the life of available water resources. For a more detailed discussion of the opportunities for reducing water consumption through conservation see "Water Conservation in Middlesex County " (March 1978).

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V. RECOMMENDATIONS FOR PROTECTING MIDDLESEX COUNTY'S GROUNDWATER RESOURCES

The urgency to protect the County's remaining critical environmental and cultural resources need not be overemphasized. It is evident from the previous discussion that several measures and techniques are currently available to protect surface and groundwater resources. It is the purpose of this section to present and discuss both general and specific methods suitable for maintaining the safe yield of the County's water resources.

A majority of the surface waters in the County with the exception of the Lawrence Brook and the Delaware and Raritan Canal, already have serious water quality problems and are unfit for potable water supply purposes. On the other hand most of the groundwater resources are still potable except those in the tidal zone and within specific portions of the Perth Amboy wellfields. As was described earlier groundwater resources need special measures for protection because once polluted they are difficult if not impossible to reclaim.

A. General Recommendations

A first step in this process of protecting the County's resource should be to map and delineate in detail such areas of concern. Areas with the greates concentration of environmental resources should be declared "conservation districts/critical areas". Utilizing municipal zoning powers these areas should then be designated as open space and conservation areas with strict development criteria and standards carefully enforced. In order to implement such a policy, a combined program of zoning, compensated regulation, public acquisition, conservation easements and transfer of development rights could be useful tools.

Flood plains and watershed lands should be included in such a mapping effort and designated as a water resource management area. Similarly woodlands marshlands, wetlands and unique natural and cultural sites should be also designated. If local municipalities choose to have stricter regulations then existing State regulations they should adopt such regulations under the State Charter. The following is a list of the actions which are recommended for immediate implementation.

- Utilizing municipal subdivision regulations/powers, groundwater recharge areas could be protected by establishing 50% open space requirements.

- No unsewered development should be allowed in aquifer recharge areas to protect water quality.

- Planned Unit Development regulations should require construction of recharge ponds when development takes place within recharge areas. These ponds should be carefully maintained to insure their recharge capacity.

- Building Construction Codes should be revised to encourage use of water conserving applicances and plumbing fixtures in new developments.

- Subdivision regulations and construction codes should encourage the use of porous parking lots to reduce urban runoff and pollution and increase infiltration.

- In order to protect water quality industrial plants within groundwater recharge areas and adjacent to water courses in the County should be identified and the type and amount of their waste effluent determined. Such an inventory is urgently needed to protect water resources from pollution.

- Ground and surface water quality should be monitored on a systematic and expanded scale with the cooperation of the NJDEP, U.S. Geological Survey, local water companies, sewerage authorities and municipalities. Such a program is essential to prevent future pollution and as a means of identifying existing pollution sources. Such a monitoring system would also act as an early warning system for the management of the County's water resources.

- Water withdrawals should be monitored on an annual basis with the safe yield of the aquifers confirmed periodically to account for land use changes. The County's monitoring program initiated by this study should be continued in the future and should provide a better understanding as to where we stand with respect to available water supplies and what specific programs are required to meet the future needs.

3. Specific Recommendations

The following discussion serves to outline specific recommendations for the maintenance of the quality and quantity of Middlesex County's aquifers and is based upon research carried out by this study supplemented by that of Middlesex County's Water Quality Management Program (October 1977).

1. Old Bridge Sand

During the last twenty years, development on the Old Bridge Sand recharge and watershed area for housing, commercial and industrial purposes has changed the character of the watersheds considerably. This region's ability to continue providing water supply is based increasingly on its ability to use the surface water flows in Prickett Brook, Tennant Brook, Deep Run, Manalapan Brook, Matchaponix Brook, Iresick Brook, Cedar Brook, and South River for recharge into the groundwater aquifers.

The potential loss of the Old Bridge Sand would not only affect Middlesex County but Monmouth County as well. While further development in the above noted watersheds may be necessary, all governmental agencies must be made aware of the importance of protecting and maintaining and quality of this natural resource. Until recently, the broad effects of new developments on watersheds have not been seriously considered.

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The water producing capacity of the Old Bridge Sand could be maintained and enhanced by the proper location of supply wells and recharge ponds. In order to assure the future water quality and supply of the area it is recommended that:

a. Watershed and floodplains of Tennant Brook, Deep Run, Prickett Brook, Iresick Brook, Manalapan Brook, Matchaponix Brook, Cedar Brook and the South River be declared multi-purpose resource conservation areas and be protected from development.

b. The rehabilitation and maintenance of Helmetta Pond and Lake Marquerite should be undertaken for both recreation and resource conservation purposes. These lakes once restored should be carefully protected from development to maintain groundwater and surface water quality.

c. Development of projects on the South River (the proposal for a South River Dam) or the Raritan River below the confluence with the South River (the Crab Island Dam) are designed to prevent brackish water from entering the Lower Raritan and South Rivers and would provide additional fresh water for recharge purposes and protect local area wellfields during low flow periods.

d. Location of industrial and commercial developments on the Old Bridge Sand and within the above watersheds should be carefully monitored for water pollution problem sources.

e. Surface and groundwater should be more fully monitored by the NJDEP and U.S.G.S., to act as an early warning system in the detection of pollutants entering the area's streams and groundwaters. Such an early warning system would allow steps to be taken to prevent pollutants from entering the groundwater system and immediately locate pollution sources so that remedial measures may be undertaken without delay.

f. Continuously monitor groundwater withdrawal from the Old Bridge and Farrington Sands so that total safe yield of the aquifers is not excee (Groundwater pumping data should be obtained from State files and private water users.)

2. Farrington Sand

As indicated earlier, the Farrington Sand is a major source of water suppl for East Brunswick, South Brunswick, Old Bridge, Perth Amboy, South River and Sayreville. At the present time groundwater withdrawal from the Farrington Sand amounts to more than 18.5 mgd while the safe yield is an estimated 16.2 mg (meaning that the safe yield of the Farrington Sand is being exceeded). In combination with increased pumping and reduced natural recharge due to urbani-

zation on the Sand, the water table in Farrington has declined and salt water intrusion has resulted. Due to the location of several wells in or near the tidal reaches of the South River and Raritan River and due to overpumping the salt water/fresh water interface has advanced some 1 to 2 miles inland. Several large wells in the Sayreville area have had to be abandoned due to high chloride contents.

In order to protect and manage the groundwater resources of the Farrington Sands it is recommended that:

a. Groundwater withdrawal from the Farrington aquifer be limited in the South River Basin area to its safe yield.

b. The recharge capacity of the aquifer should be maintained and enhanced. The following specific recommendations are offered:

   1. The natural recharge capacity of the aquifer can be maintained by keeping 40 to 50% of the total area in open space in a near natural condition. This would allow for natural and urban runoff to percolate and filter through the Sands thereby reducing the amount of pollutants that would reach the surface and groundwater system.

   2. Natural recharge can be augmented by providing artificial recharge basins or ponds adjacent to the location of pumping wells. Sawmill Brook, Bog Brook, Beaverdam Brook, Ireland Brook, Great Ditch and other smaller tributaries draining the Farrington should be protected from urbanization by their designation as resource conservation areas.

At the present time the above noted brooks drain into the Lawrence Brook system. As urbanization continues within this area these brooks will carry more runoff than at the present time in addition to carrying urban runoff pollutants. The natural groundwater recharge which would be lost due to land development could be compensated by providing well designed, operated and maintained retention basins and ponds. By proper coordination of wellfields and recharge ponds, it is estimated that the total productivity of the Farrington Sand could be increased in the same manner as the productivity of the Old Bridge Sand. Recharge ponds may also provide for a reduction in the pollution loads reaching the water supplies of the Lawrence Brook.

An exact estimation of potential recharge from these ponds is difficult to develop and would depend largely upon local geological conditions. On the basis of known hydrogeologic and soil characteristics and properties of the Farrington Sand however, it could be predicted that a 100 acre recharge basin within the Farrington Sand, when properly constructed and managed, could have a potential yield in excess of 5 mgd. The effectiveness of recharge ponds, howe would depend upon the groundwater table, the location of pumping wells and proper maintenance of the recharge basins.

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c. Existing and abandoned sand mining operations within the Farrington Sand outcrop area should be viewed with a new perspective for providing retention basins for storm runoff and recharge ponds for groundwater recharge. Instead of abandoning these areas after mining, provisions should be made to require 3 to 4 feet of sand bed to remain in each excavation for groundwaater recharge purposes. If properly managed these sand pits could provide for water pollution control, recharge and recreation. Such reclamation is already practiced in Wisconsin and other areas.

d. The U.S. Geological Survey is in the final stages of completing a digital simulation model of the Farrington aquifer which should be ready for use in 1979. This model has been developed on the basis of the present understanding fo the Farrington aquifer including a large number of existing well logs and pumping tests. The model has been calibrated by matching computed declines in the water level surface with actual measured water level changes. Such a model provides a method for predicting the effects of pumping new Farrington wells on regional water levels and is based largely on assumption that hydraulic properties of the aquifer will remain reasonably constant, although this may not prove to be the case.

This model may also provide a useful method for estimating the regional effects of proposed areawide Farrington diversions and as a means of evaluating individual Farrington diversion applications. However, in the event a new diversion is requested, specific information on the hydraulic properties of the aquifer will still have to be obtained by well testing. It is also expected that such a model will provide information on the effects of Farrington pumping on water levels in the Old Bridge, however, this will have to be verified by the measurement of groundwater leakage under controlled pumping test conditions. The model may not be capable of analyzing the effects of pumping on the intrusion of salt water into the Farrington although this can probably be analyzed indirectly from the results.

Efforts should be made to obtain access to such a model as soon as possible for use as a planning and management device. The County itself should look to developing the capability to use this type of tool on a continuous basis as part of an on-going management program involving the County, USGS and NJDEP.

3. Undifferentiated Sands

South and west of Jamesburg the Raritan formation is undifferentiated. Due to sparse population in the area at the present time, groundwater withdrawal from the Undifferentiated sands is relatively low. However, this sand extends approximately 40 square miles and has a potential safe yield estimated at 30+ mgd. A urbanization proceeds southward, groundwater will assume a greater inportance since much of the south County's water supply will likely be derived from these sands.[36]

Middlesex County has an estimated 43,000 acres of prime agricultural land in its southernmost region.[37] The Blueprint Commission has recommended that in order to preserve the productivity of the land for food production as well as to enhance the aesthetic quality of the County's environment, at least 70% of this prime agricultural land should be protected in perpetuity. This recommendation is consistent with maintaining the productivity of groundwater aquifers in the southern region of the County to supply anticipated water needs. It is recommended that the Alampi Commission's recommendations be adopted by the County and its municipalities to protect this valuable crop and water producing area of the County.

4. Brunswick Shale

As mentioned earlier, groundwater in the Brunswick Shale flows through cracks and fractures in the rocks and would not be as easy to provide for artificial recharge due to its relatively unpredictable geological character. However, in order to protect the existing groundwater supplies of the Brunswic Shale it is recommended that:

a. The portion of the Bound Brook watershed between Metuchen and South Plainfield be designated as conservation/open space, because it provides significant recharge to the Brunswick Shale and particularly the Middlesex Water Company's wellfield.

b. Within the remaining intake area at least 50% of any property to be developed should be left in open space to reduce urban runoff and to maintain minimum recharge to the Brunswick Shale.

c. Wastewater and other pollutants should not be discharged on the ground surface covered by the Brunswick Shale. (Water in this rock travels along the cracks at a rapid rate and has little opportunity to filter out pollutants). Once pollutants enter this formation it would make nearby wells unsuitable for any future use for long periods of time.

C. Additional Recommendations

At the State, county, and local level recognition has been given to the need to preserve the quality and quantity of this area's groundwater resources In bringing about a resolution of these concerns a number of specific actions are recommended. in order to achieve the goal of protecting groundwater resources. The following recommendations, developed as part of Middlesex County Water Quality Planning Program, have been included here because of their importance in protecting those groundwater resources relied upon by the County for supply purposes.

In view of the complexity of the groundwater management issue and the direct relationship between quality and quantity of supply, a number of management strategies should be considered in proceeding toward implementation of a groundwater plan for Middlesex County. The following policies and mechanisms are offered for county-wide application:

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1. Managing and Regulating Groundwater Diversions

a. County policies should be established to limit the total amount of groundwater diverted for potable use to the estimated safe yield of resources. The NJ Water Policy and Supply Council should be encouraged to grant diversions based upon the groundwater yield estimates prepared as part of Middlesex County's Water Quality Management study. The Council should also thoroughly review diversion rights (authorized and grandfathered) currently held to determine if revisions can or should be made in order to insure that groundwater use is maintained within safe yield limits.

b. It has been estimated that modest water savings could be achieved through such measures as the installation of water conservation devices and modification of water rate structures. Greater savings could be realized through the installation of water saving devices in new building construction as well as by retrofitting such devices in existing buildings. In order to achieve additional water use reductions a number of measures should be undertaken, including regulation, public education programs, and revisions to water pricing.

A further discussion on the opportunities and benefits of water conservation can be found in the County Planning Board report "Water Conservation in Middlesex County" (March, 1978).

c. A strict review process should be established to evaluate the impact of land use developments upon the availability and quality of groundwater supplies with a major focue on the extent to which proposed projects would contribute to the consumptive use of water.

d. A special provision of the Safe Drinking Water Act (PL 93-523) allows for the designation of important aquifers as sole source supplies. Both the Old Bridge and Farrington aquifers, by the nature of the reliance placed upon them, could be covered by this classification. Under the sole source amendment federally funded activities which threaten either the quality or quantity of water from these aquifers would be regulated under federal law. It is recommended that investigation of application be made to the federal government to seek sole source designation for the Farrington and Old Bridge aquifers, and that careful evaluation of the impacts and implications of such designation be carried out prior to actual application for such a designation.

e. One of the major benefits of a groundwater pumpage regulatory plan would be improved management of the salt water intrusion problem presently experienced in the region immediately south of the Raritan River. By reducing the Farrington pumpage in the Sayreville area the rate of water level drawdown presently experienced would be reduced and eventually stabilized. With stabilization,

there should be no further landward movement of salt water of any significance.

There are several structural methods to control salt water intrusion which should be considered futher. One method relies on a system of barrier wells that would be constructed in a line parallel to the salt water interface. These wells would recharge fresh water into the Farrington aquifer at a rate that would essentially balance or stabilize the landward movement of salt water. One source of water might be treated effluent from the Middlesex County Sewerage Authority, however, this would require a level of treatment that would satisfy all public health requirements. Another method would rely on a similar group of barrier wells that penetrate both the Old Bridge and Farrington aquifers. The wells, open to both units would recharge water into the Farrington aquifer from the Old Bridge by gravity flow and would require development of recharge facilities.

All new groundwater diversions including those less than 100,000 gpd should become subject to County regulation as a means of maintaining a stricter control over the safe yield of the County's aquifers.

f. The U.S. Geological Survey has completed development of a two-dimensional digital simulation model of the Farrington aquifer which should by ready for use in 1979. This model has been developed on the basis of the present understanding of the Farrington aquifer including a large number of well logs and pumping tests.

Such a model may provide a useful method for estimating the regional effects of proposed Farrington diversions including evaluation of individual Farrington diversion applications. The model was utilized to evaluate the impacts of 1978 diversion applications of East Brunswick and Monroe Townships. It is expected that a three dimensional model will be developed soon which will provide information on the effects of Farrington pumpage on water levels in the Old Bridge Sands. This aquifer interdependence will have to be verified by measurement of groundwater leakage under controlled pumping test conditions. The model will not be capable of directly analyzing the effects of pumping on the intrusion of salt water into the Farrington although the characteristics could be inferred indirectly from the results.

2. Protection of Groundwater Recharge

a. The maintenance of a continuous supply of groundwater requires that existing patterns and rates of groundwater recharge continue to be maintained. With the extent of impervious surfaces in the County continuing to expand, reductions in groundwater recharge will inevitably result. Any efforts towards implementation of a recharge maintenance program should be concentrated in those locations that will be developed as major water supply centers. In this case the objective is to maintain or augment the present level of groundwater recharge. As artificial recharge is practiced on a wider scale, efforts will have to be made to preserve the quality of the water used for recharge. To achieve this it will be necessary to implement a surface and groundwater quality monitoring program in the vicinity of all surface water recharge sources. In addition, more stringent regulation of point and non-point source upstream of the artificial recharge facilities will be required. Any changes in either the pattern or rate of recharge indicated by the monitoring program should be remedied promptly to insure that an efficient degree of recharge is maintained. Such a program should also provide for the control of undesirable inflows to the recharge basins.

At the present time there is sufficient surface water flow in the major basins to satisfy the requirements of existing artificial recharge facilities. However, as consumptive uses of water increase over the entire County (especially with the development of a regional sewer system) less water will be available for stream flow. Further studies to determine the impact of future development on surface water availability are recommended, however initial indications suggest that continuing reductions in surface water quantity may result.

The concept of establishing groundwater protection zones in the vicinity and upstream of major recharge facilities has been described more fully in the County's Water Quality Management Plan report but can be characterized generally as a number of measures designed to insure that sufficient amount of high quality water is recharged to the groundwater system. Specific land use restrictions in these areas and the exact locations of those controls have not yet been established. In the event that this groundwater protection concept is adopted, it would be necessary to institute design criteria for such mechanisms in accordance with local conditions. The objective in each area would be to control the location of all pollution sources (both point and areawide) to the extent that they would be completely isolated from the groundwater system.

b. Efforts should be made to preserve natural recharge areas to the greatest extent possible. Studies necessary to identify the extent of the recharge areas in relation to existing and proposed well locations should be initiated to include: identification of specific well locations and pumpage rates; calculation of areas of influence of wells identified; determination of permeable soils underlain by groundwater in the area of influence; recharge rates; degree to which recharge required can be maintained with or without coverage of the recharge area; the balance between recharge and withdrawal required to maintain the supply source within safe yield limits.

c. Any development that would result in a net reduction in the natural recharge rate should be discouraged. Artificial recharge facilities should be developed that would augment surface water recharge to the aquifer within the limit of the outcrop and recharge protection area. All new development and activities within the outcrop should be reviewed from the standpoint of their effects on the rate and quality of groundwater recharge.

d. A major effort should be made to retain as much surface water as possible within recharge areas to provide the necessary recharge. This would call for a variety of steps ranging from the on-lot control of surface runoff, the use of sumps and catchment basins, porous pavement and other similar measures. Local subdivision regulations and construction codes should be amenced to encourage these types of practices. Although each of these approaches would clearly be beneficial, they require full evaluation by field demonstration studies before being put into wide practice. Corresponding to the need for retaining as much high quality surface water as possible in the basin, efforts should also be made to retard the recharge of poor quality water.

3. Groundwater Quality Maintenance

The continued availability of groundwater in the County is greatly dependen upon the maintenance of water quality recharged to the aquifers. Although this is a major concern at the present time, it will become even more critical as further land development occurs and waste disposal activities arise. The following recommendations center upon groundwater pollution that occurs as a result of land development and waste disposal practices and the water quality problems that result when well locations and pumping patterns insufficiently account for the movement of pollutants in the groundwater system.

a. Controlling the further leakage of landfill leachates into the groundwater system is perhaps the most difficult of the water pollution control problems in Middlesex County. A program to identify the types of waste products disposed at each site and the disposal rates should be initiated for all existing and former landfills in the County. Test drilling should be undertaken at each location to monitor the presence and movement of leachate

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and to determine whether a leachate plume has entered the local groundwater flow system. Where plumes have formed, additional steps must be taken to map the local patterns of groundwater flow and to determine whether the leachate is moving in the direction of critical wellhead locations and at what rate this movement is occurring. Where leachate has entered the groundwater system a leachate abatement program should be undertaken, which often involves the installation of a scavenger well system to collect the leachate and discharge it into either a treatment and disposal facility or into the regional sewer system.

All new landfills will be constructed in accordance with New Jersey standards and therfore must be sufficiently removed from existing or proposed groundwater supply sources to be minimized as a pollution threat. All landfills should be provided with an impervious underliner and leachate collection system designed to trap and collect all leachate that forms. Futhermore, new landfills should be discouraged from locating in critical aquifer recharge/outcrop areas in order to insure that maximum water quality protection is afforded.

b. An extensive County-wide inventory of industrial liquid waste lagoons should be carried out to determine more precisely the location of such lagoons, the nature of the liquid waste contents and the likelihood that leakage of such wastes will occur into the groundwater system. Problem lagoons (those exhibiting or having potential for seepage into the groundwater system) should either be eliminated or reconstructed using impervious liners. As with landfills, new lagoons should be located far enough away from all existing and proposed water supply sources to minimize the risk of water pollution affecting such supplies. Permits for the installation of lagoons should indicate the disposal products with the final design appropriate for the types of waste products and quantities disposed. The lagoons should normally be lined and provided with a monitoring system to detect seepage. Permits should be issued for the use of such facilities and efforts should be made to inspect them on a regular basis. In some instances an outright ban on the disposal of toxic and hazardous wastes may be required.

c. Product storage areas should be precisely inventoried and an effort made to locate sites that are potential or probable contributors to groundwater contamination. Problem sites (those whose contaminated runoff enters the groundwater system) located within an aquifer outcrop or recharge area should be eliminated or reconstructed using an impervious base and sidewalls with an isolated catchbasin. Problem sites should be identified and areas of groundwater contamination pinpointed. Product storage and handling should be conducted in paved areas where all drainage would be collected. to the extent possible, product storage areas should be fully enclos

d. Accidental spills and the mishandling of industrial products are a major source of groundwater pollution. The only effective control methods are control and cleanup contingency plans developed to deal with such events. The handling of toxic and hazardous materials should be prohibited in designated aquifer recharge protection zones.

e. Sections of many sanitary sewer systems are presumed to leak because of their age and depth relative to the water table and also because of the fact that many carry industrial wastes. Efforts should be made to identify those sections of the system that are most likely to be leaking. Such areas should receive detailed inspections with defective sections repaired or replaced Special efforts should be made to locate leaking sections that have the potential of affecting groundwater quality in areas adjacent to existing or proposed wellfields. Part of the investigative process should include efforts to identify the chemical nature of the industrial products discharged to the sewer system. Such a program would provide an indication of those sections of the system that are likely to have the most severe impacts on groundwater quality. Furthermore, all new sewers should be built to standards that minimize exfiltration. Where new sewers are located in close proximity to existing or proposed groundwater diversion points, construction should be fully water tight.

All new pipeline installations which transport hazardous and toxic substances should install leak detection systems and automated cutoff valves that would be used to insolate leaky sections. To the extent possible, such pipelines should not be located in the vicinity of existing or proposed groundwater diversion points.

f. A septic tank suitability map of the County should be prepared which reflects such natural factors as the soil percolation rate, slope, water table elevation, cation exchange capacity of the soil the presence and thickness of important aquifers and recharge areas. Such a map should also indicate such physical limitations as existing supply wells (both public supply and private) and areas that have already exhibited water quality limitations. The decision whether or not to use on-site waste disposal, and if so what type and at what density would be governed by the site limitations indicated by the map. Under this program decisions on septic tank siting would no longer be based solely upon the percolation rate of the soil and lot size.

g. County-wide monitoring and surveillance program should be undertaken to include the location of groundwater sampling points in the vicinity of known and potential pollution sources and at major public and industrial supply wells.

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VI. NEXT STEPS

The preceding chapter outlined a number of specific actions which could and should be taken by the County and its municipalities as a means to begin addressing critically important and largely overlooked problems affecting the County's groundwater resources. However, in order to achieve implementatio of these recommended actions and to arrive at a more systematic and coordinated approach to the problems outlined by this report the following next steps are presented.

1. Meetings should be held at which the affected municipalities, Counties and the State can discuss these recommendations and approaches available for addressing groundwater protection requirements.

2. An investigation should be made of the feasibility of developing legislation permitting the implementation of a coordinated land use development regulatory program in critical areas (such as groundwater recharge areas) and should include investigation of:

   a. Transfer of development rights.

   b. Expanded Planned Unit Development controls.

   c. Consistency requirements for local comprehensive planning with County and State planning.

   d. The creation of County "development authorities" with the power to bond for the acquisition of land for resource conservation and open space purposes, and directly influencing land development patterns.

3. The Middlesex County Planning Board should undertake the preparation of detailed drainage basin studies to:

   a. Identify suitable locations for detention, retention and recharge basins

   b. The identification of pollution sources

   c. Recommend water quality monitoring sites

   d. Recommend programs to improve and maintain water quality and overall supply

4. Middlesex County should continue development of county-wide water supply, conservation and wastewater management programs.

FOOTNOTES

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8. Ibid., pp. 54.

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22. The safe yield of the Farrington Sand may actually be less than 16.2 mgd due to the encroachment of salt water from the Washington Canal area.

23. These are wells which were in operation prior to the enactment of the 1952 regulation requiring State licencing and reporting of all wells in excess of 70 gpm capacity.

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APPENDICES

GLOSSARY OF TERMS

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GLOSSARY OF TERMS

Alkaline	Water or soils in which a sufficient amoun of alkali substances are present to raise the pH value above 7.0.
Aquiclude	A layer of material with low permeability, which can absorb water but cannot transmit it at a rate sufficient for economic extraction by wells; (clay beds are an example).
Aquifer	A layer of material capable of storing and transmitting water at a rate sufficient for water supply purposes; (most sand and gravel beds are examples).
Aquifuge	An impermeable geological formation neithe storing nor transmitting water; (granite is an example).
Artesian aquifer	An aquifer in which water is under sufficient pressure to cause it to rise above the zone of saturation at that place if an opportunity were afforded.
Artesian groundwater	Groundwater confined under an aquiclude or an aquifuge, so that water rises in a nonpumping well which penetrates it.
Artificial recharge	The addition of water to the groundwater reservoir by artificial means such as irrigation or induced infiltration from streams, wells, ponds or spreading basins.
Average annual yield	The average annual supply of water produce by a given stream or aquifer over a period of time.
Base flow	That portion of the stream discharge which is derived from groundwater outflow or other sources outside the net rainfall whi provided the surface runoff.
Catchment area	The intake area of an aquifer and all areas that contribute surface water to the intake area.

Cone of influence	The depression, roughly conical in shape, produced in a water table or other piezometric surface, by the extraction of wate from a well at a given rate. The extent of the cone will vary with the rate of withdrawal of water. Also called cone of depression.
Confined aquifer	An aquifer which is bounded above and below by formations of impermeable or relatively impermeable materials.
Consumptive use	The quantity of water transpired and evaporated from soil and plant cover.
Contamination	Impairment of the quality of water resour by sewage, industrial waste or other matt to a degree which can create hazards to public health.
Critical area	An area where the use of groundwater is approaching a use equal to the current recharge rate or has already exceeded it.
Depletion (groundwater)	The withdrawal of water from groundwater sources at a rate greater than its rate of replenishment ususally occurring over an extended period of years.
Detention dam	A dam constructed for the temporary stora of flood flows where the opening for release is of fixed capacity and not manual operated.
Direct runoff	The runoff entering stream channels after rainfall or snow melt. Superimposed on bare runoff, it forms a bulk of the hydrograph of a flood.
Discharge	In its simplest concept, it means outflow
Dissolved oxygen	The amount of free oxygen (not chemically combined) in water. Usually expressed in milligrams per liter.
Dissolved solids	Solids which are present in solution.
Domestic water use	The use of water primarily for household purposes, (bathing, cooking, cleaning) the irrigation of gardens, lawns, shrubbery, surrounding a home.

Drainage area	The drainage area of a stream at a specified location in that area, measured in horizontal plane, enclosed by a drainage divide. It is expressed in acres, square miles or square kilometers.
Drainage water	Water which has been collected by a drain system. It may derive from surface water or from water passing through soil. May be of a quality suitable for reuse or it may be of no economic use at the time and place of its occurrence. In the later case, it becomes wastewater.
Drawdown	The lowering of the surface elevation of a body of water, the water table, the wat surface of a well, or the piezometric surface adjacent to the well, resulting from the withdrawal of water therefrom.
Effective porosity	The ratio, usually expressed as a percent of the volume of water (or other liquid) which a given saturated volume of soil will yield under any specified hydraulic condition, to the given volume of soil.
Effluent streams	Streams which intersect the water table and receive flow from groundwater.
Ephemeral stream	A stream that flows only in a direct response to precipitation and discontinues its flow during dry periods. Its channel is above the level of the water table.
Equilibrium drawdown	The ultimate, constant drawdown for a ste rate of pumped discharge.
Equi-potential line	A line in a field of flow, such that the total head is the same for all points on the line, and therefore the direction of flow is perpendicular to the line at all points.
Eutrophication	The process of overfertilization of a bod of water by nutrients which produce more organic matter than the self-purification process can overcome.
Evaporation	The process by which water is changed fro the liquid or solid state into the vapor state below the boiling point.

Evaporation rate	The quantity of water expressed in terms of depth of liquid water, which is evaporated from a given surface per unit of time. It is usually expressed in inc or millimeter depth per day, month, or year.
Evapo-transpiration	The volume of water evaporated and transpired from soil and plant surfaces; (essentially the same as "consumptive use" except for the water retained within the plant tissue).
Excess rain	Effective rainfall in excess of infilter ation capacity.
Firm yield	The maximum annual supply of a given wat development that is expected to be avail on demand, with the understanding that lower yields will occur in accordance wi a predetermined schedule or probability.
Flood	An overflow or inundation that comes fro a river or other body of water and cause and threatens damage. A relatively high flow as measures by either gage height c discharge quantity.
Flood plain	An area of relatively level land or plai bordering a stream, built of sediments carried by the stream and dropped in the slack water beyond the influence of the swiftest current. It is called a water flood plain if it is overflowed ir times of high water; but a fossil flood plain if it is now beyond the reach of t highest flood.
Flowing resource	A resource which is replaced such as ai water resources.
Flowing well	A well tapping an artesian aquifer, in water is under sufficient pressure to cause it to rise above the ground surfa
Glacial drift	Material which has been deposited by a glacier or in connection with glacial p cess. Consisting of rock flour, sand, bles, cobbles and boulders, it may occu hetrogeneous mass or be reasonably well sorted, depending upon its manner of deposition.

Groundwater	Water in the ground that is in the zone of saturation from which wells, springs and groundwater runoff are supplied.
Groundwater mining	Pumping groundwater from a basin where the safe yield is low, thereby pumping water from storage. Takes place when withdrawals exceed replenishment or when recharge is negligible.
Groundwater overdraft	Pumpage of groundwater in excess of safe yield.
Groundwater recharge	Inflow to a groundwater reservoir.
Groundwater runoff	That part of the runoff which has passed into the ground, has become groundwater a has been discharged into a stream channel as spring or seepage water.
Groundwater storage capacity	The reservoir space contained in a given volume of deposits.
Hydraulic permeability	The flow of water through a unit cross-sectional area of soil normal to the direction of flow when the hydraulic gradien is unity.
Hydrologic budget	An accounting of inflow to, outflow from and storage in a hydrologic unit such as drainage basin, aquifer, soil zone, lake, reservoir, or irrigation project.
Hydrologic cycle	The complete cycle through which water, commencing as atmospheric water vapor, pa into a liquid and solid form as precipita then along or into the ground surface fin returning to the form of atmospheric wate vapor by means of evaporation and transpiration. Also called the water cycle.
Impervious material	A term applied to a material through whic water cannot pass. (See also aquiclude and aquifuge).
Incidental recharge	Groundwater recharge that takes place uni tentionally as a by-product of man's use water (i.e. irrigation) which would not have been rechargednatually.

