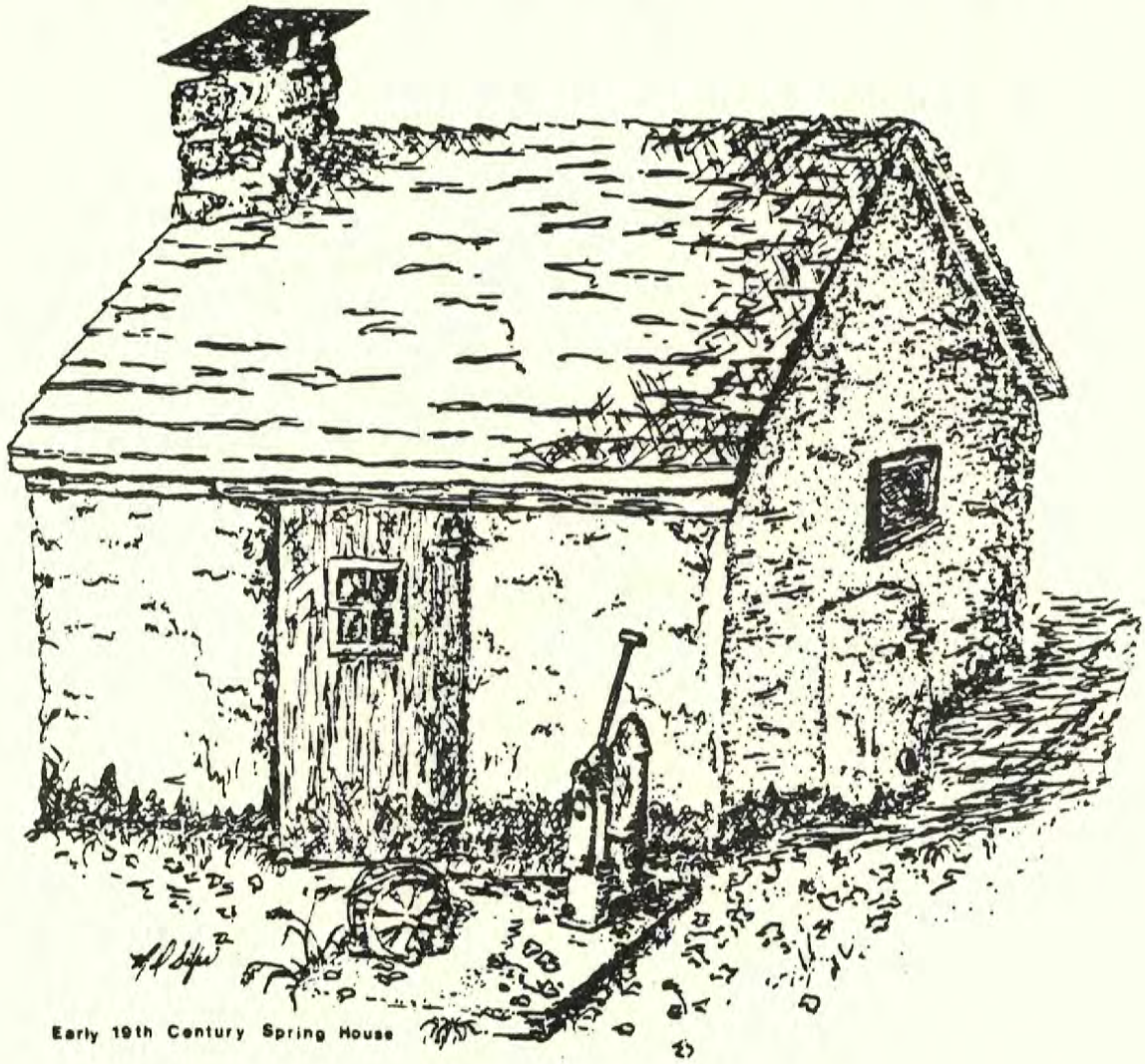
THE BURIED VALLEY AQUIFER SYSTEMS: RESOURCES AND CONTAMINATION



Early 19th Century Spring House

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1986

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THE BURIED VALLEY AQUIFER SYSTEMS
RESOURCES AND CONTAMINATION

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From the Chairman

The Passaic River Basin has long been divided according to the surface topography and hydrology. The Upper Basin is located in the Highlands Province and contains the headwaters to most of the major tributaries to the Passaic River. The Central Basin is famous for its floods. It is typified by the flat topography of the wetlands in eastern Morris and western Essex Counties. The tributaries mentioned above all meet in the Central Basin, sometimes with devastating effects on the works that mankind has carelessly placed in the floodplains. The Lower Basin is famous for the Great Falls of the Passaic, in Paterson, and for the water quality problems of the lower River. The restoration of the Lower Basin for recreation and parks is one of the great success stories and challenges of the basin.

However, the surface divisions of the basin ignore an underlying reality. The Passaic River Basin is also divided into two regions based on the sources of potable water. The eastern portion of the basin is primarily supplied by water from reservoirs and rivers in the Central and Upper Basins. The cities of Newark, Jersey City, Paterson, Clifton and many others are entirely dependent upon clean water from the western part of the basin. This was not always true. Few now know that Newark was developing wells in Belleville to augment its water supply when the City decided to purchase the Pequannock Watershed instead. Now, most of the ground water in the urban areas is gone or contaminated.

The people and businesses of the Central and Upper Basins rely almost entirely upon ground water for their drinking water supplies. Most of the surface water has long been allocated to the eastern cities. Ground water, fortunately, has been abundant and clean in the western part of the region. Not forever! This report is the first of its kind in the State of New Jersey, documenting available information on both the ground water resources and contamination of the Buried Valley Aquifer Systems, the most abundant ground water resource in northern New Jersey. The results are sobering — our aquifers do indeed have limits both of quantity and quality. Contamination is too common. Development both increases water demand and reduces recharge to the aquifers.

The residents, businesses and governments of the Buried Valley Aquifer Systems should pay close attention to the results of this report. We must work together to gain a better understanding of our aquifers, to prevent further contamination, to correct past abuses, and to manage both the quality and quantity of our ground water resources so that the health of our region's residents and the health of our economy are maintained.

The Passaic River Coalition pledges to work closely with its sister organization, the Passaic Valley Ground Water Protection Committee, and all those who are concerned about ground water protection, so that those residing here in the future will recognize the commitment we have to our welfare and theirs.

Robert J. Myers, Chairman
Passaic River Coalition

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From the Chairman

Efforts to protect the ground water resources of the Central Passaic River Basin began in 1978 when the issue was reviewed before the Northeast New Jersey Water Quality Policy Advisory Committee (PAC) established under Section 208 of the Clean Water Act. After extensive deliberations on 19 January 1979, the Passaic River Coalition and the City of East Orange petitioned the U.S. Environmental Protection Agency to designate the Buried Valley Aquifer Systems of the Central Passaic River Basin as a "sole source" aquifer under Section 1424 (e) of the Safe Drinking Water Act of 1974, to provide protection to ground water from federally funded project.

On 8 May 1980, U.S. EPA Administrator Douglas Costle formally designated the Buried Valley Aquifer Systems of the Central Passaic River Basin as the seventh sole source aquifer in the nation. The informal committee formed in early 1978 to coordinate regional efforts toward federal designation was established as the Passaic Valley Ground Water Protection Committee (PVGWPC), an intermunicipal association. We work in close cooperation with the Passaic River Coalition, which provides the commmittee with technical and administrative assistance.

This second report on the ground water resources of the Passaic River Basin provides the most complete source of hydrogeological information to date. Not only does this report provide basic information, it has accumulated extensive data on pollution threats which occurred and which may threaten groundwater quality in the future. This study establishes a sound foundation for a regional groundwater management program, which will become part III of the ongoing effort to provide protection to this valued natural resource. An effective ground water supply policy requires the assessment of two components: aquifer water quality and supply. This report generates the data base from which can be developed a comprehensive ground water protection management plan.

The members of the PVGWPC are proud and pleased to have participated in the development of this document, which will have a far reaching effect on future planning in our region. We will continue to work for the establishment of strong laws, rules and regulations for ground water protection. Without the maintenance of a high quality ground water in our region, all parts of our society will suffer. With the proper data base and recognition of the importance of this water resource, we should move toward the 21st century knowing that the quality of life we seek will continue.

Herbert J. Cannon, P.E.
Chairman, Passaic Valley Ground Water Protection Committee

Ackowledgements

To manage a resource for the benefit of society, one must know the resource. The Buried Valley Aquifer Systems: Resources and Contamination is the second of three research efforts by the Passaic River Coalition, working in cooperation with the Passaic Valley Ground Water Protection Committee, to understand the ground water resources of the Buried Valley Aquifer Systems region and the extent to which those resources have been compromised by contamination. The first report was The Hydrogeology of the Buried Valley Aquifer Systems (Van Abs, 1983). It focused upon the aquifers of the Central Passaic River Basin in what may have been the first attempt at a comprehensive literature and water use review for any aquifer in the State of New Jersey. However, the report did not cover the Rockaway Buried Valley area and did not discuss contamination issues. Both of those shortfalls now have been corrected.

The Buried Valley Aquifer Systems: Resources and Contamination makes use of every available, substantive reference and source of information relevant to the aquifer systems. The configuration and structure of the aquifers, the available water supplies, the historic and current use of the aquifers, and the contamination of the aquifers all are treated in this report. Obviously, such an effort required the cooperation of scores of people, too many to name individually. Acknowledgement of their input is clearly in order, and there is no better place than here. The most difficult decision is where to begin.

The members of the Passaic Valley Ground Water Protection Committee deserve special thanks for their supportive attitude and insights to the issues relevant to the municipalities. The Committee has been effective in representing municipal interests in ground water protection and deserves ever greater support and involvement from the municipalities of the region for its work. The Committee set the research agenda upon which this report is based, so that the member municipalities may use the information for the benefit of their residents.

Dozens of water engineers, water superintendents, municipal officials and consultants gave of their time so that this report could include a wealth of information about the local water systems and issues that directly concern those responsible for getting sufficient, clean water to every user, every time. Interviews were held with each, and every

person interviewed had an opportunity to review the results prior to use in the report. Many hours were given by each person. My thanks.

The staff members of the New Jersey Department of Environmental Protection and the United States Environmental Protection also gave unstintingly of their time, despite the already burdensome caseloads. The New Jersey Geological Survey, especially the Bureaus of Ground Water Resources Evaluation and Ground Water Pollution Analysis, provided enormous amounts of information, staff time and other assistance to this project. The United States Geological Survey also provided assistance in understanding the research they perform in the region.

Obviously, a report which relies in part upon a literature review owes a great debt to those who have actually done the field work and prepared the reports and articles referenced here. Consultants, government staff and graduate students have all played a role in bringing the level of knowledge to its current point.

Nothing comes for free. This research effort was supported by the Geraldine R. Dodge Foundation, Scott McVay, Executive Director. The Dodge Foundation also funded the first study in part, and has already approved yet a third grant to begin the next phase of work upon the interim management program for the aquifer systems. Patience is one of the Foundation's many virtues. I hope that in this product they find their reward.

Finally, my personal thanks to the Board of Trustees, Executive Director and staff of the Passaic River Coalition. Nothing is accomplished in a vacuum. Their support provided the foundation for every word you read.

Daniel J. Van Abs, Ph.D.
Technical Director
Passaic River Coalition
29 September 1986

CHAPTER I

INTRODUCTION

The Buried Valley Aquifer Systems Region

Nearly one-half of New Jersey's residents rely on ground water for potable water supplies. The major aquifers of New Jersey are the Coastal Plains aquifers used by the shore communities, the Potomac-Raritan-Magothy aquifer used by Delaware River communities in southern New Jersey, and the buried valley (or valley-fill) aquifers of glaciated areas in northern New Jersey. The Buried Valley Aquifer Systems region is included within the last category.

In terms of political boundaries (see Figure G-1), the Buried Valley Aquifer Systems region encompasses the western parts of Essex and Union Counties, northern Somerset County and north, central and eastern parts of Morris County. Hydrologically, the region includes the Central and Upper Passaic River Basin, the Whippany River watershed, the Rockaway River watershed, and the Upper Lamington River watershed. The Upper Lamington River is part of the Raritan River Basin while the remainder of the region is included within the Passaic River Basin. The aquifer underlying the Upper Lamington is directly connected with the aquifer of the Rockaway River watershed and so is included within the region.

The Buried Valley Aquifer Systems region is characterized by a network of former river valleys which were filled with glacial outwash material by the Wisconson glacier which covered much of northern New Jersey until some 11,000 years ago. The **buried valley aquifers** thus formed are often contiguous and hydraulically connected to aquifers in the fractured bedrock below. The buried valley aquifers are prolific regionally, supplying over 40 million gallons per day for potable use. The bedrock aquifers are locally prolific, especially dolomite formations in the west and some shale areas in the east.

The region includes two "sole source aquifers" designated by the United States Environmental Protection Agency. The Buried Valley Aquifer Systems of the Central Passaic River Basin was designated in 1980, while the Rockaway Valley Quaternary Aquifer was designated in 1984. Recent hydrogeologic studies clearly show that the two aquifer systems are in fact one, fully connected through a formerly unknown buried valley. Therefore, this report treats the two designated areas as one, called the **Buried Valley Aquifer Systems.**

Importance of Ground Water to the Region

Ground water has played an ever-increasing role in supplying the water needs of residents and businesses throughout the Passaic River Basin and, indeed, throughout New Jersey. Within the basin, the most productive and intensively used aquifers are the buried valley (or valley-fill) aquifers. The buried valley aquifers form an extensive network of narrow-channeled sand and gravel deposits through which large quantities of water flow. They are located in many parts of the Passaic River Basin which were affected by the latest glaciation (the Wisconsin) and are most heavily concentrated in northern and eastern Morris County and western Essex County. Public water purveyors began tapping the buried valley aquifers around the turn of the century. Now, the use of the aquifers has reached major proportions, supplying the majority of water used in a number of municipalities, and providing water for over one-half million people and scores of major industries.

The intensive use of the aquifers, coupled with their high potential for contamination and loss of recharge, led municipalities and citizen organizations to pursue local, state and federal methods for protecting the ground water resources of the area. At the same time, the compilation of existing information on the buried valley aquifers was begun for use by decision-makers throughout the region. This report is the result of the second phase of efforts to understand the characteristics of the aquifers, and ground water use and contamination, so that this knowledge might be applied toward improved management of the aquifer systems. The first phase concluded in 1983 with the publication of the Hydrogeology of the Buried Valley Aquifer Systems. This second report enlarges upon the first, makes use of new findings from research of the State and federal governments, updates information on ground water diversions, and provides a first-time overview of contamination incidents and issues within the region.

History of the Sole Source Designation

In 1974, Congress passed the Safe Drinking Water Act, which in part provided that:

> If the Administrator determines, on his own initiative or upon petition, that an area has an aquifer which is the sole or principal drinking water source for the area and which, if contaminated, would create a significant hazard to public health, he shall publish notice of the determination in the Federal Register. After the publication of any notice, no commitment for Federal financial assistance (through a grant, contract, loan guarantee, or otherwise), may be entered into for any project which the Administrator determines may contaminate such aquifer through a recharge zone so as to create a significant hazard to public health, but a commitment for Federal financial assistance may, if authorized under another provision of law, be entered into to plan or design the project to assure that it will not so contaminate the aquifer. (Section 1424 (e))

In 1978 the Borough of Chatham, through its Borough Engineer and Environmental Commission, requested the Northeast New Jersey Policy Advisory Committee (PAC) for Water Quality Management to pursue the concept of sole source aquifer designation. The PAC served as a citizen advisory body for planning which included the Passaic River Basin. Following research by the PAC and the Passaic River Coalition on the background data and boundaries for the Buried Valley Aquifers, the City of East Orange and the Passaic River Coalition petitioned the U.S. Environmental Protection Agency's Administrator, Douglas Costle, on 16 January 1979 to designate the 80-square mile "Buried Valley Aquifer Systems" as a sole source aquifer (Appendix A, Exhibit 1; Appendix B, Exhibit 1). Under Section 1424 (e) regulations, the aquifer must supply at least fifty per cent of an area's residents. The Buried Valley Aquifer System supplies nearly ninety percent of the water used by residents of thirty-one municipalities, serving a population in excess of 580,000. Signing the petition were Mayor Thomas H. Cooke, Jr., of East Orange (Chairman of the PAC) and Ella F. Filippone, Executive Administrator of the Passaic River Coalition (Vice Chairman of the PAC).

The United State Environmental Protection Agency (EPA), Region II, held a hearing on 23 May 1979 in Roseland (Appendix A, Exhibit 2) to solicit public comments on the petition. The petition received strong support from the N.J. Department of Environmental Protection (NJDEP), numerous

public officials, environmental organizations and citizens, both in letters of support and in testimony to EPA (Table I-1). EPA proposed an approach to the delineation of the area and to regulations which would implement the EPA review process over Federal programs which might adversely affect the aquifer. The most important proposed change added a "streamflow source zone" to the aquifer designation, so as to provide further protection for the aquifer by prohibiting pollution of ground water or surface water in the streamflow source zone by federal projects which might eventually pollute the aquifer. Table I-2 is a listing of municipalities covered (See also Figure G-1).

The EPA adopted the designation of the Buried Valley Aquifer Systems, including the streamflow source zone, by notice in the Federal Register on 8 May 1980 (Appendix B, Exhibit 2, Appendix A, Exhibit 3). The success of this joint municipal-citizen petition had also led to the formation of an intermunicipal Passaic Valley Ground Water Protection Committee (PVGWPC) in December 1979. The PVGWPC selected a primary goal of educating the general public as well as elected and appointed officials about the sole source aquifer designation, while encouraging municipal guidelines for development not covered by federal review.

The Committee outlined five goals for its programs:

1) Development of an education program to be presented to the Planning Boards of the region so that they consider ground water in their site plan reviews;

2) A study to identify the recharge areas for the aquifer;

3) A service to the Planning and Zoning Boards which would aid them in site plan review as it affects ground water and provide assistance for Master Plan revision;

4) A funding mechanism for setting aside lands critical to the protection of aquifer quality or recharge;

5) Respond collectively to issue of common interest.

During its first year of operation the Committee reviewed development projects with potential impacts on the aquifer, supported municipalities in the protection of their ground water resources, interacted extensively with state and federal officials and prepared educational information on the Buried Valley Aquifer Systems (Appendix A, Exhibit 5). The Committee completed five years of operations in 1985 with a public meeting on the benefits of intermunicipal cooperation for the protection of regional ground water supplies. Municipal support has consistently increased along with the sophistication of Committee operations and its influence on ground water management in the region.

TABLE I-1

BURIED VALLEY AQUIFER SYSTEMS
"SOLE SOURCE AQUIFER" PETITION SUPPORTERS

Elected Officials

Governor Brendan Byrne (represented by Daniel J. O'Hern, Commissioner, NJ Department of Env'l Protection
Congresswoman Millicent Fenwick
Congressman Andrew Maguire
Congressman Joseph Minish
Congressman Peter Rodino
Assemblyman Walter J. Kavanaugh
Assemblywoman Rosemarie Totaro
Assembly of New Jersey (resolution)
Senate of New Jersey (resolution)

Municipalities

Berkeley Heights Township
Bernards Township
Boonton Township
Caldwell Borough
Chatham Borough
Chatham Township
East Hanover Township
Essex Fells Borough
Fairfield Borough
Florham Park Borough
Hanover Township
Harding Township
Irvington, Town of
Livingston Township
Millburn Township
Montville Township
Morris Township
Newark, City of
Roseland Borough
West Orange Township

Government Agencies

Greystone Psychiatric Hospital
Northeast NJ Water Quality Policy Advisory Committee
Somerset County Planning Board
Somerset-Union Soil Conservation District
Southeast Morris County Municipal Utilities Authority

Corporations and Non-Profits

American Association of University Women
Commonwealth Water Company
Environmental Policy Center
Friends of the Earth
League of Women Voters
Mid-Atlantic Council of Watershed Associations
Millburn-Short Hills Citizens League for Environmental Action Now
Morristown Memorial Hospital
Sierra Club

Official statements were presented to the U.S. EPA between 1 February 1979 and 15 April 1979.

TABLE I-2

MUNICIPALITIES ENTIRELY OR PARTIALLY WITH THE
"BURIED VALLEY AQUIFER SYSTEMS OF THE
CENTRAL PASSAIC RIVER BASIN" DESIGNATED AREA

Morris County

Boonton, Town of
Boonton Township
Chatham Borough
Chatham Township
Denville Township
Dover, Town of
East Hanover Township
Florham Park Borough
Hanover Township
Harding Township
Jefferson Township
Kinnelon Borough
Madison Borough
Mendham Borough
Mendham Township
Mine Hill Township
Montville Township
Morris Plains Borough
Morristown, Town of
Morris Township
Mountain Lakes Borough
Parsippany-Troy Hills Township
Passaic Township
Randolph Township
Rockaway Borough
Rockaway Township
Roxbury Township
Victory Gardens Borough
Wharton Borough

Essex County

Caldwell Borough
Essex Fells Borough
Fairfield Township
Livingston Township
Millburn Township
North Caldwell Borough
Roseland Borough
West Caldwell Borough

Somerset County

Bernards Township
Bernardsville Borough
Warren Township

Union County

Berkeley Heights Township
New Providence Borough
Summit, City of

Source: 45 Federal Register 91:30537, 8 May 1980.

In 1986, the Committee won a seminal victory with approval by the New Jersey Legislature of an act to regulate underground storage tanks statewide, capping five years of effort by the Committee on this issue. The PVGWPC had developed a model municipal ordinance for the control of toxic and hazardous materials, with a special focus upon the underground storage of such materials. Municipalities began consideration of local ordinances, leading to business support for uniform, statewide provisions and the ultimately successful campaign by the Committee (begun in 1984) for strong state legislation.

The Passaic Valley Ground Water Protection Committee, working with the Passaic River Coalition, determined to analyze and synthesize the existing hydrogeologic data on the Buried Valley Aquifer System for use by public and private decision-makers throughout the designated area. The information will serve as a basis for the eventual development of an aquifer protection plan for the region predicated upon municipal action in cooperation with existing State authorities.

The Rockaway Valley Quaternary Aquifer was designated a sole source aquifer in January of 1984, having been petitioned for designation in 1979 by the Upper Rockaway River Watershed Association. The designated area includes essentially the same area as the Rockaway River portion of the "streamflow source zone" from the Buried Valley Aquifer Systems designation, but adds the Upper Lamington River watershed in recognition of new evidence linking the two buried valley aquifers (see Table I-3 for a listing of municipalities). As the Passaic Valley Ground Water Protection Committee had already included the region within its area of concern, efforts to involve municipalities from the newly designated area continued. By 1986, the municipalities of Rockaway Borough, Rockaway Township, Randolph Township and Denville Township were members of the Committee in some capacity. The municipalities listed in Table I-4 have been members or associate members of the PVGWPC at some time from 1980 to 1986.

The Passaic River Coalition and the Township of West Milford co-signed a petition to the U.S. EPA in 1985 requesting the designation of the aquifers within the Wanaque River, Pequannock River and Pochuck Creek Watersheds as a "sole source aquifer." Both public and private water supplies in that region rely very heavily upon ground water from small buried valleys and glacial outwash deposits which are very prone to contamination. The region includes municipalities in both New Jersey and New York, in the northwestern portion of the Passaic River Basin generally (Figure I-1; Table I-5).

TABLE I-3

MUNICIPALITIES ENTIRELY OF PARTIALLY WITHIN THE
"ROCKAWAY QUATERNARY AQUIFER SYSTEM" DESIGNATED AREA

Municipality
Boonton, Town of
Boonton Township
Denville Township
Dover, Town of
Jefferson Township
Mine Hill Township
Mountain Lakes Borough
Randolph Township
Rockaway Borough
Rockaway Township
Roxbury Township
Victory Gardens Borough
Wharton Borough

Source: 49 Federal Register 16:2946, 24 January 1984.

TABLE I-4

MEMBERS OF THE PASSAIC VALLEY
GROUND WATER PROTECTION COMMITTEE
1980-1986

Townships of:

Chatham
Denville
East Hanover
Fairfield
Hanover
Harding
Livingston
Millburn
Montville
Morris
Parsippany-Troy Hills
Randolph
Rockaway
West Milford
Wyckoff

Boroughs of:

Bernardsville
Chatham
Essex Fells
Florham Park
Madison
Morris Plains
Rockaway
Roseland

Cities and Towns of:

East Orange
Morristown

Commonwealth Water Company

Morris County Municipal Utilities Authority

Southeast Morris County Municipal Utilities Authority

Passaic River Coalition

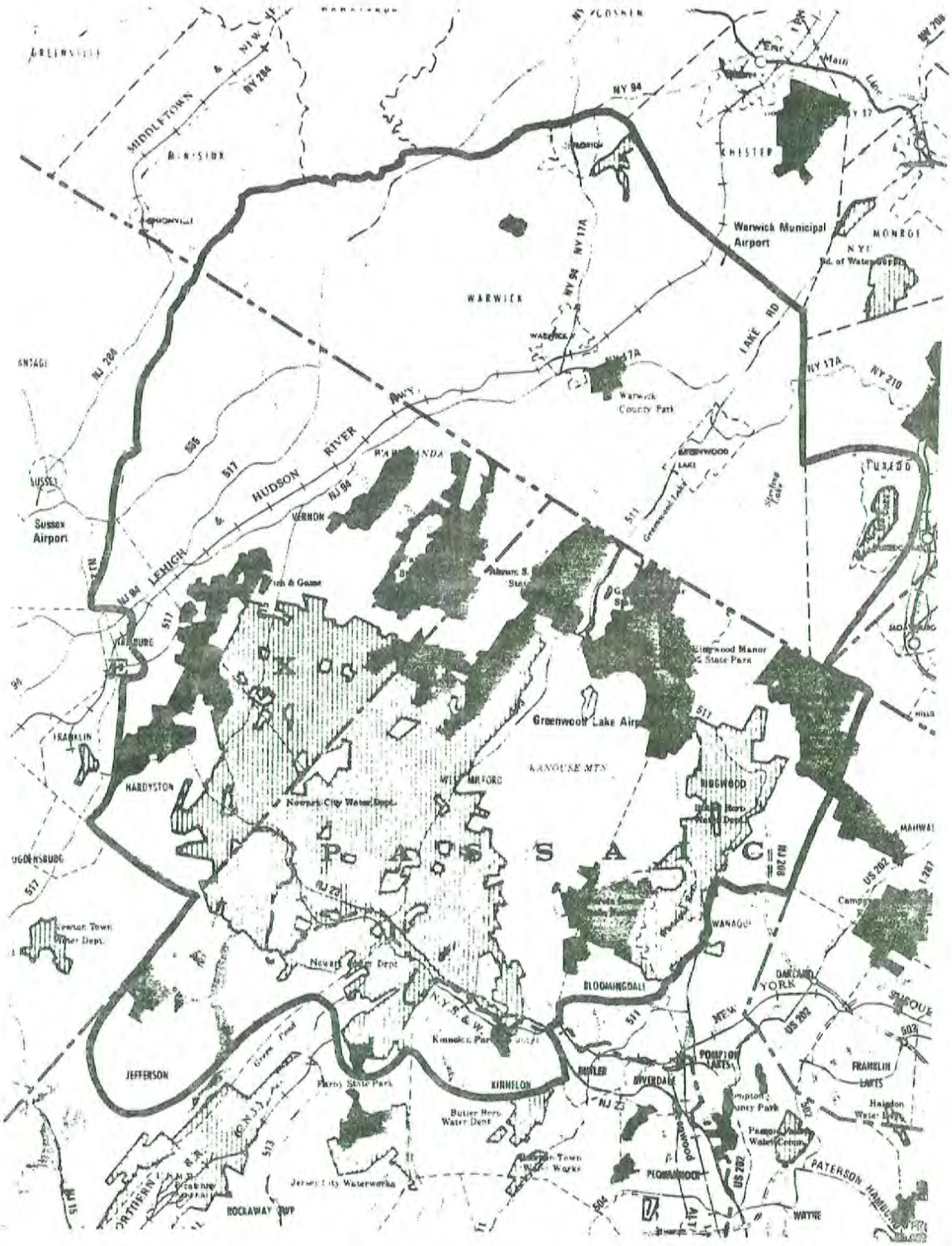

Figure I-1. Highlands Aquifer Systems Proposed Designated Area

TABLE I-5

MUNICIPALITIES ENTIRELY OR PARTIALLY WITHIN THE
"HIGHLANDS AQUIFER SYSTEMS"
PROPOSED DESIGNATED AREA

Municipalities

Bloomingdale Borough
Florida, Village of, New York
Greenwood Lake, Village of, New York
Hardyston Township
Jefferson Township
Kinnelon Borough
Ringwood Township
Rockaway Township
Tuxedo Township, New York
Vernon Township
Wanaque Borough
Warwick, Township of, New York
Warwick, Village of, New York
West Milford Township

Source: Township of West Milford and Passaic River Coalition, 28 February 1985, "Petition Before the United States Environmental Protection Agency, Lee M. Thomas, Administrator, with Respect to the Highlands Aquifer Systems of Northern Passaic, Northwestern Morris, Northeastern Sussex Counties, New Jersey and Southwestern Orange County, New York."

Purpose of Report

The Passaic River Coalition in 1982 began a collection and synthesis of available hydrogeologic data on the aquifer system of the designated area, with primary application to the "Aquifer Recharge Area" of the Buried Valley Aquifer Systems. The information (coming primarily from reports and files of the USGS, NJDEP, public water purveyors and consultants) was set forth in a style understandable and usable by the general public, public officials and private decision-makers. The study presented existing material in new and useful ways, but did not entail new hydrogeologic research. The report, Hydrogeology of the Buried Valley Aquifer Systems, was published in early 1983 by the PRC.

In cooperation with the Passaic Valley Ground Water Protection Committee, the Passaic River Coalition moved into the second phase of its research effort toward the development of an aquifer management plan for the region. The second phase involved an update of all material in the first study based on new research, current diversion data, closer analysis of the public water supply systems of the region and comments on the first study. The Rockaway and Upper Lamington River aquifers received much more extensive coverage. In addition, information on contamination incidents and issues within the region along with a general discussion of ground water pollution and pollution management were added.

This study has eight sections which constitute Chapters II through IX:

1) A discussion of the geologic setting of the designated areas;
2) A generalized examination of hydrogeology;
3) Specific discussion of the delineation and hydrogeologic characteristics of the buried valley aquifers;
4) A detailed analysis of ground water use patterns and diversions and use management in the region;
5) An overview of ground water pollution causes, mechanics and management policies;
6) A detailed analysis of ground water contamination incidents, potential sources of future contamination and local pollution prevention activities in the region;
7) Current and anticipated research efforts by the U.S. Geological Survey, the New Jersey Geological Survey and the Passaic River Coalition; and
8) A discussion of research needs, and the difficulties that arise in ground water management due to the lack of a sufficient understanding of the aquifer system.

CHAPTER II

GEOLOGY OF THE STUDY AREA

Importance of Geology to Ground Water Resources

Geology is the study of an area's surface and subsurface rocks and sediments, the relative age of the formations, the method of deposition and transformation over time of these deposits, and the variation of the rocks and sediments over an area, both vertically and horizontally.

The layering of rocks and sediments in a vertical column, starting from the earth's surface, is called the **lithology** of that column. The description of how the lithology varies over an area is called **stratigraphy.** In some areas the lithology is fairly uniform, such as in New Jersey's coastal plains where there are alternating, flat beds of sand and clay. In other areas, such as northern New Jersey, the geologic formations have a complex stratigraphy, with a lithology that varies widely over short distances. Complex stratigraphies may arise due to folding, faulting, erosion, glaciation and other geological processes.

Until the geology of an area is known in some detail, the exploitation and management of ground water resources is at best a haphazard business. The more complex the stratigraphy, the more dependence is placed on detailed geologic information for knowledge of ground water resources.

The geology of an area determines the most important physical factors controlling whether ground water is a significant resource. Once the general nature of an area's geology is known, more specific information on the age, type and structure of the rocks and surficial deposits is needed to predict the existence, magnitude and characteristics of ground water resources. These factors determine the amount of water able to infiltrate the soil and percolate to the water table, the amount of water that aquifers can store and the rate at which water can be pumped from aquifers, the natural quality of ground water, and the ease with which pollutants can enter and move with the ground water.

Geologic Time Scale

Geologic history of the earth is divided into two categories, as shown in Table II-1. The four major divisions--Precambrian, Paleozoic, Mesozoic, and Cenozoic--are called eras, indicating the increasing complexity of living organisms that evolved during them. The division of eras into periods indicates changing environmental conditions. Geologic time is measured in two fundamentally different ways. The first is relative age in which the rock layer or a fossil is determined to be older or younger than another but no actual age is given. The second is absolute age in which rock, fossil or human artifact is dated using radioactive isotopes. As radioactive substances decay at a constant rate, the amount of radioactive substance remaining today relative to the isotope into which it has decayed can give a fairly good idea of the time when the material was created (Keller, 1979).

General Geology of the Study Area

The study area lies in north-central New Jersey (Figure G-1), in parts of Morris, Union, Essex, and Somerset Counties. The bedrock formations generally trend in a southwest-northeast direction. Bedrock and surficial formations range in age from Precambrian to Cenozoic, increasing in age generally with depth from the surface and as one moves to the northwest. The different ages and erosiveness of the bedrock formations have resulted in several different types of surface topography. These are grouped as physiographic provinces, of which five are recognized in New Jersey (Figure II-1). This study is primarily concerned with the Highlands and Piedmont Provinces. The Rockaway Valley Quaternary Aquifers are located in the Highlands Province, while the Buried Valley Aquifer Systems (as originally designated) are located primarily in the Piedmont Province, except for the streamflow source zone which is essentially the same as the Rockaway River watershed in the Highlands Province.

Over the years, geologic investigations have increased in sophistication. The extensive use of surface geophysics has provided considerable data about the area's geology through investigations at ground level. The earliest investigations relied upon outcroppings of bedrock and surficial deposits supplemented with information from road cuts and other investigations to make inferences about the subsurface geology.

TABLE II-1. Geologic Time Scale[a]

Million years ago	Era	Period	Events
1.5	Cenozoic	Quaternary	Ice Age in Pleistocene Epoch
65		Tertiary	
135	Mesozoic	Cretaceous	Deposition of sediments on Inner Coastal Plain
181		Jurassic	Upper Brunswick deposition; extrusion of Watchung basalt
220-230		Triassic	Erosion of Appalachian Mountains. Deposition of Brunswick Formation. Block faulting to form Newark Basin
280	Paleozoic	Permian	Climax of Appalachian Revolution; extensive folding and faulting
310		Pennsylvanian	
345		Mississippian	
405		Devonian	Acadian Orogeny: further uplift of Appalachian geosyncline
425		Silurian	
500		Ordivician	Taconic Orogeny: uplift of Appalachian geosyncline
570-600		Cambrian	Subsidence of Appalachian geosyncline continued
4,500[b]	Precambrian		Formation of Appalachian geosyncline. Ramapo fault originated at this time. Volcanic activity formed Eastern Uplands

[a]Table is not to scale.

[b]Recent estimate of the age of the earth. However, the estimated age has been increasing steadily as older rock formations are discovered.

Source: Keller, 1979; Kelland and Kelland, 1978

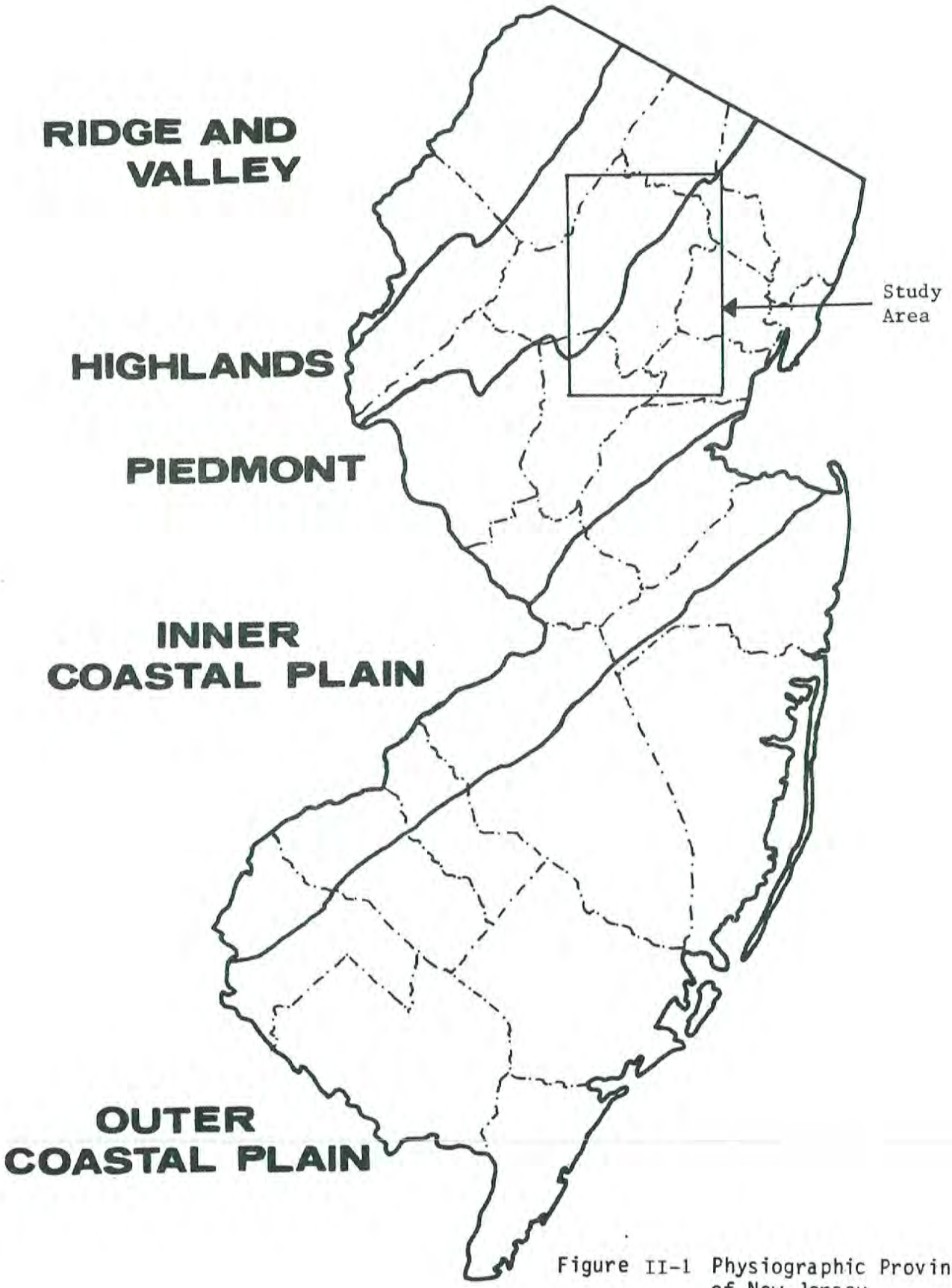

Figure II-1 Physiographic Provinces of New Jersey

Source: Kelland and Kelland, 1978

More recent and widespread use of formation logs from wells drilled deep into the ground has provided more extensive data on an area's lithology. Still, many gaps existed and still exist, as drilling gives point-by-point information without a definitive answer on the stratigraphy of the area between the wells.

This century has seen an increase in the application of physics theory to the study of geology, through a technology called geophysics. Geophysics has been used in the location of mineral fields, petroleum deposits, ground water resources and pollution plumes moving subsurface. Surface geophysical techniques, such as direct current-resistivity, electromagnetic and induced polarization, seismic reflection and refraction, gravimetry and magnetic methods, are often used in conjunction with drilling. Usually fewer observation holes are needed than if drilling was the sole technique used. The observation holes are used to verify or calibrate the data gathered through surface geophysics. Geophysics is a useful technique for geologic investigations as it can provide a more complete picture of the stratigraphy of an area and the potential existence of ground water resources than can drilling alone (Zohdy, et al., 1974).

Key Geologic Events in Northern New Jersey

Northern New Jersey, the location of the Buried Valley Aquifer Systems, has been marked by three major events: the creation and erosion of the Appalachian Mountains; the creation of the Newark Basin in the Piedmont Province; and the effects of several glaciation episodes across much of the study area. Each area's geologic history will be discussed, followed by a brief description of the aquifers.

The Ridge & Valley and Highlands Provinces

The geologic processes which occurred in New Jersey over the hundred of millions of years through the Precambrian and Paleozoic Eras produced a complex series of rock types. Sediments were deposited and compressed into rocks. The rocks were subsequently folded and faulted, intruded with volcanic materials, and metamorphosed by heat and pressure. The following rock types resulted: granite, gneiss, diorite, slate, marble, limestone, dolomite, siltstone, claystone, shale, and sandstone.

The distribution of Precambrian and Paleozoic rocks is limited to the northwestern section of New Jersey in the Ridge and Valley and the Highlands physiographic provinces (Figure II-1). Fenneman (1938), Kummell and Lewis (1940), and Wolfe (1977) provided detailed information on these areas. The study area includes some Precambrian formations along the western edge of the Upper Passaic and Whippany River watersheds and much of the Rockaway River watershed west of the Ramapo Fault, in the Highlands Province. Precambrian formations are poor aquifers.

The Paleozoic rocks also are generally poor aquifers, with the exception of the Kittatiny Formation (dolomitic limestone). The Kittatiny Limestones are located primarily within the long valley running from Picatinny Arsenal in Rockaway Township, southwest toward Chester Township. A connected valley (Flanders Valley) also contains dolomite which extends southwest parallel to the Upper Lamington valley.

Formation of the Piedmont Province

The Appalachian Mountains were uplifted at the end of the Paleozoic Era when the European and African plates collided with the North American plate.[1] Figure II-2 illustrates the assumed cross-section of New Jersey at that time. As the plates separated, faulting occurred along the eastern edge of the Highlands and the western edge of the Eastern Uplands creating a basin (Figure II-3). Eroded materials from these mountains were deposited into the basin and later became the rocks that occur in the area today.

The basin is called the Newark Basin and the rocks that formed in it are members of the Newark Group. The basin is part of the Piedmont physiographic province which extends in New Jersey from the Delaware River (from Trenton to north of Frenchtown), northeast to the New Jersey-New York line (from Mahwah to the Hudson River). The Piedmont totals approximately 20% of the area of New Jersey (Figure II-1). The Piedmont

[1] The concept of the continents and ocean basins being divided into six major plates and a number of minor ones floating atop the more plastic mantle has revolutionized modern geology. The collisions and breaking away of these plates has shed new light on the processes that form volcanos, earthquakes, faults, and mountains. From the pioneering work of Alfred Wegener (1915), a German meteorologist, a new branch of geology, "Plate Tectonics," has emerged and with it has come an explanation of the major crustal features of the earth.

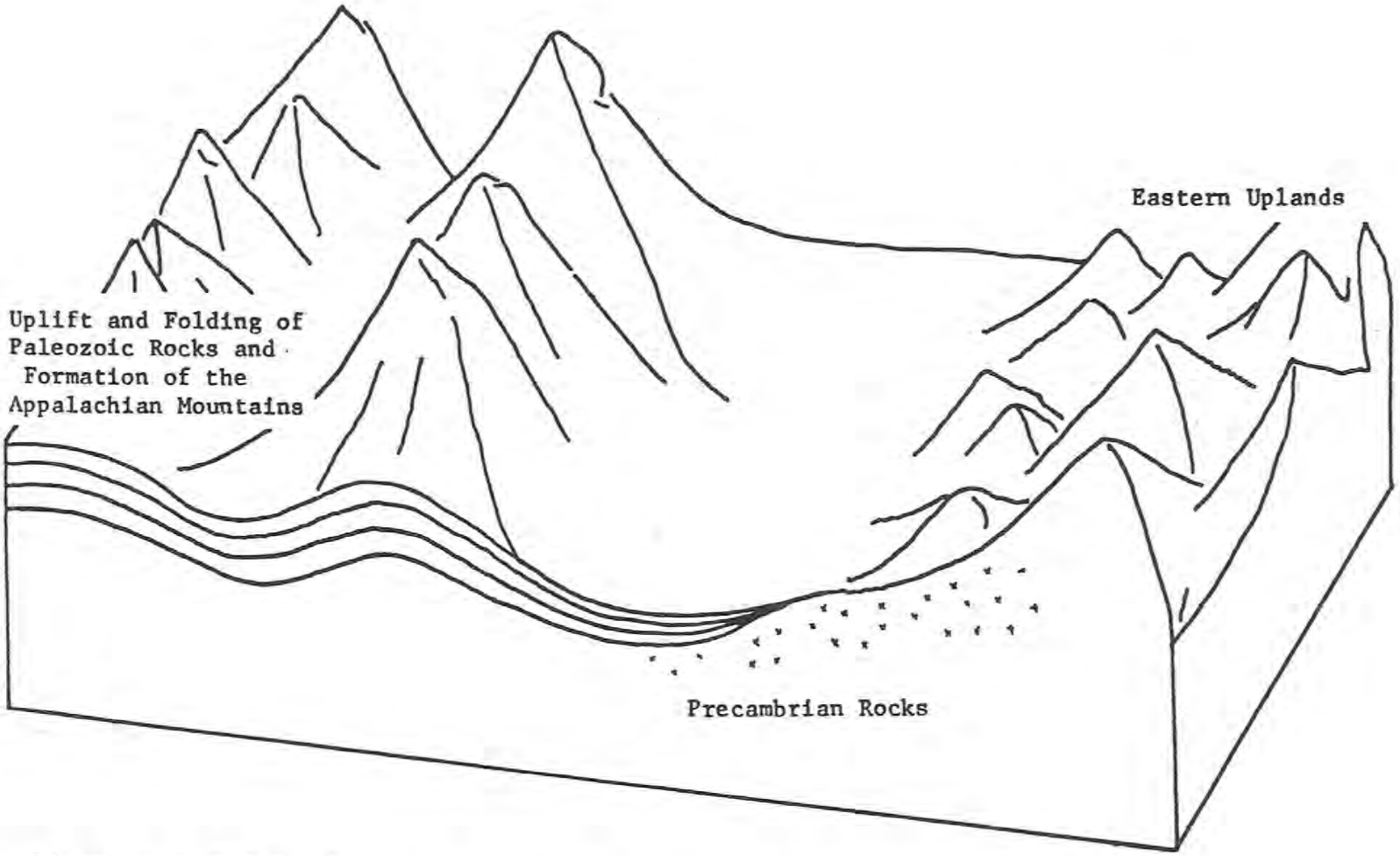

Figure II-2 Uplift of the Appalachian Mountains: Late Paleozoic.

Source: Passaic River Coalition, 1981.

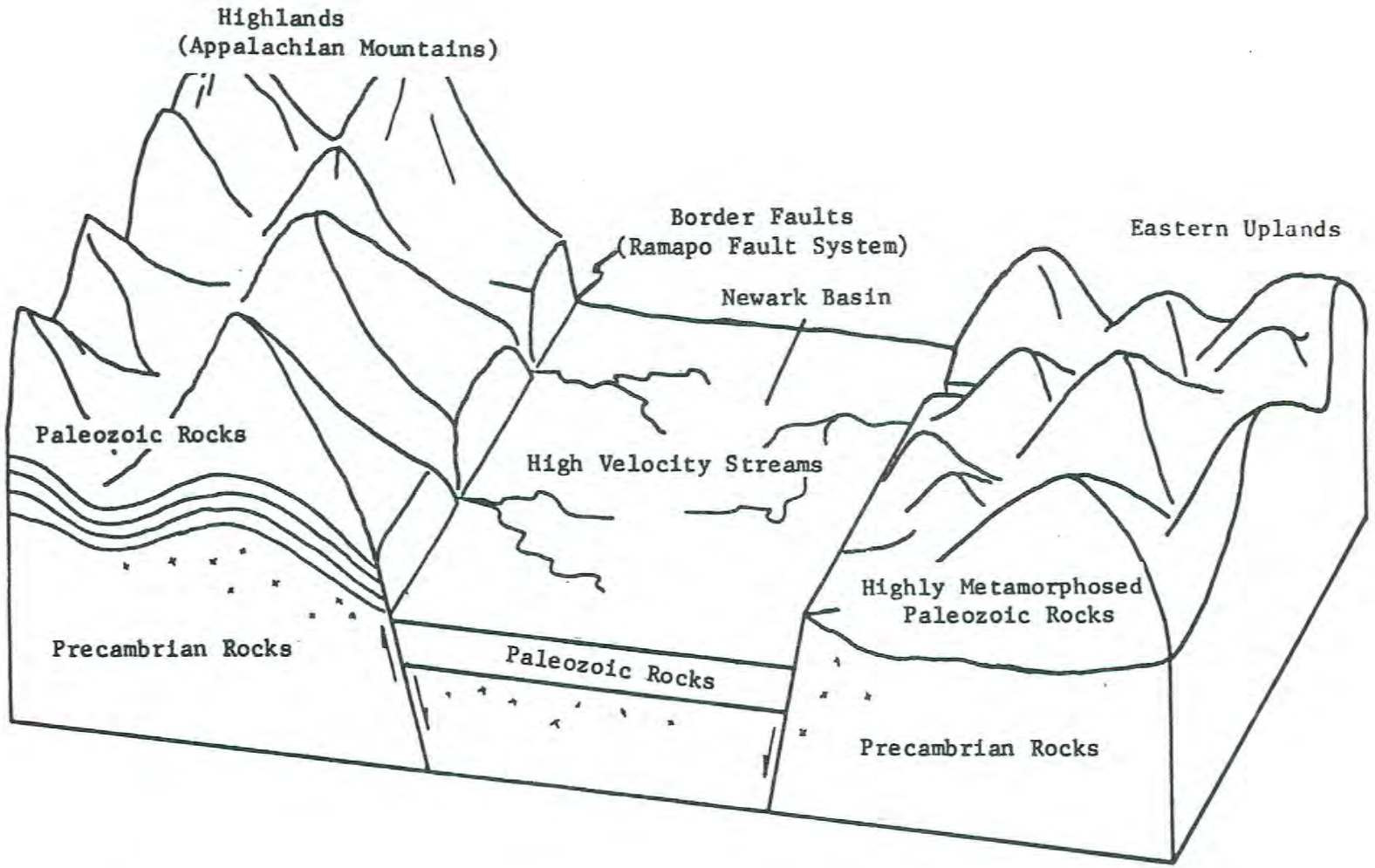

Figure II-3 Down-Faulting and Formation of the Newark Basin: Early Triassic.