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Infiltration	The flow of fluid into a substance through pores or small openings. It connotes flow into substance in contradiction to the work percolation, which connotes flow through a porous substance.
Infiltration capacity	The maximum rate at which soil, when in a given condition, can absorb rain or snow
Infiltration rate	The rate, usually expressed in cubic feet per second or million gallons per day per mile of waterway, at which groundwater enters an infiltration ditch or gallery, drain, sewer or other underground conduit
Influent streams	Streams which contribute flow to the groundwater. Also called losing streams.
Interference (wells)	A change in the water level of one well caused by the pumping at another well.
Leaching	The removal of soluble constituents from soils or other material by infiltrating or percolating water.
Observation well	A nonpumping well used for observing the elevation of the water table or the piezometric surface.
Overdraft	The quantity of water pumped in excess of the safe yield.
Percolation	The movement, under hydrostatic pressure, of water through the interstices of a rock or soil.
Percolating water	Those waters which pass through the ground beneath the earth's surface without a definite channel and not shown to be supplied by a definite flowing stream. The presumption is that groundwaters are percolating.
Percolation rate	The rate, usually expressed as a velocity at which water moves through saturated granular material. The term is also applied a quantity per unit time of such movement Has been used erroneously to designate infiltration rate or infiltration capac

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Perennial yield	The amount of usable water in a groundwate reservoir that can be withdrawn and consumed economically each year for an indefinite period of time. It cannot exceed the natural recharge to that groundwater reservoir and is ultimately limited to the maximum amount of discharge that can be utilized for beneficial use.
Safe yield	With reference to either a surface or groundwater supply, the rate of diversion or extraction for consumptive use which can be maintained indefinitely, within the limit of economic feasibility, under speci fied conditions of water supply developmen (See also Perennial yield).
Salinity	The relative concentration of salts, usual sodium chloride, in a given water.
Salt water barrier	A physical facility or method of operation designed to prevent the intrusion of salt water into a body of fresh water.
Salt water intrusion	The phenomenon occurring when a body of salt water, because of its greater density invades a body of fresh water. It can occur either in surface or groundwater systems.
Secondary porosity	Results from fractures and solution channe.
Seepage	The slow movement of water through small cracks, pores, interstices of a material into or out of a body of surface or subsurface water. It is generally expressed as flow volume per unit time.
Specific capacity of a well	The rate at which water may be drawn from a formation through a well to cause a drawdown of a stipulated depth. Measured in gallons per minute per foot.
Specific yield	The quantity of water that a unit volume of permeable rock or soil, after being saturated, will yield when drained by gravi It is expressed as a ratio or precentage of volume.

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Subsurface water	All water below the land surface, includi soil moisture, intermediate zone water, capillary fringe water, and groundwater.
Transmissibility	The flow capacity of an aquifer in gallon per day per foot width, equal to the prod of permeability times the saturation thic ness of the aquifer.
Transmissibility coefficient	The number of gallons of water per day th percolate under prevailing conditions through each square mile of water bearing bed for each foot thickness of bed. It i the product of field coefficient of permeability in units of gallons/day/square mile multiplied by thickness of the bed in feet.
Water spreading	Controlled application of water to the land for the purpose of recharging ground water aquifers.
Water table	The upper surface of a zone of saturation where the body of groundwater is not confined by an overlying impermeable formati Where an overlying confining bed exists, the aquifer in question has no water tabl
Well capacity	The maximum rate at which a well will yie water under a stipulated set of condition such as a given drawdown, pump capacity, etc. It can be expressed in gallons per minute or cubic feet per second.
Well field	A tract of land containing a set number of wells for supplying a municipality, industry or irrigation district.
Well hydrographs	A graphical representation of fluctuations of the water surface in a well plotted against time.
Well interference	The effects of neighboring pumping wells c discharge and drawdown at a particular wel
Yield	The quantity of water expressed either as a continuous rate of flow (cubic feet per second, million gallons a day, etc.) or as a volume per unit of time (acre feet per year, etc.) which can be collected for a given use or uses from surface or groundwater sources in a watershed.

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Stock resource	Resources which are capable of being consumed.
Permeability	The ability of material to transmit fluid through its poreswhen subjected to a difference in pressure.
Permeability coefficient	The rate of flow of a fluid through a cross section of porous mass under a unit hydraulic gradient, at a temperature of 60°F. Field coefficient of permeability is defined as the rate of flow of water, (in gallons per day) under prevailing conditions, through each foot of thicknes of a given aquifer at a width of 1 mile, for each foot per mile of hydraulic gradi
Piezometric surface	An imaginary surface that everywhere coin cides with the static level of water in a aquifer or artesian basin. It is a surfa to which the aquifer or basin would rise if afforded an opportunity to do so.
Pollution	The alteration of the physical, chemical or biological properties of water or a discharge of any substance into water whi adversely affects the legitimate benefici water use.
Porosity	The ratio, usually expressed as a percentage, of volume of the interstices in a given quantity of material to the total volume of the material. It is an index of the void characteristics of a soil or stratum as pertaining to percolation.
Reservoir	A pond, lake, or a basin, either natural or artificial, for the storage, regulatio and control of water.
Retention	That part of the rainfall which is intercepted, stored, or delayed, and thus fail to reach the concentration point by eithe surface or subsurface routes during the time period under consideration.
Storage coefficient	A cubic foot of water discharged from a vertical column 1 foot square as the wate level drops 1 foot.

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EXTENT OF GROUNDWATER RECHARGE AND URBANIZED AREAS

Methodology for Measurement

U.S. Geological Survey quadrangles (7.5 minute maps) were utilized for the mapping and estimation of recharge areas. On these maps 1 kilometer U.T.M. grids were first plotted. The hydrogeological map from the Barksdale report was then project onto this map and the boundaries of each of the aquifers were plotted. Later, utilizing the Middlesex County Soils Map (1953), these boundari were modified to include all other recharge areas. It should be noted that the effective recharge area of the Old Bridge and Farrington Sands are larger than the outcrop alone.

Once this area was plotted it was then measured by using the point area measurement technique. This technique is a simple method in which an aerograph chart is placed over the area to be measured, a scattering of dots are counted for the area in question and multiplied by a factor of 0.918274 to arrive at the number of acres for the area measured. In this simple manner the recharge areas of the Raritan and Newark group formations were estimated.

In order to estimate the extent or urbanization on each of the recharge areas land use maps and 1973 aerial photographs of the County were utilized.

The developed area was measured using the same aerograph chart while the paved area was measured by using aerial photographs. For sparsely developed areas housing units were counted and multiplied by 2000 square feet. The product was then divided by 43,560 to get the number of acres of paved surface. Paved area measurement for the more intensely developed area was measured off the map and multiplied by an average paved percentage factor. The extent of development is shown on Figure 3.

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TABLE C-1

Groundwater Pumpage in Middlesex County 1950 - 1975[1]

Old Bridge Sand - (million gallons/day)

Public Water Supply	1950	1960	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
New Jersey Water Co.	0.108	0.210	0.296	0.345	0.360	0.404	0.424	0.389	0.375	0.390	0.422	0.430	0.432
Monroe M.U.A.	--	--	--	--	--	0.037	0.118	0.204	0.273	0.266	0.239	0.333	0.138
Sayreville Water Dept.	0.842	1.297	1.913	2.236	2.415	2.405	3.121	2.668	2.575	2.875	3.132	3.208	3.375
Helmetta Water Dept.	0.010	0.009	0.010	0.011	0.009	0.009	0.013	0.012	0.013	0.013	0.012	0.013	0.013
South Amboy Water Dept.	0.500	0.555	0.562	0.541	0.526	0.465	0.527	0.655	0.668	0.448	0.460	0.503	0.532
Old Bridge M.U.A.	0.054	0.314	0.639	0.437	0.622	0.727	0.895	1.310	1.380	1.457	1.465	1.550	1.463
Perth Amboy Water Dept.	6.206	6.800	7.332	6.901	7.199	7.297	7.839	7.578	7.251	6.522	5.368	6.975	6.271
South River Water Dept.	0.046	0.074	0.112	0.120	0.112	0.119	0.119	0.127	0.133	0.136	0.141	0.140	0.140
Spotswood Water Dept.	--	0.228	0.368	0.396	0.434	0.492	0.525	0.601	0.605	0.614	0.645	0.656	0.605
TOTAL Public Water Use	7.766	9.487	11.232	10.987	11.677	11.955	13.581	13.544	13.273	12.721	11.884	13.808	12.969
Industrial Supply[2]													
Duhernal Water System	12.531	14.783	14.142	14.813	14.766	14.647	14.840	13.247	12.629	13.478	13.048	12.285	10.828
Kerr Glass Co.	--	--	0.118	0.107	0.112	0.090	0.052	0.068	0.112	0.121	0.137	0.099	0.057
Anheuser Busch Co.	--	0.355	0.448	0.598	0.478	0.429	0.419	0.446	0.795	0.922	0.979	1.022	1.055
P.J. Schweitzer Co.	--	2.691	2.778	2.778	2.778	2.778	3.555	3.285	3.179	3.027	2.923	3.169	3.190
BASF	--	--	--	--	0.030	0.033	0.055	0.089	0.335	0.268	0.149	0.113	0.089
Cities Service R & D	--	--	--	--	--	0.079	0.161	0.194	0.156	0.160	0.127	0.161	0.120
TOTAL Industrial Water Use	12.531	17.829	17.486	18.296	18.164	18.056	19.082	17.329	17.206	17.976	17.363	16.849	15.339
TOTAL Old Bridge Use	20.297	27.316	28.718	29.283	29.841	30.011	32.663	30.873	30.479	30.697	29.247	30.657	31.269
Percent Public Use	38.3	34.7	39.1	37.5	39.1	39.8	41.6	43.9	43.5	41.4	40.6	45.1	41.5
Percent Industrial Use	61.7	69.3	60.9	62.5	60.9	60.2	58.4	56.1	56.5	58.6	59.4	54.9	58.5

[1] All figures based on quarterly reports to the NJDEP - Bureau of Water Allocation(1977).

[2] Estimated industrial demand south of the Raritan River.

TABLE C-2

Groundwater Pumpage in Middlesex County 1950 - 1975[1]
Farrington Sand (million gallons/day)

Public Water Supply	1950	1960	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
Cranbury Water Dept.	0.057	0.081	0.122	0.141	0.118	0.123	0.121	0.131	0.149	0.139	0.134	0.123	0.122
East Brunswick Water Dept.	0.226	1.195	1.221	1.458	1.695	1.932	2.169	2.406	2.505	2.604	2.703	2.802	2.900
Forrgate Water Co.	--	--	0.019	0.227	0.275	0.272	0.241	0.269	0.324	0.350	0.419	0.483	0.730
Helmetta Water Dept.	0.010	0.009	0.010	0.011	0.009	0.009	0.013	0.012	0.013	0.013	0.012	0.013	0.013
Old Bridge M.U.A.	0.093	0.534	1.087	0.745	1.060	1.237	1.523	2.231	2.349	2.481	2.495	2.640	2.492
Perth Amboy Water Dept.	2.295	2.515	2.712	2.553	2.663	2.699	2.887	3.248	3.108	2.680	2.301	2.348	2.687
Sayreville Water Dept.	0.093	0.144	0.213	0.249	0.268	0.267	0.347	0.296	0.286	0.319	0.348	0.356	0.375
South Amboy Water Dept.	0.500	0.555	0.562	0.541	0.526	0.465	0.527	0.655	0.668	0.448	0.460	0.503	0.532
So. Brunswick Water Dept.	--	0.358	0.757	0.816	0.875	0.934	0.993	1.052	1.186	1.319	1.453	1.586	1.720
South River Water Dept.	0.413	0.666	1.008	1.076	1.004	1.072	1.069	1.146	1.197	1.226	1.268	1.264	1.271
TOTAL Public Water Use	3.687	6.057	7.711	7.817	8.493	9.010	9.890	11.446	11.785	11.579	11.593	12.118	12.842
Industrial Supply[2]													
BASF	--	--	--	--	0.069	0.077	0.129	0.207	0.781	0.625	0.347	0.299	0.207
Cities Service R & D	--	--	--	--	--	0.004	0.008	0.010	0.008	0.008	0.007	0.009	0.006
Crefco Inc.	--	--	--	--	--	0.121	0.156	0.175	0.184	0.247	0.170	0.119	0.109
P.J. Schweitzer Co.	--	2.202	2.773	2.273	2.273	2.273	2.344	2.688	2.601	2.477	2.392	2.628	2.610
Anheuser Busch Co.	--	0.721	0.800	0.821	0.819	0.912	0.909	1.213	0.795	0.922	0.979	1.022	1.055
Midcoast Anodizing Corp.	--	--	0.058	0.082	0.107	0.099	0.104	0.074	0.099	0.068	0.055	0.030	0.045
TOTAL Industrial Use	0.0	2.923	3.131	3.176	3.268	3.486	3.650	4.367	4.468	4.347	3.950	4.107	4.032
TOTAL Farrington Use	3.687	8.980	10.842	10.993	11.761	12.496	13.573	15.813	16.253	15.926	15.543	16.225	16.874
Percent Public Use	100.0	67.4	71.1	71.1	72.2	72.1	72.9	72.4	72.5	72.7	74.6	74.7	76.1
Percent Industrial Use	0.0	32.6	28.9	28.9	27.8	27.9	27.1	27.6	27.5	27.3	25.4	25.3	23.9

[1]All figures based on quarterly reports to the NJDEP - Bureau of Water Allocation (1977).

[2]Estimated industrial demand south of the Raritan River.

TABLE C-3

Groundwater Pumpage in Monmouth County - 1975
Old Bridge Sand (million gallons/day)[1]

Public Water Supply	1975
Cliffwood Water Co.	0.5
Matawan Township	0.6
Keyport Water Dept.	1.4
Matawan Borough	1.0
West Keansburg Water Co.	1.8
Matawan Twp. M.U.A.	1.1
Union Beach Water Dept.	0.3
Keansburg Water Dept.	1.8
Monmouth Consolidated	1.2 (est.)
Atlantic Highlands	0.6
Red Bank Water Dept.	0.9 (est.)
TOTAL PUBLIC USE	11.2

[1]Figures based on estimates provided by the Tri-State Regional Planning Commission (May 1978).

INSERT D

ASSUMPTIONS FOR GROUNDWATER PATHWAY

Assume: 8038 population between 1/2 and 1 mile from site is representative of Middlesex area.

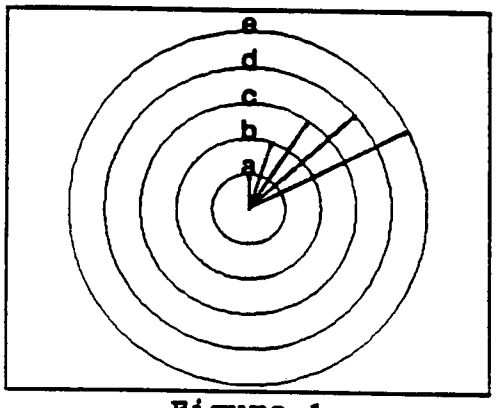

Figure 1

a = 1/2 mile
b = 1 mi
c = 2 mi
d = 3 mi
e = 4 mi

Area in 1/2 to 1 mile ring equals area in 1 mile ring minus area in 1/2 mile ring.

$A = \pi r^2$

$A_{ab} = \pi b^2 - \pi a^2$

$= \pi\ (1\ mi)^2 - \pi\ (0.5\ mi)^2$

$A_{ab} = 2.36\ mi^2$

Population (FBDU, 1979)

P_b = 0 - 1/2 mi. = 1690 people
P_{ab} = 1/2 - 1 mi. = 8038 people

Population Density = 8038 people/2.36 mi^2
= 3411.43 people/mi^2

Area for Each Ring:

$A_{bc} = \pi c^2 - \pi b^2$
$= \pi\ (2\ mi)^2 - \pi\ (1\ mi)^2$

$A_{bc} = 9.42\ mi^2$

$A_{cd} = \pi d^2 - \pi c^2$
$= \pi\ (3\ mi)^2 - \pi\ (2\ mi)^2$

$A_{cd} = 15.71\ mi^2$

$A_{de} = \pi e^2 - \pi d^2$
$= \pi\ (4\ mi)^2 - \pi\ (3\ mi)^2$

$A_{de} = 21.99\ mi^2$

Population (P):

Population from 0 - 1/4 mile equals P_a:

$$P_a = P_b\left(\frac{\pi(0.25mi)^2}{\pi(0.50mi)^2}\right)$$

$= 1690\ (0.25)$
$P_a = 423$ people

Population from 1/4 to 1/2 mile equals P_{ab}:

$P_{ab} = 1690 - 423$
$P_{ab} = 1267$ people

Population in outer ring:

$P_{bc} = (3411.43\ \text{people/mi}^2)(9.42\ \text{mi}^2)$
$P_{bc} = 32{,}136$ people

$P_{cd} = (3411.43\ \text{people/mi}^2)(15.71\ \text{mi}^2)$
$P_{cd} = 53{,}594$ people

$P_{de} = (3411.43\ \text{people/mi}^2)(21.99\ \text{mi}^2)$
$P_{de} = 75{,}017$ people

80% of water is supplied from surface water (Personal telephone communications, Mr. Sedowski, Elizabethtown Water Company). Assume remaining 20% of people get drinking water from groundwater. This is believed to be a conservative estimate of the number of people who obtain water from groundwater supplies.

Therefore,

0 - 1/4 mi:	(423)(0.20)	=	858 people
1/4 - 1/2 mi:	(1267)(0.20)	=	253 people
1/2 - 1 mi:	(8038)(0.20)	=	1,608 people
1 - 2 mi:	(32,136)(0.20)	=	6,427 people
2 - 3 mi:	(53,594)(0.20)	=	10,719 people
3 - 4 mi:	(75,017)(0.20)	=	15,003 people

REFERENCE:

Ford, Bacon, and Davis Utah Inc. (FBDU), Environmrntal Analysis of the Former Middlesex Sampling Plant and Associated Properties, Middlesex, New Jersey, July 1979.

Date: 080528

~~D78816~~

This chart provides guidelines to assist you in hypothesizing the presence of a suspected release and identifying primary targets. It is not all of this information will be available during the PA. Also, these criteria are not all-inclusive; list any other criteria you use to suspected release or to identify primary targets. This chart will record your professional judgment in evaluating these factors.

The "Suspected Release" section of the chart guides you through evaluation of some site, source, and pathway conditions to he whether a release from the site is likely. If a release is suspected, use the "Primary Targets" section to guide you through eve conditions that will help identify targets likely to be exposed to hazardous substances. You may use this section of the chart mr depending on the number of targets you feel may be considered "primary." In the "Primary Targets" section on this sheet, record for the well that you feel has the highest probability of being exposed to hazardous substances.

Check the boxes to indicate a "yes", "no", or "unknown" answer to each question. If you check the "Suspected Release" box as "ye that you assign a Likelihood of Release value of 550 for the pathway.

GROUND WATER PATHWAY

SUSPECTED RELEASE

Yes	No	Unknown	
☐	☒	☐	Are sources poorly contained?
☐	☒	☐	Is the source a type likely to contribute to ground water contamination (e.g., wet lagoon)?
☒	☐	☐	Is waste quantity particularly large?
☐	☒	☐	Is precipitation heavy and infiltration rate high?
☐	☒	☐	Is the site located in an area of karst terrain?
☐	☒	☐	Is the subsurface highly permeable or conductive?
☒	☐	☐	Is drinking water drawn from a shallow aquifer?
☐	☒	☐	Are suspected contaminants highly mobile in ground water?
☒	☐	☐	Does any circumstantial evidence of ground water or drinking water contamination exist?
☐	☒		Other criteria? _____
☒	☐		**SUSPECTED RELEASE?**

PRIMARY TARGETS

Yes	No	Unknown	
☐	☐	☒	Is any drinking-water well nearby?
☐	☐	☒	Is any nearby drinking-water well closed
☐	☐	☒	Has foul-testing or foul-smelling water be reported by any nearby drinking-water us
☐	☐	☒	Do any nearby wells have a large drawda high production rate?
☐	☐	☒	Are drinking-water wells located between and other wells that are suspected to be to hazardous substances?
☒	☐	☐	Does any circumstantial evidence of grou or drinking water contamination exist?
☐	☒	☐	Does any drinking-water well warrant sam
☐	☒		Other criteria? _____
☐	☒		**PRIMARY TARGET(S) IDENTIFIED?**

Summarize the rationale for suspected release (attach an additional page if necessary):

SEE TEXT LABELED INSERT "E"

Summarize the rationale for Primary Targets (attach an additional page if necessary):

SEE TEXT LABELED INSERT "F"

Insert "E"

The piles at MSP are engineered, bermed, and covered by impermeable (Hypalon) covers. The pile designated the MML pile has a liner and a leachage collection system, and rests on an asphalt pad. The pile designated the VP pile rests on an alphalt pad.

The transmissivity of the soil layer directly below the asphalt pad ranges from 0.087 to 0.27 m^2/day (7 to 22 gpd/ft).

A release is suspected at the MSP site. Data from the groundwater monitoring wells, established as part of an environmental monitoring program, indicates that contamination exists above background levels. This contamination can be attributed to the site, however, levels of contamination are below Derived Concentration Guidelines (DCGs).

Insert "F"

Use of groundwater in the area of MSP is not fully known. Several private wells in the area have been classified for "domestic" use, but it is not known if these wells are used for drinking water. Therefore, a conservative approach mandates that not all primary targets for groundwater have not been identified.

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release (see Ground Water Pathway Criteria List, page 7)?

Is the site located in karst terrain? Yes ___ No X

Depth to aquifer: Yes ___ No X

Distance to the nearest drinking-water well: 4 FEET / 1/4 MILE

LIKELIHOOD OF RELEASE

	A Suspected Release	B No Suspected Release
1. **SUSPECTED RELEASE**: If you suspect a release to ground water (see page 7), assign a score of 550, and use only column A for this pathway.	550	
2. **NO SUSPECTED RELEASE**: If you do not suspect a release to ground water, and the site is in karst terrain or the depth to aquifer is 70 feet or less, assign a score of 500; otherwise, ass gn a score of 340. Use only column B for this pathway.		
LR =	550	

TARGETS

3. **PRIMARY TARGET POPULATION**: Determine the number of people served by drinking water from wells that you suspect have been exposed to hazardous substances from the site (see Ground Water Pathway Criteria List, page 7). ~~0~~ people x 10 =	~~0~~	
4. **SECONDARY TARGET POPULATION**: Determine the number of people served by drinking water from wells that you do NOT suspect have been exposed to hazardous substances from the site, and assign the total population score from PA Table 2. Are any wells part of a blended system? Yes ___ No ___ If yes, attach a page to show apportionment calculations.	504	
5. **NEAREST WELL**: If you have identified any Primary Targets for ground water, assign a score of 50; otherwise, ass gn the highest Nearest Well score from PA Table 2. If no drinking-water wells exist within 4 miles, assign a score of zero.	~~0~~	
6. **WELLHEAD PROTECTION AREA (WHPA)**: Assign a score of 20 if any portion of a designated WHPA is within ¼ mile of the site, assign 5 if from ¼ to 4 miles.	~~0~~	
7. **RESOURCES**: A score of 5 is assigned.	5	5
T =	509	

WASTE CHARACTERISTICS

8. A. If you have identified any Primary Targets for ground water, assign the waste characteristics score calculated on page 4, or a score of 32, whichever is GREATER; do not evaluate part B of this factor.		
B. If you have NOT identified any Primary Targets for ground water, assign the waste characteristics score calculated on page 4.	100	
WC =	100	

GROUND WATER PATHWAY SCORE:

$$\frac{LR \times T \times WC}{82,500}$$

100

185

Site Name:
Date:

PA TABLE 2: VALUES FOR SECOND, PY GROUND WATER TARGET POPULATIONS

PA Table 2a: Non Karst Aquifers

Distance from Site	Population	Nearest Well (choose highest)	Population Served by Wells Within Distance Category: 1 to 10	11 to 30	31 to 100	101 to 300	301 to 1,000	1,001 to 3,000	3,001 to 10,000	10,001 to 30,000	30,001 to 100,000	100,001 to 300,000	Population Value
0 to ¼ mile	85	20	1	2	5	16	52	163	521	1,633	5,214	16,325	5
> ¼ to ½ mile	253	18	1	1	3	10	32	101	323	1,012	3,233	10,121	10
> ½ to 1 mile	1608	9	1	1	2	5	17	52	167	522	1,668	5,224	52
> 1 to 2 miles	6427	5	1	1	1	3	9	29	94	294	939	2,938	94
> 2 to 3 miles	10719	3	1	1	1	2	7	21	68	212	678	2,122	212
> 3 to 4 miles	15003	2	1	1	1	1	4	13	42	131	417	1,306	131

Nearest Well = ~~0~~ SEE CALCULATIONS IN "INSERT D"

Score = 504

PA Table 2b: Karst Aquifers

Distance from Site	Population	Nearest Well (use 20 for karst)	Population Served by Wells Within Distance Category: 1 to 10	11 to 30	31 to 100	101 to 300	301 to 1,000	1,001 to 3,000	3,001 to 10,000	10,001 to 30,000	30,001 to 100,000	100,001 to 300,000	Population Value
0 to ¼ mile		20	1	2	5	16	52	163	521	1,633	5,214	16,325	
> ¼ to ½ mile		20	1	1	3	10	32	101	323	1,012	3,233	10,121	
> ½ to 1 mile		20	1	1	3	8	26	82	261	816	2,607	8,162	
> 1 to 2 miles		20	1	1	3	8	26	82	261	816	2,607	8,162	
> 2 to 3 miles		20	1	1	3	8	26	82	261	816	2,607	8,162	
> 3 to 4 miles		20	1	1	3	8	26	82	261	816	2,607	8,162	

Nearest Well =

Score =

08 05 2 80 7 88 7 8

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Provide a Sketch of the Surface Water Migration Route:
(Include runoff route, probable point of entry, 15-mile target distance limit, intakes, fisheries, and sensitive environme

SEE ATTACHED MAP LABELED "STORM WATER DRAINAGE AT MSP"

ALSO SEE FIGURE 6-3 FOR LOCATIONS OF SURFACE WATER BODIES NEAR MSP.

INFORMATION ON INTAKES, FISHERIES, AND SENSITIVE ENVIRONMENTS ARE NOT PRESENTLY AVAILABLE.

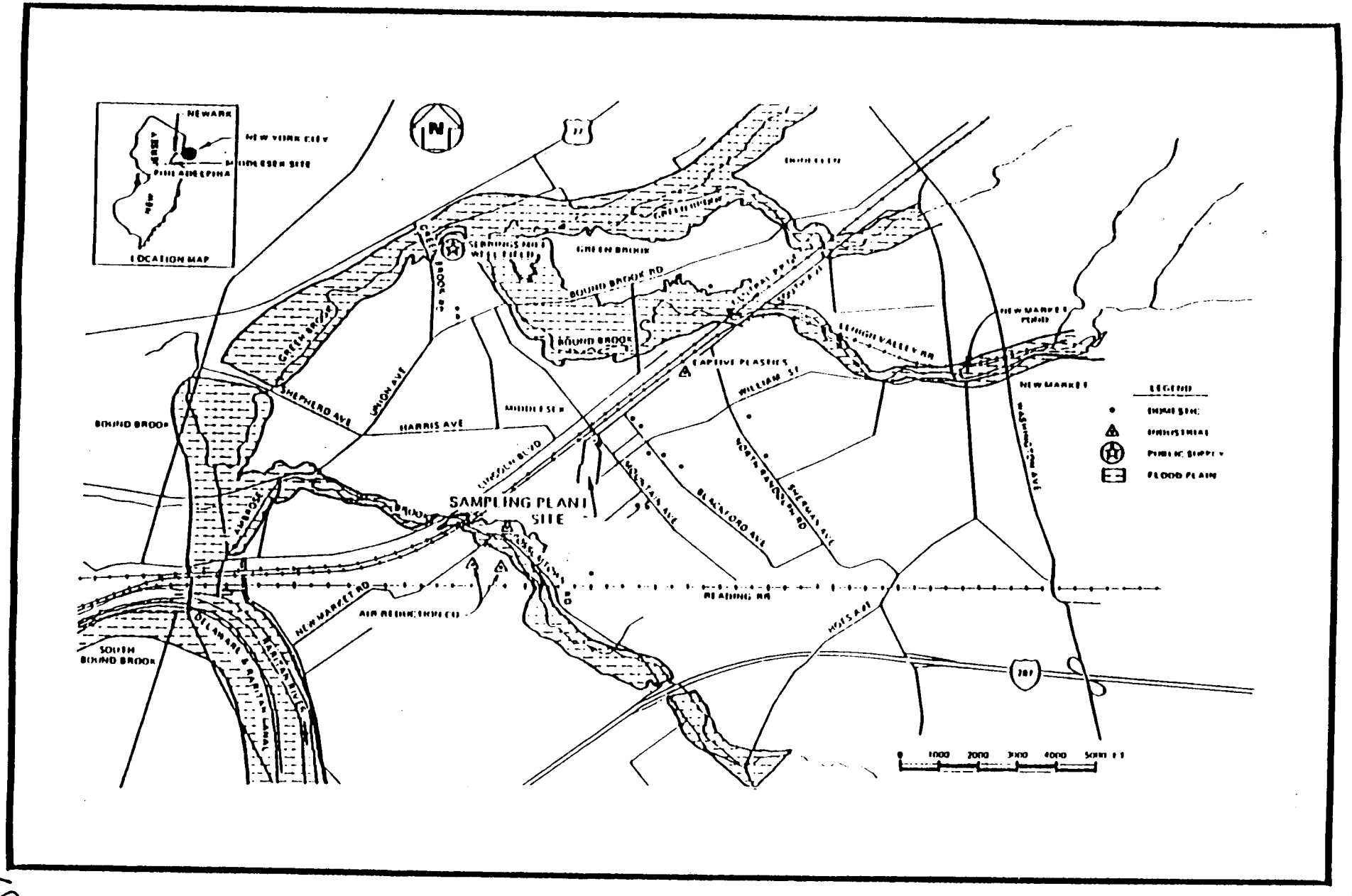

FIGURE 6-3 FLOODPLAINS AND APPROXIMATE LOCATION OF WELLS IN VICINITY OF MSP

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187

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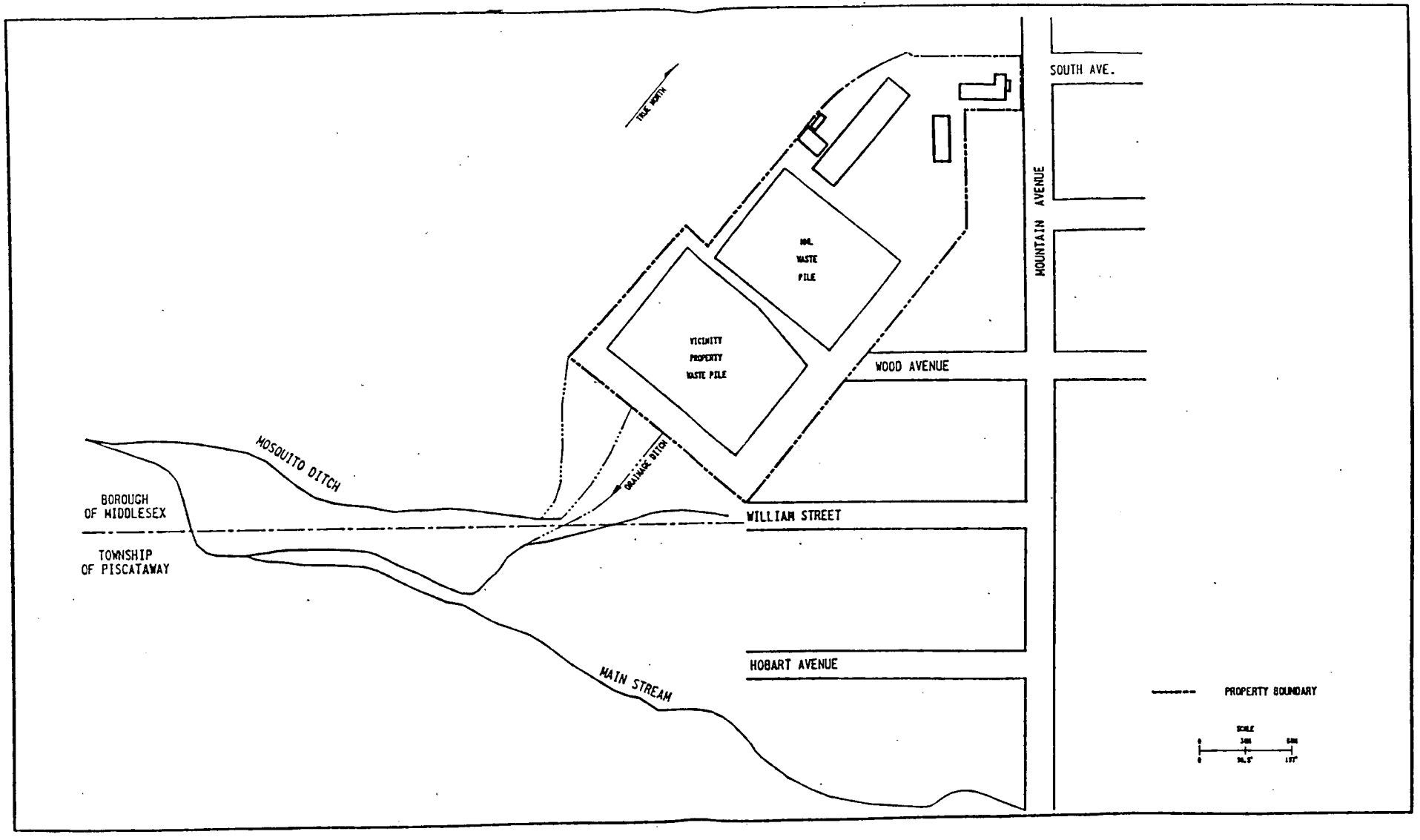

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STORM WATER DRAINAGE AT MSP

189

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...guidelines to assist you in hypothesizing the presence of a suspected release and identifying primary targets. It is not all of this information will be available during the PA. Also, these criteria are not all-inclusive: list any other criteria you use to suspected release or to identify primary targets. This chart will record your professional judgment in evaluating these factors.