Source: Passaic River Coalition, 1981.

is characterized by gently rolling plains 200 to 400 feet in elevation underlain by easily eroded rocks, and several ridges underlain by resistant rocks (Wolfe, 1977).

According to Van Houten (1969), deposition in Triassic Period began with the transport of arkosic materials (poorly sorted feldspar and quartz particles) from the Eastern Uplands forming the Stockton Formation (locally called brownstone) to a depth of 6,000 feet. Coarse materials eroded from the Highlands formed the Hammer Creek Formation, a conglomerate rock approximately 1,000 feet thick (Figure II-4). A number of outcrops of the Hammer Creek Formation occur near the western edge of the Newark Basin.

Later in the Triassic Period deposition of these formations ended. A shallow lake formed in the Newark Basin (Figure II-5). An alternating series of sediments with rock fragments derived from existing rocks, and then chemical deposits from dissolved materials in the lake water, formed a clay-like rock approximately 3,700 feet thick called the Lockatong Formation. Outcrops of this formation occur at the eastern and western ends of the basin (Van Houten, 1969).

From late Triassic to early Jurassic time,[2] the Brunswick Formation was deposited in the Newark Basin, to a depth of 6,000 feet in the central portion and 16,000 feet in the northeast. Figure II-6 shows the meandering streams that transported and deposited muddy sediments eroded from the Highlands. The Brunswick is composed mainly of soft red shales, interbedded with sandstone and some conglomerate. The red color of the shale is from iron oxide in the form of the mineral hematite (Wolfe, 1977).

Volcanic activity occurred in the Newark Basin during the early Jurassic Period. Fissures formed in the earth's surface resulting in a flow of basalt. Deposition of the Brunswick Formation continued in the periods between the lava flows. Three separate periods of volcanic activity occurred, each with numerous individual flows. Later faulting caused the flows and Brunswick Formation to be tilted to the northwest (Figure II-7). After an extended period of erosion the basalt flows were exposed forming the Watchung Mountains.

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[2] The Brunswick Formation was thought to be only of Triassic age until several studies had redated the upper 1,500 feet of the formation as well as the Watchung basalt flows and the Palisades sill to early Jurassic. (Cornet, Traverse and McDonald, 1973).

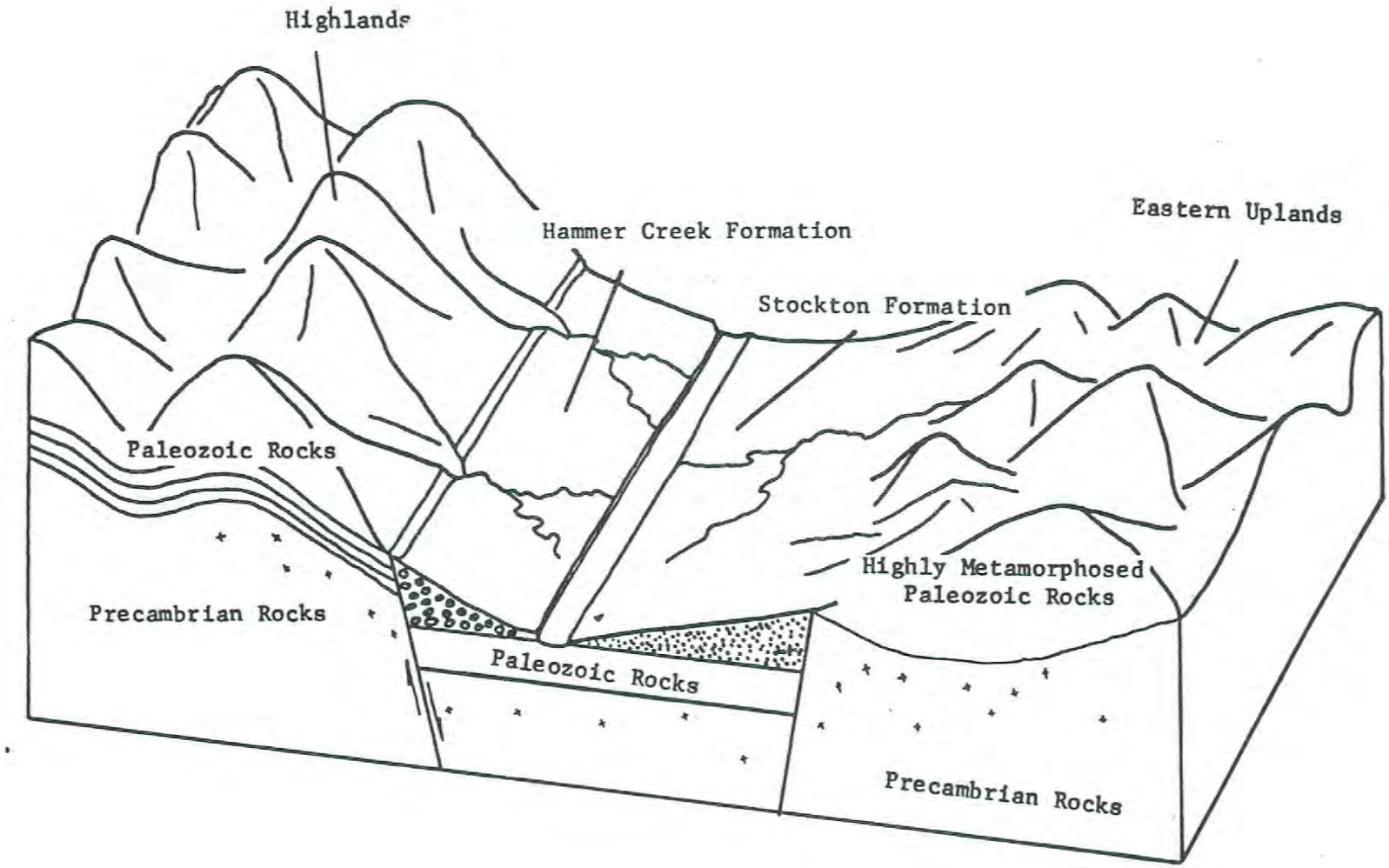


Figure II-4 Deposition of the Stockton and Hammer Creek Formations: Triassic

Source: Passaic River Coalition, 1981.

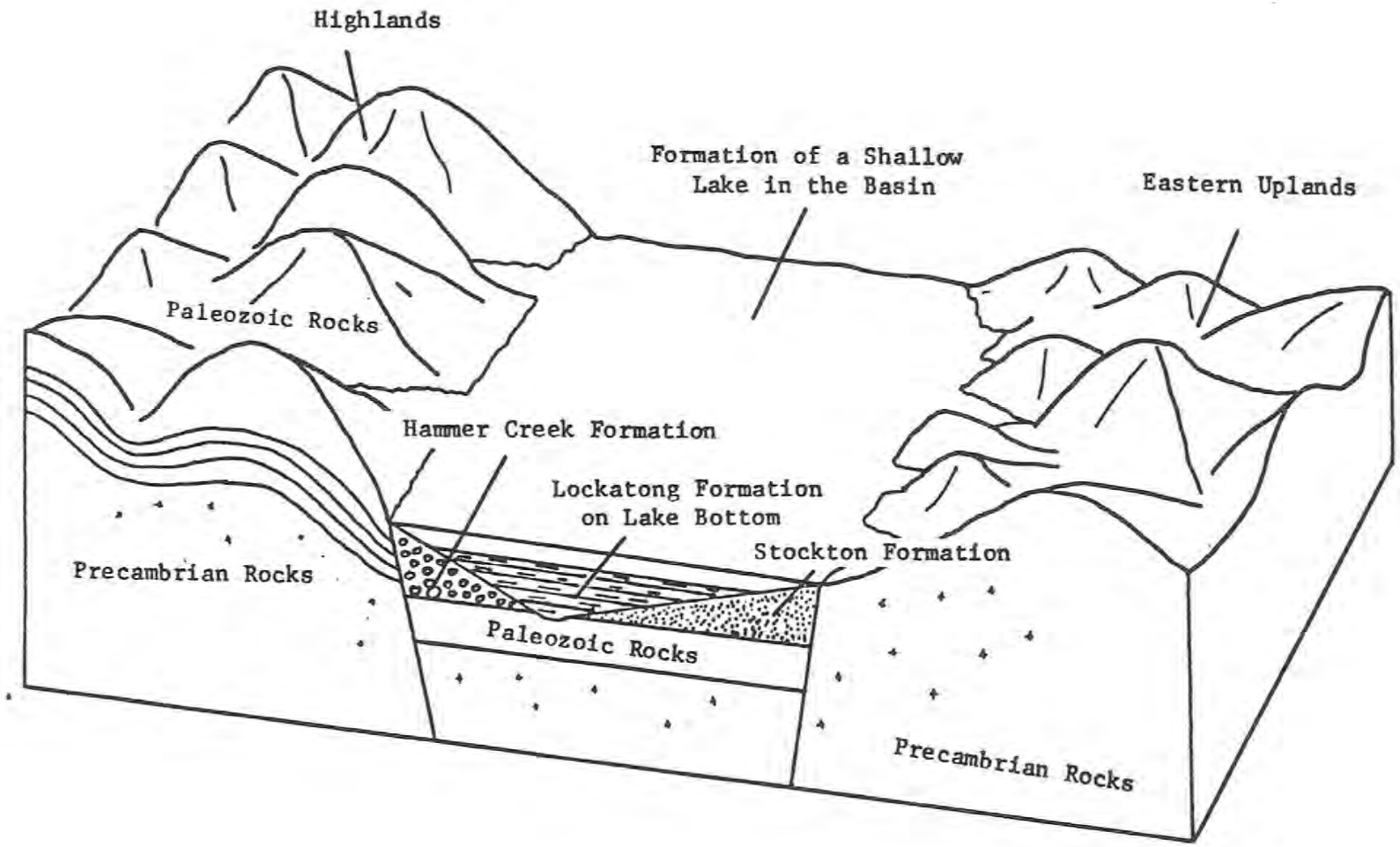


Figure II-5 Deposition of the Lockatong Formation: Triassic.

Source: Passaic River Coalition, 1981.

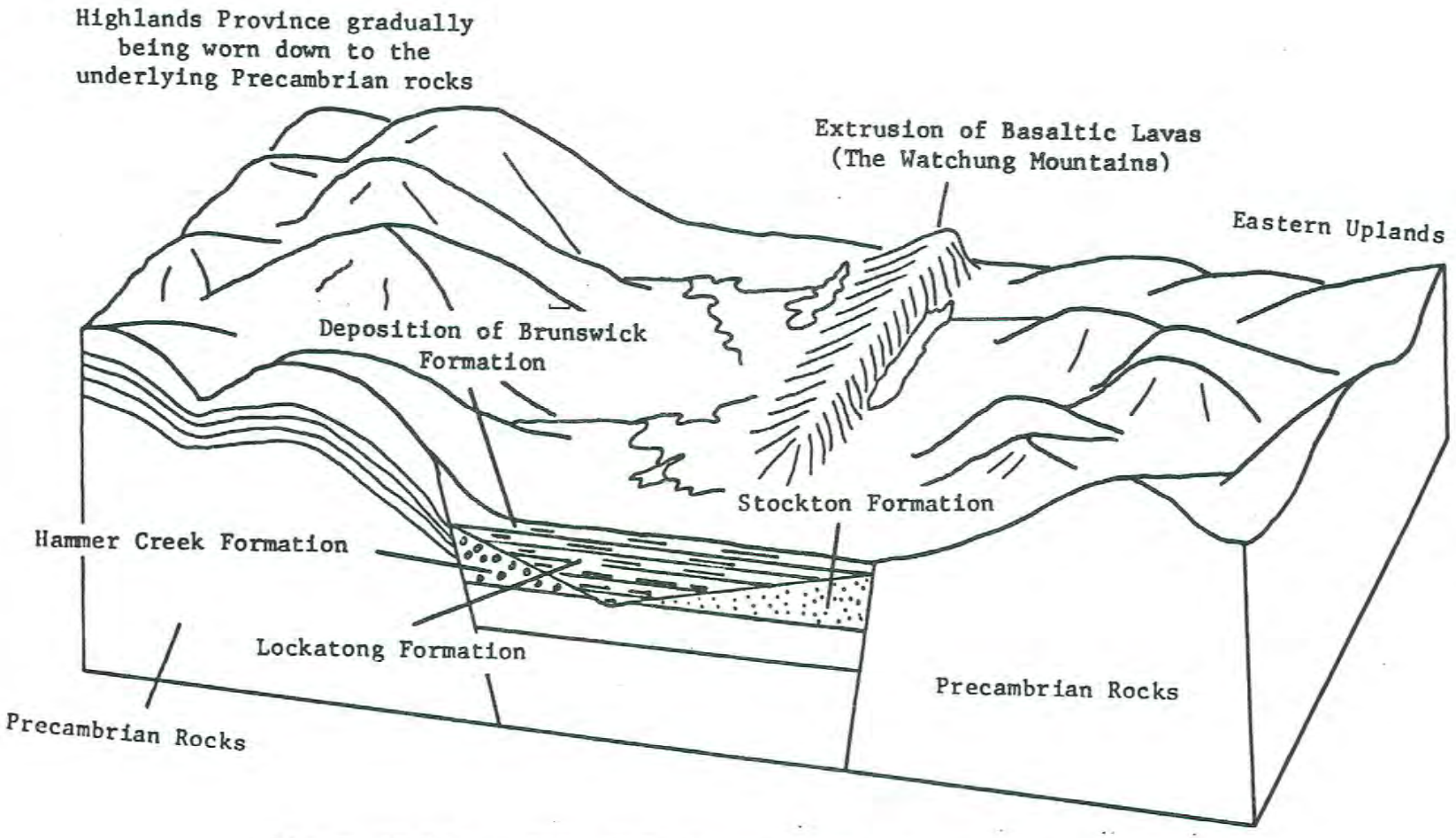


Figure II-6 Depositional Environment of the Brunswick Formation: Triassic-Jurassic.

Source: Passaic River Coalition, 1981.

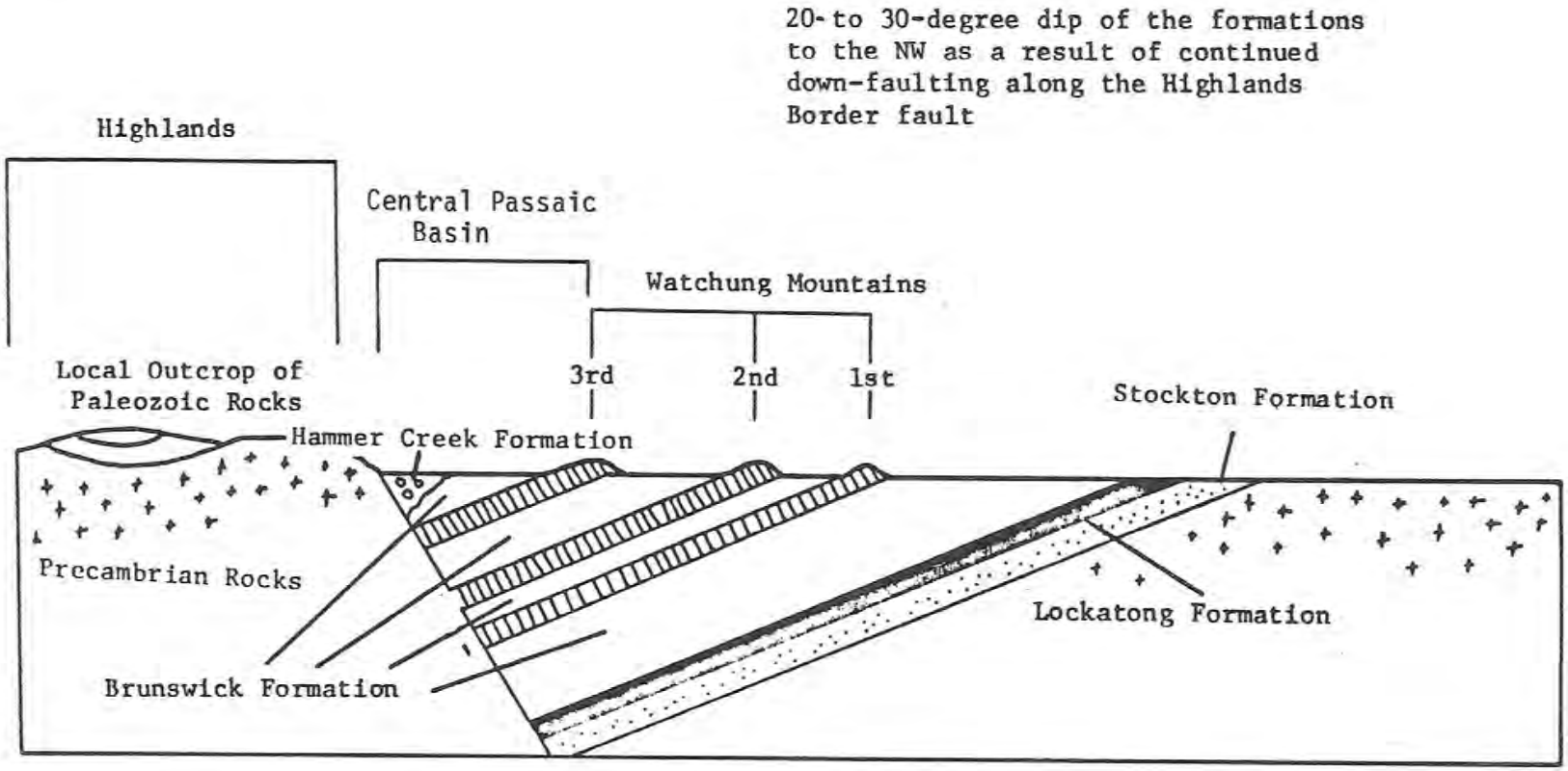


Figure II-7 Present-Day Cross-Section Through the Newark Basin.

Source: Passaic River Coalition, 1981.

The bedrock of the study area, therefore, is composed of Precambrian rocks occurring in the Highlands Province, the Hammer Creek Formation cropping out in a few places along the eastern edge of the Highlands, the Watchung Basalt forming three ridges called the Watchung Mountains, and the Brunswick Formation in the remainder of the area. The Stockton and Lockatong Formations are far below the earth's surface in this area and are of little significance to the region's ground water resources.

Glaciation

As important as the bedrock of the study area is to the region's ground water supplies, the results of glaciation in the Pleistocene Epoch (a division of the Quaternary Period, refer to Table II-1) are of greater significance. The latest Pleistocene glaciation began approximately 80,000 years ago. This ice advance, called the Wisconsin Glaciation, reached its maximum extent in New Jersey about 18,000 years ago and receded about 11,000 years ago (Wolfe, 1977). The maximum extent of this glaciation is marked by a terminal moraine, shown in Figure II-8, which extends from Perth Amboy through northern Middlesex County, the Union-Somerset County boundary, and across the center of Morris County, passing through the towns of Chatham, Madison and Morristown, and into the Rockaway River watershed.

The ice acted as a giant bulldozer pushing and carrying great quantities of soil and rock in, under, and on top of the ice. When melting along the front of the glacier halts its forward movement, these materials are deposited in a line at the face of the glacier in a **moraine**. Within a moraine, materials of all sizes are mixed together in deposits called **glacial till**. Moraines in the region consist both of the **terminal moraine** (a long ridge along the farthest advance of the glacier) and **ground moraines** (flat beds of glacial till deposited on the land surface). The melting water then carried some of the glacial materials and deposited the particles in a stratified manner. That is, the clays, silts, sands and gravels are separated in layers and over distance because of the capacity of moving water to carry fine materials farther than coarse ones. Many of the sand and gravel pits now mined for construction materials were created in this manner. In some areas, large amounts of stratified materials were deposited in preglacial channels and valleys. These sands and gravels constitute the buried valley aquifers on which much of the area depends for its water supply.

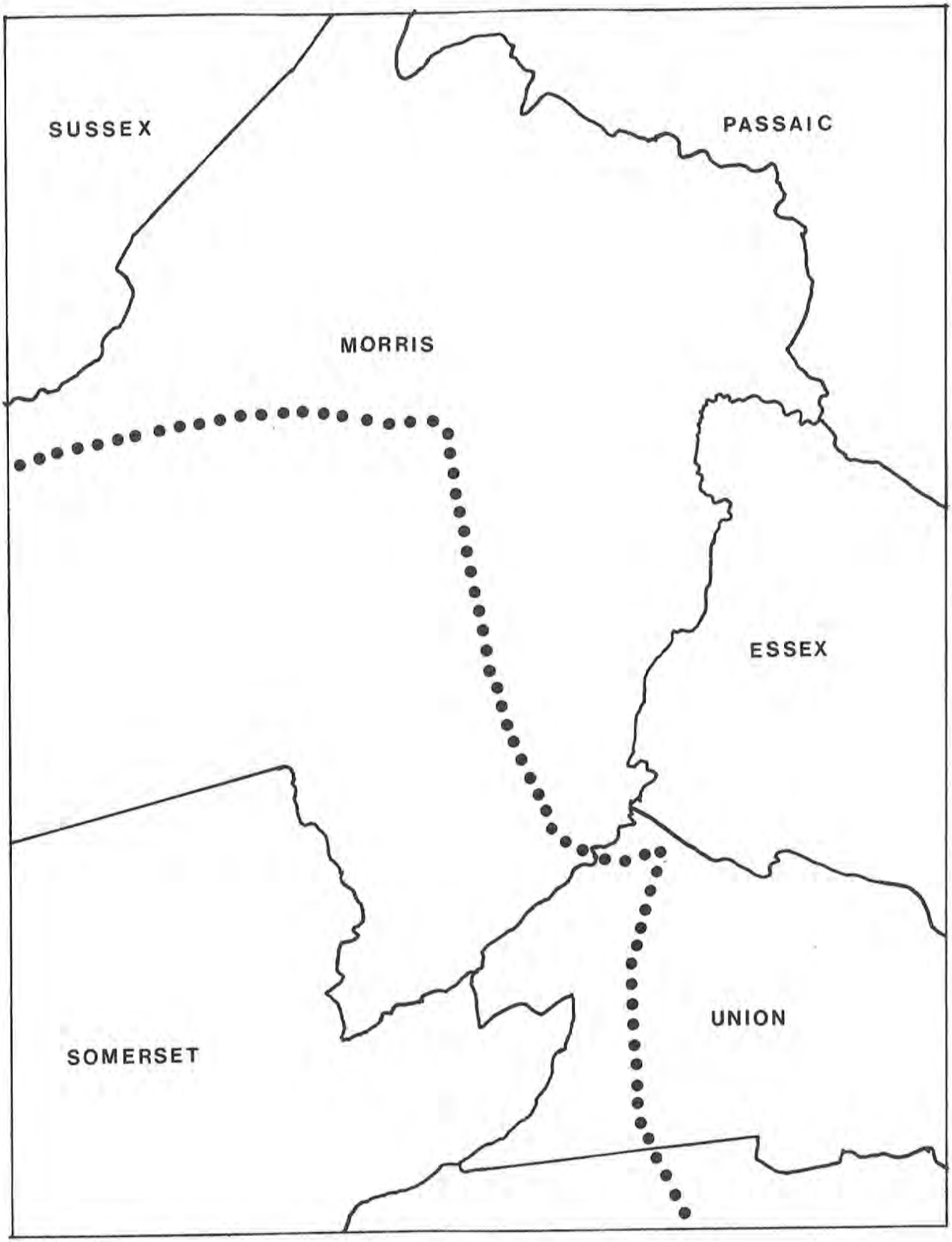


Figure II-8. Terminal Moraine of the Wisconsin Glaciation

Source: Wolfe, 1977.

Aquifers of the Study Area

Aquifers are geologic formations which have capability to store and transmit water which is recoverable in sufficient quantity to be economically usable (U.S. ACE-HEC, 1972). The capacity of an area's geologic formations to serve as aquifers is largely determined by two characteristics. First, the material must have space for water; that is, it must be **porous.** Second, water must be able to move freely through the material; that is, it must be **permeable.**

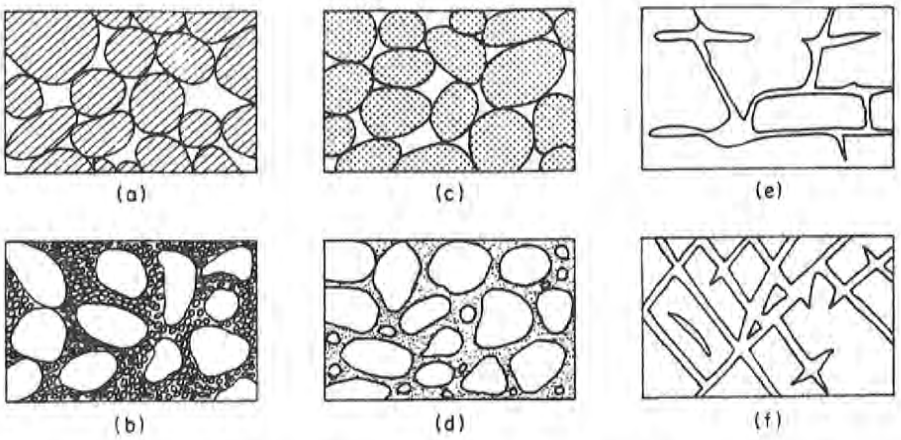
In consolidated rocks found in the study area - shale, sandstone, and basalt - both porosity and permeability are dependent on secondary fractures, joints, faults, and solution channels, because the rocks are basically not porous in their solid unbroken state. Sandstone usually is more productive as aquifers than other bedrocks because the cementing materials between the same grains may be absent in places or it may have been removed by solution.

Unconsolidated materials such as glacial deposits and alluvial deposits along streams usually make more productive aquifers than crystalline rocks. The best aquifers are composed of sands or gravels which have both high capacity for storing water and high permeability for transmitting it. Some sand and gravel deposits are not well sorted and have much of the space between the large grains filled with silt and clay. In such cases, their porosity and water-transmitting capacity are greatly reduced. Ways in which porosity may exist in rocks and sediments are illustrated in Figure II-9. Figure II-10 illustrates the basic aquifer types of the region.

An analysis of the water-bearing properties of the aquifers in the study area gives an indication of the amount of water a well will produce. A brief description of applicable characteristics of Precambrian rocks, carbonate rocks, Brunswick Formation, Watchung Basalt, and Pleistocene stratified deposits follows. A summary is shown in Table II-2.

Precambrian Rocks

The varied types of rock of Precambrian age serve as aquifers in the Highlands Province portion of Morris County, but none are located in Essex, Somerset or Union Counties. Nearly all ground water supplied from Precambrian rocks occurs in fractures, often close to the rock surface. Therefore, the amount of water available from these rocks depends on the size and number of the intersecting fractures. The yield



(a)- well-sorted aluvial material, high porosity;

(b)- poorly sorted alluvial material, low porosity;

(c)- well-sorted deposit of porous pebbles, very high porosity;

(d)- well-sorted deposit, porosity decreased by cementation;

(e)- rock rendered porous by solution;

(f)- rock rendered porous by fracturing.

Figure II-9 Types of Rock Interstices and Relation of Rock Texture to Porosity

Source: U.S. Army Corps of Engineers, Hydrologic Engineering Center, 1972 (from Meinzer, 1923).

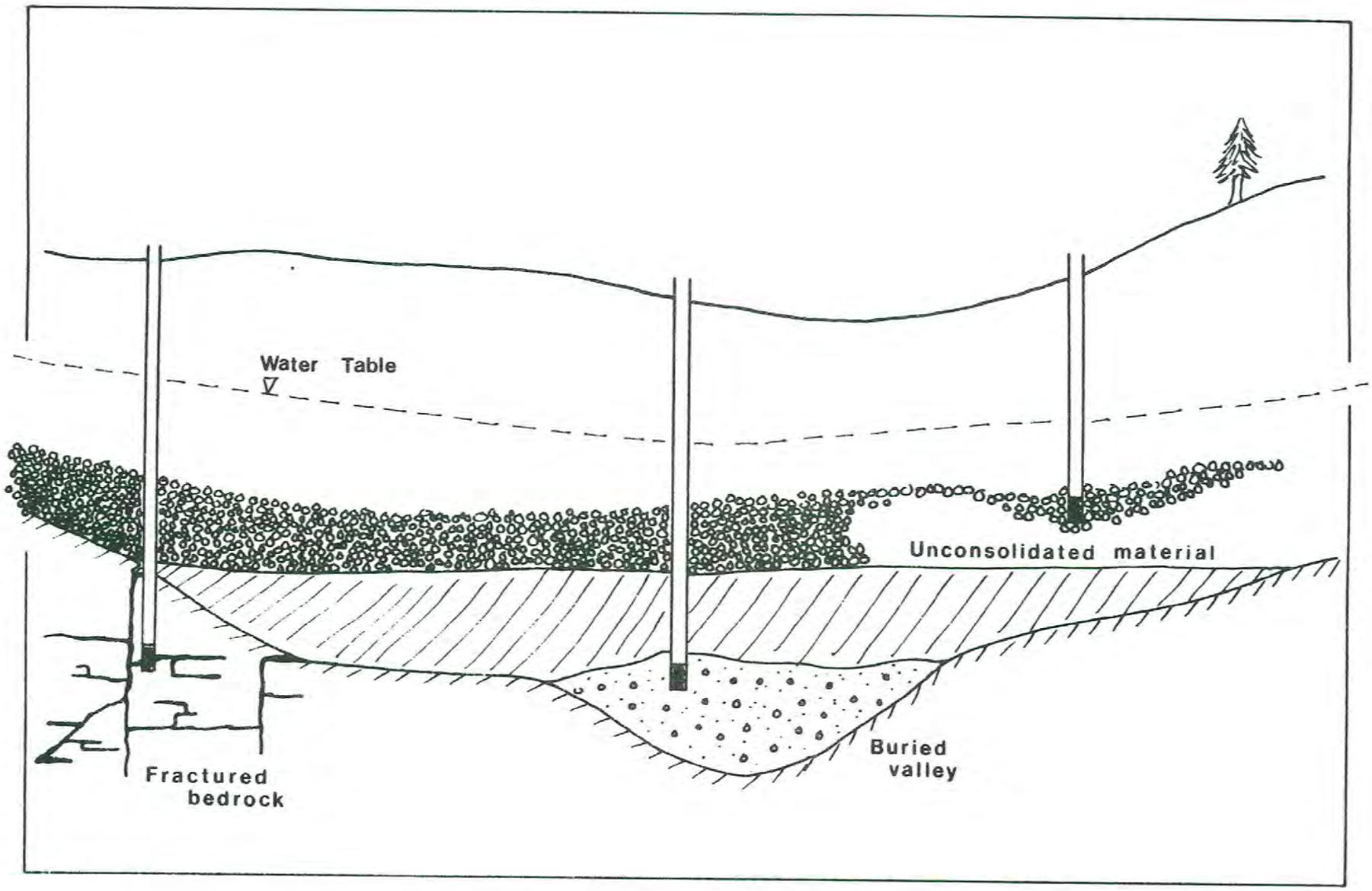


Figure II-10. Basic Types of Aquifers in Study Area

TABLE II-2

HYDROLOGIC DATA FOR AQUIFERS IN STUDY AREA

	Average	Range
Precamrian Rocks		
Yield of 79 large-diameter wells in Morris County	121 gpm	4 - 400 gpm
Coefficient of transmissivity of wells in Morris County	-	2,000 - 3,000 gpd/ft
Coefficient of storage a of wells in Morris County	-	0.001
Specific Capacity of 56 wells in Morris County	1.77 gpm/ft	0.06 - 15.1 gpm/ft
Watchung Basalt		
Yield of 5 wells in Morris County	-	30 - 53 gpm
Yield of 26 wells in Essex County	116 gpm	7 - 500 gpm
Specific capacity of wells in Morris County	1 gpm/ft	-
Specific capacity of wells	1.74 gpm/ft	0.05 - 5.66 gpm/ft
Brunswick Formation		
Yield of 37 large-diameter wells in Morris County	142 gpm	4 - 660 gpm
Yield of 35 large-diameter wells in Essex County	364 gpm	35 - 820 gpm
Coefficient of transmissivity of 7 wells in Morris County	-	7500 - 30,000 gpd/ft
Coefficient of storage of 7 wells in Morris County	0.00005	-
Specific capacity of 34 wells in Morris County	4.57 gpm/ft	0.03 - 33.33 gpm/ft
Specific capacity of 35 wells in Essex County	11.07 gpm/ft	0.21 - 70 gpm/ft

TABLE II-2 (Cont'd)

	Average	Range
Pleistocene Stratified Aquifers		
Yield of 127 large-diameter wells in Morris County	502 gpm	20 - 2,200 gpm
Yield of 27 large-diameter wells in Essex County	908 gpm	410 - 1,593 gpm
Coefficient of transmissivity of 13 wells in Morris County	135,000 gpd/ft	-
Coefficient of storage of 13 wells in Morris County	0.00039	-
Specific capacity of 110 wells in Morris County	30.86 gpm/ft	0.24 - 500 gpm/ft

[a] Storage coefficient is the quantity of water released or taken into storage in a column of aquifer with unit cross-section and length equal to the thickness of the aquifer per unit change in hydraulic level (US Army Corps of Engineers, Hydrologic Engineering Center, 1972).

Source: Gill and Vecchioli, 1965; Nichols, 1968a.

of such rocks can vary considerably within a short distance, both horizontally and vertically. Because fractures are wider toward the surface due to weathering, a well in Precambrian rock is unlikely to supply much water below 300 feet. The 79 large-diameter public supply, industrial, and commercial wells in Precambrian rock that operated in 1965 throughout Morris County yielded an approximate average of 121 gallons per minute (gpm), and the maximum and minimum yields were 400 and 5 gpm respectively. The larger amounts are usually associated with fault zones (Gill and Vecchioli, 1965).

Water quality from Precambrian wells is generally good. Hardness ranges from soft (less than 50 ppm) to moderately hard (60-120 ppm); pH ranges from slightly acidic to slightly alkaline; and iron occurs in objectionable quantities in some areas (Gill and Vecchioli, 1965).

Carbonate Rocks

The primary carbonate rock aquifer in the study area is that of the Kittatiny Formation. This is a long, deep, narrow bed of dolomitic limestone from the Paleozoic Era. Gill and Vecchioli (1965) reported that the five major wells developed in the dolomite at the time had yields ranging from 40 to 380 gpm. They suggested that the Kittatiny Formation had the potential for moderate to large ground water supplies. The Alamatong well field has Well 5 with a yield of 500 gpm and the potential for greater yields, in the Lightsville Dolomite. Markewicz (personal communication, 1986) reports that other dolomite wells have yields of up to 3000 gpm in the Pequest Valley (Warren County). He estimates, based on the sketchy data available to date, that 10 to 15 mgd may be available from the various dolomite deposits.

Newark Group: Brunswick Formation

The Brunswick Formation serves as an aquifer in the following communities of the Buried Valley Aquifer Systems: Chatham Borough, East Hanover Township, Florham Park Borough, Hanover Township, Harding Township, Lincoln Park Borough, Montville Township, Morris Township, Town of Morristown, Parsippany-Troy Hills Township, and Passaic Township in Morris County; Caldwell Borough, Fairfield Township, Livingston Township, Millburn Township, North Caldwell Borough, Roseland Borough, West Caldwell Borough, and West Orange Town in Essex County; Bernards Township, Bernardsville Borough and Warren Township in Somerset County;

and Berkeley Heights Township, New Providence Borough, Summit City in Union County (Gill and Vecchioli, 1965; Nichols, 1968a; Nemickas, 1976).

The approximately 6,000 feet-thick Brunswick Formation is composed of shale with local occurrences of sandy and pebbly consolidated beds. The sandstone ranges from a few inches to 20 feet in thickness. The many joints and fractures in the rock allow for retention and transport of a fairly large volume of ground water. Wells yield from 4 to 650 gpm in Morris County, from 35 to 820 gpm in Essex County, and from 12 to 870 gpm in Union County (Gill and Vecchioli, 1965; Nichols, 1968a; Nemikas, 1976). Wells of greatest yield are usually those between 200 and 500 feet deep where several source zones feed the well, and is usually hard.

Newark Group: Watchung Basalt

The Basalt Formation serves as an aquifer in the following communities within the study area: Florham Park Borough, Lincoln Park Borough, and Montville Township in Morris County; Essex Fells Township, Fairfield Township, Livingston Township, Millburn Township, North Caldwell Borough, West Caldwell Borough, and West Orange Town in Essex County; Warren Township in Somerset County; and Berkeley Heights Township, New Providence Borough, and Summit City in Union County (Gill and Vecchioli, 1965; Nichols, 1968a; Nemikas, 1976). The basaltic flows of the Watchung Mountains serve as a small source of ground water in the study area. Water is usually concentrated in gas-created vesicles and fractures in the rock. Wells yield volumes of 30 to 53 gpm from depths of less than 300 feet in Morris County (Gill and Vecchioli, 1965); from 7 to 400 gpm in Essex County (Nichols, 1968a); and from 20 to 164 gpm in Union County (Nemikas, 1976). Water from the Watchung rocks is usually hard, ranging from 60 to more than 180 gpm. Some wells also have high sulfate, iron and manganese levels (Gill and Vecchioli, 1965).

Pleistocene Deposits

The Pleistocene glacial deposits serve as aquifers in the following study area communities; Chatham Borough, Denville Township, Dover Town, East Hanover Township, Florham Park Borough, Hanover Township, Madison Borough, Montville Township, Morris Township, Morris Plains Borough, Mountain Lakes, Parsippany-Troy Hills Township, Rockaway Borough, Rockaway Township, Roxbury Township and Wharton Borough in Morris County; and Essex Fells Borough, Fairfield Borough, Livingston Township, Millburn Township, and West Orange Town in Essex County (NJDEP, 1985).

The stratified deposits produce the largest source of ground water in both Morris and Essex Counties (77 per cent and 81 per cent). Wells yield from 20 to 2,200 gpm and the water is of good quality. This ground water is pumped from the buried valley (valley-fill) aquifers. The valleys existed before the Pleistocene glaciation. In some areas, coarse-grained sands and gravels were washed into the valleys by melting water from the glaciers. Later some of these deposits were overlain by glacial till, by lake sediments or both. Therefore, the location of the buried valleys is difficult to ascertain by direct observation from the surface. Figure II-11 shows the assumed origin of the buried valleys.

The primary ground water resources for the Buried Valley Aquifer Systems are contained in the Brunswick Formation of eastern Morris and Western Essex Counties (shale and sandstone), the carbonate rocks of western Morris County (dolomitic limestone) and the Pleistocene deposits of the entire study area. By far the dominant producers are the buried valley aquifers for which the region is named. Chapter III presents a basic understanding of the field of hydrogeology which serves as a foundation for discussion of the buried valley aquifers in Chapter IV and of the utilization of all aquifers within the region in Chapter V.

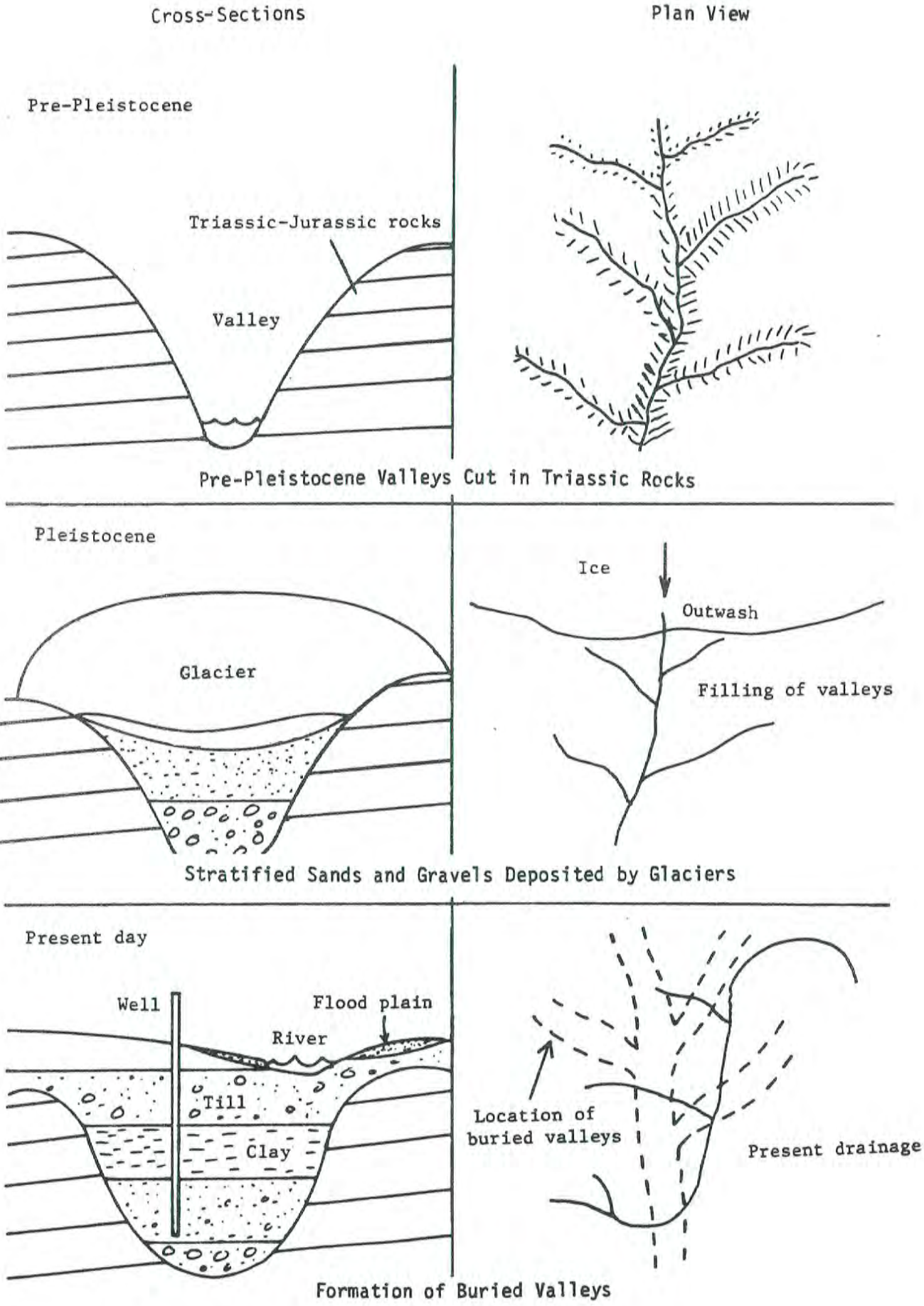


Figure II-11 Origin of the Buried Valley Aquifers
Source: Passaic River Coalition, 1981.

CHAPTER III

HYDROGEOLOGY

Hydrogeology is the study of the lithology, stratigraphy and other characteristics of geologic deposits and formations in an area as they relate to the presence, quantity, quality and movement of ground water. The science also includes a study of how ground water affects the geology of an area. Hydrogeology is a relative newcomer to the field of geology, only achieving any major body of knowledge in this century, although the first drilled well in this country was drilled in 1824 in New Brunswick, New Jersey. In many respects hydrogeology achieved standing in the United States due to the efforts of the United States Geological Survey (USGS) through its Ground Water Branch under Dr. Oscar Meinzler, the first director.

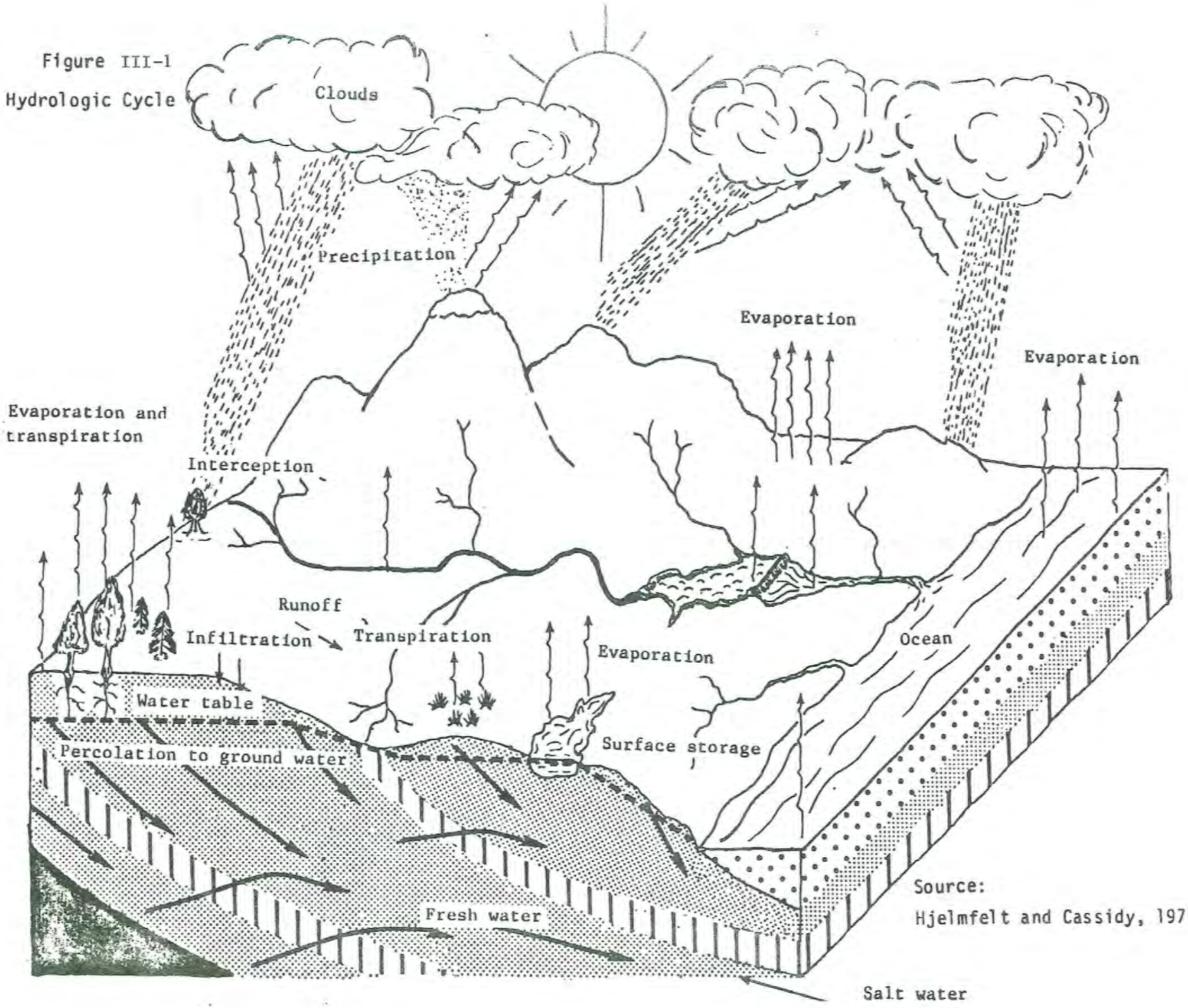
This chapter provides a brief overview of the terms and concepts of hydrogeology which are most applicable to the study of the buried valley aquifers as water resources. An understanding of the hydrologic cycle is basic to an awareness of the origin of ground water and its relation to other water resources. The flow of ground water and its interaction with the local geology also must be understood for effective utilization and management of ground water. Two useful texts on hydrogeology are Groundwater by Freeze and Cherry (1979) and Ground Water and Wells by the Johnson Division of UOP, Inc. (1975), from which much of the following information on hydrogeologic terms was derived.

The Hydrologic Cycle

Most of the water that exists on Earth moves from place to place and from form to form (i.e. ice, liquid water, water vapor) through the hydrologic cycle. A simplified version of this cycle is shown in Figure III-1. Though cycles have no beginning or end, this discussion begins with precipitation and ends with the outflow of ground water. In regions where ground water is used extensively, it is increasingly

Figure III-1

Hydrologic Cycle



Source:
Hjelmfelt and Cassidy, 1975

important to quantify each component of the hydrologic cycle for each area so that the quantity, quality and flow patterns of ground water may be determined. This knowledge is an important foundation for improved management of ground water.