The "Suspected Release" section of the chart guides you through evaluation of some site, source, and pathway conditions to he whether a release from the site is likely. If a release is suspected, use the "Primary Targets" section to guide you through evalu conditions that will help identify targets likely to be exposed to hazardous substances. You may use this section of the chart ra depending on the number of targets you feel may be considered "primary." In the "Primary Targets" section on this sheet, record for the target that you feel has the highest probability of being exposed to hazardous substances.

Check the boxes to indicate a "yes", "no", or "unknown" answer to each question. If you check the "Suspected Release" box as "ye that you assign a Likelihood of Release value of SSD for the pathway.

SURFACE WATER PATHWAY

SUSPECTED RELEASE

Yes	No	Unknown	
☒	☐	☐	Is surface water nearby?
☒	☐	☐	Is waste quantity particularly large?
☐	☒	☐	Is the drainage area large?
☒	☐	☐	Is precipitation heavy or infiltration rate low?
☐	☒	☐	Are sources poorly contained or prone to runoff or flooding?
☒	☐	☐	Is a runoff route well defined (e.g., ditch or channel leading to surface water)?
☐	☒	☐	Is vegetation stressed along the probable runoff path?
☐	☒	☐	Are suspected contaminants highly persistent in surface water?
☐	☒	☐	Are sediments/water unnaturally discolored?
☐	☒	☐	Is wildlife unnaturally absent?
☒	☐	☐	Has deposition of waste into surface water been observed?
☐	☒	☐	Is ground water discharge to surface water likely?
☒	☐	☐	Is there any circumstantial evidence of surface water contamination?
☒	☐		Other criteria? Contamination in sediments in stream channel
☒	☐		**SUSPECTED RELEASE?**

PRIMARY TARGETS

Yes	No	Unknown	
☒	☐	☐	Is any target nearby? If yes:
			☒ Drinking-water intake
			☒ Fishery
			☐ Sensitive environment
☐	☒	☐	Has an intake, fishery, or recreational area closed?
☐	☒	☐	Is there any circumstantial evidence of surface water contamination at or downstream of a target?
☐	☒	☐	Does any target warrant sampling? If yes:
			☐ Drinking-water intake
			☐ Fishery
			☐ Sensitive environment
☐	☒		Other criteria? _____
☒	☐		**PRIMARY INTAKE(S) IDENTIFIED?**
☒	☐		**PRIMARY FISHERY IDENTIFIED?**
☒	☐		**PRIMARY SENSITIVE ENVIRONMENT IDENTIFIED?**

Summarize the rationale for suspected release (attach an additional page if necessary):

SEE ATTACHED TEXT LABELED "SURFACE WATER PATHWAY"

Summarize the rationale for Primary Targets (attach an additional page if necessary):

SEE ATTACHED

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SURFACE WATER PATHWAY

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Pathway Characteristics

The surface water pathway includes three threats: Drinking Water Threat, Human Food Chain Threat, an Environmental Threat. Answer the questions at the top of the page. Refer to the Surface Water Pathwa Criteria List (page 11) to hypothesize whether you suspect hazardous substances have been released to surfac water. Enter the distance to surface water (the shortest overland drainage distance from a source to a surfac water body). State the floodplain in which the site is located (e.g., 100-yr, 200-yr). If the site is locatec more than one floodplain, use the most frequent flooding event. Identify surface water uses for the 15-m surface water migration path.

Likelihood of Release (LR)

1. Suspected Release: Hypothesize based on professional judgment guided by the Surface Water Pathwa Criteria List (page 11). Remember to use only Column A for this pathway if you score a suspected release surface water, and do not evaluate factor 2.

2. No Suspected Release: Determine score based on the shortest overland drainage distance from a source a surface water body. If distance to surface water is greater than 2,500 feet, determine this score basec flood frequency. Remember to use only Column B to score this pathway if you do not suspect that hazarde substances have been released.

Drinking Water Threat Targets (T)

3. List all drinking-water intakes on downstream surface water bodies within the 15-mile target distance Provide the intake name, the type of water body on which the intake is located, the flow of the water body the number of people served by the intake (apportion the population if part of a blended system).

4. Primary Target Population: Evaluate any populations served by drinking-water intakes that you suspect been exposed to hazardous substances released from the site. Use professional judgment guided by the Su Water Pathway Criteria List (page 11) to make this determination. In the space provided, enter the population served by all intakes you suspect have been exposed to hazardous substances, and multiply by 10 to derive Primary Target Population score. Remember, if you do not suspect a release, there is no Primary Tar Population.

5. Secondary Target Population: On PA Table 3 (page 13), evaluate any populations served by drinking-wa intakes that you do not suspect have been exposed to hazardous substances. Enter the population served intakes for each flow category. Circle the assigned population value and enter it in the far right column. S the population values and enter the total as the Secondary Target Population score.

Gauging station data for most surface water bodies should be available from USGS or other sources. In absence of gauging station data, see PA Table 4 (page 13) for a listing of surface water body types associated flow categories. The flow for lakes is determined by the sum of flows of streams entering or leav the lake. Note that the flow category "mixing zone of quiet flowing rivers" can be used for rivers with of at least 10 cfs, but only for intakes within 3 miles of the probable point of entry.

6. Nearest Intake score represents the threat posed to the drinking-water intake that is most likely to exposed to hazardous substances. If you have identified a Primary Target Population, assign a score of Otherwise assign the score determined from PA Table 3 (page 13) for the lowest-flowing water body on w there is an intake.

7. Resources: Score automatically assigned. Do not override; do not investigate resources.

Target Scoring Instructions: Sum the target scores in Column A (Suspected Release) or Column B Suspected Release).

SURFACE WATER PATHWAY

Rationale for Suspected Release

Runoff from the site drains to a drainage ditch at the southern edge of the site. (See figure showing storm water runoff.) Sampling sediments in the drainage ditch, and surface water sampling has revealed the presence of contamination. Because the contamination in the ditch is consistent with contamination that would be expected from runoff from this site, the ditch contamination is attributed to the site.

One of the two storage piles at MSP is constructed on an asphalt pad, and as such the infiltration rate is high.

Rationale for Primary Targets for Surface Water

Targets have been identified within 15 miles of the site.

Sampling has been performed for the length of the drainage ditch, and the level of contamination decreases to background levels within .5 miles of the site.

ADDENDUM 9

SURFACE WATER PATHWAY

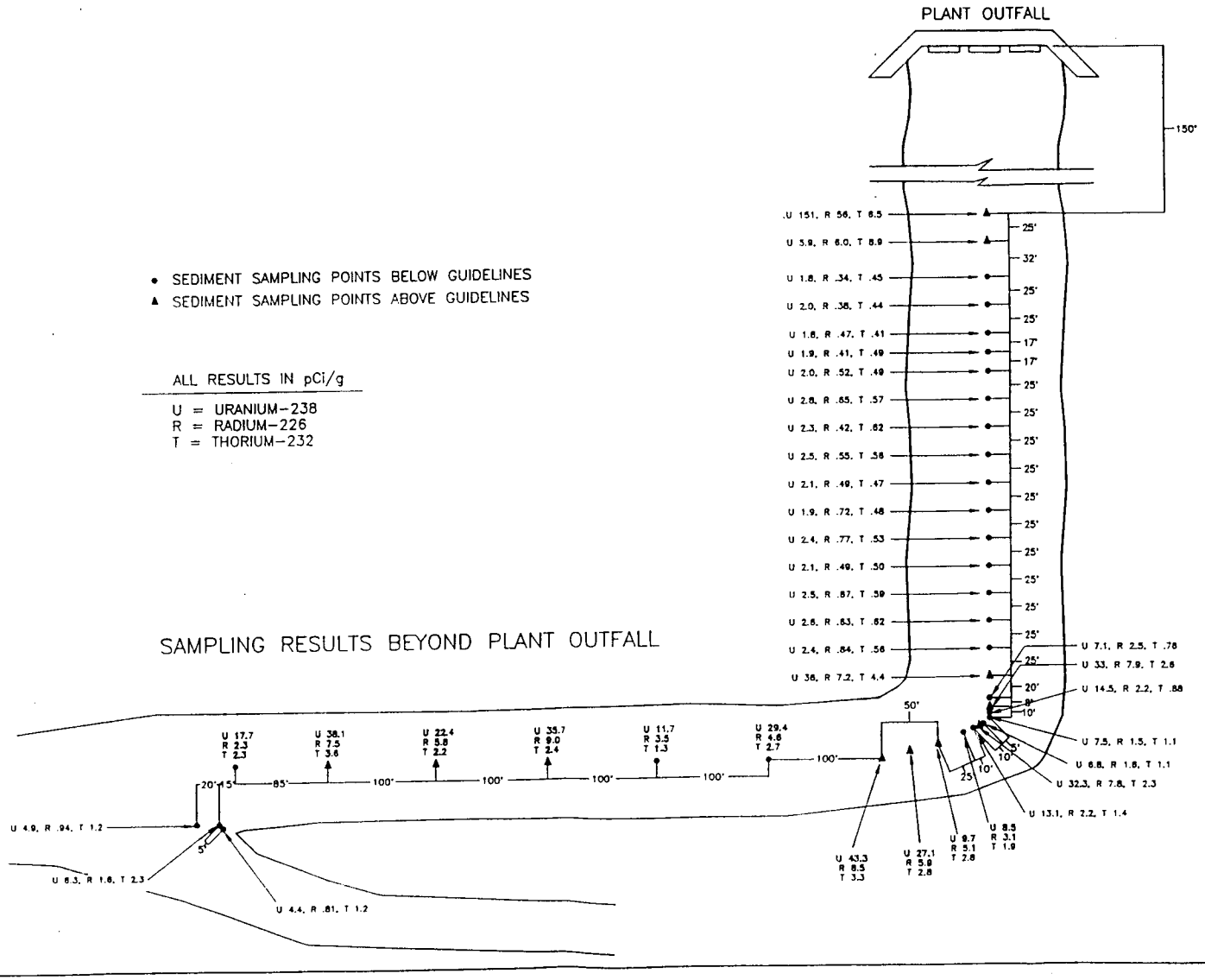
As noted in Addendum 4 to this revised package, sampling has been performed along the length of the drainage ditch, to the confluence with Ambrose Brook. Attached are two figures, previously identified in Addendum 4, showing sampling locations and concentrations of contaminants.

Under the SURFACE WATER PATHWAY explanation, delete the last sentence of the first paragraph and insert:

"Because the contaminants detected in the ditch are the same as those present on site, the ditch contamination is attributed to the site."

Under the SURFACE WATER PATHWAY explanation, delete the second paragraph and insert:

"Because contaminated soils exist under the asphalt pad overlying the site, and contaminated soils directly contact the asphalt pad under the VP pile, the potential for contaminant discharge into surface water is high."


PLANT OUTFALL
150'
• SEDIMENT SAMPLING POINTS BELOW GUIDELINES
▲ SEDIMENT SAMPLING POINTS ABOVE GUIDELINES
ALL RESULTS IN pCi/g
U = URANIUM-238
R = RADIUM-226
T = THORIUM-232
SAMPLING RESULTS BEYOND PLANT OUTFALL
U 151, R 56, T 8.5
U 3.9, R 6.0, T 8.9
U 1.8, R .34, T .45
U 2.0, R .38, T .44
U 1.8, R .47, T .41
U 1.9, R .41, T .49
U 2.0, R .52, T .49
U 2.8, R .85, T .57
U 2.3, R .42, T .82
U 2.5, R .55, T .58
U 2.1, R .49, T .47
U 1.9, R .72, T .48
U 2.4, R .77, T .53
U 2.1, R .49, T .50
U 2.5, R .87, T .59
U 2.8, R .83, T .62
U 2.4, R .84, T .56
U 36, R 7.2, T 4.4
25'
32'
25'
25'
17'
17'
25'
25'
25'
25'
25'
25'
25'
25'
25'
25'
25'
25'
20'
8'
10'
U 7.1, R 2.5, T .78
U 33, R 7.9, T 2.6
U 14.5, R 2.2, T .88
U 7.5, R 1.5, T 1.1
U 6.8, R 1.8, T 1.1
U 32.3, R 7.8, T 2.3
U 13.1, R 2.2, T 1.4
U 8.5 R 3.1 T 1.9
U 9.7 R 5.1 T 2.8
U 27.1 R 5.9 T 2.8
U 43.3 R 8.5 T 3.3
50'
25'
10'
5'
10'
U 17.7 R 2.3 T 2.3
U 38.1 R 7.5 T 3.6
U 22.4 R 5.8 T 2.2
U 35.7 R 9.0 T 2.4
U 11.7 R 3.5 T 1.3
U 29.4 R 4.6 T 2.7
100'
100'
100'
100'
100'
85'
15'
20'
U 4.9, R .94, T 1.2
5'
U 6.3, R 1.6, T 2.3
U 4.4, R .81, T 1.2

BS:TRENCH:V1

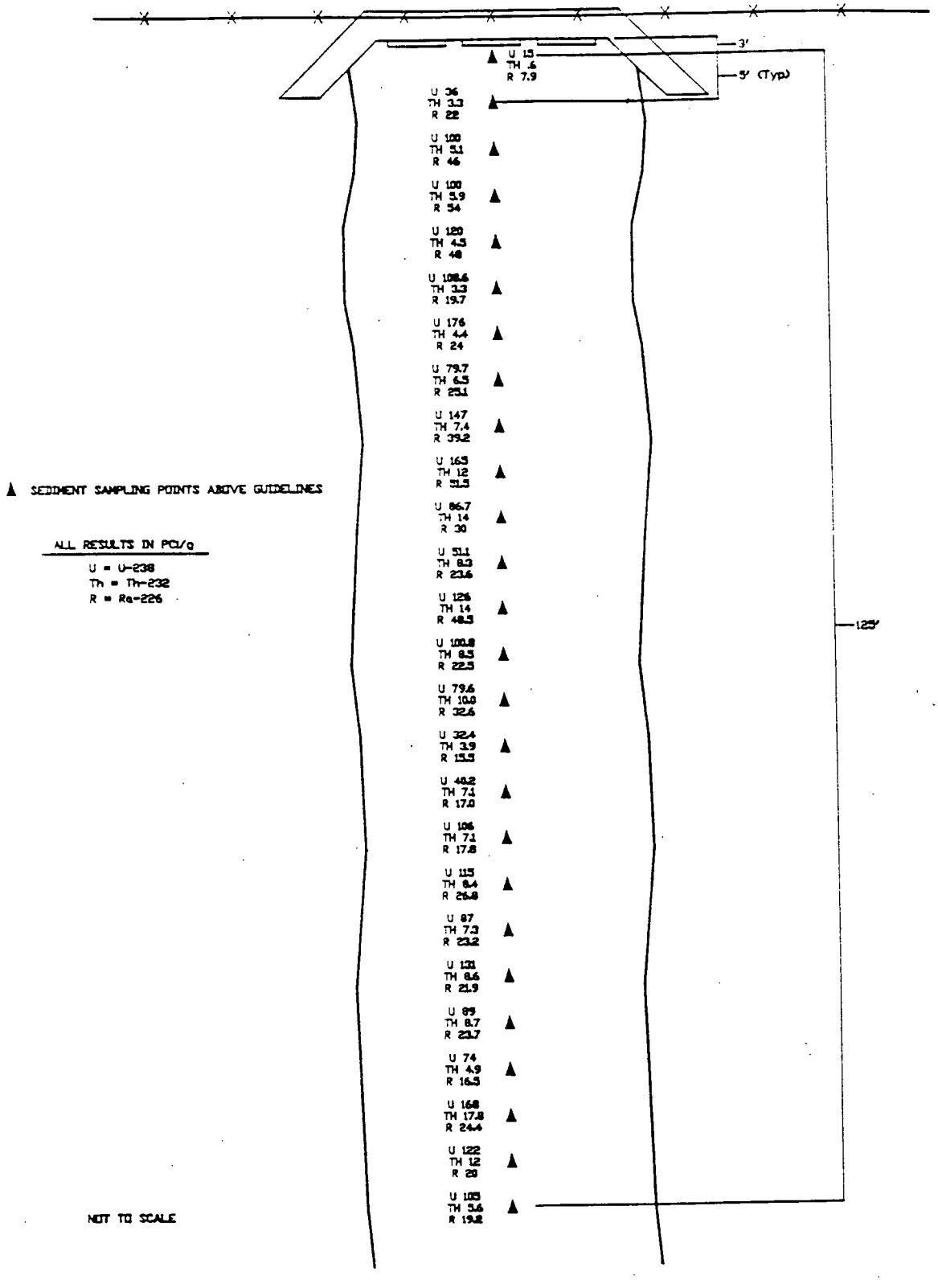


FIGURE 1 SAMPLING RESULTS FROM PLANT OUTFALL

35:MSXSL1B:V1

SURFACE WATER PATHWAY WASTE CHARACTERISTICS, THREAT, AND PATHWAY SCORE

Waste Characteristics (WC)

14. Waste Characteristics score is assigned from page 4. However, if any Primary Target has been ident for any surface water threat, assign the higher of the score calculated on page 4 or a score of 32.

Surface Water Pathway Threat Scores

Fill in the matrix with the appropriate scores from the previous pages. To calculate the score for each thr multiply the scores for LR, T and WC, divide the product by 82,500, and round the result to the nearest inte The Drinking Water Threat and Human Food Chain Threat are subject to a maximum of 100. The Environmr Threat is subject to a maximum of 60. Enter the rounded threat scores into the right side of the table.

Surface Water Pathway Score

Sum the individual threat scores to determine the Surface Water Pathway Score. If the sum is greater than assign 100.

Pathway Characteristics

Do you suspect a release (see Surface Water Pathway Criteria List, page 11)? Yes XX No ___

Distance to surface water: 10500 ft

Flood Frequency: ≥100 yr's.

What is the downstream distance to the nearest drinking-water intake? ~ 3.3 miles

nearest fishery? ___ miles nearest sensitive environment? ___ miles

LIKELIHOOD OF RELEASE

	A Suspected Release	B No Suspected Release
1. **SUSPECTED RELEASE:** If you suspect a release to surface water (see page 11), assign a score of 550, and use only column A for this pathway.	550	
2. **NO SUSPECTED RELEASE:** If you do not suspect a release to surface water, and the distance to surface water is 2,500 feet or less, assign a score of 500; otherwise, assign a score from the table below. Use only column B for this pathway.		
LR =	550	

Floodplain	Score
Site in annual or 10-yr floodplain	500
Site in 100-yr floodplain	400
Site in 500-yr floodplain	300
Site outside 500-yr floodplain	100

DRINKING WATER THREAT TARGETS

3. Determine the water body types, flows (if applicable), and number of people served by all drinking-water intakes within the 15-mile target distance limit. If there are no drinking-water intakes within the target distance limit, assign a total Targets score of 5 at the bottom of this page (Resources only) and proceed to page 14.

Intake Name	Water Body Type	Flow	People Served
SEE ATTACHED	LARGE RIVER	1320 cfs	> 1,000,000

4. **PRIMARY TARGET POPULATION:** If you suspect any drinking-water intake listed above has been exposed to hazardous substances from the site (see Surface Water Pathway Criteria List, page 11), list the intake name(s) and calculate the factor score based on the number of people served.

___, ___, ___

0 people x 10 = 0

5. **SECONDARY TARGET POPULATION:** Determine the Secondary Target Population score from PA Table 3 based on the populations using drinking-water from intakes that you do NOT suspect have been exposed to hazardous substances from the site.

Are any intakes part of a blended system? Yes ___ No ___ Unknown XX

If yes, attach a page to show apportionment calculations.

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6. **NEAREST INTAKE:** If you have identified any Primary Targets for the drinking water threat (Factor 4), assign a score of 50; otherwise, assign the Nearest Intake score from PA Table 3. If no drinking-water intake exists within the 15-mile target distance limit, assign a score of zero.

0

7. **RESOURCES:** A score of 5 is assigned.

5 | 5

T = 163

Pathway Characteristics

Flood Frequency: Greater than 100 years.

MSP is in an area of minimal flood frequency, (Federal Insurance Administration, 1976).

Drinking Water Threat Targets

The number and name of intakes on the Raritan River is not presently available; nor is the number or people served, or the flow rate of the river. As a result, the population within 15 miles of MSP has been conservatively assumed to be greater than 1,000,000. The mean annual flow of the Raritan River is 1320 cfs at Fieldville Dam (Middlesex Outtake) and the mean annual flow of Ambrose Brook is 10.5 cfs at Victor Crowell Park in Middlesex (Personal Communication, J. Novick, BNI, and USGS, 8/20/91).

Site Name:
Date:

PA TABLE 3: VALUES FOR SECONDARY SURFACE WATER TARGET POPULATIONS

Surface Water Body Flow Characteristics (see PA Table 4)	Population	Nearest Intake (choose highest)	Population Served by Intakes Within Flow Category: 1 to 30	31 to 100	101 to 300	301 to 1,000	1,001 to 3,000	3,001 to 10,000	10,001 to 30,000	30,001 to 100,000	100,001 to 300,000	300,001 to 1,000,000	1,000,001 to 3,000,000	Population Value
< 10 cfs	____	20	2	5	16	52	163	521	1,633	5,214	16,325	52,136	163,246	____
10 to 100 cfs	____	2	1	1	2	5	16	52	163	521	1,633	5,214	16,325	____
> 100 to 1,000 cfs	____	1	0	0	1	1	2	5	16	52	163	521	1,633	____
> 1,000 to 10,000 cfs	>1,000,000	0	0	0	0	0	1	1	2	5	16	52	163	163
> 10,000 cfs or Great Lakes	____	0	0	0	0	0	0	0	1	1	2	5	16	____
3 mile Mixing Zone	____	10	1	3	8	26	82	261	816	2,607	8,162	26,088	81,663	____

Nearest Intake = 0

Score = 163

PA TABLE 4: SURFACE WATER TYPE / FLOW CHARACTERISTICS WITH DILUTION WEIGHTS FOR SECONDARY SURFACE WATER SENSITIVE ENVIRONMENTS

Type of Surface Water Body: Water Body Type	OR	Flow Characteristics	Dilution Weight
minimal stream		flow less than 10 cfs	1
small to moderate stream		flow 10 to 100 cfs	0.1
moderate to large stream		flow greater than 100 to 1,000 cfs	N/A
large stream to river		flow greater than 1,000 to 10,000 cfs	N/A
large river		flow greater than 10,000 cfs	N/A
3-mile mixing zone of quiet flowing streams or rivers		flow 10 cfs or greater	N/A
coastal tidal water (harbors, sounds, bays, etc.), ocean, or Great Lakes		N/A	N/A

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LIKELIHOOD OF RELEASE

	Suspected Release	No Suspected Release
Enter the Surface Water Likelihood of Release score from page 12. LR =	550	

HUMAN FOOD CHAIN THREAT TARGETS

8. Determine the water body types and flows (if applicable) for all fisheries within the 15-mile target distance limit. If there are no fisheries within the target distance limit, assign a Targets score of 0 at the bottom of this page and proceed to page 15.

Fishery Name	Water Body Type	Flow
Raritan River	Lg. Stream or River	1320 cfs
Ambrose Brook	Sm.-Mod. Stream	10.5 cfs
		cfs
		cfs
		cfs
		cfs

9. PRIMARY FISHERIES: If you suspect any fishery listed above has been exposed to hazardous substances from the site (see Surface Water Criteria List, page 11), assign a score of 300 and do not evaluate Factor 10. List the Primary Fisheries:

_____, _____,

_____, _____.

~~0~~

10. SECONDARY FISHERIES: If you have not identified any Primary Fisheries, assign a Secondary Fisheries score from the table below using the LOWEST flow at any fishery within the 15-mile target distance limit.

Lowest Flow	Secondary Fisheries Score
< 10 cfs	210
10 to 100 cfs	30
> 100 cfs, coastal tidal waters, oceans, or Great Lakes	12

30

T = 30

200

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	A Suspected Release	B No Suspected Release
LIKELIHOOD OF RELEASE		
Enter the Surface Water Likelihood of Release score from page 12. LR =	550	
ENVIRONMENTAL THREAT TARGETS		
11. Determine the water body types and flows (if applicable) for all surface water sensitive environments within the 15-mile target distance limit (see PA Tables 4 and 5). If there are no sensitive environments within the 15-mile target distance limit, assign a Targets score of 0 at the bottom of this page, and proceed to page 17.		

Environment Name	Water Body Type	Flow
SEE ATTACHED		cfs
		cfs
		cfs
		cfs
		cfs

12. PRIMARY SENSITIVE ENVIRONMENTS. If you suspect any sensitive environment listed above has been exposed to hazardous substances from the site (see Surface Water Criteria List, page 11), assign a score of 300 and do not evaluate Factor 13. List the Primary Sensitive Environments:

_____ _____

_____ _____

0

13. SECONDARY SENSITIVE ENVIRONMENTS.

A. For Secondary Sensitive Environments on surface water bodies with flows of 100 cfs or less, assign scores as follows, and do not evaluate part B of this factor:

Flow	Dilution Weight (PA Table 4)	Environment Type and Value (PA Tables 5 and 6)	Total
cfs	x	=	
cfs	x	=	
cfs	x	=	
cfs	x	=	
cfs	x	=	

Sum = 0

B. If NO Secondary Sensitive Environments are located on surface water bodies with flows of 100 cfs or less, assign a score of 10.

T = 0

201

Environmental Threat Targets

There are no sensitive environments within 15 miles downstream of MSP that fit descriptions of sensitive environments in PA Table 5.

WASTE CHARACTERISTICS

	A Suspected Release	B No Suspected Release
14. A. If you have identified ANY Primary Targets for surface water (pages 12, 14, or 15), assign the waste characteristics score calculated on page 4, or a score of 32, whichever is GREATER; do not evaluate part B of this factor.		
B. If you have NOT identified any Primary Targets for surface water, assign the waste characteristics score calculated on page 4.	100	
WC =	100	

SURFACE WATER PATHWAY THREAT SCORES

Threat	Likelihood of Release (LR) Score (from page 12)	Targets (T) Score	Pathway Waste Characteristics (WC) Score (determined above)	Threat : LR x T : / 82.5
Drinking Water	550	163	100	100
Human Food Chain	550	30	100	20
Environmental	550	~~0~~	100	~~0~~

SURFACE WATER PATHWAY SCORE
(Drinking Water Threat + Human Food Chain Threat + Environmental Threat) 100

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This chart provides guidelines to assist you in hypothesizing the presence of a resident population. It is expected that all of this information will be available during the PA. Also, these criteria are not all-inclusive; list any other criteria you use to hypothesize resident population. This chart will record your professional judgment in evaluating this factor.

Use the resident population section to guide you through evaluation of some site and source conditions that will help identify targets exposed to hazardous substances. You may use this section of the chart more than once, depending on the number of nearby people who be considered part of a resident population. Record the responses for the resident population target that you feel has the highest probability exposed to hazardous substances.

Check the boxes to indicate a "yes", "no", or "unknown" answer to each question.

SOIL EXPOSURE PATHWAY

SUSPECTED CONTAMINATION	RESIDENT POPULATION			
	yes	no	unknown	
Surficial contamination is assumed.	X	☐	☐	Are there residences, schools, or day care facilities on or within 200 feet of areas of suspected contamination?
	☐	X	☐	Are residences, schools, or day care facilities located on adjacent land previously owned leased by the site owner/operator?
	☐	X	☐	Is there an overland migration route that may spread hazardous substances near residences, schools, or day care facilities?
	☐	X	☐	Are there any reports of adverse health effects from onsite or adjacent residents or students exclusive of apparent drinking water or air contamination problems?
	☐	X	☐	Does any offsite property warrant sampling?
	☐	X		Other criteria? _____
	X	☐		RESIDENT POPULATION IDENTIFIED

Summarize the rationale for resident population (attach an additional page if necessary):

SEE ATTACHED

SOIL EXPOSURE PATHWAY

Rationale for Resident Population

Vicinity properties in the MSP area underwent remedial action prior to 1986 (DOE, 1986). The Middlesex Municipal Landfill, which was contaminated by MSP waste disposal, underwent remedial action between 1984 and 1986 (DOE, 1989). The cleanups of all vicinity properties and the landfill have been completed, and have been certified clean (DOE 1986, DOE 1989). The only contaminated soils at MSP are in the piles or contained within the site boundary.

References: DOE 1986, Certification Docket for Vicinity Properties (Phase II) Associated with the Former Middlesex Sampling Plant, Middlesex, New Jersey.

DOE 1989, Certification Docket for the Remedial Action Performed at the Middlesex Municipal Landfill in Middlesex, New Jersey in 1984 and 1986.