Precipitation

As aquifers tend to be regional or local in scale, it becomes important to determine the total amount of water which falls upon the area as precipitation. Precipitation will be a major and sometimes the only source of water for an aquifer. The smaller the region considered, the more localized the precipitation data should be for accurate analysis. Precipitation is a basic datum for hydrology. Multiplied across the watershed area, one can determine the total volume of water entering the watershed in this manner. Precipitation is either defined as depth of precipitation (or the equivalent amount of water) over time, or as a volume of water per acre of land surface over time. Once precipitation falls to earth, it may experience a variety of fates, both short and long term. Figure III-2 shows a schematic diagram of the possible routes for rainfall during the precipitation event. More routes are available as time progresses.

Evapotranspiration

Large quantities of water are released to the atmosphere by evaporation from surface water, soils, rocks and other surfaces. Transpiration by plants and animals (especially plants) adds more moisture to the atmosphere. The two functions are often combined into **evapotranspiration.** Depending on the climate, soils type, vegetative cover, impermeable surfaces and other factors, evapotranspiration can reach 50 percent of the total annual precipitation for a region (Geonics, 1979).

Water lost through evapotranspiration cannot become ground water in the region, but supplies rainfall for other areas. Evapotranspiration is highest during warm periods, during the day and during the growing season of vegetation. These factors combine in the summer with the result that relatively little water reaches the aquifers during that time of year (Geraghty & Miller, 1978).

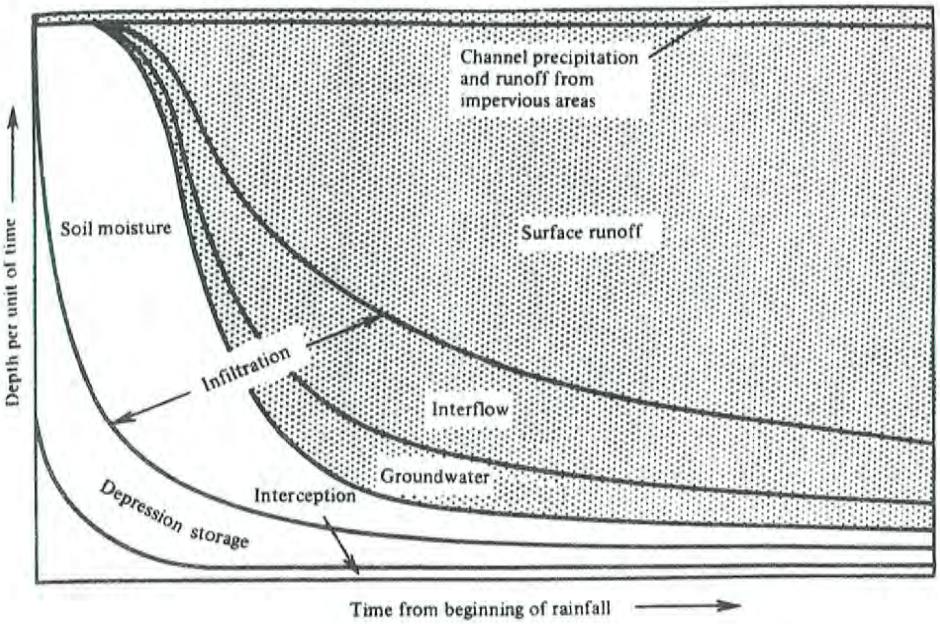


Figure III-2 Schematic Diagram of the Disposition of Storm Rainfall.

Source: Linsley, Kahler and Paulus, 1982.

Runoff

Some water from each precipitation event enters surface water bodies directly by falling on them, while more enters lakes and streams through runoff, either overland or subsurface. In general, overland runoff originates from land close to the water body. Runoff from a distance is more likely to penetrate the soil layers, becoming subsurface runoff, soil moisture or part of the water table.

Overland runoff increases with the intensity and duration of the rainfall, slope of the land surface, and impermeability of the soil. The longer that water is in contact with soil, the more likely it is to infiltrate rather than run off. The permeability of the soil varies according to the type and texture of the soil, its porosity, the moisture content prior to the precipitation, and whether the soil is frozen. Runoff is less in areas with vegetation, thick leaf litter and highly permeable soils. Runoff is greater, of course, where development has occurred and the ground is covered with impervious surfaces, unless methods are employed to artificially enhance water movement into the soil. Runoff is also greater in proportion to the slope of the land's surface.

Subsurface runoff occurs where water penetrates the surface layers of the soil but flows along that layer to lakes or streams instead of percolating downward. Subsurface runoff is slower than overland runoff, resulting in a significant delay between the rainfall and the subsurface runoff to the water bodies. As with overland runoff, subsurface runoff is less likely to reach surface waters the farther it must travel.

Infiltration

In many respects, infiltration is the obverse of runoff. Except for evapotranspiration, water that infiltrates does not run off and vice versa.

Infiltration is greatest in highly permeable, deep soils that have a low moisture content, low slope and are not frozen. Absolutely flat topography (0 percent slope) tends to develop "tight", or impermeable, soils so that a low slope is better for infiltration than highly sloped or flat ground. Infiltration decreases over the course of a rainfall, as pore spaces fill with water and clay particles (if present) expand.

Water that infiltrates the soil layer does not necessarily reach the water table. It may evaporate at a later time, be held to soil particles, or be taken by vegetation. When water is available in greater quantities than these uses and losses, it may percolate to lower soil, sediment and rock layers. However, permeable soils may overlay impermeable layers of soils or sediments. These impermeable layers may halt or divert the water, as shown in Figure III-3.

Percolation

At some depth below the surface, water will be below the reach of plant roots and evaporation from the soil. This water will continue to move downward, percolating through the soil, sediments and bedrock until it reaches the water table. The zone above the water table is unsaturated (the vadose zone). Water exists in the pore spaces but does not completely fill them. The **water table** is the top of the saturated zone, where all of the pore spaces are filled with water.

Once water has percolated to the water table, it is part of the ground water regime, where it flows until released (discharged) to streams, lakes, marshes, springs and seeps, or is pumped through wells.

Ground Water Flow Patterns

The most basic fact of ground water movement is that ground water flows from points of high pressure to points of lower pressure. In the case of a uniform, permeable aquifer (i.e., sand) under a flat land surface, the water will flow until it is flat. In reality, aquifers are variable and limited in size. They dip, bend and fold, and they come in contact with a variety of permeable and less permeable geologic structures. This diversity makes the study of ground water flow quite difficult, as the existing hydraulic pressures must be measured prior to a determination of flow patterns. The pressures are created by the weight of the atmosphere and the ground water column on the water below.

A simple corollary is that ground water tends to flow toward discharge points, such as streams, springs and wells. In the case of streams, lakes and springs, the water table intersects with the land surface (Figure III-3) and releases water to the surface. Wells either pump water up, thereby causing an area of low pressure that water will flow toward, or allow water that is under pressure to rise to the surface, creating a low pressure area.

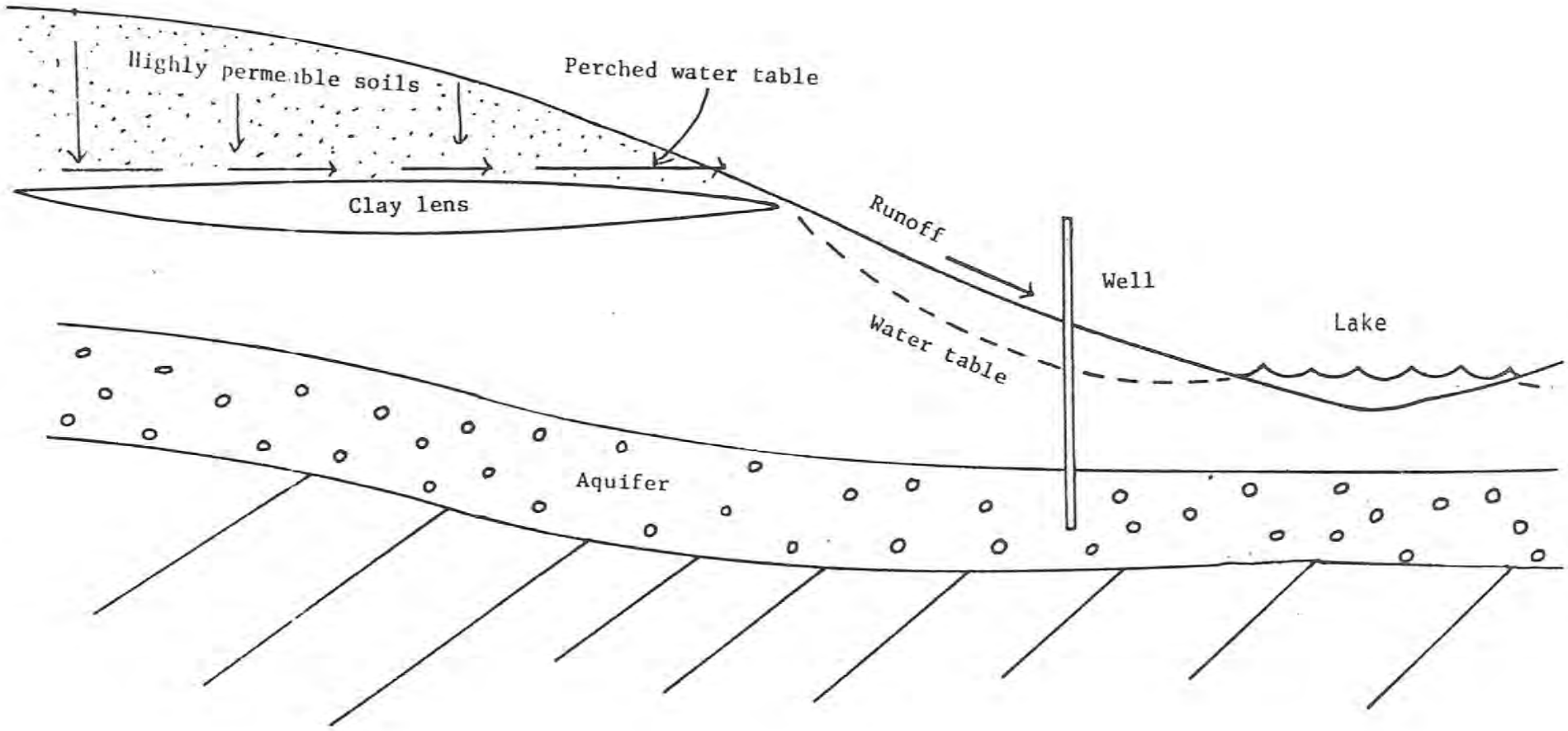


Figure III-3 Effects of an Impermeable Bed on Infiltration

Source: Passaic River Coalition, 1981.

Where the water table discharges into a stream, it provides a source of streamflow which does not rely on day-to-day rainfall. Ground water provides **base flow** for rivers in this fashion, releasing water over long periods without rain. Reservoirs and direct surface water users are highly dependent upon base flow to maintain safe yields during droughts.

Ground water is part of the hydrologic cycle. Water enters an aquifer (recharge), is stored, moves through the aquifer (interflow) and leaves it (discharge). Given a complete understanding of the water budget for a region and the characteristics of an aquifer, flow patterns can be predicted for resource management purposes.

Characteristics of Water Flow in Aquifers

An aquifer is a geologic formation containing sufficient quantities of water to be produced in an economic manner. Water-bearing formations that were at one time too costly to use are now usable, due to improved well-drilling or pumping techniques or higher water prices. To be usable, an aquifer must permit yields that match or exceed the intended use over a time period that allows an economic return. The return need not always be monetary or direct. Aquifers provide base flows for rivers, allowing downstream communities to use the rivers year-round for water supply, recreation and commerce. In addition, significant ecosystems depend on water discharges from aquifers. One can expand "economic use" to include these non-private uses, putting aquifers in the class of "public goods."

There are two basic kinds of aquifers--unconfined and confined. These terms are defined below. Water flows through them at a quantity and velocity defined by several factors, and water can be extracted from them at rates and quantities defined by the nature of the aquifers and the rate of recharge. While the following sections cannot possibly impart a full understanding of aquifer behavior, they should suffice for a nontechnical discussion of hydrogeology.

How Fast and How Far?

Ground water does flow from recharge points to discharge points (from high pressure to low pressure). Hydrogeologists speak of the water flowing from an **upgradient** area to a **downgradient** area. The flow is not fast, relative to the speed of surface waters. Surface water velocities

are measured in feet per second, while ground water is measured in feet per day. In unconsolidated deposits a flow of more than 5 feet per day is considered rapid, while flows sometimes are as little as a few hundredths of a foot per day. Ground water can move more rapidly in open channels such as fissures or limestone solution channels, but the total quantity of water may be very limited.

The distance that ground water flows is limited by the nature of the aquifer system. Because ground water flows in a downgradient direction, it eventually will discharge to a surface water source either directly or by pushing up to the surface. Springs are a clear example of a ground water discharge. Because of ground water's natural tendency to discharge and the limited extent of most geological formations, ground water rarely flows more than ten or twenty miles prior to discharge, at least in New Jersey. There are aquifers such as the Ogallala in the midwest which extend over several states, but New Jersey's geology is such that the aquifers have a limited extent. The aquifers of southern New Jersey are the largest in the State, in terms of quantity, area and distance from source to discharge. The aquifers of northern New Jersey are much less extensive in volume and length. The Buried Valley Aquifers, extending from the upper Rockaway Buried Valley in Jefferson Township to the lower Chatham Buried Valley in Millburn may be the longest connected system of aquifers in northern New Jersey, and certainly are the most prolific. However, notions that the aquifers of northern New Jersey derive recharge from the Hudson, Delaware or other far watersheds is not founded in fact. The source of water for the study region is local and regional.

Confined and Unconfined Aquifers

Unconfined, or water table, aquifers are those where the flow of the ground water is unimpeded by impermeable formations at the top of the aquifer. Water may penetrate relatively easily to unconfined aquifers, as may pollution. Unconfined aquifers can be thought of as bathtubs, where the surface of the water is the water table. In an unconfined aquifer, the water table roughly conforms to the contours of the land surface, and the hydraulic pressure at the water table is equal to atmospheric pressure (Figure III-4). As more water enters the aquifer, the water table rises. The reverse occurs as water discharges or is withdrawn. Where the land slopes downward more quickly than the water table and intersects the water table, ground water discharges into surface waters. Wells drilled into unconfined aquifers must pump the water to the surface. Flowing wells do not exist in unconfined aquifers.

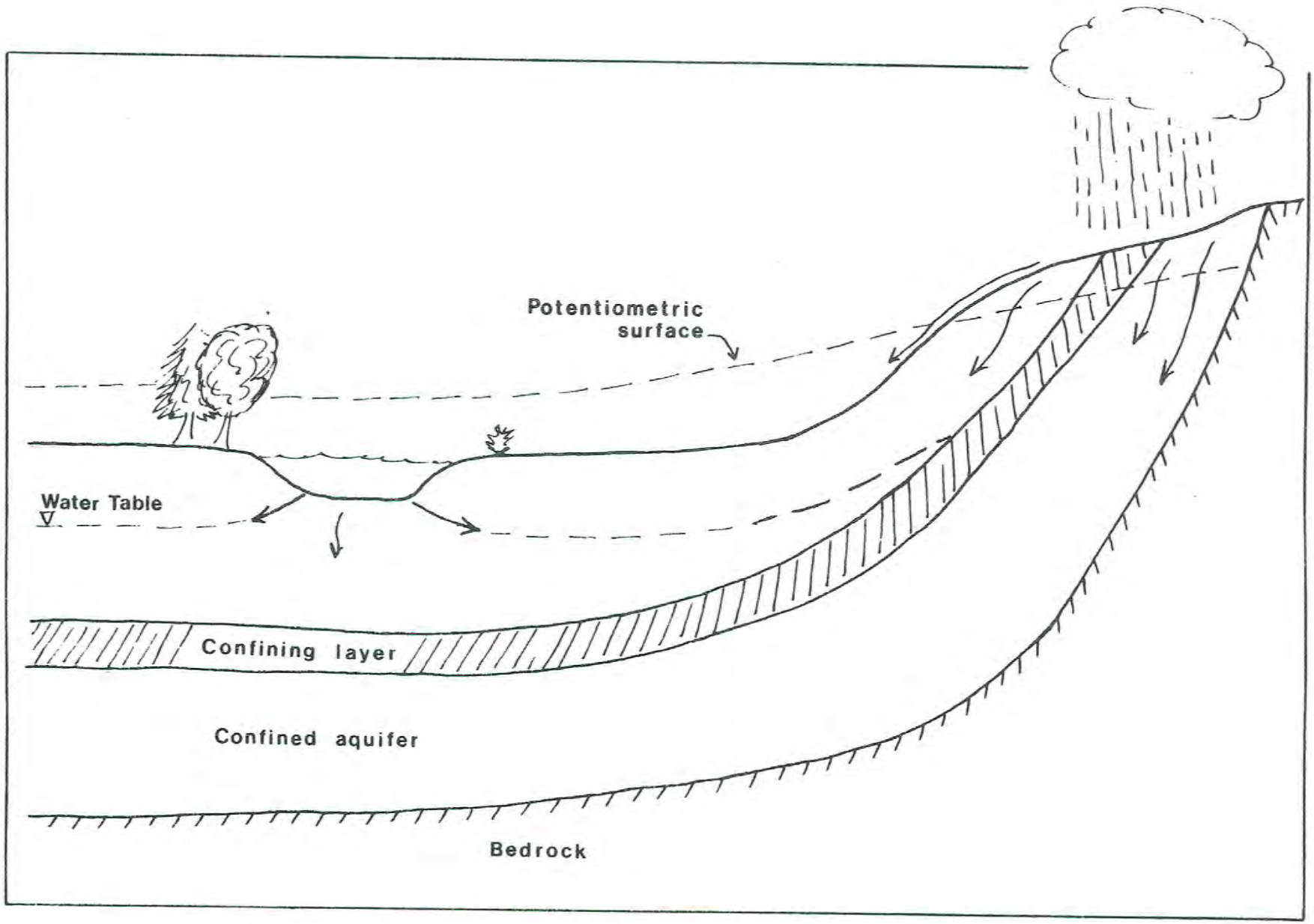


Figure III-4. Water Table and Piezometric (Potentiometric) Surface

A **confined aquifer** occurs where the water-bearing formation is capped by a formation which is relatively impermeable (aquitard) or totally impermeable (aquiclude). As more water enters the aquifer, pressure builds up so that the top of the aquifer has a pressure higher than atmospheric pressure. This type of aquifer is also called "artesian", and wells that penetrate it are artesian wells. In such wells, the level of the water rises above the top of the aquifer, to a level determined by the water pressure in the aquifer. In Figure III-5, the **piezometric surface** (or potentiometric surface) indicates the water pressure of the confined aquifer. Water levels in wells will rise almost to the piezometric surface (some loss of height occurs, determined by the relative efficiency of the well construction).

Where the piezometric surface intersects with the land surface, artesian wells will flow without pumping, as the hydraulic pressure of the confined aquifer pushes the water above the surface of the land. If the confining layer is somewhat permeable, water will push up to the surface in these places, providing seepage into swamps and marshes. Wetlands in New Jersey are most often discharge points for water table and confined aquifers, rather than recharge areas. Recharge can occur from wetlands which lie over relatively impermeable soils (such as clays) which leak water slowly to unconfined aquifers below.

Important differences exist between confined and unconfined aquifers. First, an unconfined aquifer is recharged directly from the surface and is more susceptible to pollution than confined aquifers which are recharged through surrounding aquifers, a recharge area, and confining layers which are not totally impermeable. Second, water taken from an unconfined aquifer causes a natural dewatering of the formation, through a lowering of the water table in what is known as a "cone of depression" around the well. Withdrawals from a confined aquifer do not dewater the formation, usually, but rather reduce the hydraulic pressure near the well (and therefore the piezometric surface as well). This second difference can be important, as dewatering a formation can cause it to compact and allow less water to enter it than was withdrawn. Some areas in the western United States have subsided 10 to 30 feet due to ground water withdrawal for irrigation. Extreme withdrawal of ground water from aquifers near the ocean or saline aquifers may induce flow of salt water into fresh water aquifers, a process called salt water intrusion which may render the aquifers nonpotable. Although this effect has occurred along the New Jersey shore, salt water intrusion is not a concern in the Buried Valley Aquifer Systems.

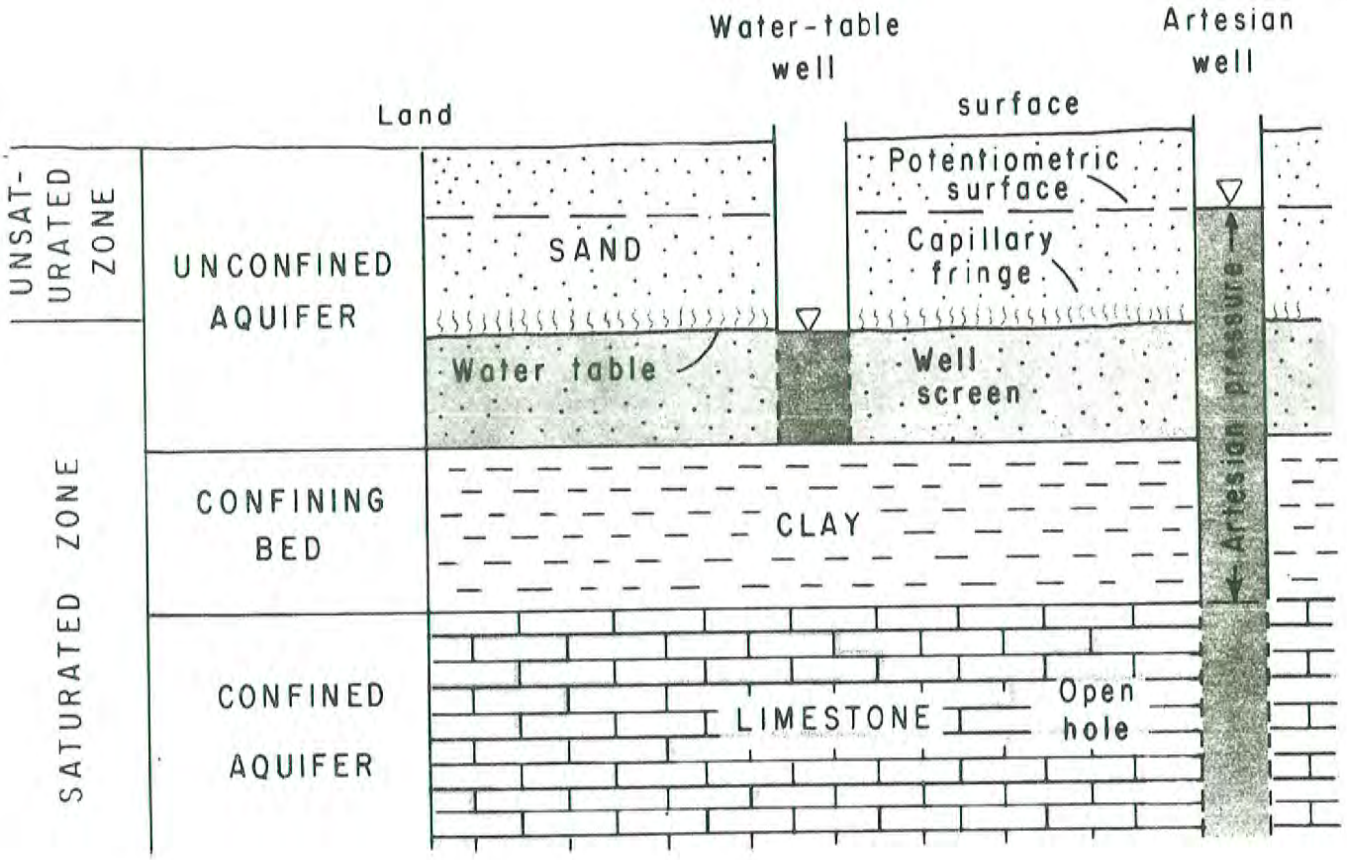


Figure III-5. Well Effects in Confined and Unconfined Aquifers

Source: Heath, 1983

Porosity and Permeability

Two major characteristics of an aquifer control the amount of water that can be stored and can flow through. The first is **porosity**, defined as the percent volume of open spaces with respect to the total formation volume. Greater porosities allow formations to store more water. Figure II-9 (page 17) demonstrates how the rock type and texture and the sorting of sediments effect porosity. Generally, porosity increases as texture roughens and size increases, as long as the fragments or sediments are well sorted. For bedrock formations, porosity depends in part on the nature of the rock and in part on the degree of fracturing (See Table III-1 for common values of porosity).

While porosity determines the amount of water that can be stored, a formation's utility for water supply depends also on the **permeability** of the formation. Permeability indicates the extent to which the pore spaces in a formation are interconnected to allow the free flow of water. It is measured as the quantity of water that will pass through a cross-section of the formation at a certain hydraulic gradient.[1] In units used in the United States, permeability is measured in gallons per day per square foot (gpd/ft^2). The higher the permeability of a formation, the more quickly water can move through it at a given hydraulic gradient. The gradient can be thought of as the slope of the water table or piezometric surface for the aquifer.

Hydrogeologists speak of two types of permeability, primary and secondary. Primary permeability is a function of the formation as it is originally deposited. Shales, limestone, many sandstones and most volcanic and metamorphic rocks in the Passaic River Basin have a very low primary permeability. In their initial condition, these rocks have few cracks or interconnected pore spaces. Stratified drift (sand and gravel well sorted by water action) has good primary permeability.

Secondary permeability is caused by the folding, faulting, weathering, compaction, dissolution or de-cementing of the original formation. The movement of bedrock from geologic faulting or folding causes cracks and

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[1] Hydraulic gradient is the loss of "head" (water table elevation or hydraulic pressure in a piezometric surface) per foot that the water travels. Water movement through a geologic formation is slowed by the friction of the water against the formation. Velocity of the water increases in proportion to the hydraulic gradient, which is why water moves toward a well, where the gradient is increased by pumping (Johnson Division, 1975).

TABLE III-1

RANGE OF VALUES OF POROSITY

Formation	N (percent)
Unconsolidate deposits	
Gravel	25-40
Sand	25-50
Silt	35-50
Clay	40-70
Rocks	
Fractured basalt	5-50
Karst limestone	5-50
Sandstone	5-30
Limestone, dolomite	0-20
Shale	0-10
Fractured crystalline rock	0-10
Dense crystalline rock	0-5

Source: Freeze and Cherry, 1979.

crevices to open, allowing the flow of water. Limestone and shales crack along bedding planes, opening channels for water flow. Weathering of upper bedrock layers causes hard bedrock to soften and chip (brecciate), which increases both porosity and permeability. When this weathered bedrock is covered by later deposits, the weathered layer allows a good flow of water. Cracks in limestone can be enlarged by water flowing through them and dissolving minerals from the walls of the cracks, forming solution channels. The cementing material in sandstone can be removed at times by the flow of water. Even clays and unstratified till can be fractured or crack along bedding planes, increasing permeability by a factor of two to three (Freeze and Cherry, 1979). Thus, secondary permeability is often more important in aquifer productivity than primary permeability, except for stratified sand and gravel deposits. However, permeable deposits may also be clogged over time through cementing or the introduction of fine materials (especially clays and silts).

Transmissivity

Permeability is a limited concept because it only describes how good an aquifer might be in a particular formation. Permeability refers to the flow of water through a unit cross-section of the aquifer (gpd/ft^2). The true measure of an aquifer, though, is defined by the storage capacity of the aquifer and its ability to transmit that water through a column that runs the entire depth of the saturated aquifer.

Transmissivity is a measure of the quantity of water that can flow horizontally through a column of a confined aquifer that is one foot wide and extends the full vertical saturated thickness of the aquifer. This factor basically equates to the permeability multiplied by the aquifer thickness. Values of more than 100,000 gpd/ft indicate good aquifers for large-diameter, large-yield wells (Freeze and Cherry, 1979). Table II-2 (page 19) provides average transmissivity values for aquifers in the study area. Specific transmissivity values for the buried valley aquifers are discussed in Chapter IV.

The definition given for transmissivity is the one usually encountered, but it actually defines horizontal transmissivity, the flow of water through an aquifer on a horizontal plane. Horizontal transmissivity often differs considerably from vertical transmissivity, the flow of water vertically through an aquifer, especially in sedimentary deposits and rocks. Sedimentary rocks tend to fracture and crack along bedding planes, which are weak lines in the formation due to variations in the

sediments which were deposited. As sediments usually accumulate in flat layers, the bedding planes are horizontal and allow better flow in a horizontal direction than vertically.

Likewise, stratified sediments which are still unconsolidated are layered. In a vertical direction, a sequence of sand, clay, sand, gravel, clay and sand might be encountered. While horizontal flow through the sand and gravel layers is relatively free, vertical flow would be impeded by the clay layers.

For these reasons, wells are developed to take advantage of horizontal flow, and horizontal transmissivity is the proper value to determine the ability of the aquifer to handle large-yield wells. However, vertical transmissivity plays a very important role in the recharge and natural discharge of the aquifers.

Specific Yield and Storage Coefficients

The second major factor, along with transmissivity, that determines the utility of an aquifer for major production wells is the amount of water that an aquifer will release when the water table or piezometric surface is lowered by one foot. For a water-table aquifer, this measure is called **specific yield**, while for an artesian aquifer it is called the **coefficient of storage**.

When the water table is lowered by one foot, it means that a volume of rock one foot thick and the area of the aquifer has been dewatered (except water adsorbed to the formation or held through capillary action). An artesian aquifer, however, is not dewatered. The water released from an artesian aquifer is due to the expansion of the remaining water as pressure is reduced, and compression of the aquifer formation for the same reason. Obviously, the specific yield for an unconfined aquifer will be much greater than the storage coefficient for a confined aquifer (both values have no units). The former has ranges of 0.01 to 0.35, while the latter ranges from 10^{-5} to 10^{-3} (Johnson Division, 1975). A substantial change in the piezometric surface (hydraulic pressure or head) is required over extensive areas to produce substantial water yields from confined aquifers. For this reason, large wells in confined aquifers will affect other wells over a greater distance, generally, than would be true in an unconfined aquifer. With values for transmissivity and storage and the overall size of the aquifer, estimates can be made of the capacity of the aquifer for withdrawal, given an understanding of the water budget for the aquifer.

Well Characteristics

Well Construction

The NJ Department of Environmental Protection regulates all drilling of wells for potable and nonpotable water diversions, along with all observation and monitor wells. Two basic construction standards exist. One is for wells that penetrate into and draw from bedrock, while the other is for wells in unconsolidated materials such as sand and gravel. The general construction of a well in unconsolidated materials is shown in Figure III-6. A casing is provided around the upper portion of the well to protect the pump column and to seal the well from the surrounding ground water. Wells are designed to draw water only from the intended aquifer; a confined aquifer in the case of Figure III-6. Once the well has penetrated into a confining layer, a riser pipe leads to the screen set in the best-yielding portion of the aquifer. Large wells will tend to screen the entire depth of the best-yielding strata, while small wells will use enough screen to provide the desired pumping rate. The screen is essentially a sieve to keep aquifer sediments from clogging the well.

A well into bedrock will have essentially the same structure except that the riser pipe is dispensed with once the well is into solid (competent) rock. The well is drilled as an open hole into rock below that point. Along with reducing drilling costs, this method allows for the capture of small water flows from the myriad cracks and fissures in bedrock.

The NJDEP-Division of Water Resources, Bureau of Water Allocation is charged with regulating well drilling and the licensing of well drillers. Each well drilled must have a permit and follow the detailed specifications provided by the Bureau.

Pumping Rates

Pumping rates for private, residential wells are often in the range of 2 to 20 gallons per minute. The lower the pumping rate, the greater the storage of water must be to provide sufficiently for the residence (a single running shower may use 6 to 12 gallons per minute). While most formations are capable of providing sufficient pumping rates (yields), some bedrock aquifers may be very limited. Many private wells in bedrock aquifers are drilled to great depth (as much as several hundred feet) to encounter enough ground water for a single home.

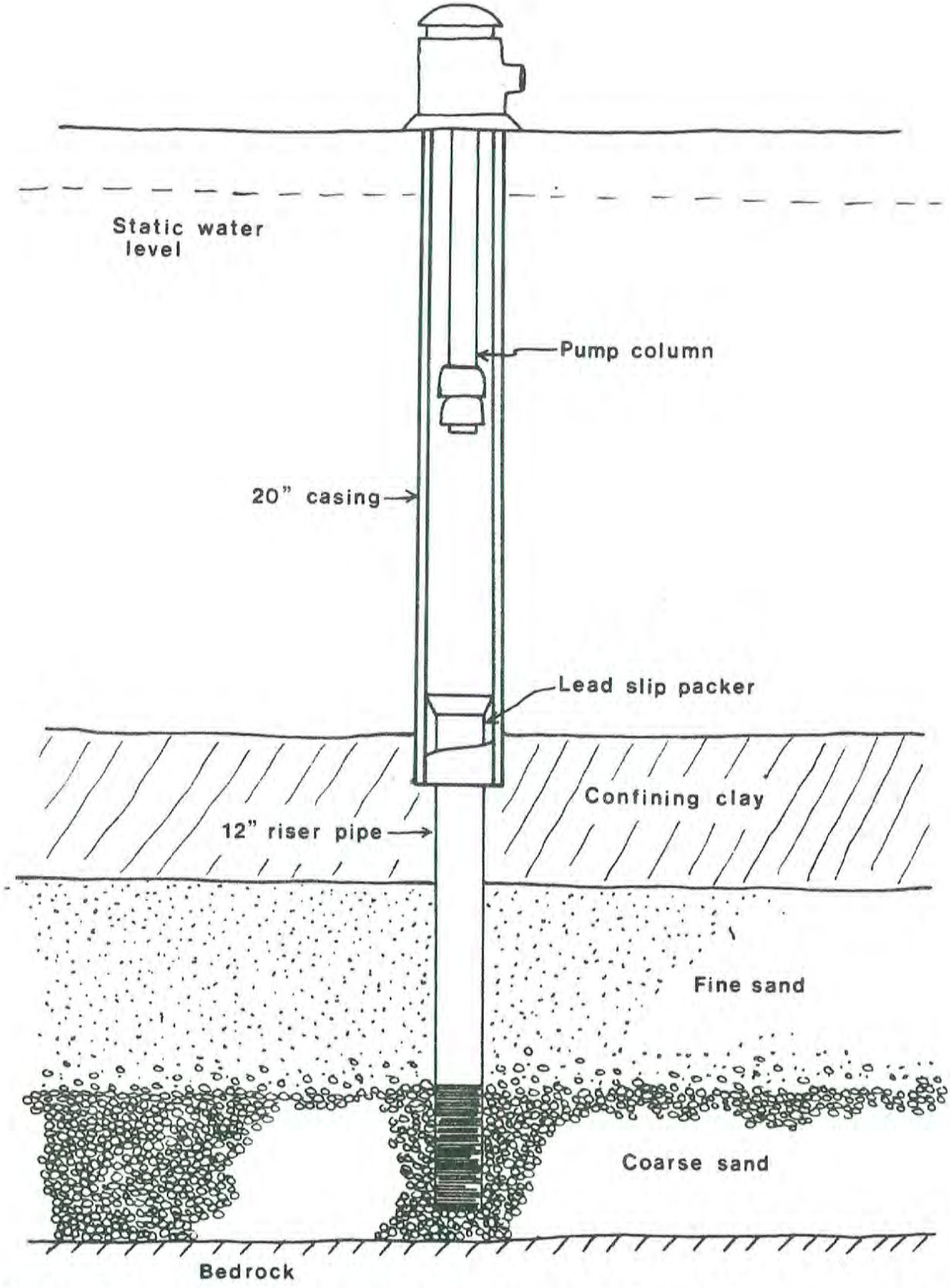


Figure III-6. Well Construction in Unconsolidated Deposits

Major wells, such as for large industries or public water supplies, may have pumping rates from as low as 75 gallons per minute to as high as 1500 gallons per minute or more. These wells are naturally larger in diameter and tend to use only the most prolific aquifers. In the Buried Valley Aquifer Systems region, the larger wells tend to be drilled either in Brunswick shale or glacial deposits though several new wells in the Rockaway Valley region draw from dolomite formations.

The NJDEP-Bureau of Water Allocation also determines the pumping rates for each major well drilled or existing in the State. More detailed information is presented in Chapter V. In brief, the Bureau attempts to determine the effect of each new well on existing wells in the area, so that interference between the wells is minimized. (Interference between wells results in a loss of supply to each well, as they are competing for the same water from the aquifer. The aquifer is drawn down more than usual in the area between the two wells.) The level of water in a well when it is has been pumping enough to stabilize is termed the **pumping level**, and interference between wells can actually reduce the pumping level for a well below its pump, effectively ruining the utility of the well. The Bureau is also responsible for determining whether the total pumping from all wells in an aquifer can be sustained over the long term by that aquifer.

Static Level

Static level is simply the level of the water within a well during a rest period, when the pump has been shut off long enough to allow the water level to stabilize. Static level roughly approximates the level of the water table or piezometric surface in an aquifer. Measurements of static levels in a well over many years can provide some insight as to the trend for the aquifer level. Observation wells are often used as dedicated points for measuring static levels in aquifers. When enough observation points are used, static level trends are invaluable for determining whether ground water diversions are affecting the aquifer's ability to maintain sufficient yields over the long term.

Specific Capacity

Specific capacity, unlike the preceding terms, is a measure of the relative capacity of a well to draw a certain yield from an aquifer itself. Specific capacity is defined as the yield (in gallons per minute) per foot of drawdown. Drawdown is the difference between the

water level in the well before pumping starts (static water level) and the water level in the well during pumping at a stable yield, once the water level has stabilized (pumping level). Figure III-7 indicates the basic parameters used to determine specific capacity. A high specific capacity indicates a good well for higher yields.

Specific capacity is related to transmissivity, as a high specific capacity relies on an aquifer with a high transmissivity. However, the specific capacity of a well also is affected by the efficiency of the well (losses due to friction against the well screen, excess drilling mud, etc.), how deeply the well probes the aquifer (maximum specific capacity when the well is open to the entire saturated depth of the aquifer), the age of the well (resulting in encrustations from minerals in ground water, pump wear, decreases in the water table or piezometric surface over the aquifer, and the growth of iron-dependent bacteria - not a health hazard - on the steel well screen), and interference from new wells or increased well pumping in the area. Specific capacity, therefore, is a good measure of how a well fits an owner's needs, but not of the aquifer itself (Hoffman, personal communication, 1982).

Cone of Influence

Each well will affect the water table or piezometric surface in a different manner. The variables include the pumping rate, the specific capacity of the well, the permeability and transmissivity of the aquifer and the presence of other pumping wells in the area. A pumping well draws water from the immediate area, creating a void or low pressure area. This area is called the **cone of influence** or the cone of depression. The distance from the well to the edge of the affected area is termed the **radius of influence**. In the Buried Valley Aquifer Systems, radii of influence for major wells range from scores of feet to thousands of feet, generally more in confined aquifers and less in unconfined aquifers.

The cone of influence is actually a dewatered area in a water table aquifer (Figure III-8). In an artesian aquifer, the cone of influence is an area of reduced pressure in the aquifer itself. Whichever the case, the gradient from the "surface" of the aquifer to the pumping level of the well is increased greatly. Water increases in velocity as the gradient increases, so the pumping of a well causes ground water in the area to rush toward the well. Continued pumping eventually will lead to a stabilized cone of influence which can be measured by observation wells around the pumping well (Figure III-9). When the well is

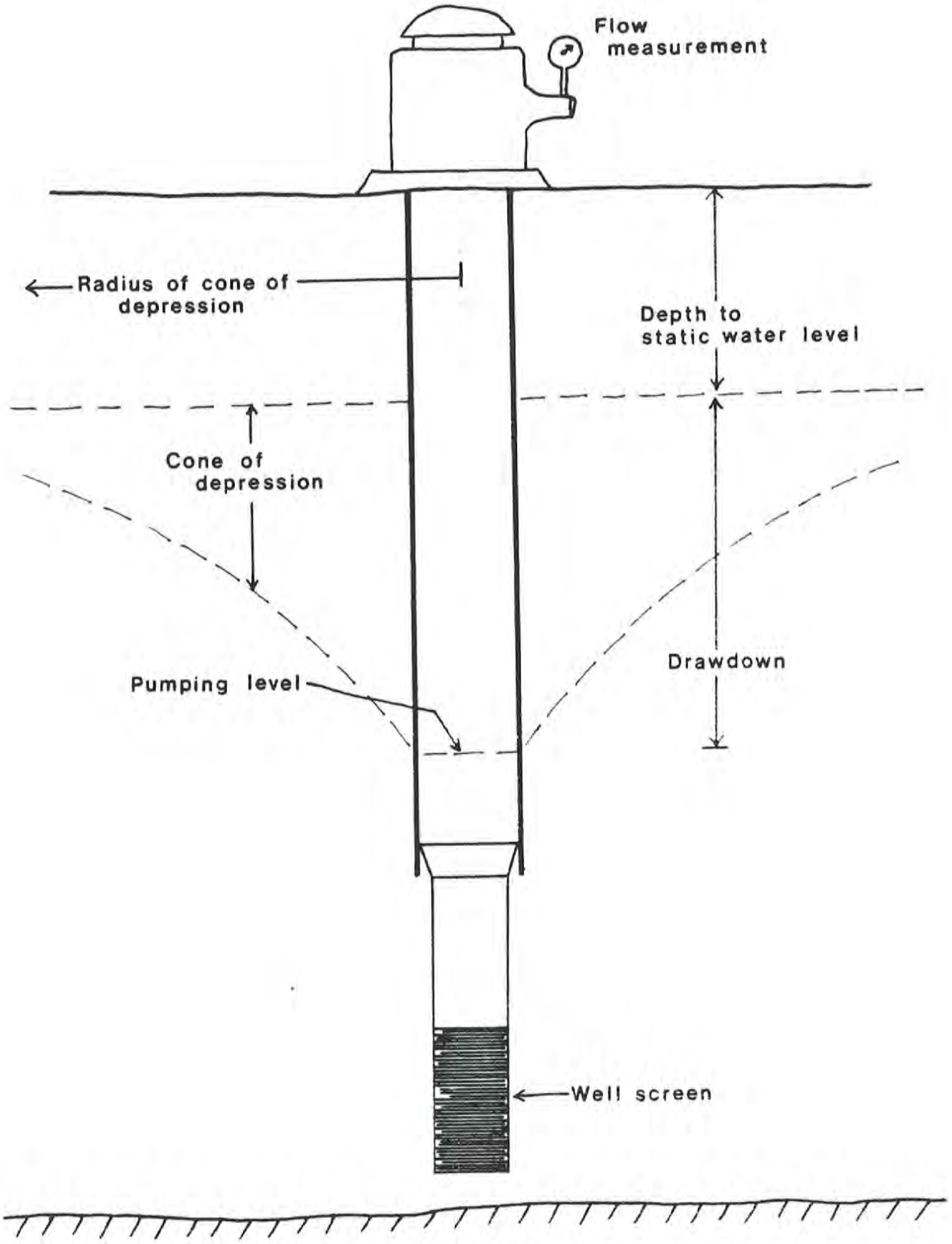


Figure III-7. Measurement of Specific Capacity

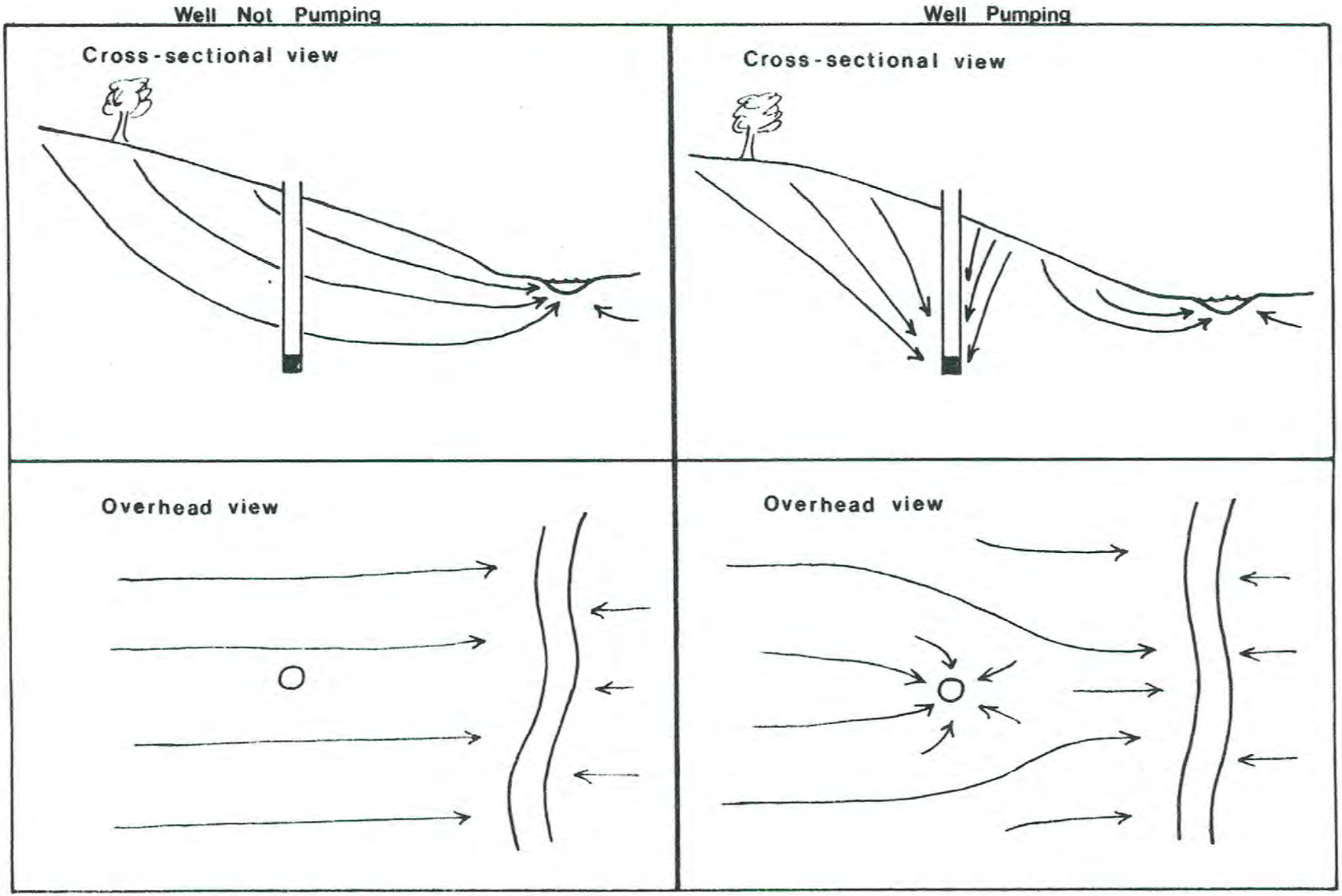


Figure III-8. Schematic Diagram of the Cone of Influence

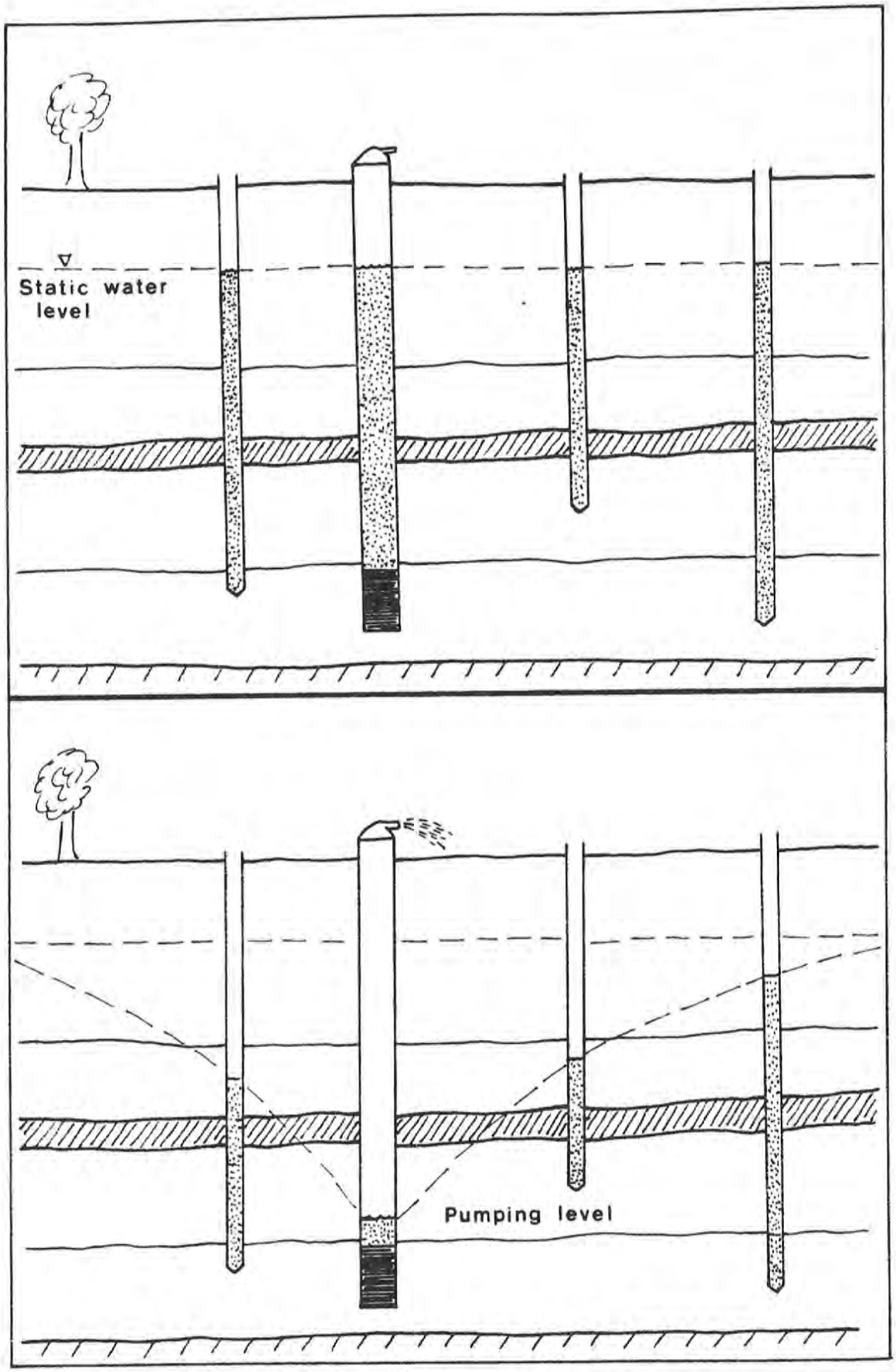


Figure III-9. Measurement of Cone of Influence

shut off, ground water will continue to move toward the well until the hydraulic gradient is equal to the surrounding area and the cone of influence is gone.