Do any people attend school or day care on or within 200 ft of areas of suspected contamination? Yes XX No ___

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Is the facility active? Yes XX No ___ If yes, estimate the number of workers: 4 Yes ___ No XX

LIKELIHOOD OF EXPOSURE

	A Suspected Contamination	B No Suspected Contamination
1. SUSPECTED CONTAMINATION: Surficial contamination is assumed. A score of 550 is assigned. LE =	550	

RESIDENT POPULATION THREAT TARGETS

2. RESIDENT POPULATION: Determine the number of people occupying residences or attending school or day care on or within 200 feet of areas of suspected contamination (see Soil Exposure Pathway Criteria List, page 18). 15 people x 10 =	150	
3. RESIDENT INDIVIDUAL: If you have identified any Resident Population (Factor 2), assign a score of 50; otherwise, assign a score of 0.	50	
4. WORKERS: Assign a score from the following table based on the total number of workers at the facility and nearby facilities with suspected contamination:	5	
5. TERRESTRIAL SENSITIVE ENVIRONMENTS: Assign a value from PA Table 7 for each terrestrial sensitive environment that is located on an area of suspected contamination: Sum =	~~0~~	
6. RESOURCES: A score of 5 is assigned.	5	
T =	210	

Number of Workers	Score
0	0
1 to 100	5
101 to 1,000	10
> 1,000	15

Terrestrial Sensitive Environment Type	Value

WASTE CHARACTERISTICS

7. Assign the waste characteristics score calculated on page 4. WC =	100

RESIDENT POPULATION THREAT SCORE: $\frac{LE \times T \times WC}{82,500}$ = 100

NEARBY POPULATION THREAT SCORE:
Assign a score of 2 2

SOIL EXPOSURE PATHWAY SCORE:
Resident Population Threat + Nearby Population Threat 100

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PA TABLE 7: SOIL EXPOSURE PATHWAY TERRESTRIAL SENSITIVE ENVIRONMENT VALUES

Terrestrial Sensitive Environments	
Terrestrial critical habitat for Federally designated endangered or threatened species	4s
National Park	
Designated Federal Wilderness Area	
National Monument	
Terrestrial habitat known to be used by Federally designated or proposed threatened or endangered species	
National Preserve (terrestrial)	
National or State terrestrial Wildlife Refuge	
Federal land designated for protection of natural ecosystems	
Administratively proposed Federal Wilderness Area	
Terrestrial areas utilized by large or dense aggregations of animals (vertebrate species) for breeding	
Terrestrial habitat used by State designated endangered or threatened species	
Terrestrial habitat used by species under review for Federally designated endangered or threatened status	
State lands designated for wildlife or game management	
State designated Natural Areas	
Particular areas, relatively small in size, important to maintenance of unique biotic communities	

Date: 0R 0528

This chart provides guidelines to assist you in hypothesizing the presence of a suspected release. It is expected that not all of this inform be available during the PA. Also, these criteria are not all-inclusive; list any other criteria you use to hypothesize a suspected release. T will record your professional judgment in evaluating this factor.

The "Suspected Release" section of the chart guides you through evaluation of some conditions to help hypothesize whether a release site is likely. For the Air Pathway, if a release is suspected, "Primary Targets" are any residents, workers, students, or sensitive environmen ¼ mile of the site.

Check the boxes to indicate a "yes", "no", or "unknown" answer to each question. If you check the "Suspected Release" box as "yes", m that you assign a Likelihood of Release value of 550 for the pathway.

AIR PATHWAY

SUSPECTED RELEASE				PRIMARY TARGETS
Yes	No	Unknown		
☐	☒	☐	Have odors been reported?	*If you suspect a release to air, evaluate all populations i sensitive environments within ¼ mile* (including those o *as Primary Targets.*
☐	☒	☐	Has a release of hazardous substances to the air been directly observed?	
☐	☒	☐	Are there any reports of adverse health effects (e.g., headaches, nauses, dizziness) potentially resulting from migration of hazardous substances through the air?	
☐	☒	☐	Is there any circumstantial evidence of an air release?	
☐	☒		Other criteria? _____	
☐	☒		SUSPECTED RELEASE?	

Summarize the rationale for suspected release (attach an additional page if necessary):

Insert "Rationale for Suspected Air Releases"

The only suspected air contaminants emitted from the site are radon and thoron. Radon emissions are present due to the radium and thorium contaminated soil stored in the piles.

No release of radon is suspected, as defined in the Guidance Manual. The Annual Average Concentration of radon in 1990 was just above background. No values as high as two to three times background were obtained.

Reference: Middlesex Sampling Plant Annual Environmental Report for Calendar Year 1990, June 1991, BNI, Inc., (DOE/OR/21949-285).

Pathway Characteristics

Answer the questions at the top of the page. Refer to the Air Pathway Criteria List (page 21) to hypothesize whether you suspect hazardous substances have been released from the site to the air. Due to dispersion, releases to air are not as persistent as releases to water migration pathways and are much more difficult to detect. Develop hypotheses concerning the release of hazardous substances to air based on "real time" considerations. Record the distance (in feet) from any source to the nearest regularly occupied building.

Likelihood of Release (LR)

1. Suspected Release: Hypothesize based on professional judgment guided by the Air Pathway Criteria List (page 21). Remember to use only Column A for this pathway if you score a Suspected Release, and proceed to the target evaluation section.

2. No Suspected Release: If you do not score a Suspected Release, enter 500. Remember to use only Column B to score this pathway if you do not suspect hazardous substances are being released.

Targets (T)

3. Primary Target Population are those people subject to exposure from a suspected air release of hazardous substances from the site. Use professional judgment, guided by the Air Pathway Criteria List (page 21), to make this determination. Note that if you do not suspect a release, there are no primary population targets. If you score a Suspected Release, record the residential, student, and worker population located on or within ¼-mile of the site. Multiply this number of people by 10; enter the factor score in Column A.

4. Secondary Target Population are those people in distance categories not suspected to be subject to exposure from airborne hazardous substances. Determine the number of residents, students, and workers, and enter the summed population in PA Table 8 (page 23) for each distance category. Circle the population value for the distance category and record the value in the far right column of the table. Sum these values and enter the total as the factor score.

5. Nearest Individual represents the threat posed to the person most likely to be exposed to hazardous substances released from the site. If you have identified any Primary Population, enter 50. Otherwise, assign the score from the "Nearest Individual" column of PA Table 8 (page 23), for the nearest distance ring in which you have identified a Secondary Population.

6. Primary Sensitive Environments: List the sensitive environments (on or within ¼ mile of the site) subject to exposure from a suspected air release of hazardous substances from the site. Assign values for sensitive environment type (from PA Table 5, page 16) and/or wetland acreage (from PA Table 9, page 23). Sum the values and enter the total as the factor score.

7. Secondary Sensitive Environments: On PA Table 10 (page 23), list the sensitive environments that are in distance categories within ½ mile not suspected to be subject to exposure from airborne hazardous substances. Assign a value for each environment (PA Tables 5 and 9). Record the value for each Secondary Sensitive Environment on PA Table 10 (page 23), and multiply by the distance weight for that distance category. Sum the products, and enter the total as the factor score.

8. Resources: Score automatically assigned. Do not override; do not investigate resources.

Target Scoring Instructions: Sum the target scores in Column A (Suspected Release) or Column B (No Suspected Release).

Waste Characteristics (WC)

9. Waste Characteristics score is assigned from page 4. However, if any Primary Target has been identified for the air pathway, assign the higher of the score calculated on page 4 or a score of 32.

Air Pathway Score: Multiply the scores for LR, T, and WC. Divide the product by 82,500. Round the result to the nearest integer. If the result is greater than 100, assign 100.

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AIR PATHWAY SCORESHEET

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Pathway Characteristics	
Do you suspect a release (see Air Pathway Criteria List, page 21)?	Yes ___ No ___
Distance to the nearest individual:	___ ft

	A Suspected Release	B No Suspected Release
LIKELIHOOD OF RELEASE		
1. SUSPECTED RELEASE: If you suspect a release to air (see page 21), assign a score of 550, and use only column A for this pathway.		
2. NO SUSPECTED RELEASE: If you do not suspect a release to air, assign a score of 500, and use only column B for this pathway.		500
LR =		500
TARGETS		
3. PRIMARY TARGET POPULATION: Determine the number of people subject to exposure from a release of hazardous substances through the air (see Air Pathway Criteria List, page 21). ~~0~~ people x 10 =		~~0~~
4. SECONDARY TARGET POPULATION: Determine the number of people within the 4-mile target distance limit, and assign the total population score from PA Table 8.		76
5. NEAREST INDIVIDUAL: If you have identified any Primary Targets for the air pathway, assign a score of 50; otherwise, assign the highest Nearest Individual score from PA Table 8.		20
6. PRIMARY SENSITIVE ENVIRONMENTS: Sum the sensitive environment values (PA Table 5) and wetland acreage values (PA Table 9) for environments subject to exposure from air hazardous substances (see Air Pathway Criteria List, page 21).		
Sum =		
7. SECONDARY SENSITIVE ENVIRONMENTS: Use PA Table 10 to determine the score for secondary sensitive environments.		
8. RESOURCES: A score of 5 is assigned.	5	5
T =		101
WASTE CHARACTERISTICS		
9. A. If you have identified any Primary Targets for the air pathway, assign the waste characteristics score calculated on page 4, or a score of 32, whichever is GREATER; do not evaluate part B of this factor.		
B. If you have NOT identified any Primary Targets for the air pathway, assign the waste characteristics score calculated on page 4.		100
WC =		100

AIR PATHWAY SCORE: $\frac{LR \times T \times WC}{82,500}$ = 60.6

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Site Name:
Date:

PA TABLE 8: VALUES FOR SECONDARY AIR TARGET POPULATIONS

Distance from Site	Population	Nearest Individual (choose highest)	Population Within Distance Category: 1 to 10	11 to 30	31 to 100	101 to 300	301 to 1,000	1,001 to 3,000	3,001 to 10,000	10,001 to 30,000	30,001 to 100,000	100,001 to 300,000	300,001 to 1,000,000	1,000,001 to 3,000,000	Populati Value
Onsite	—	20	1	2	5	16	52	163	521	1,633	5,214	16,325	52,136	163,246	0
>0 to ¼ mile	423	20	1	1	1	4	13	41	130	408	1,303	4,081	13,034	40,811	13
>¼ to ½ mile	1267	2	0	0	1	1	3	9	28	88	282	882	2,815	8,815	9
>½ to 1 mile	8038	1	0	0	0	1	1	3	8	26	83	261	834	2,612	8
>1 to 2 miles	32136	0	0	0	0	0	1	1	3	8	27	83	266	833	27
>2 to 3 miles	53594	0	0	0	0	0	1	1	1	4	12	38	120	376	12
>3 to 4 miles	75017	0	0	0	0	0	0	1	1	2	7	23	73	229	7

Nearest Individual = 20

Score = 76

PA TABLE 9: AIR PATHWAY VALUES FOR WETLAND AREA

Wetland Area	Assigned Value
Less than 1 acre	0
1 to 50 acres	25
Greater than 50 to 100 acres	75
Greater than 100 to 150 acres	125
Greater than 150 to 200 acres	175
Greater than 200 to 300 acres	250
Greater than 300 to 400 acres	350
Greater than 400 to 500 acres	450
Greater than 500 acres	500

PA TABLE 10: DISTANCE WEIGHTS AND CALCULATIONS FOR AIR PATHWAY SECONDARY SENSITIVE ENVIRONMENTS

Distance	Distance Weight	Sensitive Environment Type and Value (from PA Table 5 or 9)	Product
Onsite	0.10		
0-1/4 mi	0.025		
1/4-1/2mi	0.0054		
			0
			0

Total Environments Score = 0

2/3

SITE SCORE CALCULATION

In the column labeled S, record the Ground Water Pathway score, the Surface Water Pathway score, the Soil Exposure Pathway score, and the Air Pathway score. Square each pathway score and record the result in the S^2 column. Sum the squared pathway scores. Divide the sum by 4, and take the square root of the result to obtain the Site Score.

Recommendation

Provide a recommendation for site disposition in accordance with EPA guidelines.

	S	S²
GROUND WATER PATHWAY SCORE (S_{gw}):	100	10,000
SURFACE WATER PATHWAY SCORE (S_{sw}):	100	10,000
SOIL EXPOSURE PATHWAY SCORE (S_{se}):	100	10,000
AIR PATHWAY SCORE (S_a):	60.6	3672
SITE SCORE:	$\sqrt{\frac{S_{gw}^2+S_{sw}^2+S_{se}^2+S_a^2}{4}}$ =	91.75

RECOMMENDATION

SEE ATTACHED TEXT LABELED "RECOMMENDATION"

SUMMARY

	YES
1. Is there a high possibility of a threat to nearby drinking water wells by migration of hazardous substances in ground water?	
A. If yes, identify the wells recommended for sampling during the SI. _____	=
B. If yes, how many people are served by these threatened wells? _____	
2. Are any of the following suspected to have been exposed to hazardous substances through surface water migration from the site?	
A. Drinking water intake	=
B. Fishery	=
C. Sensitive environment: wetland, critical habitat, others	=
D. If yes, identify the targets recommended for sampling during the SI. _____	
3. Do people reside or attend school or day care on or within 200 ft of any area of suspected contamination?	☒
4. Are there public health concerns at this site that are not addressed by PA scoring considerations? If yes, explain: _____	=

Recommendation

MSP is currently subject to an environmental monitoring program. Ground water, surface water and sediments, air monitoring (radon), and soil samples are monitored to detect the presence of any contaminants migrating off-site.

Environmental monitoring activities, site maintenance activities, and site characterization should continue until remedial action at MSP is complete.

REFERENCE NO. 13

DOE/OR/20722-265

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

MIDDLESEX SAMPLING PLANT ENVIRONMENTAL REPORT FOR CALENDAR YEAR 1989

Middlesex, New Jersey

May 1990

Bechtel National, Inc.

0189-0280.5

DOE/OR/20722-265

MIDDLESEX SAMPLING PLANT
ENVIRONMENTAL REPORT FOR
CALENDAR YEAR 1989

MAY 1990

Prepared for

UNITED STATES DEPARTMENT OF ENERGY

OAK RIDGE OPERATIONS OFFICE

Under Contract No. DE-AC05-81OR20722

By

Bechtel National, Inc.

P. O. Box 350

Oak Ridge, Tennessee

Bechtel Job No. 14501

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SUMMARY ASSESSMENT
ENVIRONMENTAL COMPLIANCE ACTIVITY
U.S. DEPARTMENT OF ENERGY
FORMERLY UTILIZED SITES REMEDIAL ACTION PROGRAM
MIDDLESEX SAMPLING PLANT

BACKGROUND AND OVERVIEW

To evaluate the environmental compliance record of the Middlesex Sampling Plant (MSP), managed as part of the Formerly Utilized Sites Remedial Action Program (FUSRAP), it is necessary to describe the history of the site.

The Manhattan Engineer District (MED) established MSP in 1943. The facility was used for sampling, storage, and/or shipment of uranium, thorium, and beryllium ores. All ores received at the facility were handled in a similar manner, including thawing (if necessary), drying, crushing, and screening. Samples were taken for assay from collection hoppers beneath the screens. The ores were subsequently packaged, weighed, and shipped to processing facilities.

Operation of MSP was terminated in 1955 by the U.S. Atomic Energy Commission (AEC), successor to MED. Later, AEC used the site for storage and limited sampling of thorium residues. All AEC activities at MSP ended in 1967. On-site structures were decontaminated, and the site was certified for use with no radiological restrictions under criteria in effect at that time.

In 1968, AEC returned the MSP site to the General Services Administration, which transferred the property to the Department of the Navy. The site served as a reserve training center for the U.S. Marine Corps from 1969 to 1979. MSP was returned to the custody of the U.S. Department of Energy (DOE) in 1980. That same year DOE initiated remedial action to clean up properties in the vicinity of MSP; the cleanup continued into 1981. Approximately 27,000 m^3 (35,000 yd^3) of contaminated soil from these removal

actions were transported to MSP, where an asphalt pad was constructed as a base for an interim storage area.

Operations at the Middlesex Municipal Landfill (MML), a vicinity property of MSP, began in the mid-1940s. In 1948, soil contaminated with pitchblende was removed from MSP and placed on top of existing fill at MML. Subsequent landfill operations resulted in varying depths of cover material being placed over the contaminated material. The landfill has not been used for solid waste disposal since 1974.

A second storage pad at MSP was constructed in 1984 to accommodate the materials excavated from MML during that year. The pad is enclosed with concrete curbing. A geomembrane is attached to the curbing and covers the stored materials.

In 1986, removal actions at MML were completed. Approximately 50,000 m^3 (66,000 yd^3) of contaminated materials were excavated from the landfill in 1984 and 1986. The excavation was backfilled with clean soil, and the area was seeded.

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

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

MSP does not have any state or federal air permits. As a non-operating facility, only Subparts H and Q of NESHAPs are applicable. Compliance with the non-radon radionuclide standard in Subpart H will be determined by evaluating the site using a computer model (e.g., AIRDOS-PC) approved by the Environmental Protection Agency (EPA). A strategy for determining compliance with the radon flux standard in Subpart Q was submitted to EPA. Comments were received from EPA on the proposed compliance strategy on April 19, 1990. The comments require minor modifications to the compliance strategy. Radon flux measurements of the pile will begin by July 18, 1990, absent further comments from EPA.

DOE Orders for Radionuclide Releases

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

Clean Water Act (CWA)

MSP does not have any state or federal water permits. An environmental compliance assessment conducted by Oak Ridge National Laboratory (ORNL) in October 1989 did not find any deficiencies under the CWA. However, an inspection conducted on December 7, 1989, by the New Jersey Department of Environmental Protection (NJDEP) resulted in the issuance of a notice of violation (NOV) for a non-permitted point-source discharge of stormwater. The NOV was resolved on January 19, 1990, by submission of a permit application for the discharge. NJDEP has not yet acted on the application.

Resource Conservation and Recovery Act (RCRA)

RCRA-regulated waste is not present at MSP. Additionally, an environmental compliance assessment conducted by ORNL in October 1989 did not find any deficiencies under RCRA.

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

MSP is not on the National Priorities List. Remediation of the site will be managed by DOE under the authority of the Atomic Energy Act of 1954.

Toxic Substances Control Act (TSCA)

TSCA-regulated waste is not present at MSP. The environmental compliance assessment of the site by ORNL did not find any deficiencies under TSCA.

National Environmental Policy Act (NEPA)

In the past, compliance with NEPA has been accomplished through the use of action description memoranda and corresponding memoranda-to-file. Actions taken to date have been determined to have no significant impact on the environment. Compliance with NEPA for site remedial actions will be accomplished by incorporating those elements required by an environmental assessment into the format of the CERCLA remedial investigation/feasibility study.

ABSTRACT

The environmental monitoring program, which began in 1980, was continued in 1989 at the former Middlesex Sampling Plant (MSP) site, located in the Borough of Middlesex, New Jersey. The MSP site is part of the Formerly Utilized Sites Remedial Action Program (FUSRAP), a Department of Energy (DOE) program to decontaminate or otherwise control sites where residual radioactive materials remain either from the early years of the nation's atomic energy program or from commercial operations causing conditions that Congress has authorized DOE to remedy. The environmental monitoring program is being conducted by Bechtel National, Inc. (BNI), project management contractor for FUSRAP.

The monitoring program at MSP measures radon concentrations in air; external gamma radiation levels; and uranium and radium concentrations in surface water, groundwater, and sediment. Additionally, several nonradiological parameters are measured in groundwater samples. To verify that the site is in compliance with the DOE radiation protection standard (100 mrem/yr) and to assess its potential effect on public health, the radiation dose was calculated for a hypothetical maximally exposed individual. Based on the conservative scenarios described in the report, this hypothetical individual at MSP would receive an annual external exposure equivalent to 2.3 percent of the DOE radiation protection standard. This is approximately equivalent to the exposure a person receives during one flight from New York to Los Angeles because of the greater amounts of cosmic radiation at higher altitudes. The cumulative dose to the population within an 80-km (50-mi) radius of the site that results from radioactive materials present at the MSP is indistinguishable from the dose that the same population receives from naturally occurring radioactive sources.

Results of the 1989 monitoring show that MSP is in compliance with applicable DOE radiation protection standards.

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1.0 INTRODUCTION

This report presents the findings of the environmental monitoring program conducted in the area of the Middlesex Sampling Plant (MSP) site during calendar year 1989. The first environmental monitoring report for this site reported data for 1980, 1981, and 1982; data for subsequent years have been reported annually. The site is part of the United States Department of Energy (DOE) Formerly Utilized Sites Remedial Action Program (FUSRAP) and is located in the Borough of Middlesex, Middlesex County, New Jersey, as shown in Figure 1-1.

1.1 LOCATION AND DESCRIPTION

The MSP site occupies 3.9 ha (9.6 acres). As shown in Figure 1-2, there are four buildings on the site, which is surrounded by a 2.1-m- (7-ft-) high chain-link fence. Most of the site is paved with asphalt. MSP is currently used for interim storage of contaminated soils excavated from vicinity properties, including the Middlesex Municipal Landfill (MML). Figure 1-3 is an aerial photograph of the site. At the completion of remedial action at MML in 1986, 50,748 m^3 (66,372 yd^3) of contaminated soils were stored at MSP. The interim storage pad constructed at the MSP for the soil excavated from MML during the 1984 and 1986 remedial action activities includes a leachate collection system to preclude release of contaminants from the stored material to waters in the area.

The site slopes gently from approximately 18 m (60 ft) above mean sea level (msl) on the northern side to 15 m (50 ft) above msl on the southern side. Soils at MSP are silty to sandy loams with thickness over bedrock ranging from 0.46 to 2.4 m (1.5 to 8.0 ft). All on-site surface water is conveyed via an underground drainage system to a settling basin and then to the easement ditch south of the site that discharges into a small brook known as Main Stream.

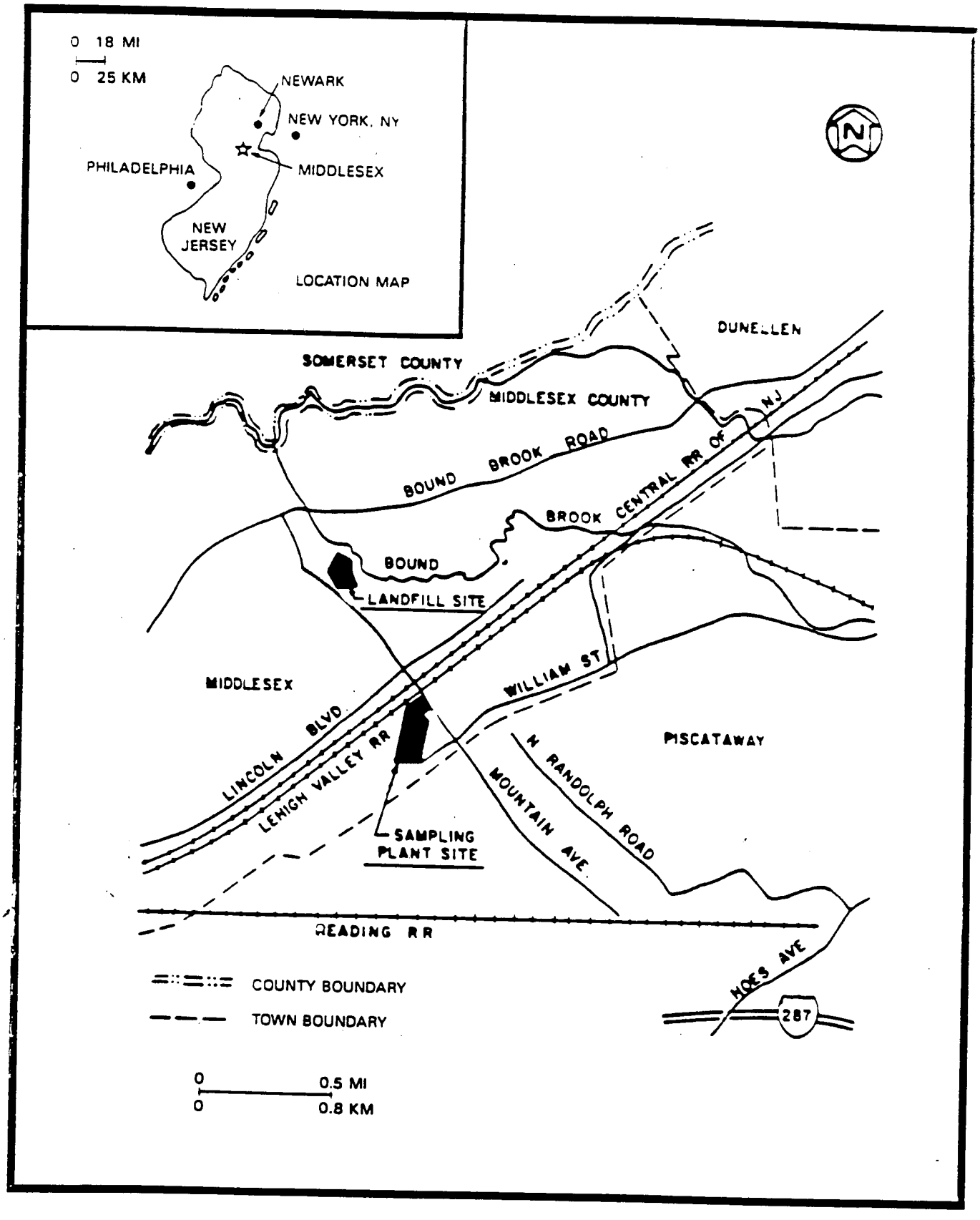

FIGURE 1-1 LOCATION OF MSP

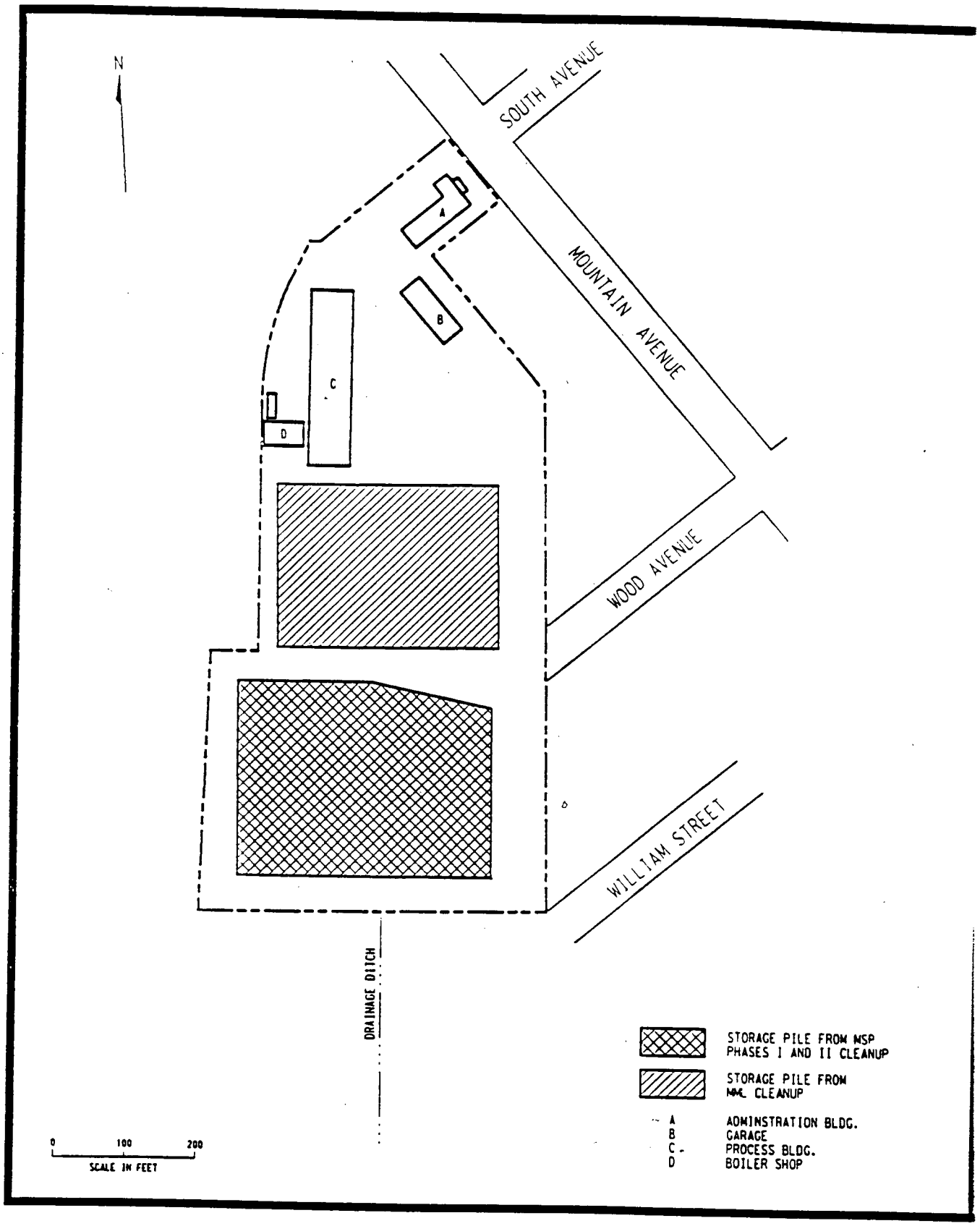

FIGURE 1-2 MAP OF THE MSP SITE

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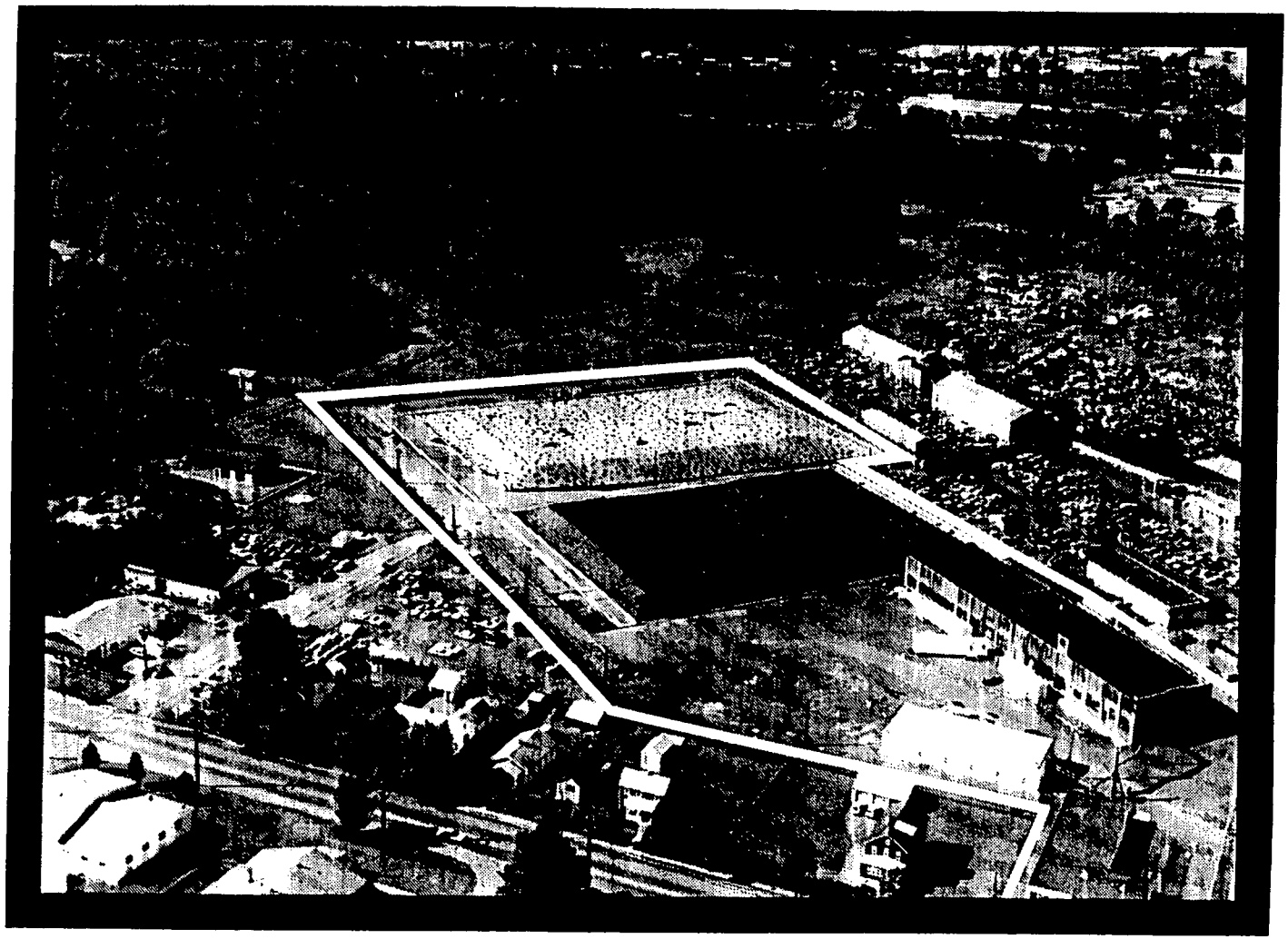


FIGURE 1-3 AERIAL VIEW OF MSP

The Brunswick formation is the predominant bedrock unit in the MSP vicinity; it is a major aquifer in the western part of Middlesex County and adjoining Essex County. Numerous private water supply wells are located within 1.6 km (1 mi) of MSP. A public well field, Sebrings Mill well field, lies 2 km (1.25 mi) northwest of MSP.