Water Budgets and Dependable Yields

Each aquifer exists within a fairly constant geographical area and geologic regime. When use of the aquifer becomes sufficient to warrant active management of the resources, a major goal of research activities must be a determination of the water budget for the region and its aquifer system. A water budget is critical when defining the limitations and potential of the aquifer and the impacts of land and water uses on the aquifer.

Water is generally conserved over time. It is not gained or lost so much as moved from place to place--the ground, the land surface and the atmosphere all are involved in the circulation of water. Given enough data, it should be possible to trace the fate of water in a region from the time it falls as precipitation to the time it leaves as water vapor and stream flow (Figure III-10). This accounting is called a water budget. Aquifer management, of course, is concerned with the sources, storage and discharges of water that percolates to the aquifer system.

Methodologies for Water Budgets

In a simple form, the water budget follows the Equation (1);

$$P = Q + E + \triangle S_g + \triangle S_s \qquad (1)$$

where P is precipitation, Q is runoff and E is evapotranspiration (Figure III-11). All of these factors have been discussed. $\triangle S_s$ is the change in surface water storage over time, and $\triangle S_g$ is the change in ground water storage. Given a long enough time, a constant climate and no water resources development, there will be no change in surface or ground water storage, resulting in Equation (2);

$$P = Q + E \qquad (2)$$

The equation of a usable water budget for ground water management, however, must be more explicit about $\triangle S_g$, including a breakdown of recharge, discharge (natural and from wells), changes over time due to a

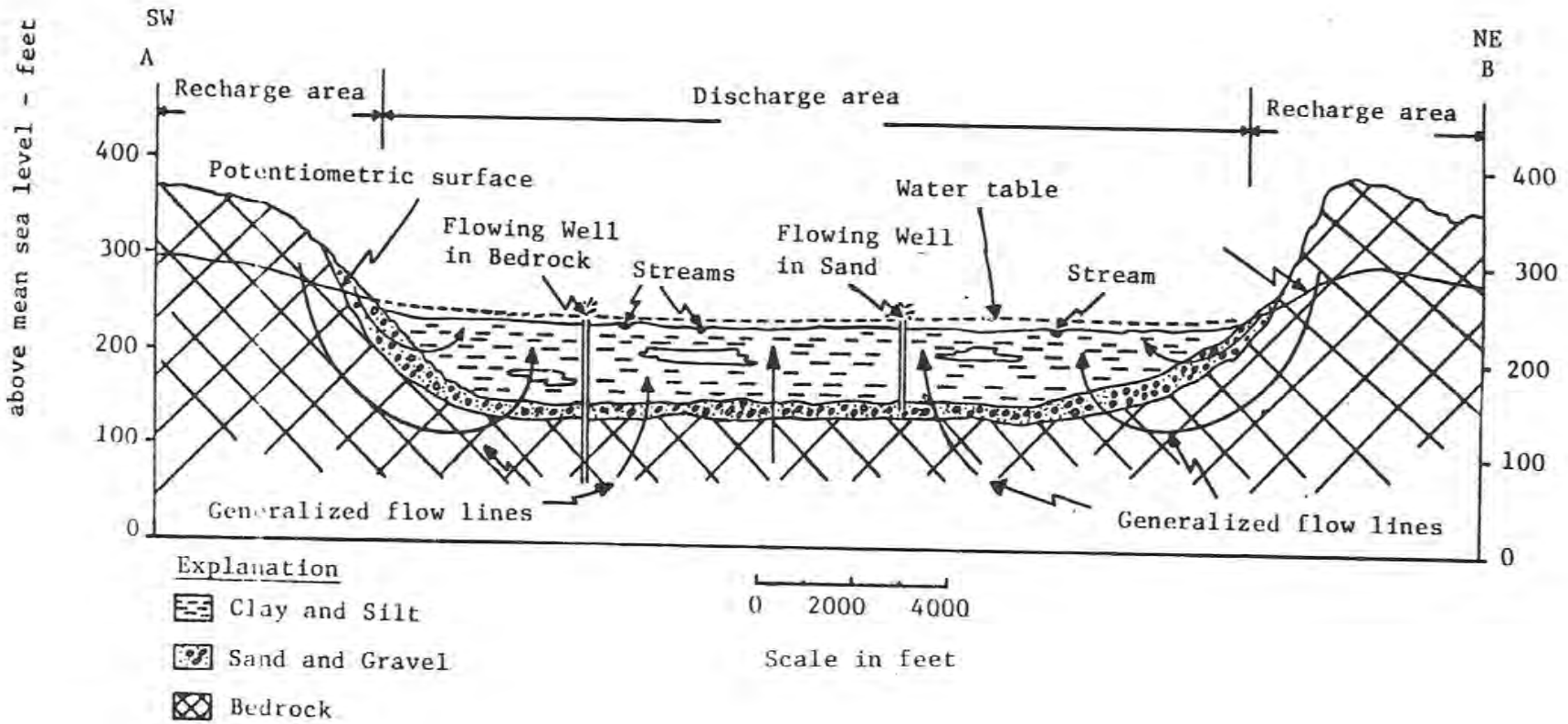


Figure III-10 Schematic Diagram Showing Movement of Ground Water in Norris County, New Jersey

Source: Gill and Vecchioli, 1965

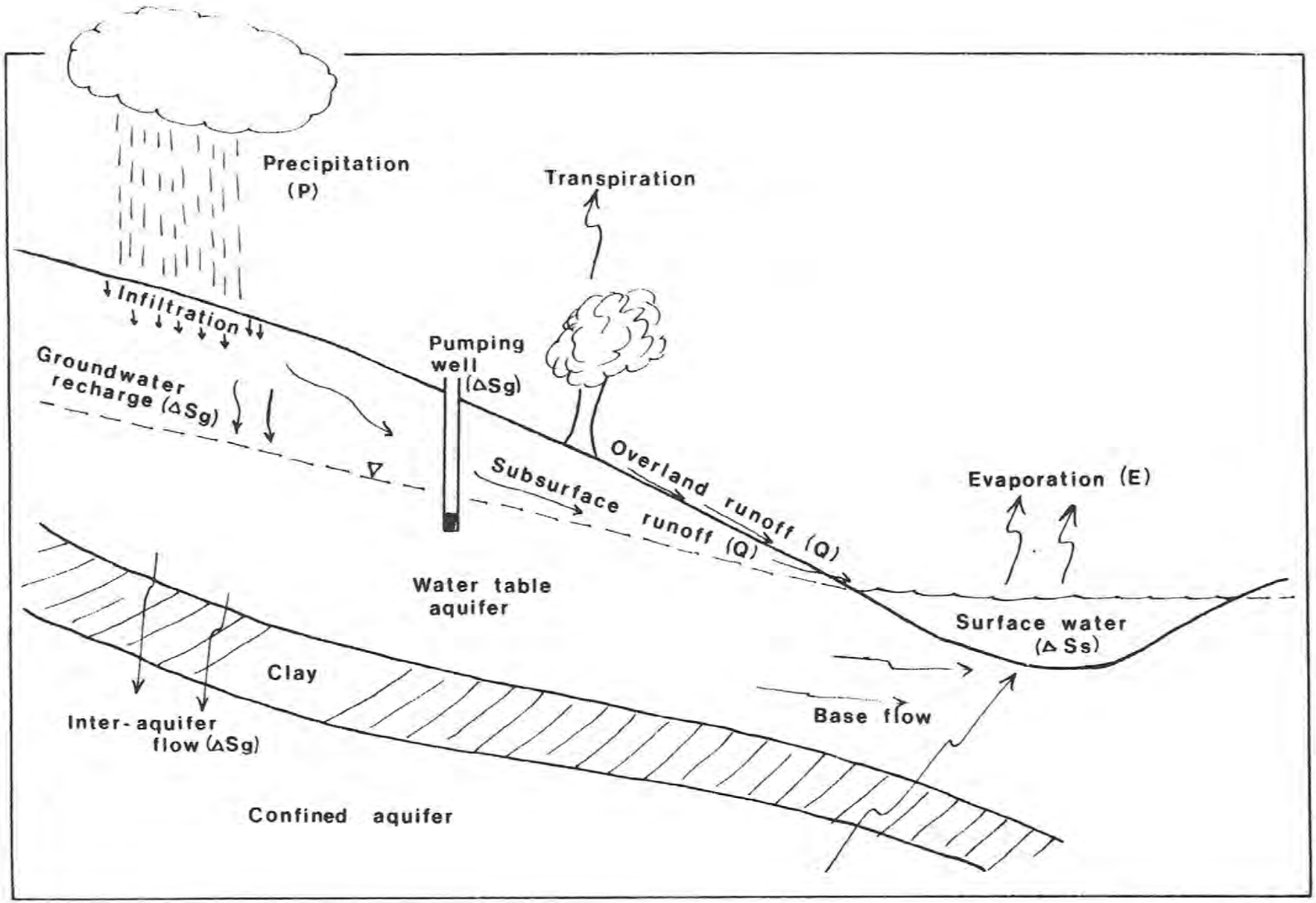


Figure III-11. Schematic Diagram of a Water Budget for an Aquifer

variety of factors, and differences between subregions of the aquifer system (Figure III-12). Precipitation is highly variable over time and area, as is evapotranspiration. Runoff also changes with time, depending upon several parameters. Though water budgets tend to stabilize over the long term, variations in the short term have serious use and management implications.

Two methods have been used by Geraghty and Miller (1976 and 1978) to develop an approximation of the water budget for an aquifer. One method uses the average recharge rates per square mile of recharge area, based on a generalized picture of the lithology in each area. An assumption is made that recharge rates equal the amount of water available for withdrawal. Average recharge rates for the study area are indicated in Table III-2.

Another method estimates the base flow of streams leaving the basin, which is approximately equal to the total recharge. The recharge rate is determined by dividing the average annual base flow by the basin area. This method yields a conservative estimate for the total ground water recharge of the area.

Geonics (1979b) computed a general water budget using the weighted recharge-averages method, but refined the method by considering ground water that is transported to the buried valley aquifer through the surrounding bedrock and a fault zone.

An important factor in both studies was that the analysis was confined to a portion of the total aquifer system. In such a case, estimates must be made of the ground water transport to and from the region that is not expressed as precipitation/infiltration or discharge within the study area.

Value Assumptions and Margin for Error in Water Budgets

Small or restricted aquifers require more careful water budgeting than large, interconnected systems, as a small aquifer will be more readily affected by changes in precipitation and evapotranspiration over the course of a year, and by changes in recharge and pumpage as well.

Large aquifer systems, and especially large artesian aquifers, are less susceptible to annual variations. In such cases, the long-term trends are more important. Somewhat greater generalization of the data (i.e., precipitation over the region) is possible without major errors in the

Figure III-12. Water Budget Flow Chart

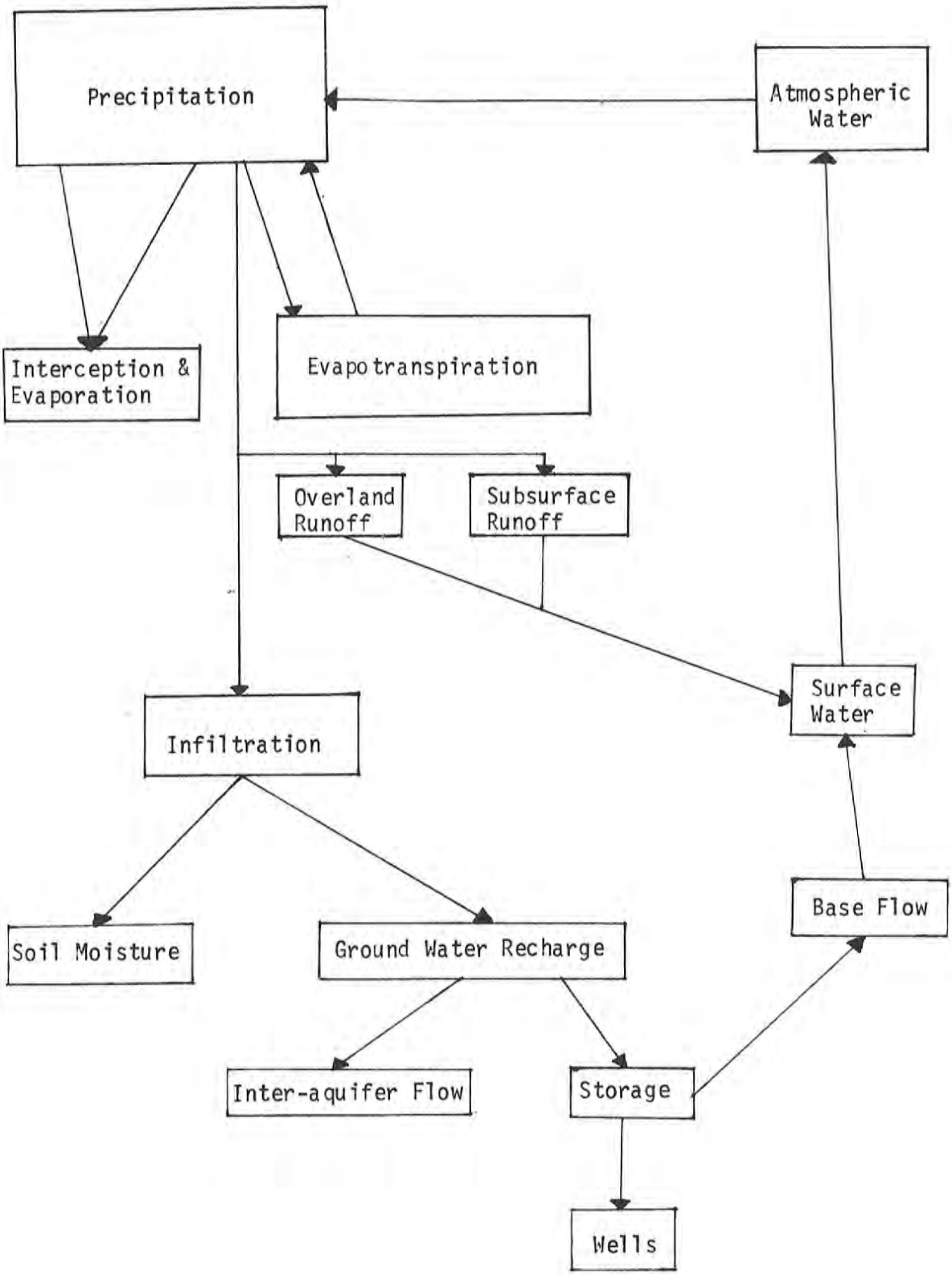


TABLE III-2

GROUND WATER RECHARGE RATES FOR GEOLOGIC FORMATIONS
(GALLONS PER DAY PER SQUARE MILE OF SURFACE AREA)

Geologic Unit	Normal Year	Dry Year
Pleistocene stratified deposits	650,000	450,000
Pleistocene terminal moraine	200,000	Not available
Brunswick formation (shale)	500,000/350,000	225,000
Watchung Basalt	250,000-380,000	170,000-200,000

Note: Two values were provided for the normal year recharge rate to a Brunswick formation aquifer. No differentiation was made between the two rates. It is possible that the rates were meant to be provided as a range of values.

Source: NJ Department of Environmental Protection, 1974; Geraghty & Miller, 1978.

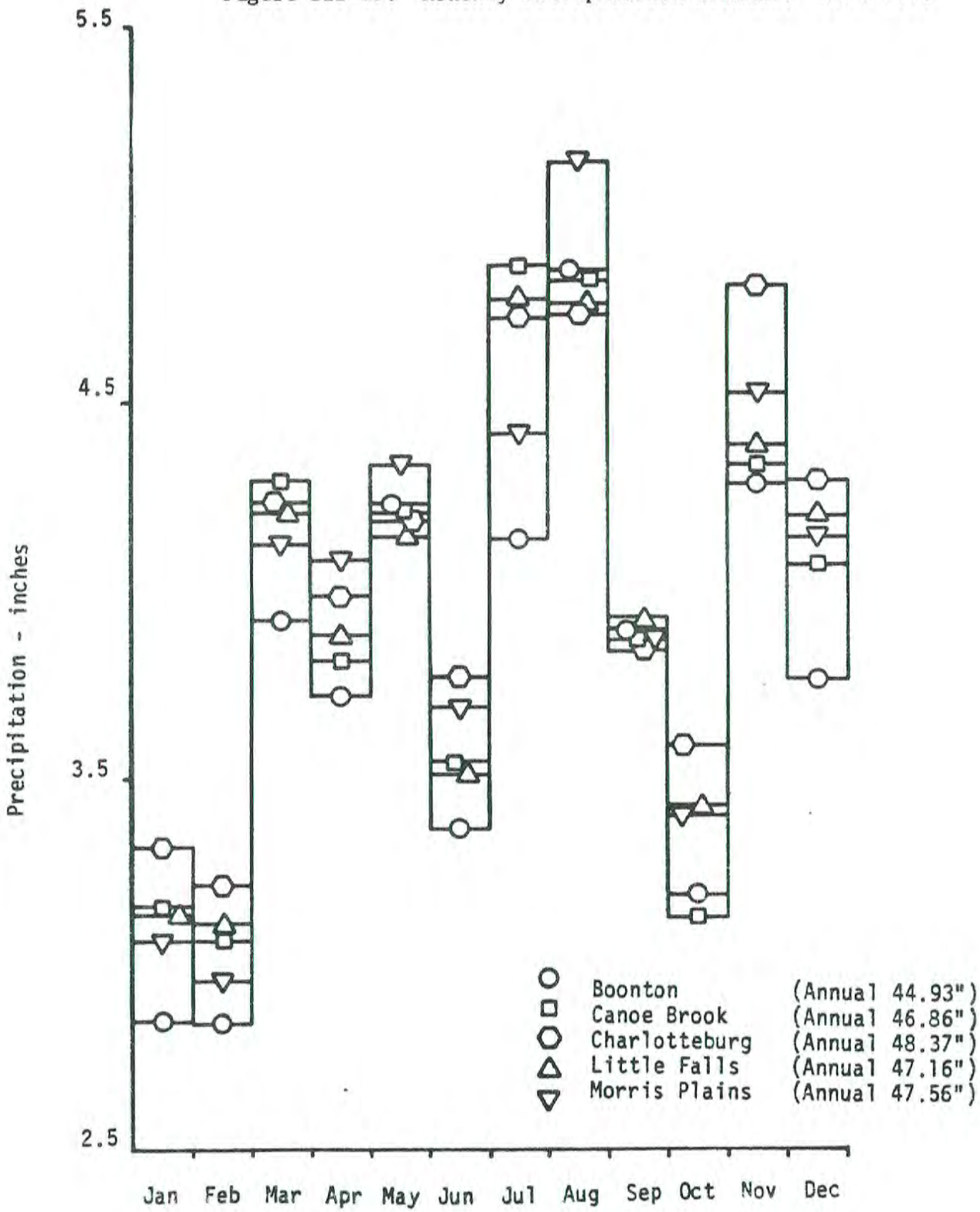
calculations. Still, precise water budgets are very difficult to develop in much of northern New Jersey due to the variability of the topography, aquifers, aquifer interconnections, aquifer-surface water connections, vegetation, land uses and ground water withdrawals. To date, no calibrated water budget has been developed for the Buried Valley Aquifer Systems. Many assumptions must be made to approach a working model of a water budget. The need for accuracy becomes paramount when development of a region causes the withdrawal of ground water to approach the available dependable yield. New development generally reduces the amount of recharge to an aquifer and also requires additional withdrawals, introducing a double debit to the system. The allowable margin for error in the determination of water budgets is relatively low in the Buried Valley Aquifer Systems and higher in less developed areas of New Jersey.

Precipitation--Unless an intensive meteorological network exists within a region, precipitation data will be limited to a few points. In small watersheds there may be no precipitation gauging station in the watershed. For this reason, assumptions must be made about the distribution of precipitation. Although precipitation is a major factor in a water budget, variations from reality should not be major if the gauging station is close to the region being studied. Figure III-13 is a graph of precipitation for a station within the study area.

Evapotranspiration--Photographic surveys and research on water losses from vegetation, water bodies and developed surfaces have reached a level of sophistication which allows good approximation of the water lost to evaporation and transpiration in a region. However, sophisticated research is also expensive, beyond the means of most local governments. Therefore, estimates of land development and vegetation patterns are used in combination with generalized data on evapotranspiration to determine regional losses. The estimates become more precise in proportion to the level of information available. For that reason, evapotranspiration estimates for small watersheds may be more precisely determined than for large regions.

Runoff--Most large streams and rivers in New Jersey have flow gauges measuring the quantity of water leaving the watershed at a specific point. However, most smaller streams and some of the larger streams lack streamflow gauging stations. Where the data exist, they are generally compiled by the U.S. Geological Survey into annual reports for the State. Where streamflow data do not exist, assumptions must be made as to the annual flow based on the character of the land and its relative impervious surface within the watershed. Streamflow reflects

Figure III-13. Monthly Precipitation Normals: 1941-1970



Source: National Oceanic and Atmospheric Administration, 1973

both runoff and base flow for the watershed, so estimates of runoff rely on estimates of base flow as well. Few continuous streamflow gauging stations exist within the study area. Most are used to gauge the availability of surface water supplies in the region and the proper flow that must be maintained within the Rockaway and Passaic Rivers downstream of the surface water intakes. A hydrograph from the Rockaway River streamflow station just downstream of the Jersey Reservoir is shown in Figure III-14.

Surface Water Storage--The area and depth of most significant water bodies are known. Changes in surface water storage are caused primarily by the filling or creation of impoundments, such as reservoirs. Generally, surface water storage can be assumed to remain stable unless new reservoirs are built. The water budget must also account for losses to the watershed from the transport of surface water to outside users, and drought effects.

Ground Water Storage--Unlike surface water bodies, the total volume of ground water storage is unknown. However, the critical concern with water budgets is not the total aquifer volume but rather the changes in volume that result from various inputs and losses to the system. Inputs include percolation, inter-aquifer flow and induced recharge. Outputs include inter-aquifer flow, base flow to surface waters and water diversions through wells. Percolation depends upon the existence of recharge areas and precipitation. Estimates of recharge are very difficult, and often are inferred from base flow rather than estimated directly. Inter-aquifer flow is also very difficult to measure. In the Buried Valley Aquifer Systems, inter-aquifer flow occurs frequently. Flow may exist between upper and lower unconsolidated aquifers, between bedrock and unconsolidated aquifers, and along lengths of buried valleys or fissures in the bedrock. Induced recharge, on the other hand, can be measured. However, the relative importance of induced recharge (the flow of water from surface waters to aquifers under the effect of a pumping well) changes with the well pumping rate, the relative levels of the surface water and aquifers, and other factors.