The average annual daily maximum temperature for the Middlesex area is 16.9°C (62.5°F), and the average daily minimum is 7.33°C (45.2°F). The highest average monthly temperature is 29.8°C (85.6°F) (July), and the lowest is -4.28°C (24.3°F) (January). Average annual precipitation is 107 cm (42 in.) with an average annual snowfall of 69.85 cm (27.5 in.) (Ref. 1). As shown in Figure 1-4, winds in the area blow predominantly from the southwest at a mean speed of 16 km/h (10 mph).

Approximately 15 million people reside within 80 km (50 mi) of Middlesex. The 1980 populations of Middlesex and Piscataway were 13,480 and 42,233, respectively; they are expected to increase over the next 10 to 15 years (Ref. 2).

As shown in Figure 1-5, land use in the vicinity of MSP is primarily residential and industrial. An expanse of vacant land borders the southern end of the site.

1.2 SITE HISTORY

The Manhattan Engineer District (MED) established MSP in 1943. The facility was used for sampling, storage, and/or shipment of uranium, thorium, and beryllium ores. All ores received at the facility were handled in a similar manner, including thawing (if necessary), drying, crushing, and screening. Samples were taken for assay from collection hoppers beneath the screens. The ores were subsequently packaged, weighed, and shipped to processing facilities.

Operation of MSP was terminated in 1955 by the Atomic Energy Commission (AEC), successor to the MED. Later, AEC used the site for storage and limited sampling of thorium residues. All AEC

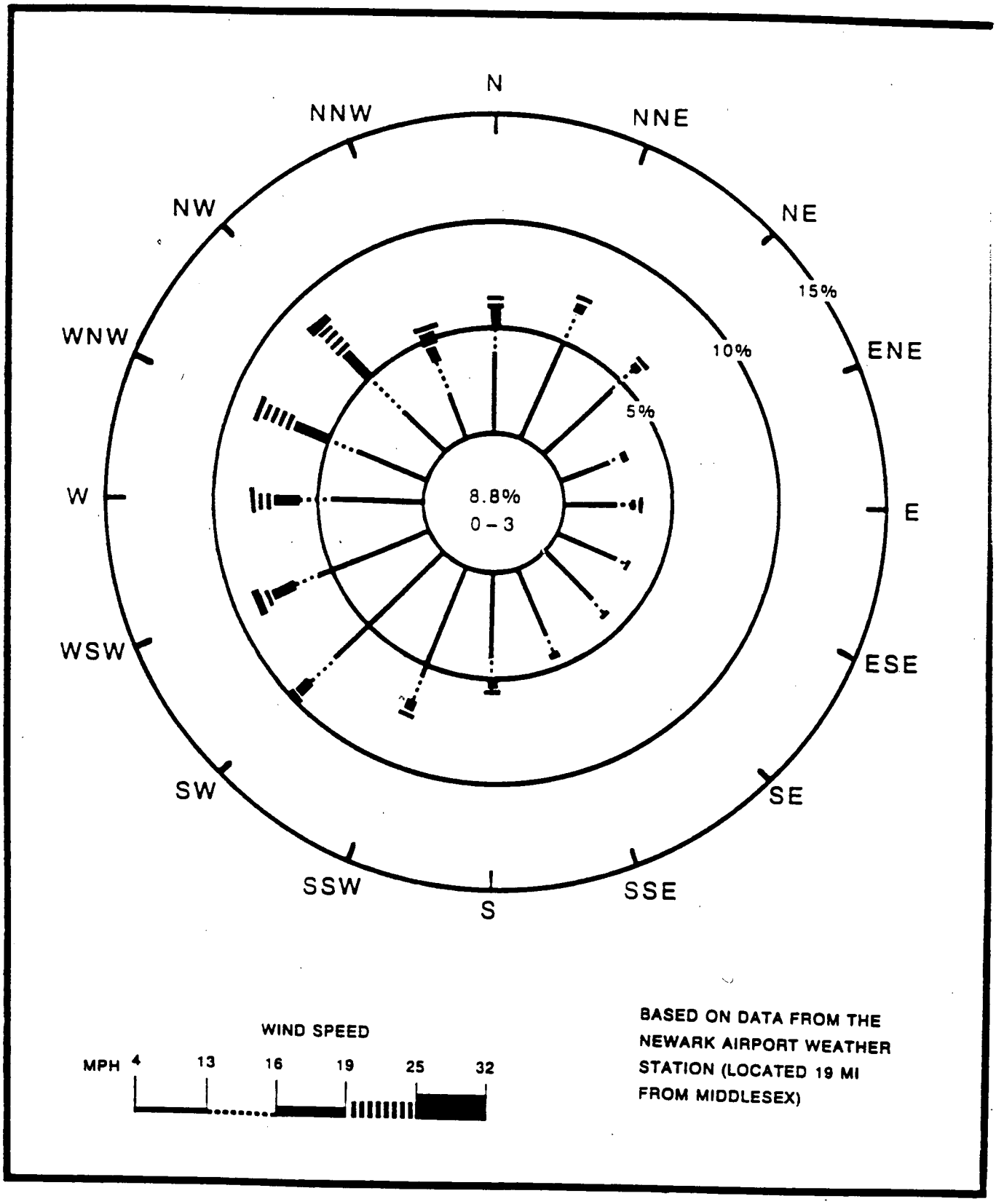
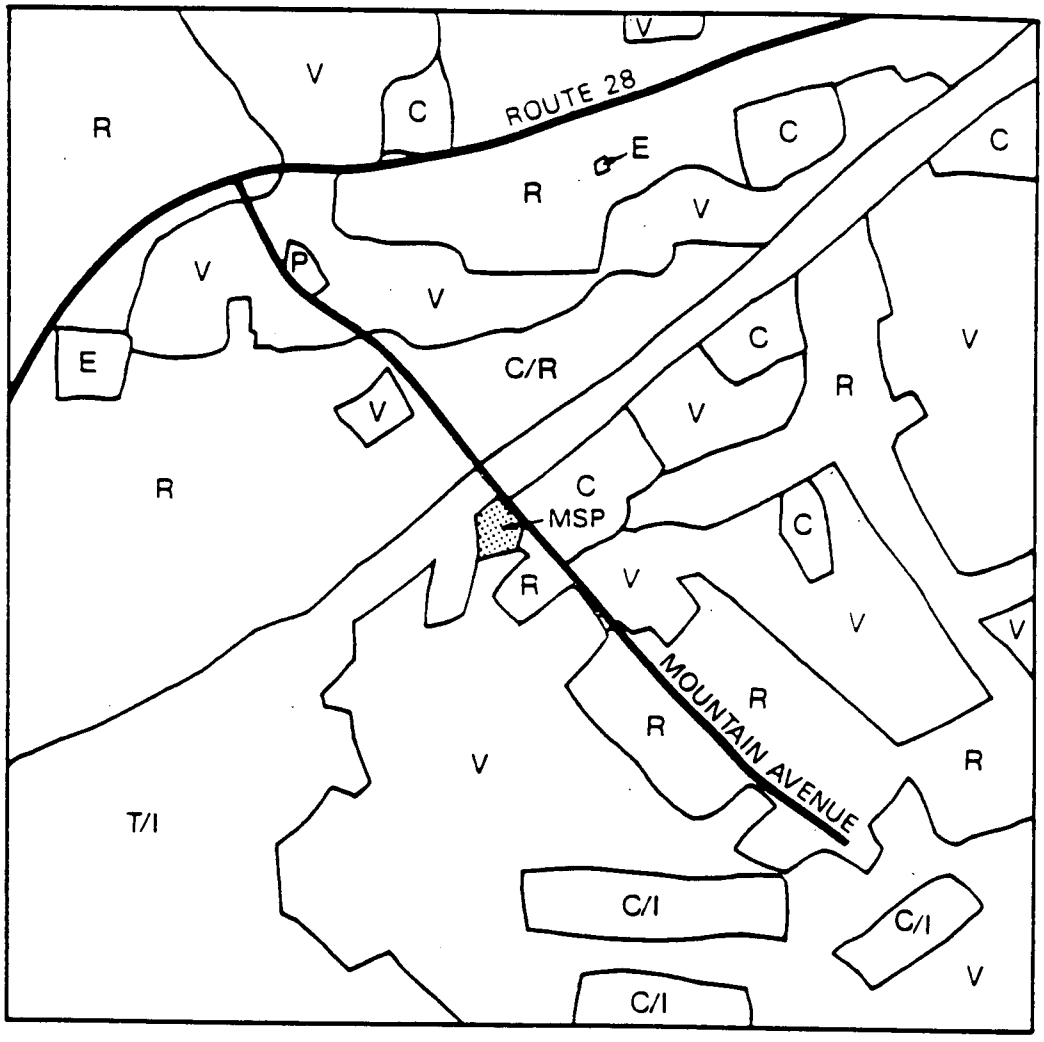


FIGURE 1-4 ANNUAL WIND ROSE FOR MSP



BASED ON AERIAL PHOTOGRAPHS, SITE VISITS, AND USGS TOPOGRAPHIC MAPS, 1:24000 SCALE, PLAINFIELD NJ QUADRANGLE, (PHOTO REVISED 1981) AND BOUND BROOK, (PHOTO REVISED 1970)

R RESIDENTIAL
C COMMERCIAL
C/R MIXED RESIDENTIAL COMMERCIAL
P PUBLIC
C/I COMMERCIAL/INDUSTRIAL
T/I TRANSPORTATION/INDUSTRIAL
V VACANT
E EDUCATIONAL

0 0.5 MI
0 0.8 KM

FIGURE 1-5 GENERALIZED LAND USE IN THE VICINITY OF MSP

activities at MSP ended in 1967. On-site structures were decontaminated, and the site was certified for unrestricted use under criteria in effect at that time.

In 1968, AEC returned the MSP site to the General Services Administration, which transferred the property to the Department of the Navy. The site served as a reserve training center for the U.S. Marine Corps from 1969 to 1979. MSP was returned to DOE custody in 1980. That same year DOE initiated remedial action to clean up properties in the vicinity of MSP, and the cleanup continued into 1981. Approximately 27,000 m^3 (35,000 yd^3) of contaminated soil from these remedial actions was transported to MSP, where an asphalt pad was constructed as a base for an interim storage area.

Operations at MML began in the mid-1940s. In 1948, dirt contaminated with pitchblende (high-grade uranium ore) was removed from MSP and placed on top of the existing fill at MML. Subsequent landfill operations resulted in varying depths of cover material being placed over the contaminated material. The landfill has not been used for solid waste disposal since 1974.

Two radiological surveys had indicated that the portion of the MML site requiring remedial action covered about 0.2 ha (0.5 acre) (Refs. 3, 4). Excavation of radioactively contaminated material from MML began in 1984; approximately 12,000 m^3 (16,000 yd^3) of contaminated soils were transported to MSP for interim storage. This excavation and subsequent investigations indicated that the contaminated area covered approximately 1.2 ha (3 acres).

A second storage pad was constructed at MSP in 1984 to accommodate the materials excavated from MML during that year. The pad is enclosed with concrete curbing to prevent migration of the stored materials. A geomembrane is attached to the curbing and was used to cover the stored materials whenever remedial action was not in progress. Table 1-1 lists the volumes and sources of the materials placed on the storage pads by year of emplacement and indicates the total volume of contaminated material presently stored at MSP.

TABLE 1-1

VOLUMES OF CONTAMINATED SOIL

ON MSP STORAGE PADS

Date and Source	Volume (m^3)[a]	Volume (yd^3)
1980 (Phase I) MSP Cleanup	7,203	9,421
1981 (Phase II) MSP Cleanup	19,681	25,742[b]
1984 MML Cleanup (Second Storage Pad)	11,942	15,620
1986 MML Cleanup (Extended Second Storage Pad)	11,919	15,589
Total on Storage Pads	50,745	66,372

[a]Numbers given in earlier reports were incorrect as a result of conversion error; they have been corrected, as reflected here.

[b]BNI (Ref. 5).

During 1985, site preparation work was conducted at MSP and MML in preparation for resuming remedial actions initiated in 1984. Work at MSP included the construction of a further extension to the storage area to accommodate material to be excavated from MML during 1986.

In 1986, remedial actions at MML were completed with the removal of the last 11,919 m^3 (15,620 yd^3) of contaminated soil. The excavation was backfilled with clean soil, and the area was seeded. The environmental monitoring program at MML was terminated because the site was remediated and returned to the Borough of Middlesex in December 1987.

There are no continuing commercial, industrial, or remedial activities at MSP; therefore, there are no airborne radioactive effluents from the site, and waterborne radioactive effluents are limited to extremely low concentrations in surface drainage.

1.3 HYDROGEOLOGICAL CHARACTERISTICS OF THE SITE

The two groundwater systems monitored have been designated "shallow" and "deep" in previous environmental monitoring reports (Refs. 6 through 12). In this report, the terms "shallow" and "deep" are replaced with "upper" and "lower," respectively. Groundwater monitoring wells (Figure 1-6) were installed at the MSP site in two phases by Roy F. Weston, Inc.--Phase I in 1980 and Phase II in 1981. A summary of well construction information is shown in Tables 1-2 and 1-3. Further background information on site geology and hydrogeology can be found in Ref. 13. See Appendix E for examples of well construction details (Ref. 14).

The hydrogeological characteristics of MSP in 1989 remain unchanged from 1988, though the database are sporadic. Water level readings were obtained quarterly in 1988 and scheduled weekly in 1989 but were collected only from March to August and October to December.

Readings for January, February, and September were inadvertently omitted from the database.

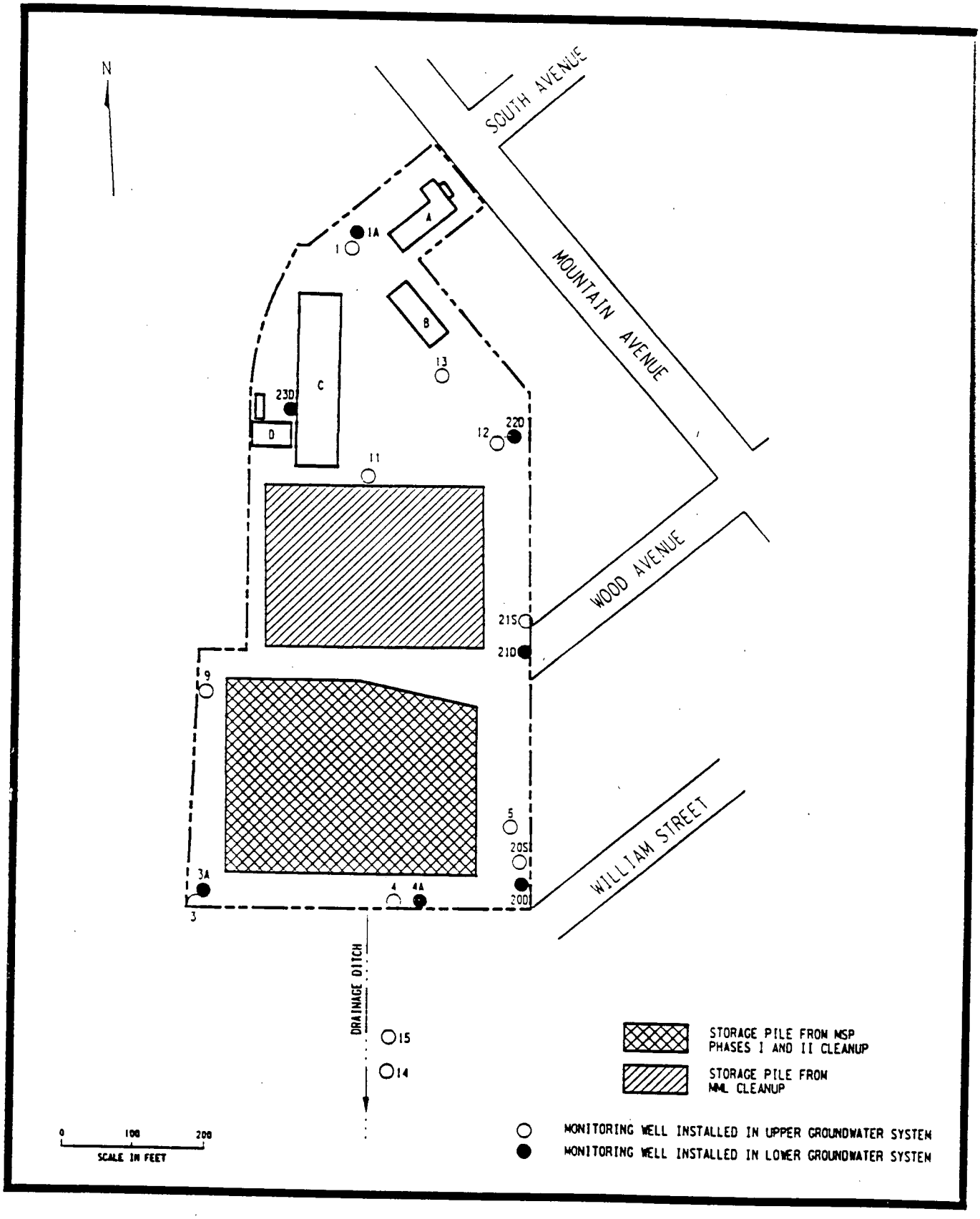


FIGURE 1-6 GROUNDWATER MONITORING WELL LOCATIONS AT MSP

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TABLE 1-2

MSP PHASE I MONITORING WELL CONSTRUCTION SUMMARY[a]

Well Number	Completion Date	Total Depth [m (ft)]	Screened or Open Interval Below Ground [m-m (ft-ft)]	Construction Material[b]
1	May 1980	3.05 (10.0)	1.1 - 3.05 (3.5-10.0)	PVC
1A	May 1980	15.3 (50.0)	Open[c]	PVC[d]
3	May 1980	3.05 (10.0)	0.30 - 3.05 (1.0-10.0)	PVC
3A	May 1980	15.3 (50.0)	Open[c]	PVC[d]
4	May 1980	3.05 (10.0)	0.50 - 3.05 (1.5-10.0)	PVC
4A	May 1980	9.2 (30.0)	Open[c]	PVC[d]
5	May 1980	3.05 (10.0)	1.1 - 3.05 (3.5-10.0)	PVC
9	May 1980	3.05 (10.0)	0.0 - 3.05 (0.0-10.0)	PVC
11	May 1980	3.05 (10.0)	0.30 - 3.05 (1.0-10.0)	PVC
12	May 1980	3.05 (10.0)	0.30 - 3.05 (1.0-10.0)	PVC
13	May 1980	3.05 (10.0)	0.9 - 3.05 (3.0-10.0)	PVC
14	May 1980	4.6 (15.0)	1.2 - 4.6 (4.0-15.0)	PVC
15	May 1980	1.5 (5.0)	0.0 - 1.5 (0.0- 5.0)	PVC

[a]Wells installed by Roy F. Weston, Inc.

[b]PVC - polyvinyl chloride.

[c]Open at total depth; no documentation for top of interval.

[d]PVC conductor in overburden; open hole in bedrock.

TABLE 1-3

MSP PHASE II MONITORING WELL CONSTRUCTION SUMMARY[a]

Well Number	Completion Date	Total Depth [m (ft)]	Screened Interval Below Ground [m-m (ft-ft)]	Construction Material
20D	July 1981	15.3 (50.0)	12.2 - 15.3 (40.0-50.0)	PVC[b]
20S	July 1981	3.05 (10.0)	0.90 - 3.05 (3.0-10.0)	PVC
21D	July 1981	15.3 (50.0)	12.2 - 15.3 (40.0-50.0)	PVC
21S	July 1981	3.05 (10.0)	0.9 - 3.05 (3.0-10.0)	PVC
22D	July 1981	15.3 (50.0)	12.2 - 15.3 (40.0-50.0)	PVC
23D	July 1981	15.3 (50.0)	12.2 - 15.3 (40.0-50.0)	PVC

[a]Wells installed by Roy F. Weston, Inc.

[b]PVC - polyvinyl chloride.

1.3.1 Upper Groundwater System

The upper groundwater system is an unconfined saturated zone located approximately 0.6 to 3.0 m (2 to 10 ft) below the ground surface. Wells installed in this system are screened in the weathered, fissile Brunswick shale at depths of 1.5 to 4.6 m (5 to 15 ft). Groundwater level elevations measured in 1989 for each shallow well are shown as hydrographs in Figures 1-7, 1-8, and 1-9. Precipitation records for the site are also shown beneath each hydrograph.

The hydrographs for wells in the upper groundwater system do not indicate any seasonal variation in water levels. This observation can be confirmed when a complete cycle of annual measurements is taken. Correlation with precipitation events is slight to none, indicating either that no surface recharge takes place on the site, or that the upper groundwater system reaches equilibrium rapidly after a precipitation event.

The slope and flow direction of the upper groundwater system were determined from water table surface maps. (The water table, or potentiometric surface, is defined as the level to which water will rise in a tightly cased well. Delineation of the potentiometric surface of an aquifer indicates groundwater slope and flow direction.) The general direction of flow is from north to south, as shown on two potentiometric surface maps (Figure 1-10 for April and Figure 1-11 for December). The shape of the contours suggests that the potentiometric surface represents a subdued reflection of the site topography (Ref. 13). The gradient of the potentiometric surface for both sampling dates is on the order of 0.01, which represents no change from conditions observed in 1988 (Ref. 12).

1.3.2 Lower Groundwater System

The potentiometric surface of the confined lower groundwater system is approximately 2.4 to 9.1 m (8 to 30 ft) below the ground surface. Wells installed in the lower groundwater system monitor

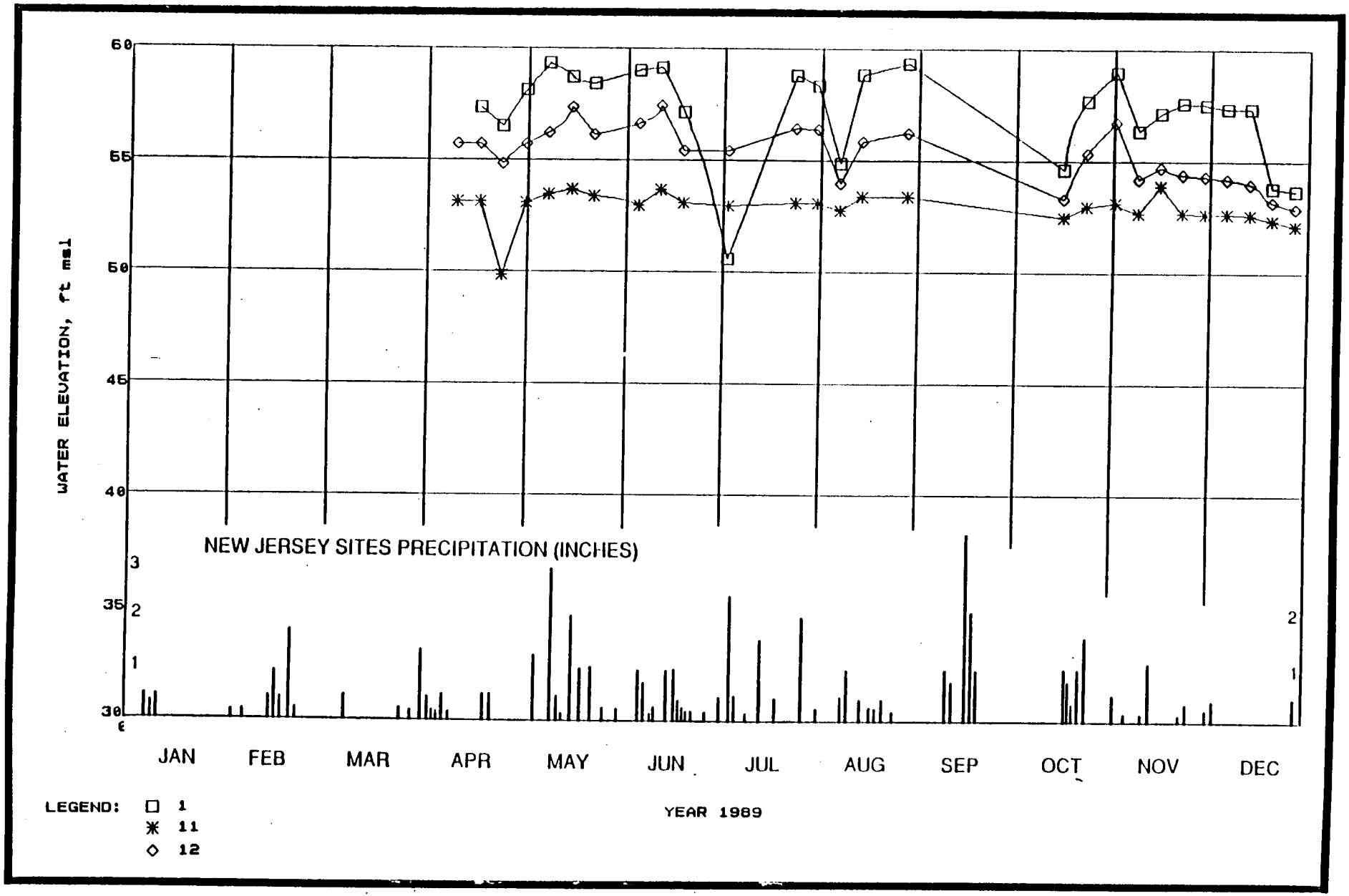

FIGURE 1-7 HYDROGRAPHS OF UPPER GROUNDWATER SYSTEM WELLS 1, 11, AND 12

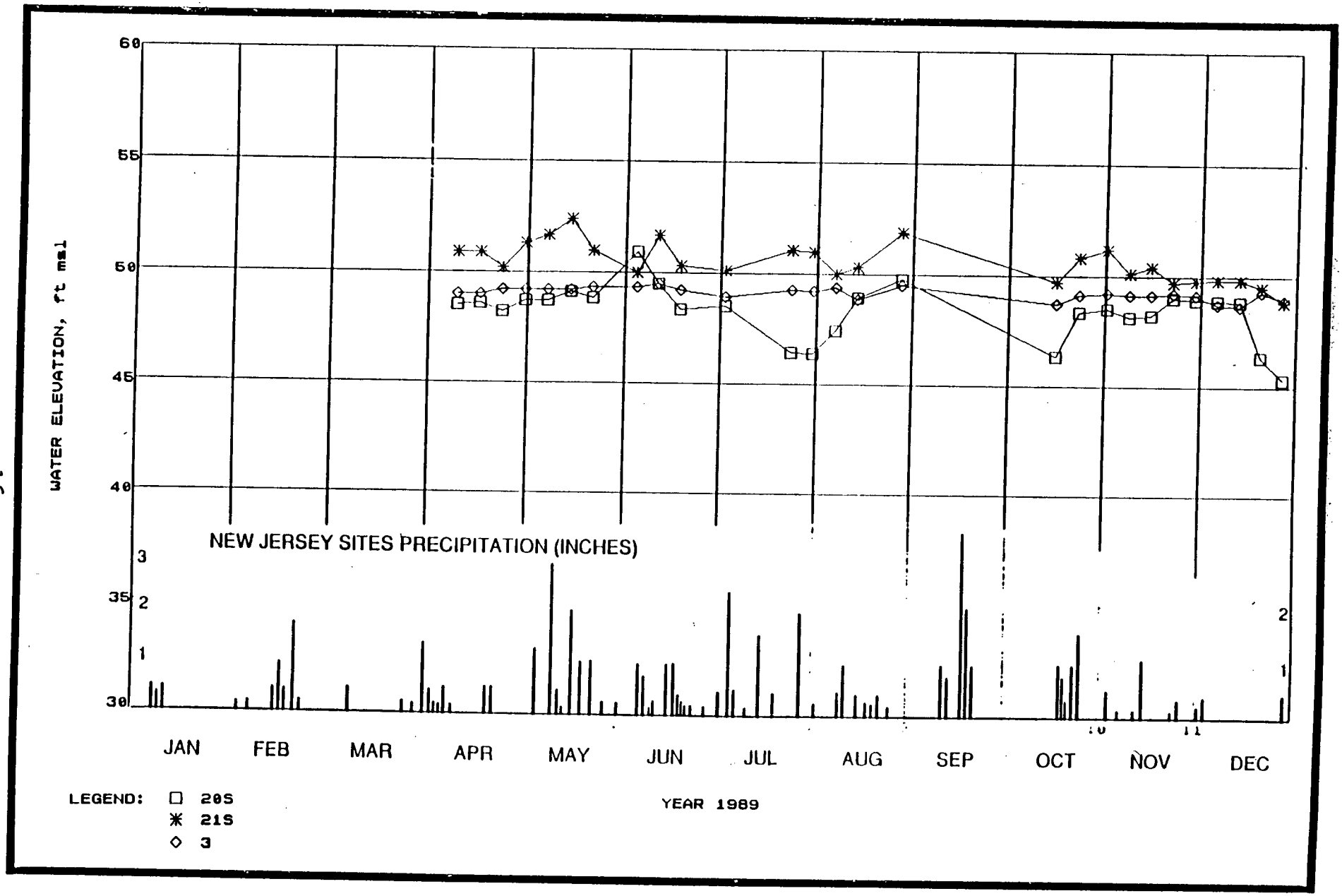

FIGURE 1-8 HYDROGRAPHS OF UPPER GROUNDWATER SYSTEM WELLS 20S, 21S, AND 3

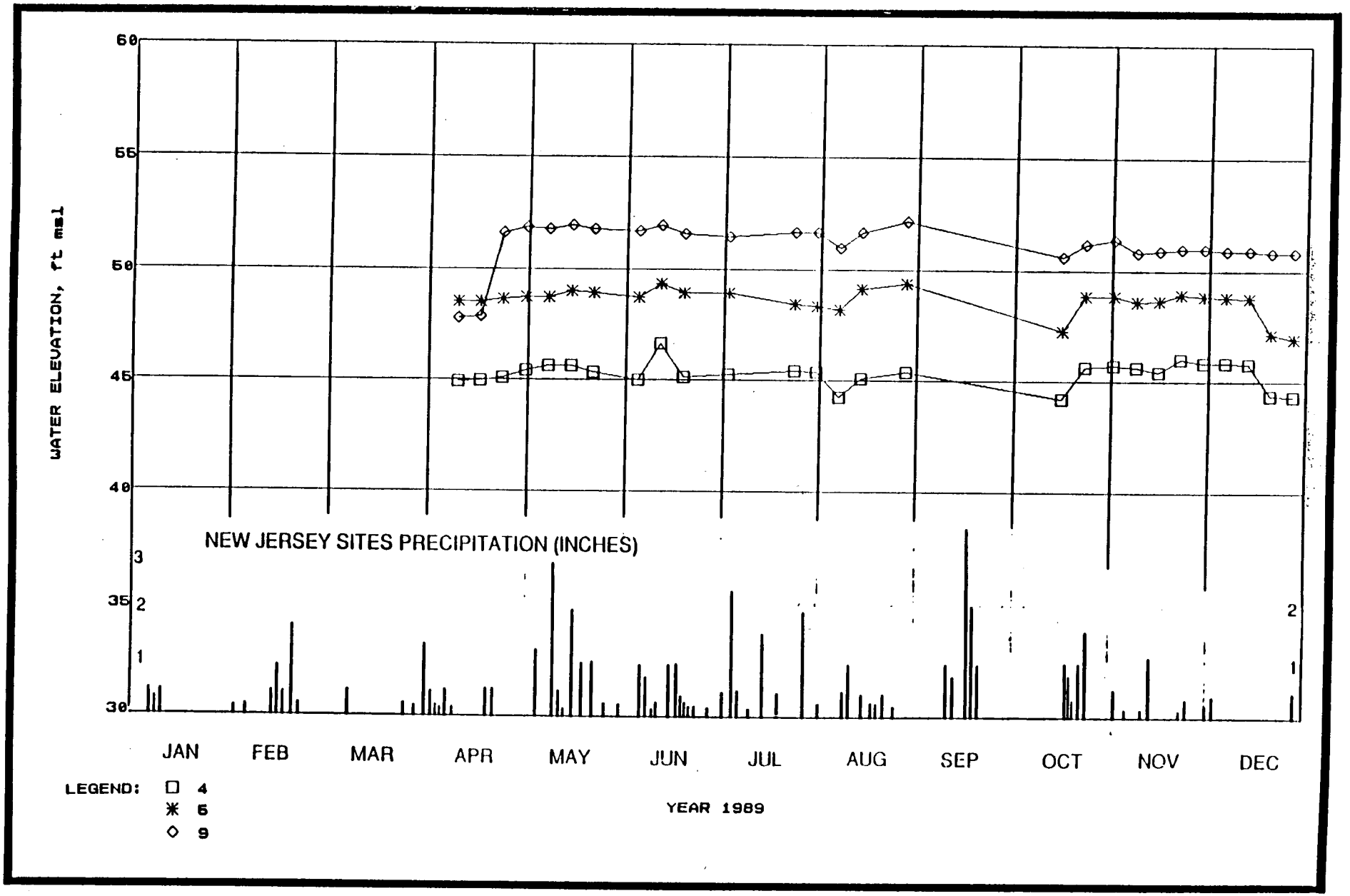

FIGURE 1-9 HYDROGRAPHS OF UPPER GROUNDWATER SYSTEM WELLS 4, 5, AND 9

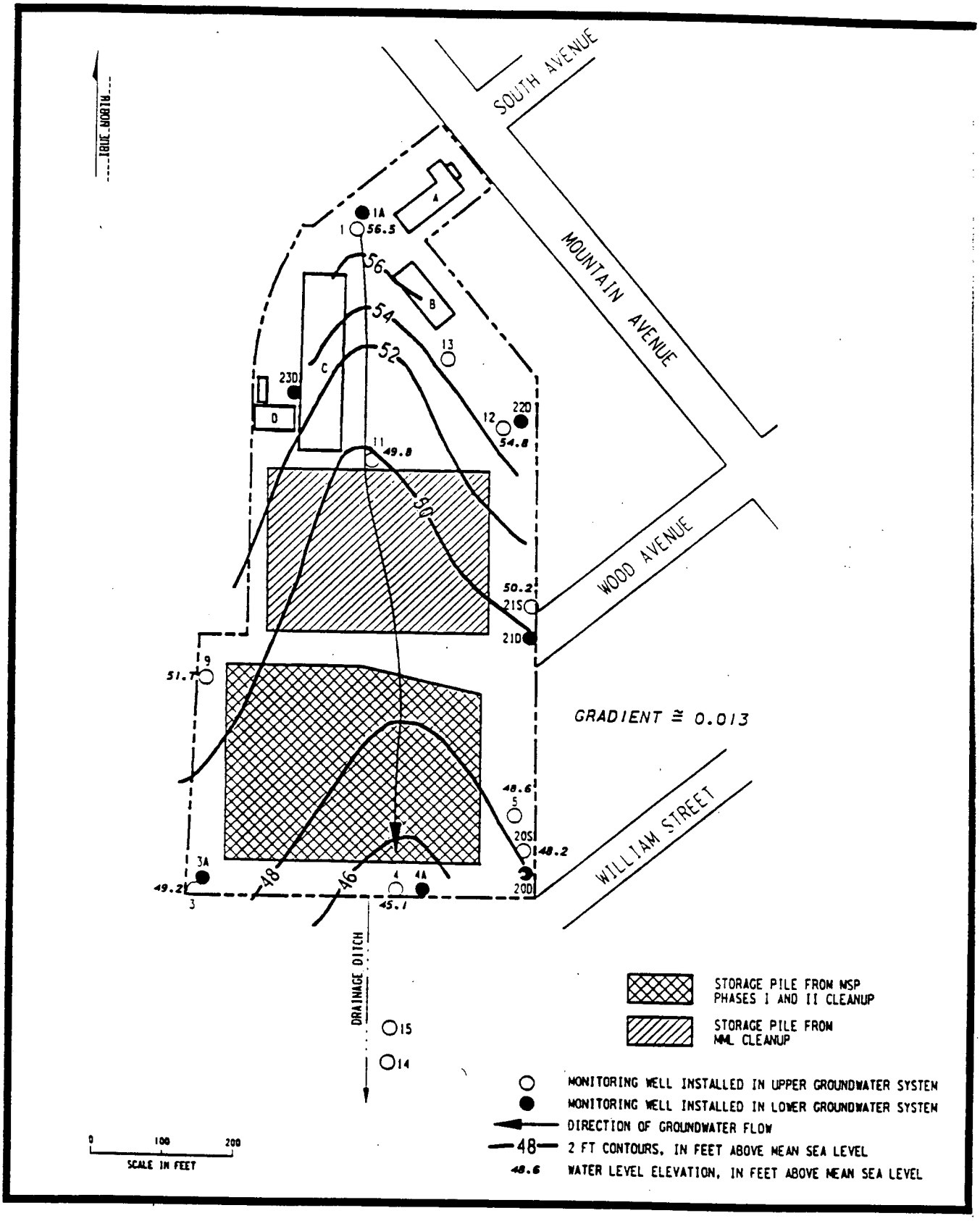

FIGURE 1-10 MSP UPPER GROUNDWATER SYSTEM POTENTIOMETRIC SURFACE (4/24/89)

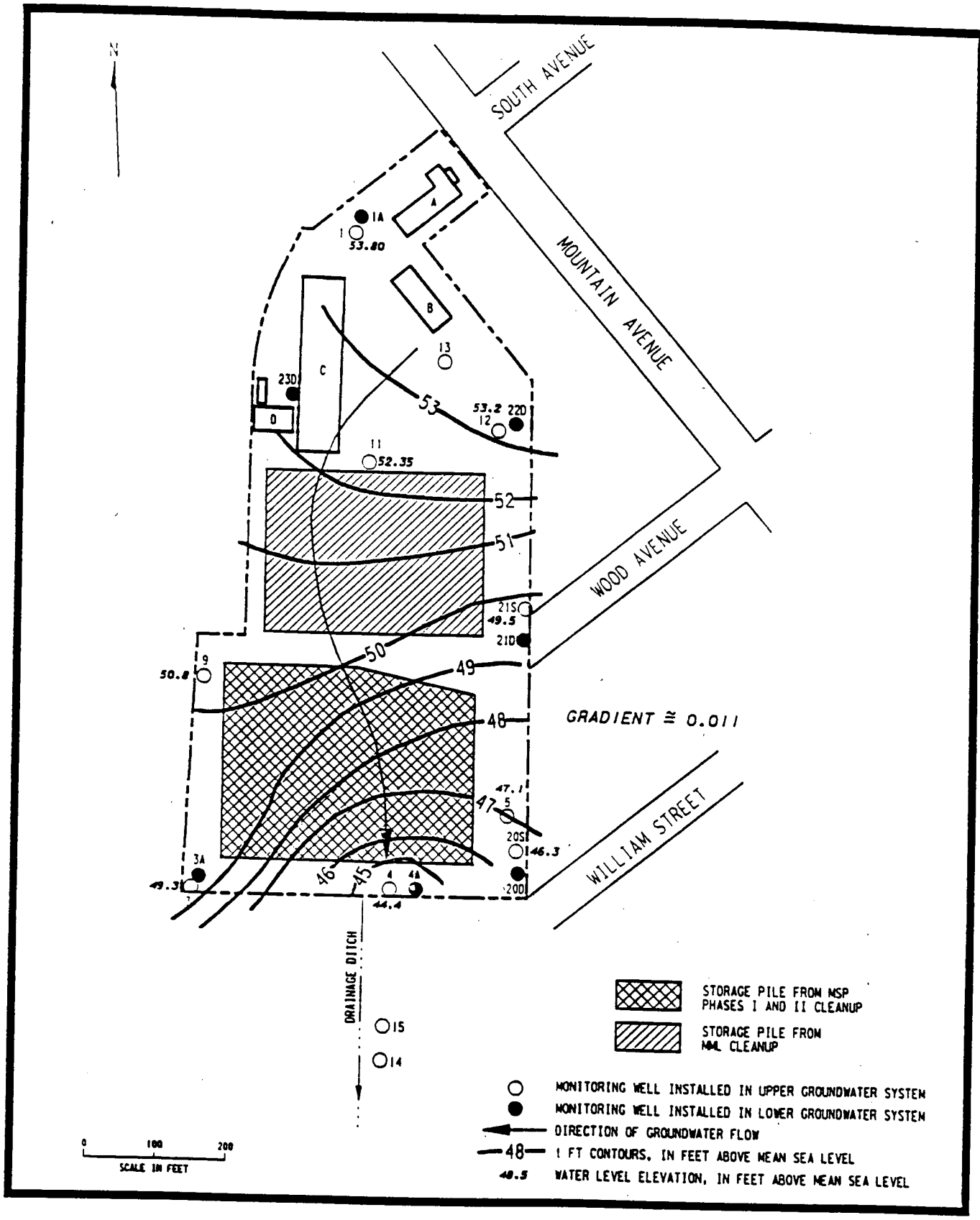

FIGURE 1-11 MSP UPPER GROUNDWATER SYSTEM POTENTIOMETRIC SURFACE (12/20/89)

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water in the Brunswick formation in the interval from 4.6 to 15.3 m (15 to 50 ft) below the ground surface. Wells 1A, 3A, and 4A are open holes, and wells 20D, 21D, 22D, and 23D are screened with PVC. Groundwater level measurements taken in 1989 for each deep well are shown as hydrographs in Figure 1-12. Wells 22D and 23D were accidentally omitted from the water level measuring program in 1989. The precipitation records for the site are shown beneath the hydrographs.

As with the shallow groundwater system, the lower system does not display any apparent seasonal fluctuation in 1989, and correlation of groundwater levels with precipitation events is poor. Slope and flow direction for the lower groundwater system were calculated from two potentiometric surface maps (Figure 1-13 for April and Figure 1-14 for December). As with the upper groundwater system, the groundwater gradient is on the order of 0.01, but the flow is in the opposite direction (from south to northeast).

1.3.3 Conclusions

Conditions observed for the upper and lower groundwater systems indicate no change from the slope and flow directions reported in 1988. No indications of seasonal fluctuations were observed for either system.

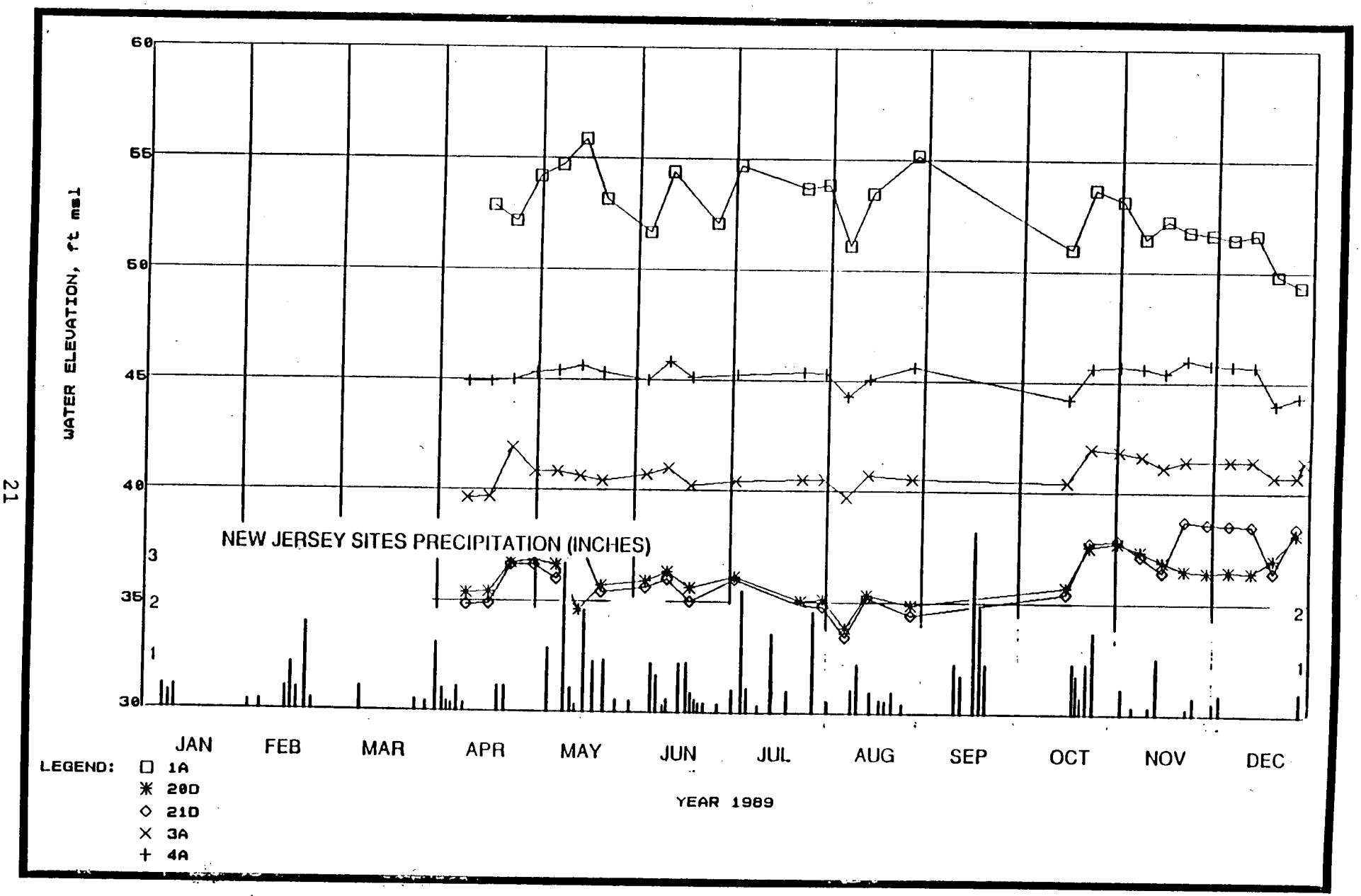

FIGURE 1-12 HYDROGRAPHS OF LOWER GROUNDWATER SYSTEM WELLS 1A, 20D, 21D, 3A, AND 4A

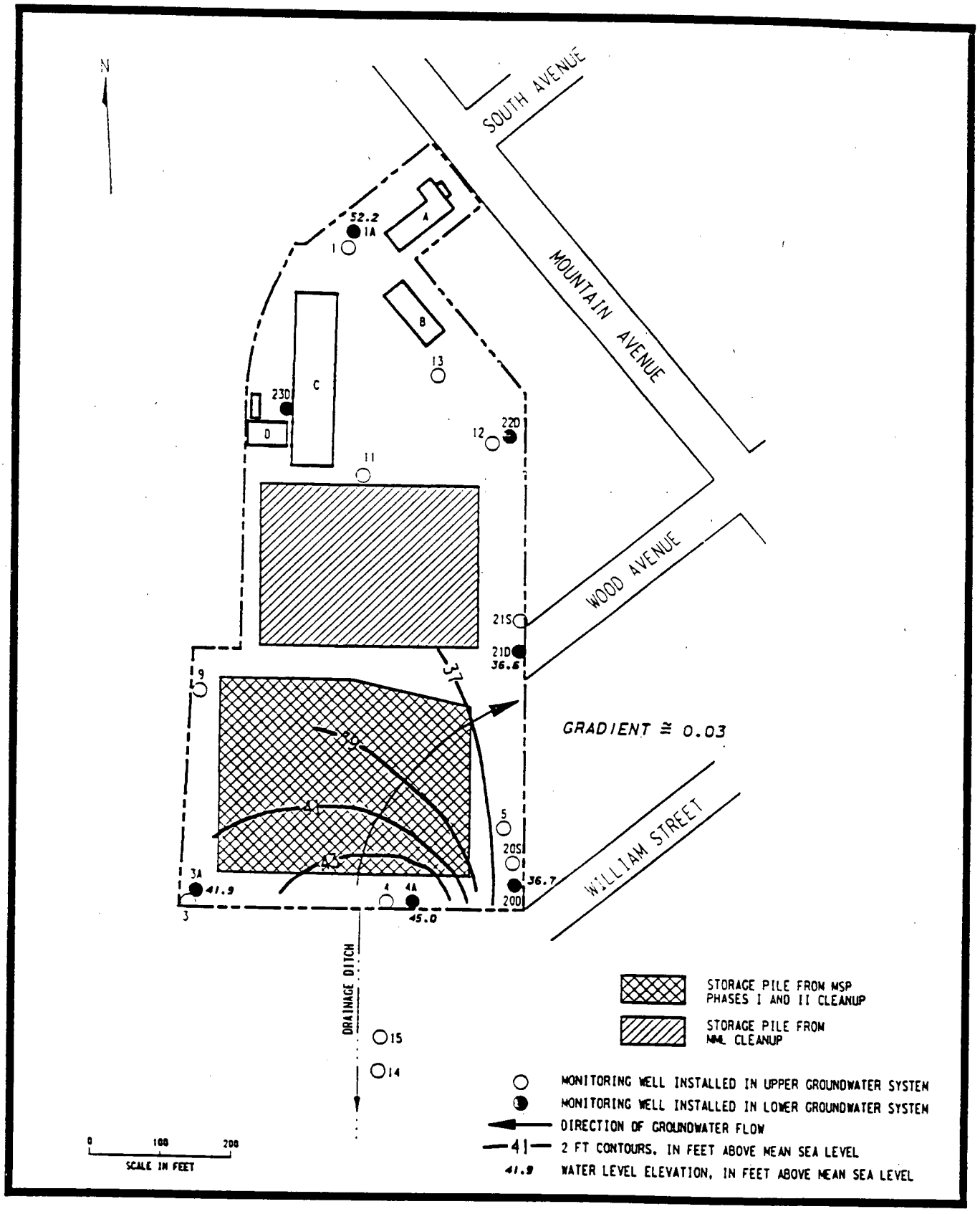

FIGURE 1-13 MSP LOWER GROUNDWATER SYSTEM POTENTIOMETRIC SURFACE (4/24/89)

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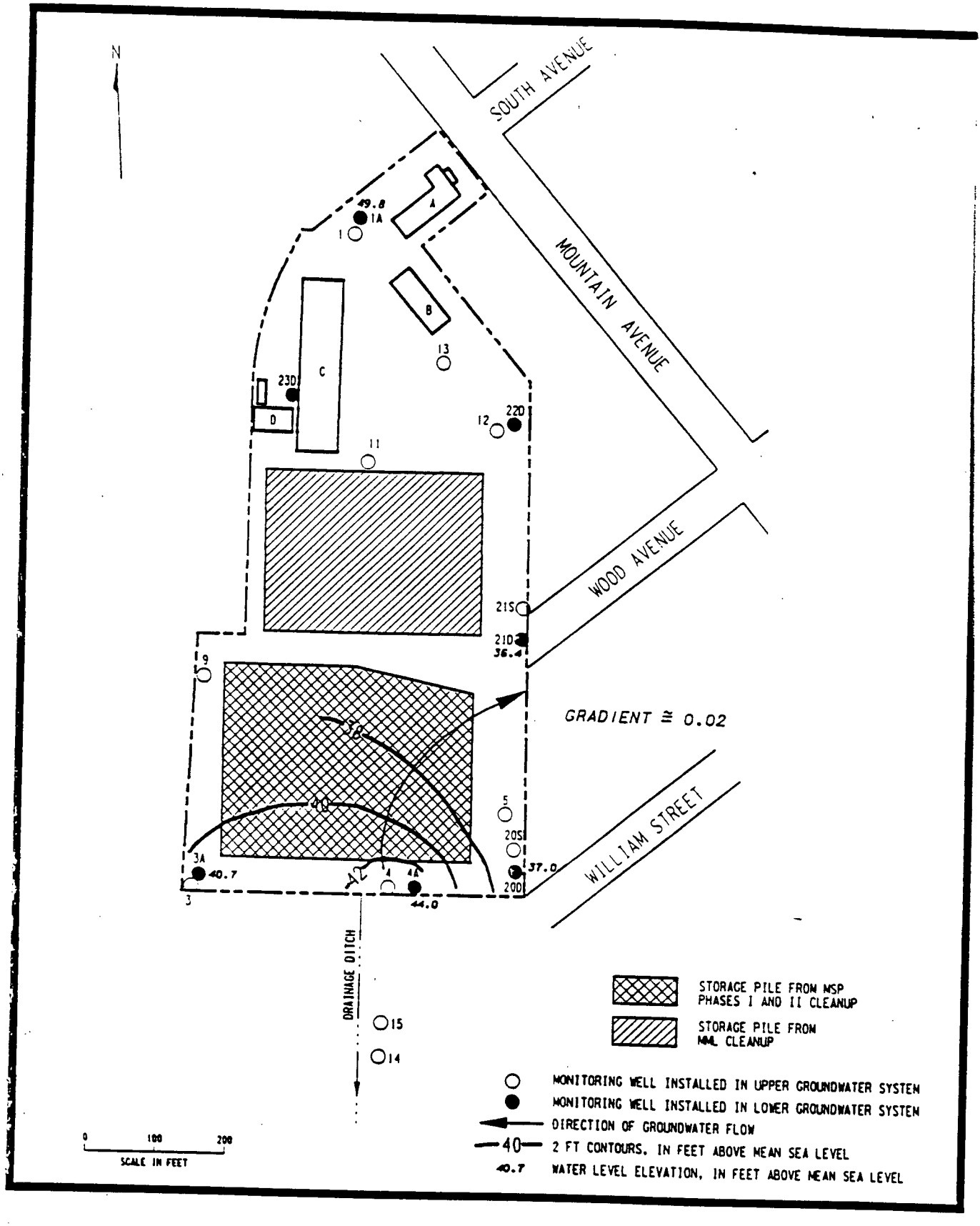

FIGURE 1-14 MSP LOWER GROUNDWATER SYSTEM POTENTIOMETRIC SURFACE (12/20/89)

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2.0 SUMMARY OF MONITORING RESULTS

The environmental monitoring program at MSP continued in 1989; air, water, and sediment samples were taken, and radon and external gamma radiation levels were monitored to verify compliance with the DOE radiation protection standard of 100 mrem/yr (Ref. 15). The potential dose that might be received by a hypothetical maximally exposed individual at the MSP was calculated to determine the degree of compliance with the radiation protection standard.

During 1989, the annual average concentrations of radon (including background) were measured around the perimeter of MSP. Annual average concentrations at MSP ranged from 4×10^{-10} to 1.8×10^{-9} μCi/ml (0.4 to 1.8 pCi/L). Radon concentrations at MSP in 1989 are discussed in Subsection 3.1.

Annual average external radiation levels recorded at the MSP boundary ranged from background to 125 mrem/yr above background. These levels may be compared with the external radiation level from naturally occurring background radiation in the vicinity of MSP, which averaged 76 mrem/yr in 1989. External radiation levels are discussed in Subsection 3.2.

In surface water (Subsection 3.3), the highest annual average concentration of total uranium at the site was 2.2×10^{-8} μCi/ml (22 pCi/L); for radium-226 it was 1.7×10^{-9} μCi/ml (1.7 pCi/L). There have been no definite trends in annual average concentrations of uranium or radium-226 in surface water at MSP (see Subsection 3.7.3).

In groundwater (Subsection 3.4), the highest annual average concentration of total uranium, measured in an on-site well at MSP, was 1.31×10^{-7} μCi/ml (131 pCi/L). For radium-226, the maximum annual average concentration was 7.0×10^{-9} μCi/ml (7.0 pCi/L). Concentrations of radionuclides in surface water and groundwater are within DOE derived concentration guidelines. Chemical analyses of groundwater detected a total of seven pollutants. There is no evidence that MSP is adversely affecting surrounding aquifers.

In stream sediments, the highest annual average concentration of total uranium at the site was 31.8 pCi/g. The highest annual average concentration of radium-226 was 15.2 pCi/g. These concentrations may be compared with the levels of radioactivity in phosphate fertilizers listed in Appendix D.

Calculations were made of the radiological dose received by a hypothetical maximally exposed individual (Subsection 3.6.1). This individual is one who is assumed to be adjacent to the site and who, when all potential routes of exposure are considered, receives the greatest dose. Exposure to external gamma radiation was the exposure pathway quantified because it is the only one that is plausible. The calculated exposure to this hypothetical maximally exposed resident individual at the MSP from this pathway was 2.3 mrem/yr above background. This exposure is approximately equivalent to 2.3 percent of the DOE radiation protection standard.

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

Results of the 1989 monitoring show that MSP is in compliance with the DOE radiation protection standard of 100 mrem/yr.

3.0 DATA COLLECTION, ANALYSIS, AND EVALUATION

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

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

Trend tables are provided for radon and external gamma radiation levels and for radionuclides measured in surface water and groundwater. These tables list annual averages for each monitoring location for 1985 through 1989 to allow for comparisons of data and identification of trends in monitoring results (see Subsection 3.7).

3.1 RADON MONITORING

Radon detectors were maintained at 20 locations at MSP (Figure 3-1). Sampling locations were selected on the basis of the potential for elevated radon releases. Detectors are spaced along the site boundary or area of contamination to ensure adequate detection capability under most atmospheric conditions.

The radon data reported for MSP are from 17 monitors around the storage piles and along the site boundary. Data from monitors located inside buildings or situated centrally on the site are not reported because they are not considered representative of conditions at the site boundary.

To measure background radon levels, two additional detector locations were established. One detector was retained at MML. This location is listed in Table 3-1 as MML 4 and is approximately 0.8 km (0.5 mi) north of MSP. The second detector used to measure background radon levels is sampling location 29, located approximately 16 km (10 mi) south of the site.

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

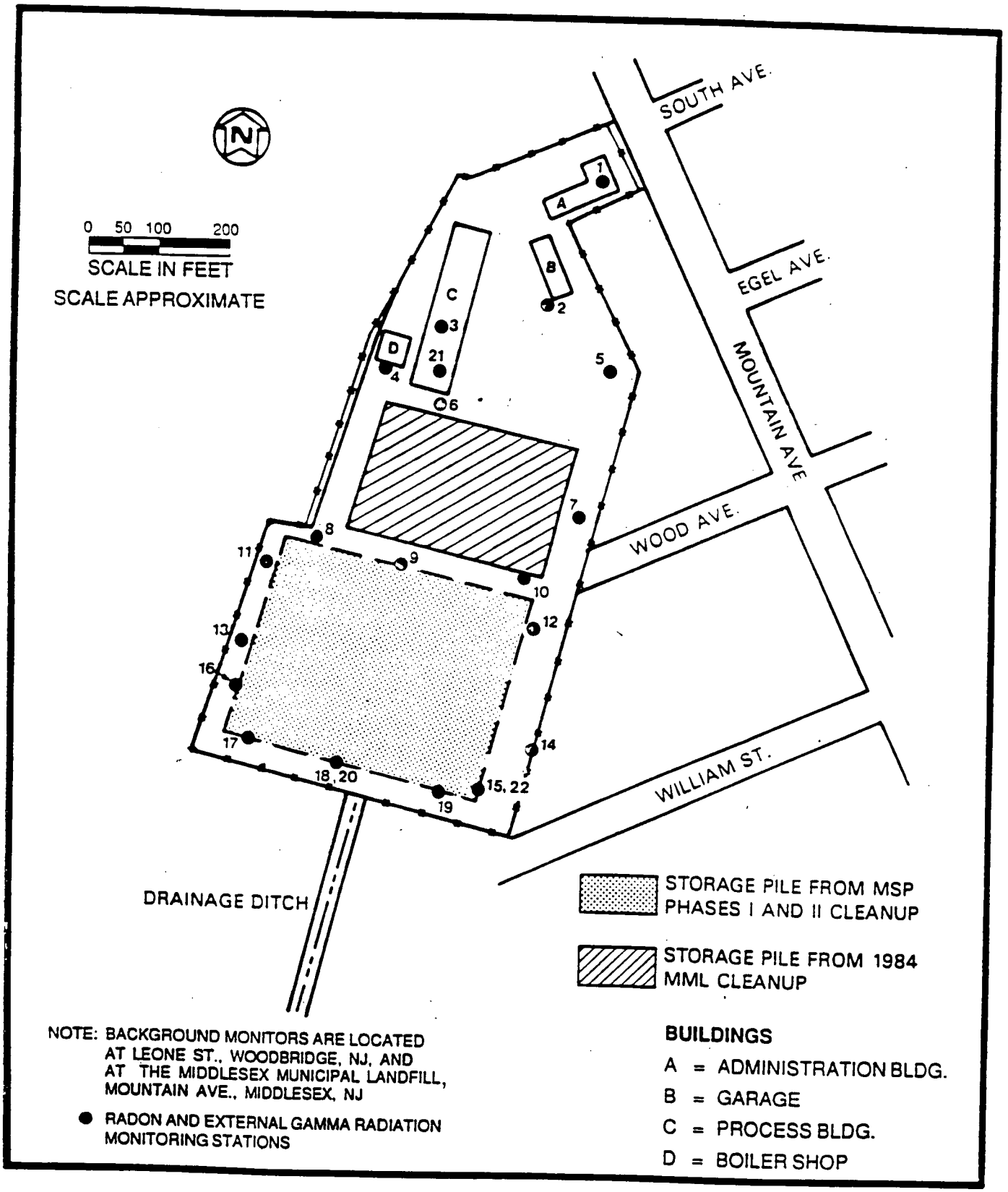

FIGURE 3-1 RADON AND EXTERNAL GAMMA RADIATION MONITORING LOCATIONS AT MSP

Table 3-1 reports the measured concentrations of radon (including background) in air at MSP. Annual average concentrations ranged from 4×10^{-10} to 1.8×10^{-9} μCi/ml (0.4 to 1.8 pCi/L). The annual average background concentration for both background locations was 4×10^{-10} μCi/ml (0.4 pCi/L). Radon levels at MSP are within DOE derived concentration guidelines. For comparisons of the radon concentrations measured from 1985 through 1989, see Subsection 3.7.1.

3.2 EXTERNAL GAMMA RADIATION

External gamma radiation levels were measured at 20 locations at MSP that correspond to the radon (Terradex) detector locations shown in Figure 3-1. Detectors are located around the site boundary to ensure adequate measurement of radiation levels.

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

Because the current measurement system allows for dosimeter detection interval of approximately a year versus the 3-month interval previously used, the curent system is more sensitive to

TABLE 3-1

RADON-222 CONCENTRATIONS MEASURED AT MSP SITE BOUNDARY, 1989

Sampling Station[a]	Number of Samples	Concentration (10^{-9} μCi/ml)[b,c] Minimum	Maximum	Averag
2	4	<0.3	0.5	0.4
4	4	0.8	3.2	1.8
5	4	<0.3	0.7	0.4
7	4	0.3	0.5	0.4
8	4	0.3	0.5	0.4
10	4	0.3	<0.5	0.4
11	4	<0.4	0.6	0.4
12	4	<0.3	0.4	0.4
13	4	<0.3	0.4	0.4
14	4	0.3	0.4	0.4
15	4	<0.4	1.1	0.6
16	4	<0.3	0.9	0.5
17	4	<0.3	0.7	0.5
18	4	<0.3	0.5	0.4
19	4	<0.3	1.0	0.6
20[d]	4	<0.3	0.7	0.5
22[d]	4	<0.3	<0.4	0.4
Background				
29[e]	4	<0.3	0.5	0.4
MML 4[f]	4	<0.3	0.6	0.4

[a]Locations of sampling stations are shown in Figure 3-1. Stations 1, 3, and 21 are inside buildings; stations 6 and 9 are centrally located on the site and are not reported because they are not considered representative of radon concentrations at the site boundary.

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

[c]The measurements are total radon concentrations; background has not been subtracted because of the variability in the distribution of radon.

[d]Stations 20 and 22 are quality controls for stations 18 and 15, respectively.

[e]Located at Leone St., Woodbridge, NJ, approximately 16 km (10 mi) south of MSP.

[f]Located at the Middlesex Municipal Landfill, Mountain Ave., Middlesex, NJ, 0.8 km (0.5 mi) north of MSP.

low radiation levels. Although the tissue-equivalent TLDs used are "state-of-the-art," one should keep in mind when examining the external gamma radiation results that the dosimeter accuracy is approximately ±10 percent at levels from 100 mrem/yr to 1 rem/yr and ±25 percent at radiation levels around 70 mrem/yr.

The results of external gamma radiation monitoring are presented in Table 3-2. For each quarter, an average of the background levels measured was subtracted from the site boundary measurements to provide an estimate of radiation levels resulting from residual materials at the site. Because data from background location MML 4 were incomplete, they were not used in these calculations. The highest annual average gamma radiation level of 125 mrem/yr was measured at station 11 (see Figure 3-1).

The background external gamma radiation value for a given location is not constant. Because the background value is a combination of both natural terrestrial sources and cosmic radiation sources, factors such as the location of the detector in relation to surface rock outcrops, stone or concrete structures, or highly mineralized soil can affect the value measured. Independent of the placement of the detector at the site are the factors of site altitude, annual barometric pressure cycles, and the occurrence and frequency of solar flare activity (Ref. 16).

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

For comparisons of external radiation levels measured from 1985 through 1989, see Subsection 3.7.2.

3.3 SURFACE WATER SAMPLING

During 1989, sampling was performed to determine the concentrations of total uranium and radium-226 in surface water in the MSP vicinity.

TABLE 3-2

EXTERNAL GAMMA RADIATION LEVELS AT MSP, 1989

Sampling Station[a]	Number of Measurements	Radiation Level (mrem/yr)[b] Minimum	Maximum	Average[c]
2	4	75	94	86
4	4	-[d]	33	20
5	4	41	71	55
7	4	-[d]	24	14
8	4	38	58	48
10	4	50	78	66
11	4	112	140	125
12	4	65	103	90
13	4	33	59	51
14	4	-[d]	22	16
15	4	22	46	35
16	4	14	49	36
17	4	-[d]	28	20
18	4	-[d]	25	15
19	4	13	46	30
20[e]	4	-[d]	-[d]	-[d]
22[e]	3[f]	39	133	54
Background				
29[g]	4	59	101	76
MML 4[h]	1[i]	58	58	58[j]

[a]Locations of sampling stations for MSP are shown in Figure 3-1. Stations 1, 3, and 21 are inside buildings; stations 6 and 9 are centrally located on the MSP site and are not reported because they are not considered representative of dose rates at the site boundary.

[b]Measured background at station 29 has been subtracted from readings at MSP locations.

[c]Average is calculated from the actual number of measurements collected.

[d]Measurement was less than or equal to measured average background value.

[e]Stations 20 and 22 are quality controls for stations 18 and 15, respectively.

[f]TLD recovery error in the second quarter.

[g]Located at Leone St., Woodbridge, NJ, approximately 16 km (10 mi) south of MSP.

[h]Located at the Middlesex Municipal Landfill, Middlesex, NJ, 0.8 km (0.5 mi) north of MSP. Established in April 1988.

[i]No data were available for first quarter because the equipment had been in service for less than a year; no data were available for second and fourth quarters because of sampling errors.

[j]This background reading was not used in calculating the radiation levels.

Surface water samples were collected quarterly at five locations (Figure 3-2). Sampling locations were established on the basis of potential contaminant migration and discharge routes from the site. Sampling points were established both upstream, to establish background conditions; and downstream, to determine the effect of runoff from the sites on surface waters in the vicinity.

Nominal 1.0-L (0.26-gal) grab samples were collected to fill a 3.8-L (1-gal) container and analyzed by TMA/E. The concentration of total uranium was determined by a fluorometric method. Radium-226 concentrations were determined by radon emanation. (This method consists of precipitating radium as sulfate and transferring the sulfate to a radon bubbler, where the radon-222 daughter is allowed to come to equilibrium with its radium-226 parent. The radon-222 is then withdrawn into a scintillation cell and counted by the gross alpha technique. The quantity of radon-222 detected in this manner is directly proportional to the quantity of radium-226 originally present in the sample.)

The results of analyses for total uranium and radium-226 in surface water are presented in Table 3-3. In the vicinity of MSP, annual average total uranium concentrations ranged from $<3 \times 10^{-9}$ to 3.4×10^{-8} μCi/ml (<3 to 34 pCi/L). Average radium-226 levels ranged from 6×10^{-10} to 1.7×10^{-9} μCi/ml (0.6 to 1.7 pCi/L). The highest annual average concentrations of both uranium and radium-226 occurred at the MSP outfall (location 1). All levels measured are well within DOE derived concentration guidelines. For comparisons of radionuclide concentrations measured in surface water from 1985 through 1989, see Subsection 3.7.3.

3.4 GROUNDWATER SAMPLING

During 1989, groundwater samples were collected quarterly from 19 wells at MSP (Figure 1-6). Wells designated 1, 3, 4, 5, 9, 11, 12, 13, 14, 15, 20S, and 21S are installed in the upper groundwater system [approximately 3 m (10 ft) deep]. Groundwater flows from north to south in the upper system; therefore, well 1 is upgradient of the site. Wells 1A, 3A, 4A, 20D, 21D, 22D, and 23D extend into

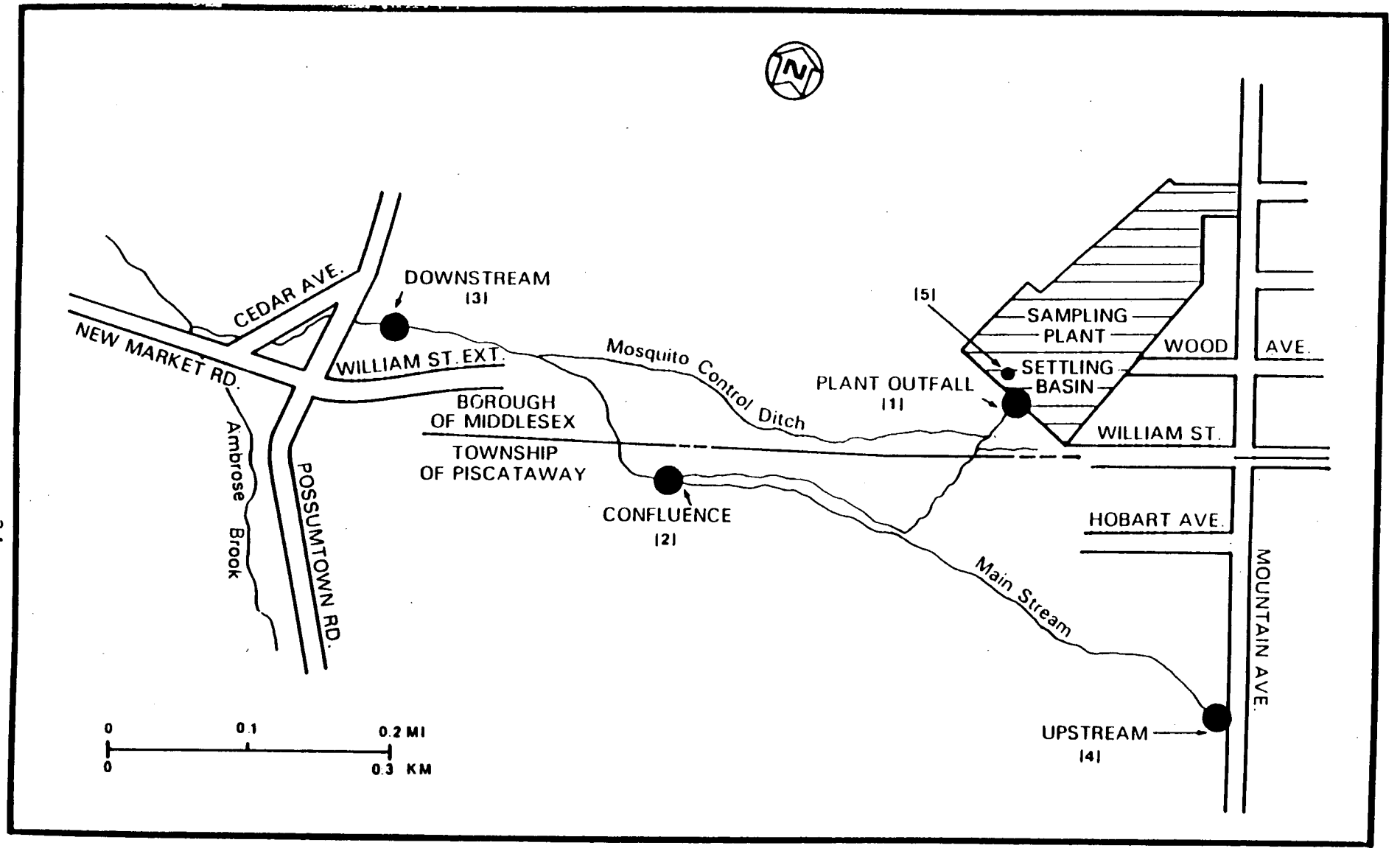

FIGURE 3-2 SURFACE WATER AND SEDIMENT SAMPLING LOCATIONS IN THE VICINITY OF MSP

TABLE 3-3

CONCENTRATIONS OF URANIUM AND RADIUM-226 IN SURFACE WATER IN THE VICINITY OF MSP, 1989

Sampling Location[a]	Number of Samples	Concentration (10^{-9} µCi/ml)[b,c] Minimum	Maximum	Averag
Uranium				
1 Plant outfall	4	<3	54	34
2 Confluence	4	<3	<3	<3
3 Downstream (or Main Stream)	4	<3	10	5
4 Upstream[d]	4	<3	<3	<3
5 Settling basin	4	<3	<3	<3
Radium-226				
1 Plant outfall	4	0.8	2.2	1.[illegible]
2 Confluence	4	0.3	1.4	0.[illegible]
3 Downstream (or Main Stream)	4	0.4	1.0	0.[illegible]
4 Upstream[d]	4	0.3	2.8	1.[illegible]
5 Settling basin	4	0.5	1.1	0.[illegible]

[a]Sampling locations are shown in Figure 3-2.

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

[c]Background has not been subtracted from any values.

[d]Background monitoring location.

the Brunswick formation bedrock aquifer [approximately 15 m (50 ft) deep], which represents the lower groundwater system. Groundwater flows from the south to the northeast in the lower groundwater system; therefore, wells 3A and 4A are the upgradient wells for this system.

Sampling locations were established on the basis of available hydrogeological data and the locations of radioactive materials. Wells are either individual or paired; pairing permits sampling of both the upper and lower groundwater systems at the same location. Nominal 1.0-L (0.26-gal) grab samples were collected to fill a 3.8-L (1-gal) container after the wells had been bailed dry or three casing volumes had been removed and ample recharge time had elapsed. Samples were analyzed by TMA/E for dissolved radium-226 by the methods applied to surface water analyses. The analytical method used to determine total uranium concentration in groundwater was changed from fluorometric analysis to alpha spectrometry in 1986 as required by the New Jersey Department of Environmental Protection (NJDEP). As an analytical method, alpha spectrometry is more precise than the fluorometric method and has the additional advantage that it provides information about the individual isotopes as well as total uranium. Chemical analyses were performed by Weston Analytical Laboratory.

3.4.1 Radiological

Analytical results for uranium are reported in Table 3-4, and radium-226 concentrations are reported in Table 3-5. The highest annual average uranium concentration, 1.31×10^{-7} μCi/ml (131 pCi/L), was measured in well 5, which is located on the southeastern boundary of the site. The maximum uranium concentration of 2.13×10^{-7} μCi/ml (213 pCi/L) was measured in April 1989. Well 20S and well 5 are both shallow wells [approximately 3.05 m (10.0 ft)] that monitor the upper groundwater system and are very close to each other (Figure 1-6). The average uranium value of 2×10^{-9} μCi/ml (2 pCi/L) for well 20S, compared with the much higher average value of 1.31×10^{-7} μCi/ml

TABLE 3-4

CONCENTRATIONS OF URANIUM IN GROUNDWATER AT MSP, 1989

Sampling Location[a]	Number of Samples	Concentration (10^{-9} µCi/ml)[b]		
		Minimum	Maximum	Average
1	4	<3	8	4
1A	4	5	15	9
3	4	2	4	3
3A	4	5	6	5
4	3[c]	5	7	6
4A	4	14	25	17
5	3[c]	80	213	131
9	4	2	7	4
11	4	22	79	42
12	4	3	12	7
13	4	<3	<3	<3
14	1[d]	<3	<3	<3
15	4	<3	5	4
20D	4	2	3	2
20S	4	1	2	2
21D	4	2	5	3
21S	4	1	2	1
22D	4	<3	<3	<3
23D	4	<3	<3	<3
Background				
MML 17[e]	3[c]	<3	5	4

[a]Sampling locations are shown in Figure 1-6. "A" and "D" designate wells installed in the lower groundwater system; "S" designates wells installed in the upper system.

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

[c]Well was dry in the first quarter.

[d]Well was dry in the first three quarters.

[e]Located at the Middlesex Municipal Landfill, Middlesex, NJ, 0.8 km (0.5 mi) north of MSP. This well was reinstated in the monitoring program in October 1988 to represent background. Background has not been subtracted from other well measurements.

TABLE 3-5

CONCENTRATIONS OF RADIUM-226 IN GROUNDWATER AT MSP, 1989

Sampling Location[a]	Number of Samples	Concentration (10^{-9} µCi/ml)[b] Minimum	Maximum	Average
1	4	0.7	1.0	0.9
1A	4	0.5	0.9	0.7
3	4	1.1	2.0	1.6
3A	4	0.8	1.2	1.0
4	3[c]	1.7	2.4	2.1
4A	4	0.6	1.2	0.9
5	3[c]	2.3	2.6	2.4
9	4	2.5	13.5	7.0
11	4	2.9	7.3	4.7
12	4	1.0	3.3	2.2
13	4	0.3	0.9	0.7
14	1[d]	1.0	1.0	1.0
15	4	0.5	0.9	0.8
20D	4	<0.5	1.0	0.8
20S	4	0.3	1.1	0.7
21D	4	0.4	0.9	0.7
21S	4	0.6	1.2	0.9
22D	4	0.4	1.2	0.7
23D	4	0.4	0.8	0.6
Background				
MML 17[e]	3[c]	0.5	0.8	0.7

[a]Sampling locations are shown in Figure 1-6.

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

[c]Well was dry in the first quarter.

[d]Well was dry in the first three quarters.

[e]Located at the Middlesex Municipal Landfill, Middlesex, NJ, 0.8 km (0.5 mi) north of MSP. This well was reinstated in the monitoring program in October 1988 to represent background. Background has not been subtracted from other well measurements.

(131 pCi/L) for well 5, indicates that well 5 is located adjacent to or within an area of contaminated material.

The elevated uranium level in well 5 was enhanced by reduced precipitation during the early part of 1989, which decreased the volume of infiltration; thus water collected from well 5 had increased concentrations of dissolved solids from the waste material. Purging the well during the sampling cycle increased the local hydraulic gradient and introduced additional suspended solids from the adjacent waste materials. The slow recovery time after purging allowed further accumulation of the solids and therefore increased uranium concentrations in samples taken from this well. Water in this well is not available for human consumption. The highest annual average concentration of radium-226 was 7.0×10^{-9} μCi/ml (7.0 pCi/L). All uranium and radium-226 concentrations measured in 1989 groundwater samples were within DOE derived concentration guidelines.

3.4.2 Chemical

As required by a New Jersey Pollutant Discharge Elimination System permit, groundwater samples from MSP wells were analyzed quarterly for pH, total organic carbon (TOC), total organic halides (TOX), and specific conductance. Analyses are performed annually for the New Jersey priority pollutants. Table 3-6 lists analytical results for indicator parameters and chemical contaminants that were detected. Numerous other chemical contaminants for which analyses were completed were not detected in any groundwater sample (see Table 3-7).

Specific conductance and pH measure changes in the inorganic composition of the groundwater. Acidity or basicity of water is expressed as pH. A change in pH affects the solubility and mobility of chemical contaminants in groundwater. Specific conductance measures the capacity of water to conduct an electrical current. Generally, conductivity increases with an elevated concentration of dissolved solids. Waters with high salinities or high total dissolved solids exhibit high conductivities.

TABLE 3-6

INDICATOR PARAMETERS AND CHEMICAL CONTAMINANTS DETECTED IN GROUNDWATER AT MSP, 1989[a]

Parameter (unit)	Analysis Results by Sampling Location (Monitoring Well Number)											
	3	3A[b]	4	4A[b]	5	9	11	12	20D	20S	21D	21S
pH (standard units)	7.3-7.4	7.2-7.4	6.0-6.3	5.9-6.9	5.7-6.4	6.6-7.1	7.1-7.2	6.3-7.4	7.7-8.0	5.7-6.1	7.6-7.9	6.0-6.3
Total organic carbon (mg/L)	8.8-15.5	6.9-11.2	1.9-5.0	2.2-4.2	2.3-3.2	18.5-131.0	0.86-23.9	2.7-8.3	0.75-4.6	2.4-7.5	0.55-2.0	2.8-4.7
Total organic halides (µg/L)	ND-36	20-32	ND-40	ND-31	ND-56	ND-48	ND	ND-24	ND-14	ND-32	24-79	ND-45
Specific conductance (µmhos/cm)	472-495	534-592	164-235	207-294	158-210	435-712	74.2-166	72.1-209	294-368	179-195	315-386	151-184
Benzene (µg/L)	ND	ND	ND	ND	ND	7	ND	ND	ND	ND	ND	ND
Acetone (µg/L)	ND	ND	ND	42	410	110	ND	ND	ND	ND	25	ND
Trichloroethylene (µg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	53	ND
Toluene (µg/L)	ND	ND	ND	ND	ND	25	ND	ND	ND	ND	ND	ND
Xylene (µg/L)	ND	ND	ND	ND	ND	12	ND	ND	ND	ND	ND	ND
Bis(2-ethylhexyl)phthalate (µg/L)	70	50	50	11	16	29	23	21	16	98	ND	19
Methylene chloride (µg/L)	ND	5	5	5	ND	5	ND	7	5	5	5	5

[a]Does not include parameters for which concentrations were below the limit of sensitivity of the analytical method used.

[b]Upgradient background well for lower groundwater system.

ND - no detectable concentration.

TABLE 3-7

CHEMICAL CONTAMINANTS NOT DETECTED IN GROUNDWATER AT MSP, 1989

Acrolein	Bis(2-chloroethoxy)methane	Phenanthrene
Acrylonitrile	Bis(2-Chloroisopropyl)ether	Pyrene
Bromoform	4-bromophenyl phenyl ether	2-chlorophenol
Carbon tetrachloride	Butylbenzyl phthalate	2,4-dichlorophenol
Chlorobenzene	2-chloronaphthalene	2,4-dimethylphenol
Chlorodibromomethane	4-chlorophenyl phenyl ether	2,4-dinitrophenol
Chloroethane	4-chloroaniline	2-nitrophenol
Chloroform	4-chloro-3-methylphenol	4-nitrophenol
2-chloroethyl vinyl ether	Chrysene	Pentachlorophenol
Dichlorobromomethane	Dibenzo(a,h)anthracene	Phenol
1,3-dichloropropylene	Dibenzofuran	2,4,5-trichlorophenol
1,2-trans-dichloroethylene	Di-n-butyl phthalate	2,4,6-trichlorophenol
1,1-dichloroethane	Di-n-octyl phthalate	Aldrin
1,2-dichloroethane	1,2-dichlorobenzene	BHC, alpha
1,1-dichloroethylene	1,3-dichlorobenzene	BHC, beta
1,2-dichloropropane	1,4-dichlorobenzene	BHC, gamma
1,3-dichloropropene	3,3'-dichlorobenzidine	BHC, delta
Ethylbenzene	Diethyl phthalate	Alpha chlordane
Methyl bromide	Dimethyl phthalate	Beta chlordane
Methyl chloride	2,4-dinitrotoluene	Dieldrin
Styrene	2,6-dinitrotoluene	Endosulfan I
1,1,2,2-tetrachloroethane	4,6-dinitro-2-methylphenol	Endosulfan II
1,1,1-trichloroethane	Fluoranthene	Endosulfan sulfate
Trichlorofluoromethane	Fluorene	Endrin
1,1,2-trichloroethane	Hexachlorobenzene	Endrin ketone
Tetrachloroethylene	Hexachlorobutadiene	Heptachlor
Vinyl chloride	Hexachloroethane	Heptachlor epoxide
Anthracene	Hexachlorocyclopentadiene	4,4'-DDT
Acenaphthene	Indeno(1,2,3-cd)pyrene	4,4'-DDE
Acenaphthylene	Isophorone	4,4'-DDD
Benzo(a)anthracene	2-methylnapthalene	Methoxychlor
Benzo(k)fluoranthene	2-methylphenol	Aroclor 1016
Benzo(a)pyrene	4-methylphenol	Aroclor 1221
Benzo(g,h,i)perylene	Naphthalene	Aroclor 1232
Benzyl alcohol	Nitrobenzene	Aroclor 1242
Benzoic acid	2-nitroaniline	Aroclor 1248
Bis(2-chloroethyl)ether	3-nitroaniline	Aroclor 1254
	4-nitroaniline	Aroclor 1260
	N-nitrosodi-n-propylamine	Toxaphene
	N-nitrosodiphenylamine	

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

Specific conductivity and pH measurements ranged from 72.1 to 592 µmhos/cm and 5.7 to 8.0, respectively. TOX results ranged from below detection limits to 79 µg/L, and TOC results ranged from 0.55 to 131 mg/L. Except for TOC levels in well 9, indicator parameter results for downgradient wells are similar to those for upgradient wells and probably represent background conditions for the area. The elevated TOC level in well 9 reflects the presence of organic pollutants. There is no evidence that these pollutants have migrated.

The appearance of bis(2-ethylhexyl)phthalate is almost certainly a result of laboratory contamination; it appeared in all of the laboratory blanks at concentrations up to 100 µg/L. The laboratory is aware of the problem and is taking steps to correct it.

Although the presence of the detected contaminants would not be expected in pristine groundwater, their occurrence at trace levels is not unusual in groundwater underlying areas developed for industrial purposes.

Measurement of water levels and water quality continues to provide additional information on groundwater gradient and flow directions.

3.5 SEDIMENT SAMPLING

During 1989, sediment samples consisting of composites weighing approximately 500 g (1.1 lb) were collected at the five surface water sampling locations shown in Figure 3-2. The sampling locations correspond with surface water sampling locations.

TMA/E analyzed the samples for uranium and radium-226. The concentration of total uranium was determined by summing the

results of analyses for isotopic uranium. Isotopic uranium concentration was determined by alpha spectrometry, where the uranium is leached, organically extracted, and electroplated on a metal substrate. Radium-226 concentrations were determined by radon emanation (described earlier).

Results of these analyses, based on dry weight, are presented in Table 3-8. Annual average concentrations of uranium and radium-226 in the vicinity of MSP ranged from 2.8 to 31.8 pCi/g and 1.0 to 15.2 pCi/g, respectively. Sampling locations 1, 2, and 3 each yielded one quarterly sample with elevated levels of uranium and radium-226. Although levels of these radionuclides were low at all locations in the fourth quarter of 1989, they will be closely monitored in 1990. An expanded sampling plan for locations 1, 2, and 3 has been scheduled for April 1990 to better determine sediment quality in these areas and to locate the source(s) of the contamination.

3.6 RADIATION DOSE

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

The dose from ingesting groundwater or surface water from sources on MSP property was not calculated because it was considered unrealistic to assume that ingestion of this water would occur. MSP is fenced and locked, and security is well maintained. Therefore, a member of the public could only consume water on the site by trespassing on the property every day to gain access to the water. To consume groundwater from a well at the site, the member of the public would also have to be equipped with a means of removing the locked well cap and extracting the groundwater.

TABLE 3-8

CONCENTRATIONS OF URANIUM AND RADIUM-226 IN SEDIMENT IN THE VICINITY OF MSP, 1989

Sampling Location[a]	Number of Samples	Concentration [pCi/g (dry)] Minimum	Maximum	Average
Uranium				
1 Plant outfall	3[b]	<1.4	37.7	13.5
2 Confluence	2[b,c]	12.5	51.0	31.8
3 Downstream (or Main Stream)	4	<1.6	41.8	12.6
4 Upstream	4	<1.0	6.4	2.8
5 Settling basin	3[c]	2.5	<4.0	3.4
Radium-226				
1 Plant outfall	3[b]	0.5	18.0	6.4
2 Confluence	2[b,c]	2.3	28.0	15.2
3 Downstream (or Main Stream)	4	0.4	19.0	5.4
4 Upstream	4	0.4	2.5	1.0
5 Settling basin	3[c]	1.7	2.0	1.8

[a]Sampling locations are shown in Figure 3-2.

[b]No sediment present during the third quarter.

[c]Frozen in the first quarter.

Radon concentrations measured at the MSP boundaries were within the normal variation associated with background measurements for this area. Consequently, this pathway would not increase the dose received by the hypothetical maximally exposed individual.

3.6.1 Dose to the Maximally Exposed Individual

To identify the individuals in the vicinity of the MSP who would receive the highest doses from on-site radioactive materials, the dose from exposure to external gamma radiation was calculated at all the monitoring locations that could be accessible to the public. These doses were then reviewed with regard to land use and occupancy factors for areas adjacent to the monitoring points. For the properties surrounding MSP, the highest dose would be received to the east of the site in a residential area near location 5 and west of the site at a commercial scrap metal facility near location 11. The dose calculations were based on certain assumptions, described below.

At the scrap metal facility, if an occupancy factor near location 11 of 2 h/week is applied, the dose to the maximally exposed individual would be 1.5 mrem/yr. The annual average dose rate measured at location 5 was 55 mrem/yr. The dose to an individual working in the backyard of the residence nearest this location for 1 h/day, 365 days/yr, would be 2.3 mrem/yr. These exposures are approximately equivalent to the exposure a person receives during one flight from New York City to Los Angeles because of greater amounts of cosmic radiation at higher altitudes (see Appendix D).

These values reflect the assumption that the maximally exposed individual is exposed to the radiation fields present at the locations of the detectors. The individual's exposure rate would actually be much lower because gamma radiation levels decrease rapidly as distance from the source of contamination increases.

3.6.2 Dose to the Population in the Vicinity of MSP

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

The contribution to the population dose made by external gamma radiation from the radioactive materials present on the site is too small to be measured, since gamma radiation levels decrease rapidly as distance from the source of contamination increases. For example, if the gamma exposure rate at a distance of 1 m (3 ft) from a small-area radioactive source were 100 mrem/yr, the exposure rate at a distance of 6.4 m (21 ft) from the source would be indistinguishable from naturally occurring background radiation.

Similarly, radon is known to dissipate rapidly as distance from the radon source increases (Ref. 17). Therefore, exposure from the low radon concentrations at MSP (approximately equal to the natural background level) does not contribute significantly to population dose.

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

Because the contributions to population dose via all three potential exposure pathways are inconsequential, calculation of dose to the population is not warranted. The cumulative dose to the population within an 80-km (50-mi) radius of MSP that would result from radioactive materials present at the site would be indistinguishable from the dose that the same population receives from naturally occurring radioactive sources.

3.7 TRENDS

The environmental monitoring program at MSP was established to allow an annual assessment of the environmental conditions at the site, provide a historical record for comparisons from year to year, and permit detection of trends over time. In the following subsections, 1989 annual averages for each monitoring location for radon, external gamma radiation, surface water, and groundwater are compared with results for 1985-1988 (Refs. 9 through 12).

3.7.1 Radon

Radon concentrations measured at MSP in 1989 are approximately the same as 1988 levels. Table 3-9 shows radon levels at MSP from 1985-1989. When compared with background variations, measured MSP radon concentrations show no notable trends and seem to contribute little, if any, to naturally occurring radon levels in the area.

The behavior of radon and the variables that affect its concentration are difficult to predict. Such factors as moisture content of the soil, disturbance of the soil, barometric pressure, temperature inversions, and hydrogeologic conditions all affect local radon concentrations over both the short term and the long term.

3.7.2 External Gamma Radiation

Comparison of the 1989 external gamma radiation data with data from other years yields no apparent trends (see Table 3-10). Although some locations exhibit higher levels than others, radiation levels from year to year at any given location vary within what are becoming characteristic ranges for those locations.

3.7.3 Surface Water

As shown in Table 3-11, few notable trends have been identified as to the concentrations of uranium and radium-226 in surface water

TABLE 3-9

ANNUAL AVERAGE RADON-222 CONCENTRATIONS MEASURED AT MSP SITE BOUNDARY, 1985-1989[a]

Sampling Station[b]	Concentration (10^{-9} µCi/ml)[c,d]				
	1985	1986	1987	1988	1989
MSP					
2	0.3	0.6	1.0	0.3	0.4
4	0.5	1.0	0.8	0.7	1.8
5	0.2	0.8	0.8	0.6	0.4
7	0.3	1.0	0.9	0.3	0.4
8	0.3	1.0	0.6	0.3	0.4
10	0.2	1.0	0.7	0.4	0.4
11	0.2	1.1	1.0	0.3	0.4
12	0.3	0.9	0.4	0.5	0.4
13	0.3	0.9	1.4	0.4	0.4
14	0.4	1.2	0.9	0.4	0.4
15	0.3	0.3	0.3	0.4	0.6
16	0.2	0.7	0.8	0.3	0.5
17	0.2	0.7	0.7	0.4	0.5
18	0.2	0.8	1.0	0.6	0.4
19	0.2	1.1	1.3	0.4	0.6
20[e]	0.3	1.1	1.5	0.5	0.5
22[e]	0.4	0.9	1.6	0.3	0.4
Background					
29[f]	0.8	2.0	1.2	0.3	0.4
MML 4[g]	0.3	0.4	0.9	0.4	0.4

[a]Sources of data for prior years are the annual site environmental reports for those years (Refs. 9-12).
[b]Locations of sampling stations are shown in Figure 3-1. MSP locations 1, 3, and 21 are inside buildings; locations 6 and 9 are centrally located on the MSP site and are not reported because they are not considered representative of radon concentrations at the site boundary.
[c]1×10^{-9} µCi/ml is equivalent to 1 pCi/L.
[d]The measurements are total radon concentrations. Because of the variability in the distribution of radon, background has not been subtracted.
[e]In 1985, locations 20 and 22 were established as quality control stations for locations 18 and 15, respectively.
[f]Located at Leone St., Woodbridge, NJ, approximately 16 km (10 mi) south of MSP.
[g]Located at the Middlesex Municipal Landfill, Middlesex, NJ, approximately 0.8 km (0.5 mi) north of MSP.

TABLE 3-10

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

Sampling Station[b]	Radiation Level (mrem/yr)[c]				
	1985	1986	1987	1988	1989
2	129	75	60	112	86
4	57	41	31	48	20
5	111	125	99	115	55
7	49	22	17	25	14
8	67	46	23	63	48
10	101	60	44	115	66
11	167	121	94	155	125
12	80	72	55	142	90
13	78	33	40	61	51
14	48	29	19	32	16
15	41	37	27	50	35
16	59	36	17	34	36
17	49	25	13	31	20
18	42	28	14	21	15
19	41	32	13	28	30
20[d]	1	3	0[e]	0[e]	0[e]
22[d]	60	43	20	48	54
Background					
29[f]	99	71	71	90	76
MML 4[g]	--	--	--	--	58

[a]Sources of data for 1985-1988 are the annual site environmental reports for those years (Refs. 9-12).
[b]Locations of sampling stations are shown in Figure 3-1. Stations 6 and 9 are centrally located on the MSP site and are not reported because they are not considered representative of external gamma radiation levels at the site boundary.
[c]Measured background has been subtracted from readings obtained at MSP sampling locations.
[d]In 1985, stations 20 and 22 were established as quality controls for stations 18 and 15, respectively.
[e]Measurement was less than or equal to the measured background value.
[f]Located at Leone St., Woodbridge, NJ, approximately 16 km (10 mi) south of MSP.
[g]Located at the Middlesex Municipal Landfill, Middlesex, NJ, approximately 0.8 km (0.5 mi) north of MSP. Established April 1988.

TABLE 3-11

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

Sampling Location[b]	Concentration (10^{-9} μCi/ml)[c]				
	1985	1986	1987	1988	1989
Uranium					
1 Plant outfall	80	56	54	47	22
2 Confluence	10	23	5	3	<3
3 Downstream (or Main Stream)	4	21	<3	4	5
4 Upstream	3	<3	<3	3	16
5 Settling basin	7	<3	<3	4	<3
Radium-226					
1 Plant outfall	3.3	2.2	1.7	2.0	1.7
2 Confluence	0.3	1.0	0.7	0.3	0.6
3 Downstream (or Main Stream)	0.2	1.1	0.6	0.2	0.6
4 Upstream	0.4	0.2	0.6	0.2	1.0
5 Settling basin	0.7	0.5	0.7	0.3	0.7

[a]Data sources for 1985-1988 are the annual site environmental reports for those years (Refs. 9-12).

[b]Sampling locations are shown in Figure 3-2.

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

at MSP. Localized decreases in uranium concentration at the confluence and downstream sampling points are similar to previously measured ranges. Uranium levels at the plant outfall appear to be dropping steadily from a peak in 1984 of 1.03×10^{-7} μCi/ml (103 pCi/L)(Ref. 8) to 2.2×10^{-8} μCi/ml (22 pCi/L) in 1989. The increased 1989 annual average for uranium at location 4 may be due to laboratory error during the first quarter of sampling; the reported value for that quarter was 5.42×10^{-8} μCi/ml (54.2 pCi/L). Subsequent quarterly samples were all measured as having the more typical level of $<3 \times 10^{-9}$ μCi/ml (<3.0 pCi/L).

3.7.4 Groundwater

As shown in Tables 3-12 and 3-13, uranium levels measured in groundwater in 1989 appear to approximate those of previous years. Radium-226 levels appear unchanged. No long-term trends for either uranium or radium-226 can be inferred.

A comparison of upgradient and downgradient conditions at MSP indicates that groundwater quality is not degraded as it crosses the site. Wells 3A and 4A are upgradient and 21D and 22D are downgradient for the lower groundwater system. For the upper system, well 1 is upgradient and wells 3 and 4 are downgradient.

TABLE 3-12

ANNUAL AVERAGE CONCENTRATIONS OF URANIUM IN GROUNDWATER AT MSP, 1985-1989[a]

Sampling Location[b]	Concentration (10^{-9} µCi/ml)[c]				
	1985	1986	1987	1988	1989
1	4	<3	<3	12	4
1A	13	8	9	9	9
3	<3	2	1	3	3
3A	4	8	6	12	5
4	<3	-[d]	1	7	6
4A	33	12	13	20	17
5	56	20	82	192	131
9	4	3	2	5	4
11	55	143	20	67	42
12	4	2	1	7	7
13	4	<3	<3	5	<3
14	4	<3	<3	-[d]	<3
15	<3	<3	<3	4	4
20D	<3	2	2	3	2
20S	<3	1	1	4	2
21D	4	2	2	3	3
21S	<3	1	0.4	2	1
22D	<3	<3	<3	3	<3
23D	<3	<3	<3	4	<3
Background					
MML 17[e]	<3	<3	<3	3	4

[a]Data sources for 1985-1988 years are the annual site environmental reports for those years (Refs. 9-12). Background has not been subtracted.

[b]Sampling locations are shown in Figure 1-6.

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

[d]Well was dry in all four quarters.

[e]Located at the Middlesex Municipal Landfill, Middlesex, NJ, approximately 0.8 km (0.5 mi) north of MSP.

TABLE 3-13

ANNUAL AVERAGE CONCENTRATIONS OF RADIUM-226 IN GROUNDWATER AT MSP, 1985-1989[a]

Sampling Location[b]	Concentration (10^{-9} µCi/ml)[c]				
	1985	1986	1987	1988	1989
1	0.5	0.2	0.3	0.3	0.9
1A	0.3	0.3	0.3	0.3	0.7
3	0.4	0.7	0.3	1.2	1.6
3A	0.6	0.5	0.5	0.9	1.0
4	0.2	-[d]	0.4	2.0	2.1
4A	0.3	0.5	0.6	1.0	0.9
5	0.5	0.4	0.6	2.4	2.4
9	0.7	0.8	0.8	2.8	7.0
11	0.7	0.6	0.5	4.1	4.7
12	0.3	0.3	0.3	2.3	2.2
13	0.1	0.2	0.4	0.3	0.7
14	0.2	0.1	0.1	-[d]	1.0
15	0.1	0.2	0.3	0.4	0.8
20D	0.4	0.5	0.8	0.8	0.8
20S	0.3	0.5	0.3	1.1	0.7
21D	0.7	0.4	0.4	0.9	0.7
21S	0.3	0.5	0.4	0.7	0.9
22D	0.3	0.3	0.4	0.3	0.7
23D	0.2	0.3	0.3	0.3	0.6
Background					
MML 17[e]	0.5	0.1	0.2	0.7	0.7

[a]Data sources for 1985-1988 are the annual site environmental reports for those years (Refs. 9-12). Background has not been subtracted.

[b]Sampling locations are shown in Figure 1-6.

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

[d]Well was dry in all four quarters.

[e]Located at the Middlesex Municipal Landfill, Middlesex, NJ, 0.8 km (0.5 mi) north of MSP.

4.0 RELATED ACTIVITIES AND SPECIAL STUDIES

4.1 RELATED ACTIVITIES

Site security, maintenance, and monitoring continued.

4.2 SPECIAL STUDIES

There were no special studies at MSP in 1989.

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APPENDIX A
QUALITY ASSURANCE

QUALITY ASSURANCE

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

QA sampling requirements were ensured through the following:

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

Data management QA was achieved through:

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

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

documented, tracked, and resolved, as verified by the project QA supervisor.

Routine radioanalyses for the FUSRAP Environmental Monitoring Program were performed under subcontract by TMA/E, Albuquerque, New Mexico. This laboratory maintained an internal quality assurance program that involved routine calibration of counting instruments, source and background counts, routine yield determinations of radiochemical procedures, and replicate analyses to check precision. The accuracy of radionuclide determination was determined through the use of standards traceable to the National Institute of Standards and Technology (NIST), when available. When NIST standards were not available, standards from the New Brunswick Laboratory were used. The laboratory also participated in the Environmental Protection Agency's (EPA) Laboratory Intercomparison Studies Program. In this program, samples of different environmental media (water, milk, air filters, soil, foodstuffs, and tissue ash) containing one or more radionuclides in known amounts were prepared and distributed to the participating laboratories. After the samples were analyzed, the results were forwarded to EPA for comparison with known values and with the results from other laboratories. This program enabled the laboratory to regularly evaluate the accuracy of its analyses and take corrective action if needed. Table A-1 summarizes results of the EPA comparison studies for water samples. TMA/E has applied and been accepted for readmission into the DOE Laboratory Quality Assessment Program for Radioactive Materials, coordinated by the DOE Environmental Laboratory, New York, New York.

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

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

For inorganic analyses, the program includes:

TABLE A-1

SUMMARY COMPARISON OF WATER SAMPLE RESULTS

(EPA and TMA/E)

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

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

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

For organic analyses, the program includes:

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

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

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

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

APPENDIX B

ENVIRONMENTAL STANDARDS AND CONVERSION FACTORS

ENVIRONMENTAL STANDARDS

The DOE long-term radiation protection standard of 100 mrem/yr above background level includes exposure from all pathways except medical treatments (Ref. 15). Evaluation of exposure pathways and resulting dose calculations is based on assumptions such as occupancy factors in determining the dose from external gamma radiation; subtraction of background concentrations of radionuclides in air, water, and soil before calculating dose; closer review of water use, using the data that most closely represent actual exposure conditions rather than maximum values as applicable; and using average consumption rates of food and water per individual rather than maximums. Use of such assumptions will result in calculated doses that more accurately reflect the exposure potential from site activities.

TABLE B-1

CONVERSION FACTORS

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

APPENDIX C
ABBREVIATIONS AND ACRONYMS

ABBREVIATIONS

cm	centimeter
cm/sec	centimeters per second
ft	foot
ft msl	feet above mean sea level
g	gram
gal	gallon
h	hour
ha	hectare
in.	inch
km	kilometer
km/h	kilometers per hour
lb	pound
m	meter
m^3	cubic meter
mg	milligram
mg/L	milligrams per liter
mi	mile
ml	milliliter
mph	miles per hour
mrem	millirem
mrem/yr	millirem per year
µCi/ml	microcuries per milliliter
µg/L	micrograms per liter
µmhos/cm	micromhos per centimeter
pCi	picocurie
pCi/g	picocuries per gram
pCi/L	picocuries per liter
yd^3	cubic yard
yr	year

ACRONYMS

AEC	Atomic Energy Commission
BNI	Bechtel National, Inc.
CLP	Contract Laboratory Program
DOE	Department of Energy
EPA	Environmental Protection Agency
FUSRAP	Formerly Utilized Sites Remedial Action Program
HSL	Hazardous Substances List
MED	Manhattan Engineer District
MML	Middlesex Municipal Landfill
MSP	Middlesex Sampling Plant
NIST	National Institute of Standards and Technology
NJDEP	New Jersey Department of Environmental Protection
QA	quality assurance
QC	quality control
TLD	thermoluminescent dosimeter
TMA/E	Thermo Analytical/Eberline
TOC	total organic carbon
TOX	total organic halides

APPENDIX D

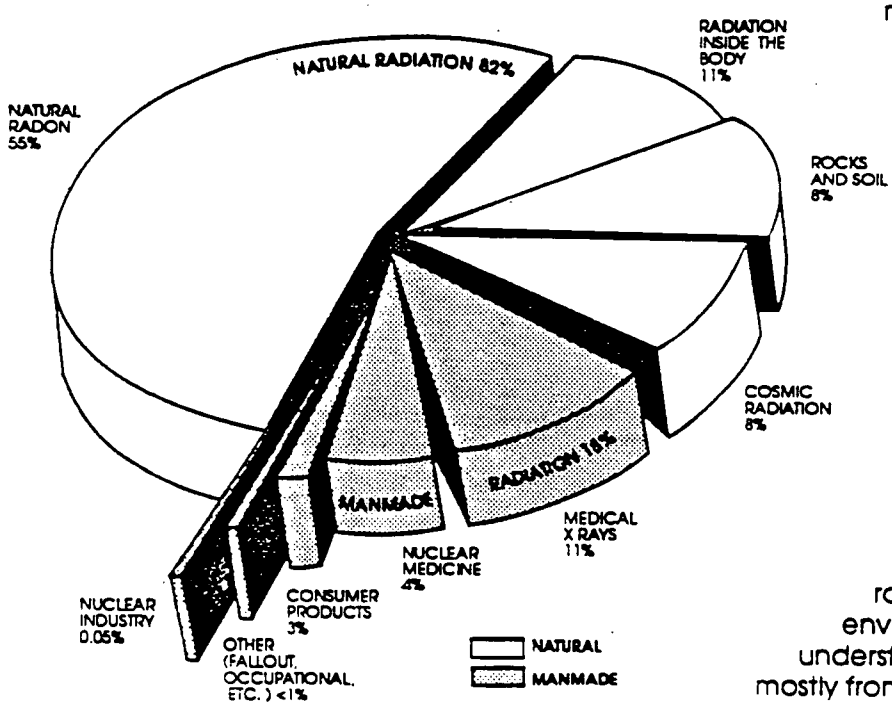
RADIATION IN THE ENVIRONMENT

Radiatio in th Environmer

Radiation is a natural part of our environment. When our planet was formed, radiation wc present—and radiation surrounds it still. Natural radiation showers down from the distant reacr 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 contr As a result, some manmade radiation has been added to the natural amounts present in our environment.

Sources of Radiation



Many materials—both naturc manmade—that we come intc contact with in our everyday are radioactive. These mc are composed of atoms t release energetic partic: waves as they change more stable forms. The particles and waves c referred to as *radiatic* and their emission as *radioactivity*.

As the chart on th shows, most environme radiation (82%) is from r sources. By far the large source is radon, an odorle colorless gas given off by n radium in the Earth's crust. W radon has always been presen environment, its significance is be understood today. Manmade radiat mostly from medical uses and consumer products—adds about eighteen percent tc total exposure.

TYPES OF IONIZING RADIATION

Radiation that has enough energy to disturb the electrical balance in the atoms of substanc 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 of electromagnetic wave travels at the speed of It takes a thick shield of : lead, or concrete to stop gar rays. X rays and cosmic ray similar to gamma radic X rays are produced manmade devices; cosmic reach Earth from outer spa

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 The level of gamma radiation in the air is measur the *roentgen*. This is a relatively large unit, so measurements are often calculated in milliroen: Radiation absorbed by humans is measured in *rad* or *rem*. The rem is the most descriptive bec it measures the ability of the specific type of radiation to do damage to biological tissue. A typical measurements will often be in the m (mrem), or one-thousandth of a rem, range. In the international scientific community, abs dose and biological exposure are expressed in and *seiverts*. 1 gray (Gy) equals 100 rad. 1 seive equals 100 rem. On the average, Americans receive about 360 mrem of radiation a year. of this (97%) is from natural radiation and medic exposure. Specific examples of common sourc 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 ..... 26 mrem/year
(increases about 1/2 mrem for each additional 100 feet in elevation)
Atlanta, Georgia (1,050 feet) ..... 31 mrem/year
Denver, Colorado (5,300 feet) ..... 50 mrem/year
Minneapolis, Minnesota (815 feet) ..... 30 mrem/year
Salt Lake City, Utah (4,400 feet) ..... 46 mrem/year

Terrestrial Radiation

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

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

Buildings

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

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

Radon

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

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

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
Color Television ..... <1 mrem
Gas Lantern Mantle (thorium-232) ..... 2 mrem
Highway Construction ..... 4 mrem
Airplane Travel at 39,000 feet (cosmic) ..... 0.5 mrem
Natural Gas Heating and Cooking (radon-222) ..... 2 mrem
Phosphate Fertilizers ..... 4 mrem

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

	Normal Superphosphate	Concentrated Superphosphate	Gyp
Ra-226	21.3	21.0	33
U-238	20.1	58.0	6
Th-230	18.9	48.0	13
Th-232	0.6	1.3	0.

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

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

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PERSPECTIVE: How Big is a Picocurie?

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

The basis for the curie is the radioactivity of one gram of radium. Radium decays c a rate of about 2.2 trillion disintegrations (2.2×10^{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 unit 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.

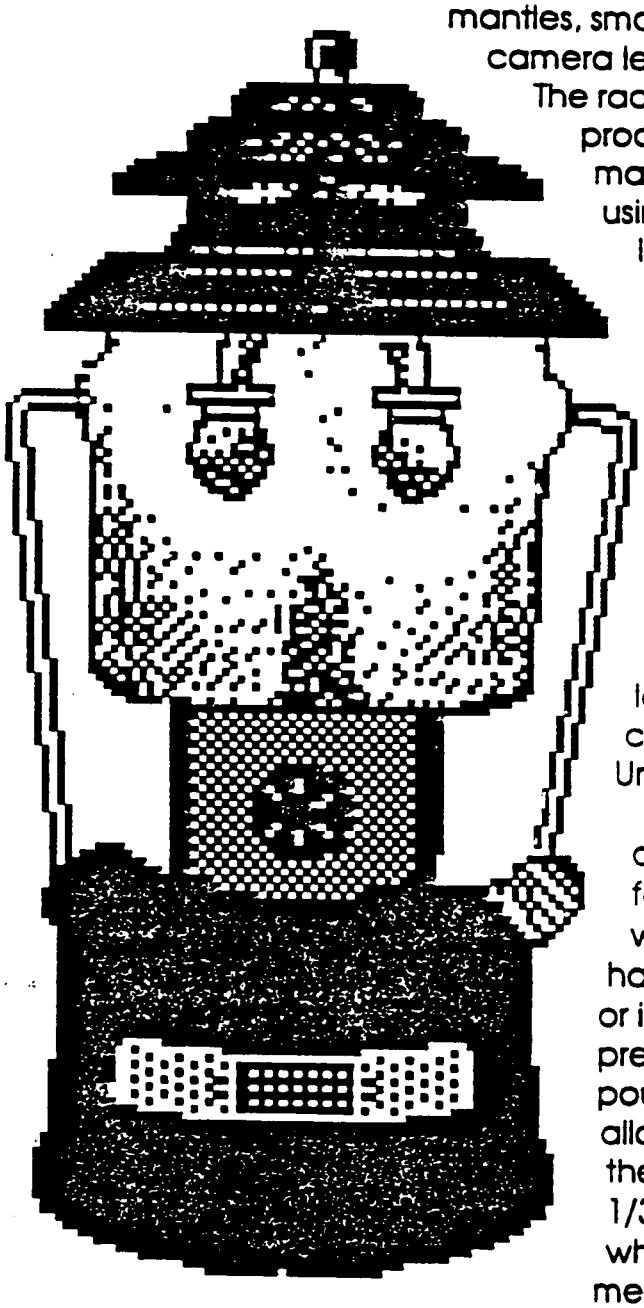
UNIT OF RADIOACTIVITY	SYMBOL	DISINTEGRATIONS PER MINUTE	DOLLAR ANALOGY	EXAMPLES OF RADIOACTIVE MATERIALS
1 Curie	Ci	2×10^{12} or 2 Trillion	2 Times the Annual Federal Budget	Nuclear Medicine Generator
1 Millicurie	mCi	2×10^{9} or 2 Billion	Cost of a New Interstate Highway from Atlanta to San Francisco	Amount Used for a Brain or Liver Scan
1 Microcurie	µCi	2×10^{6} or 2 Million	All-Star Baseball Player's Salary	Amount Used in Thyroid Tests
1 Nanocurie	nCi	2×10^{3} or 2 Thousand	Annual Home Energy Costs	Consumer Products
1 Picocurie	pCi	2	Cost of a Hamburger and Coke	Background Environmental Levels

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

PERSPECTIVE: Radioactivity in Gas Lantern Mantles

Around the House

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



Lanterns: In a New Light

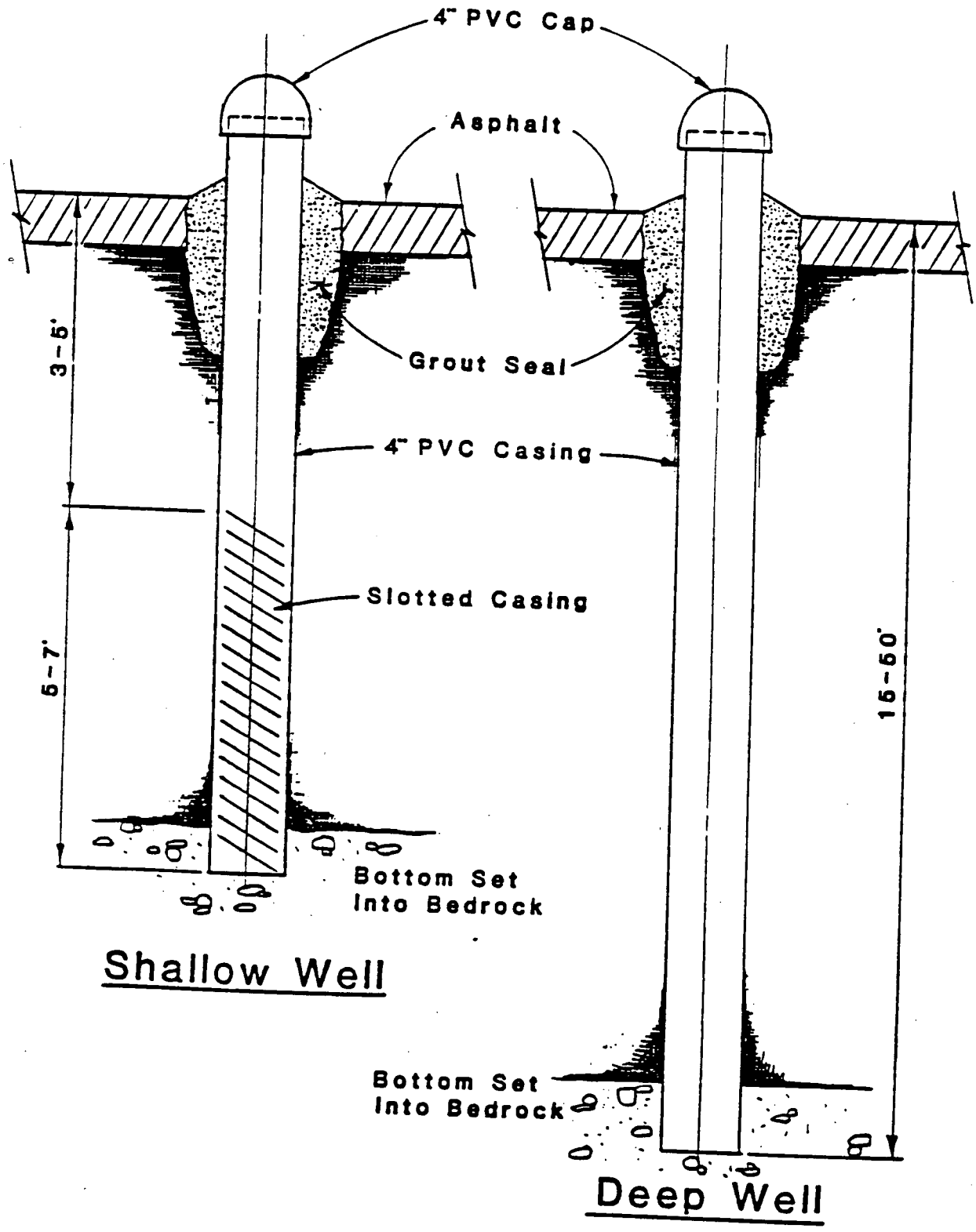
About 20 million gas lantern mantles are used by campers each year in the United States.

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

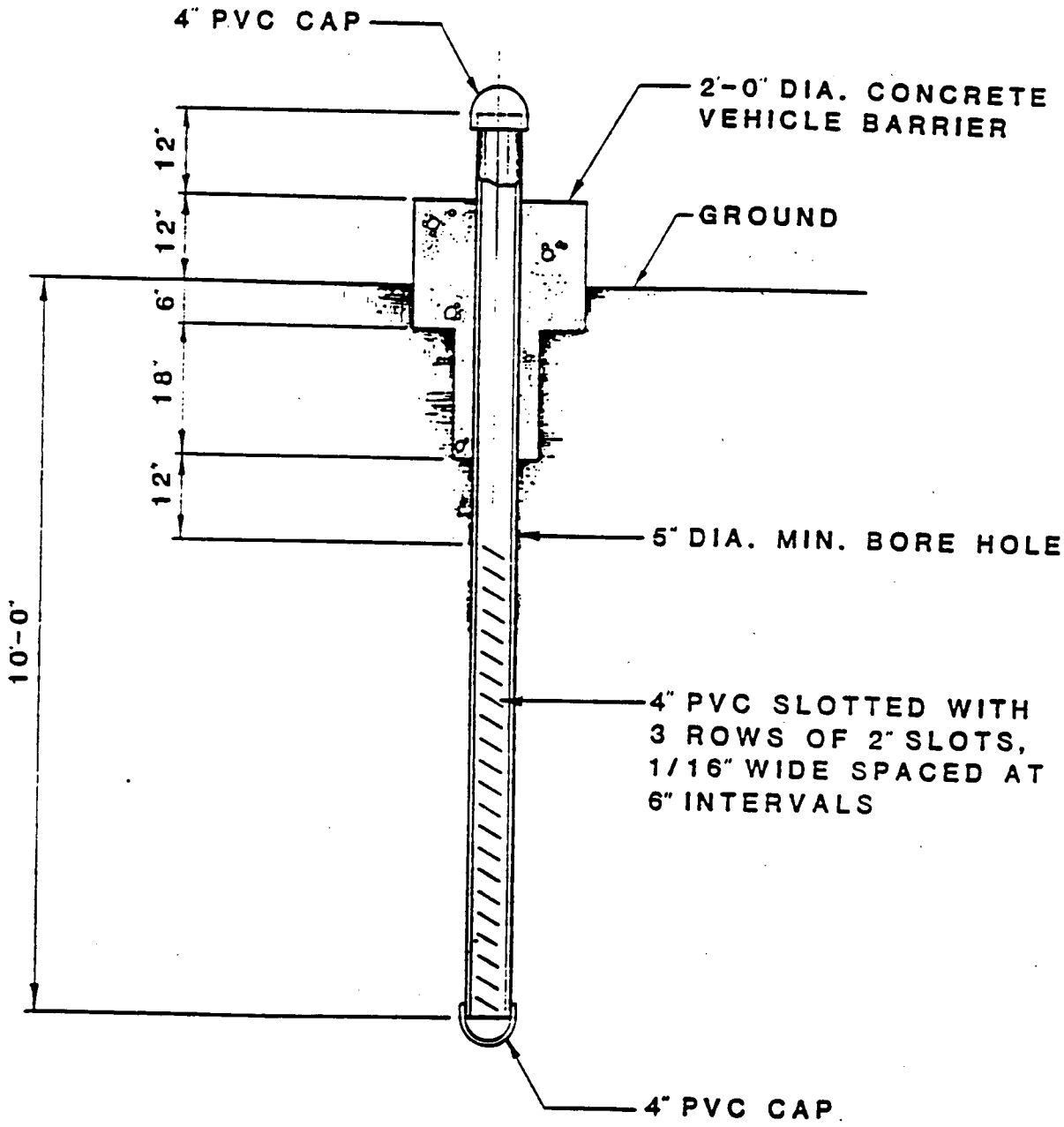
From information provided by W.L. Beck, Bechtel National, Inc.

APPENDIX E

WELL CONSTRUCTION LOG

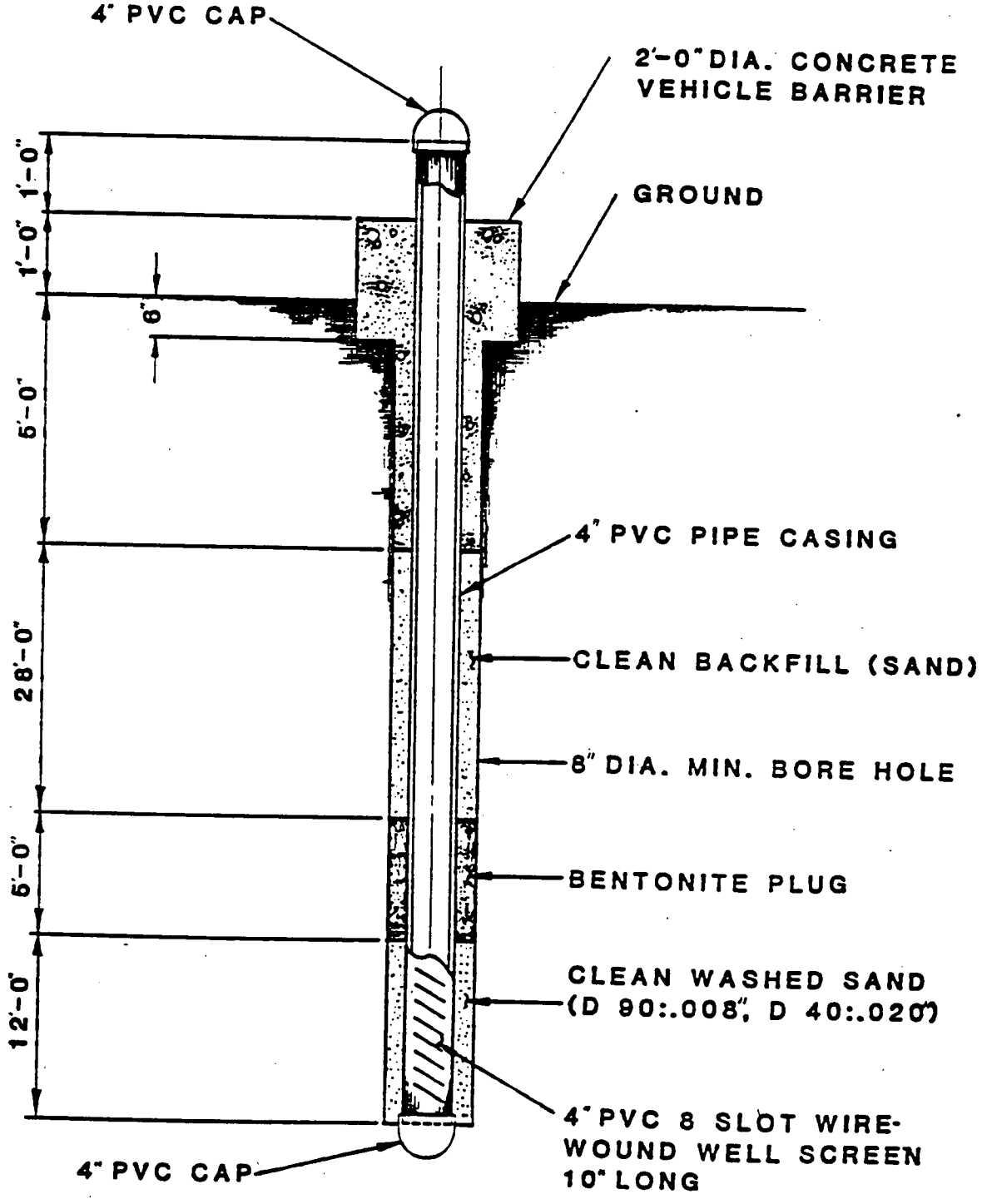


MONITORING WELL INSTALLATION DETAIL
PHASE I



SHALLOW MONITORING WELL INSTALLATION DETAIL

(PHASE II)



DEEP MONITORING WELL INSTALLATION DETAIL

(PHASE II)

APPENDIX F

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