The output from aquifers is more simple, and therefore is often used as a surrogate for the estimation of inputs. Diversions from the aquifer to wells can be readily ascertained from diversion records required of owners of each major well by the NJDEP-Bureau of Water Allocation. Base flow can be determined through a mathematical analysis of streamflow records, where runoff is excluded from the hydrograph, leaving only the contribution of ground water to the streamflow. The remaining output, inter-aquifer flow, is no easier to determine as an output than as an

Figure III-14
Average Daily Flow
For U.S.G.S. Station 0138100
Rockaway River, 2,000 Feet Downstream
From Boonton Reservoir, Boonton, N.J.
From 1960-1979

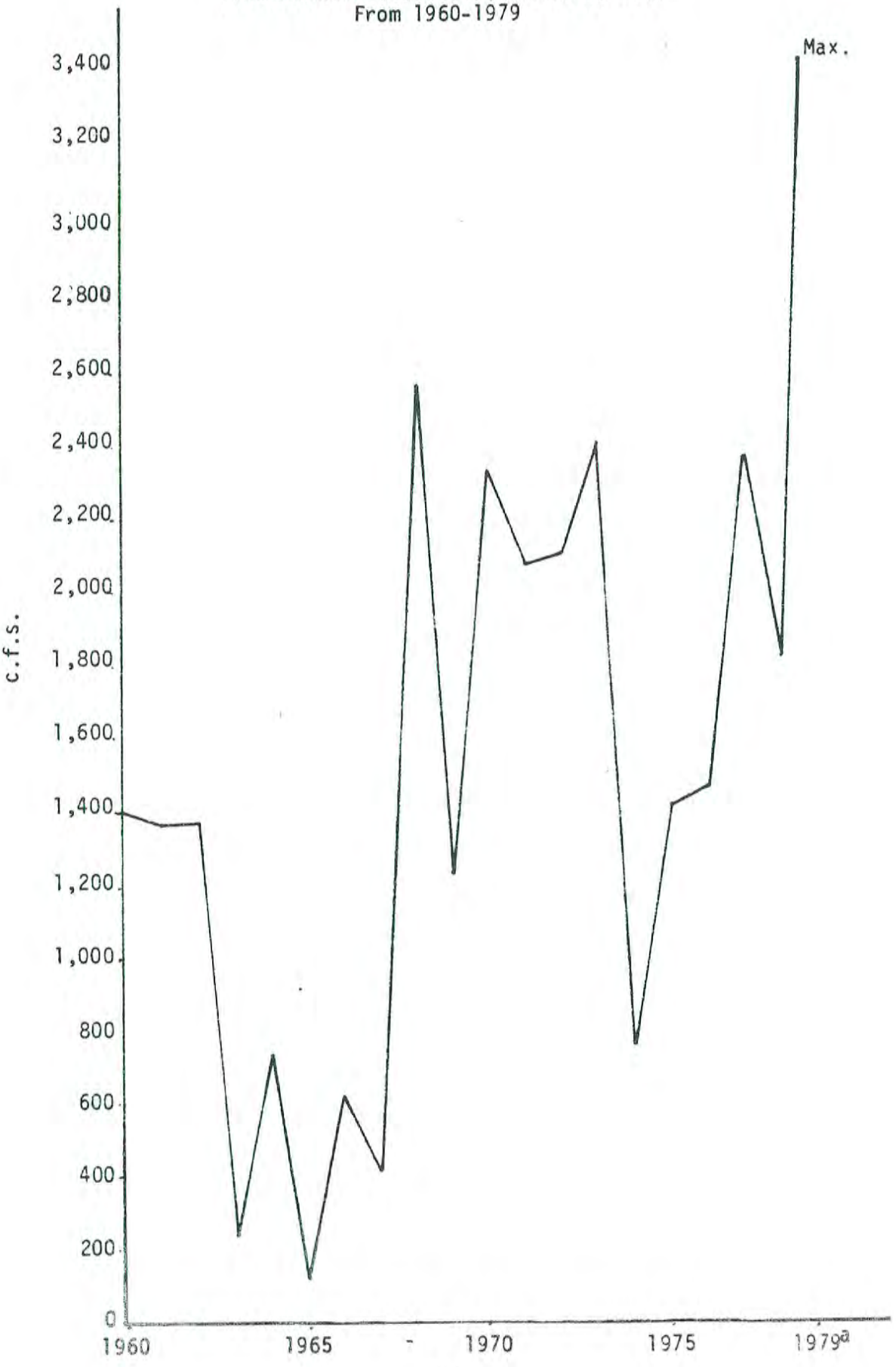
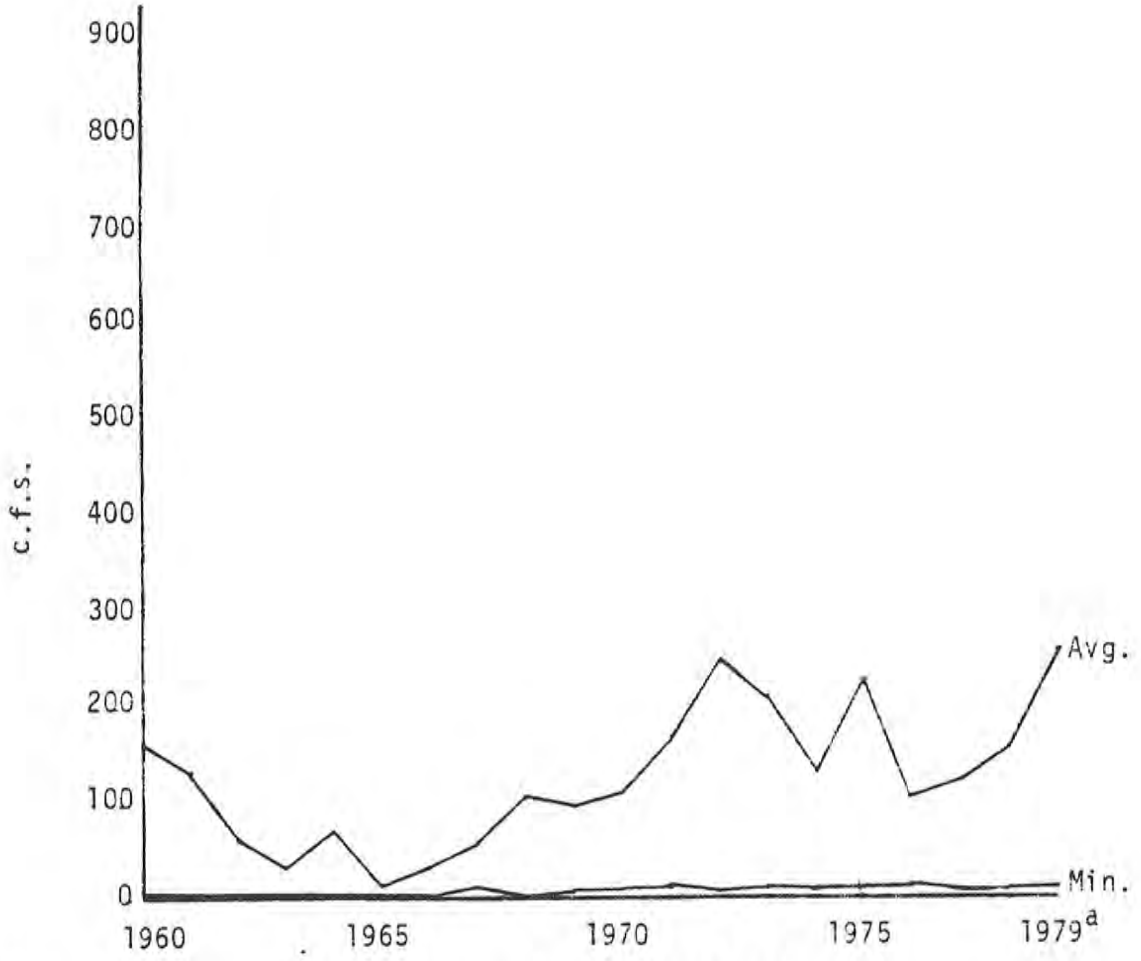


Figure III-14 (Cont'd)



[a] 1979 Only January through September available at this time.

Source: U. S. Geological Survey, 1961-1979.

input. However, the accuracy of interflow estimates are less critical when the other outputs can be measured with some precision.

Definition of Recharge Areas

Recharge areas, defined simply, are those land and water areas which contribute water that percolates to an aquifer. The recharge per acre may be very small or very great, and the importance of a particular recharge rate must be considered in light of the range of recharge rates in the aquifer region. Prime recharge areas contribute more water per acre than other recharge areas, and so are the most efficient recharge sources. However, it is entirely possible that the sum of contributions from prime recharge areas may not constitute a majority of the total recharge to the aquifer. Such a situation may hold true in the Buried Valley Aquifer Systems in the Central Passaic River Basin, where Meisler (1976) estimated that most recharge derived from less than prime areas.

Prime recharge areas generally have highly permeable soils which directly overlie the aquifer or are connected by highly permeable deposits. A good example would be coarse, sandy soils over a gravel aquifer. Recharge areas become less efficient as the permeability of the soils and strata declines. Mapping recharge areas is complex and expensive (Kasabach, 1985, personal communication), as highly permeable soils may be separated from an aquifer by clay strata. However, if the clay is discontinuous, recharge may occur indirectly with water flowing through the sands, along the clay lens and into the aquifer when the clay ends.

Recharge areas, prime and otherwise, have only been identified in a few areas of the Buried Valley Aquifer Systems. The City of East Orange has identified prime recharge areas within portions of its Water Reserve. Elsewhere, some recharge areas have been identified on a site specific basis.

Impacts of Ground Water Withdrawals on Aquifers

The concept of a water budget has extremely important management implications. The precipitation to a region is the total available water supply. Except for evapotranspiration, the remaining water leaves the system via surface water flow, either directly or indirectly (e.g. base flow contributions from ground water, water supply transport out of the region). Therefore, any new withdrawal of ground water from an

aquifer will either reduce the total ground water storage or increase the flow of surface water to the aquifer through recharge. If withdrawals are limited, a new equilibrium may evolve. Otherwise, the aquifer may decline continuously, eventually resulting in a loss of the supply. The total yield that is continuously available from an aquifer without long term drawdown of the aquifer is termed **dependable yield.**

Using the example of a small watershed with a sand aquifer and a stream, withdrawals from the aquifer may either result in a lowering of the aquifer (drawdown) or an increase in the flow of water from the stream to the aquifer. In the latter case, the flow of the stream will decline immediately. In either case, the flow of ground water to the stream (base flow) will be reduced (Figure III-11) and the safe yield of any downstream surface water supplies will also be reduced (especially direct intakes from the stream). It is readily apparent that the stream and the aquifer are actually a single water resource, with the aquifer serving as a reservoir for the base flow of the stream.

Severe drawdown of an aquifer may result in a loss of storage capacity, as the aquifer settles with its own weight. Permeability and porosity may be reduced. The effect is more readily seen with water table aquifers. Confined aquifers may be affected in the same manner if the drawdown is so severe as to dewater the aquifer.

Impacts of Droughts

Droughts are variously defined, but generally mean a significant reduction of precipitation to an area for an extended period of time. Droughts can be measured in terms of their shortfall from average precipitation over time in inches or percent, or in terms of their statistical probability. As the water budget implies, a reduction in precipitation will affect all parameters on the right side of the equation. Evaporation will be reduced from ground surfaces and falling precipitation, but will increase from open water surfaces. Runoff is greatly reduced and the streamflow will primarily derive from ground water. Surface water storage is less, especially in the case of reservoirs. Where no reservoirs are present, surface water storage in stream channels is less but ponds and lakes will not drop a great deal if not used as surface water supplies.

Ground water storage is also affected by drought. However, since the flow-through period for ground water (the statistical length of time from entry of water to an aquifer to its discharge as base flow) is

often much longer than for surface water, the effects may not be seen as quickly. Aquifers tend to remain relatively stable through the initial period of a drought and then decline in proportion to the drought's severity. After the drought has ended, the aquifer generally will continue its decline and then rise in proportion to the precipitation. Both the decline and rise in the water table or piezometric surface will be more pronounced in small aquifers with limited storage than for large aquifers. In large aquifers within the Buried Valley Aquifer Systems, a lag of one year or more is common.

Recharge Losses to Aquifers

A primary cause of recharge losses to aquifers is development. Any impervious surface placed on the land surface will reduce the area available for recharge. The extent of that reduction will depend on the natural efficiency of the land for recharge and the extent to which recharge is restored or enhanced through development practices. As a general rule, however, development causes both the decrease of aquifer recharge and an increase in water demand.

A second major cause of recharge loss is the transport of water from the aquifer system. Although private wells withdraw water from aquifers, a majority of this water is replaced through lawn sprinkling and septic systems. Public water supplies, however, withdraw great quantities of ground water which are not recharged. Instead, the used water is generally treated and discharged to surface waters, often far downstream of the aquifer of origin. The loss of recharge through water transport to distant users and sewage treatment is a major imbalance in the water budget of a region, and a primary cause for changes in the ground water storage of an aquifer.

Artificial Recharge Techniques

Recharge can be natural or artificially induced (Figure III-15). One method of artificial recharge which is common in the Buried Valley Aquifer System (though often not by the original intent of the well drilling) is induced recharge caused by the pumping of major wells next to rivers and large streams. Research findings of the U.S. Geological Survey indicate that some wells draw up to 50 percent of their yield by inducing recharge from the river.

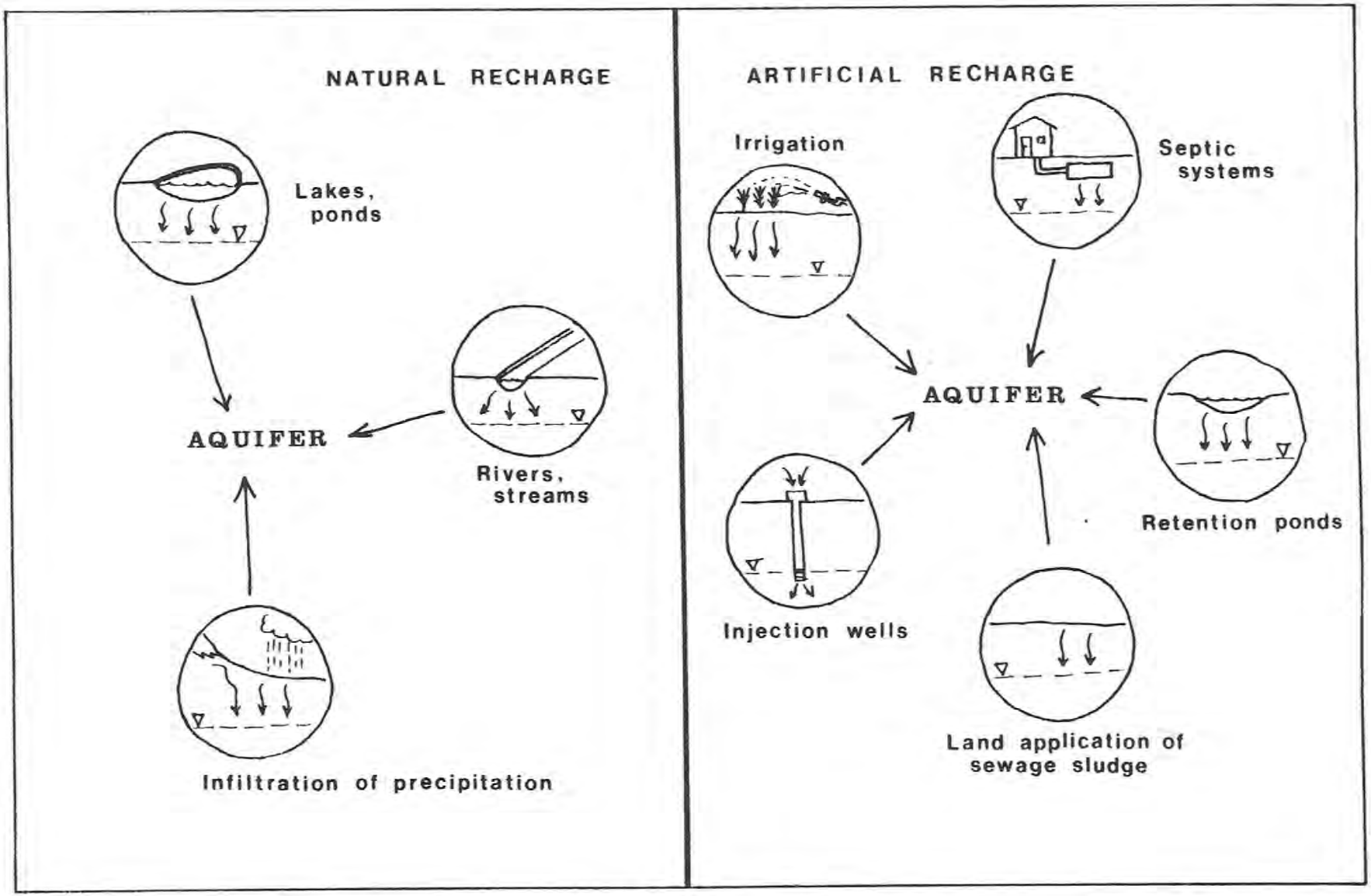


Figure III-15. Natural and Artificial Aquifer Recharge

Additional techniques for artificial recharge are shown in Figure III-16. Retention ponds over permeable deposits can provide large amounts of recharge to an aquifer. The drawbacks include increased evaporation and the cost of land for the ponds. Injection wells are a more direct method of recharging water, and are used in several instances to recycle non-contact cooling water from industrial facilities. Not only is the water recharged to the aquifer, but it is also cooled prior to repumping through a nearby well. Irrigation also results in recharge, as do the land application of sewage sludge and household septic systems. The last method is sometimes a major source of recharge, reintroducing up to 80 percent of the water pumped through private wells.

Artificially recharged water is rarely as pure as the ground water which naturally occurs in the aquifer. Fertilizers, pesticides and salts are carried along with recharged irrigation water. Sewage sludge and septic systems may provide insufficient treatment of the wastes prior to recharge. Numerous private wells have been contaminated by septic systems on the same lot, for instance. Injection wells are easier to monitor for water quality and may be turned off and the water diverted if problems arise, but thermal pollution may have some affect on the aquifer quality, such as accelerating the leaching of some chemical components of the geologic formation. Retention ponds may be relatively clean, if they are designed to capture precipitation without the introduction of discharges from lawns, parking lots, etc. In most cases the water quality in retention ponds will reflect the surrounding land uses. Wherever the quality of the recharged water will be less than the natural ground water quality, it may be preferable to treat the surface water prior to recharge or prior to recycled use without recharge. One example of treatment prior to recharge occurs at contaminated sites, where ground water is withdrawn, treated and recharge through injection wells just upgradient of the site. Eventually the ground water will reach acceptable levels and the operation ceases.

Natural Contamination of Ground Water

The presence of natural contaminants (not caused by the actions of people) in ground water can be ascribed to the mineral make-up of the rocks through which the ground water flows. Ground water usually contains no suspended material or bacteria and has a pH that ranges from 5.5 - 8.0, quite close to neutral (Johnson Division, 1975).

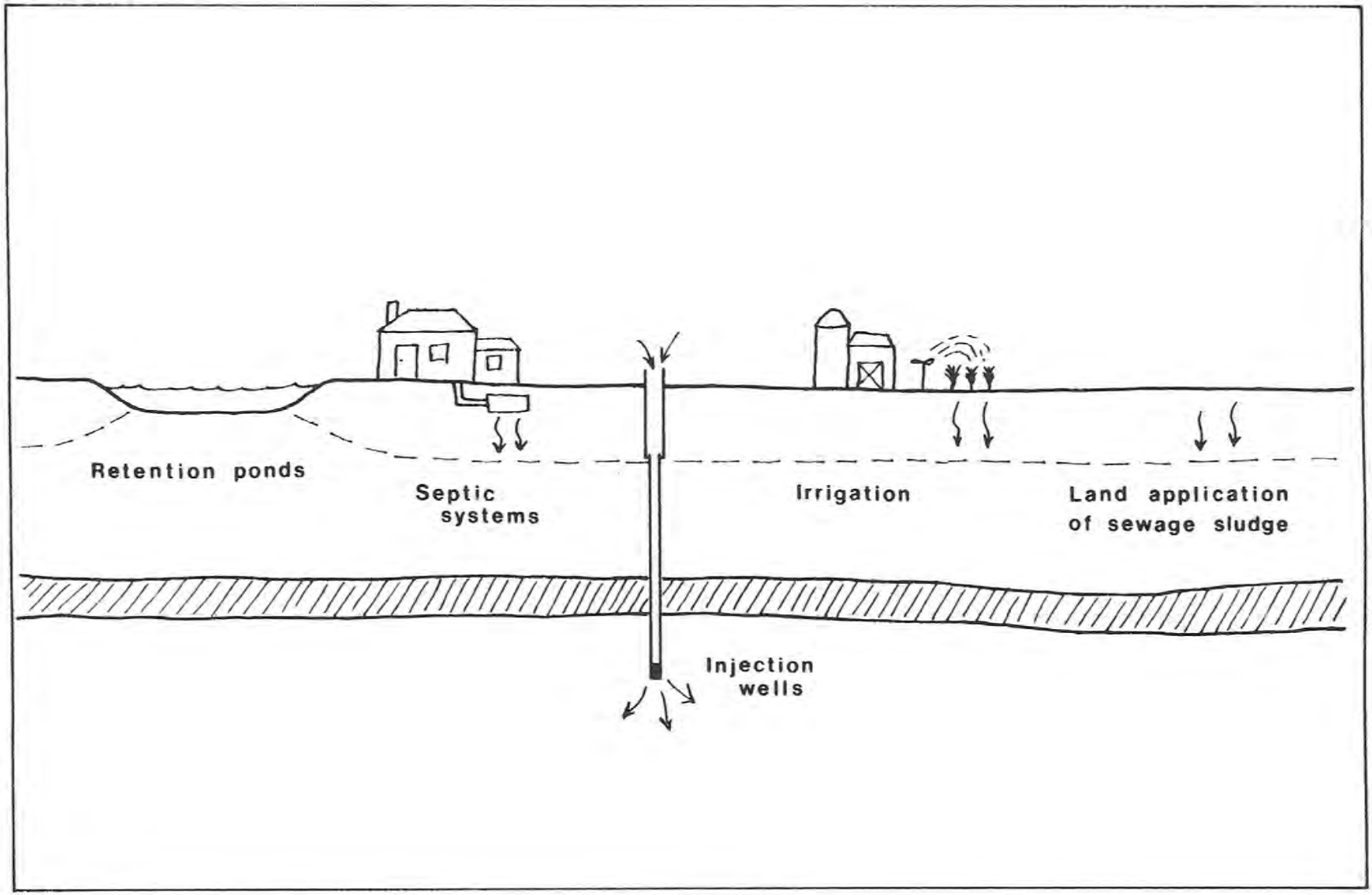


Figure III-16. Artificial Recharge of Aquifers

Within the Buried Valley Aquifer Systems, ground water problems usually are limited to iron, manganese or hardness in objectionable quantities. Sulfates are also found as natural contaminants.

Iron has been found exceeding potable limits in localized areas throughout the designated area. It has several possible sources, depending on the location: 1) leached from sand and gravel deposits by water percolating to the water table; 2) darker-colored gneisses and granites; and 3) other dark-colored rocks (Geraghty & Miller, 1978; Banino, Markewicz and Miller, 1970).

Manganese in objectionable quantities has also been found, though less frequently. It has sources similar to those for iron. Both minerals are objectionable for aesthetic reasons, such as the staining of sinks and fabrics, not for health reasons. Hard water occurs locally, especially in sand and gravel aquifers.

A small number of wells encounter high sulfate levels. Sulfates are leached from sulfate minerals in dikes of trap rock (basalt) and layers of red shale (Banino, Markewicz and Miller, 1970). Only the presence of sulfates of the four quality parameters cited is sufficient reason to avoid using the water. The remainder may be treated or, at times, ignored.

In sum, the problems of natural contamination are small both in terms of wells affected and supplies lost. Treatment is available for manganese and iron levels which exceed secondary standards. Chapter VI discusses ground water contamination and its health effects in some detail, while Chapter VII is an extensive exploration of anthropogenic ground water contamination within the Buried Valley Aquifer Systems.

CHAPTER IV

DELINEATION AND DESCRIPTION OF THE BURIED VALLEY AQUIFERS

Introduction

This chapter presents the information currently available on the delineation of buried valleys and buried valley aquifers in the region. Although many research reports have been prepared, much of the detailed information necessary for informed management is lacking. Even such basic steps as the complete delineation of the aquifers have not been completed. An overview of the hydrogeological investigations performed to date is presented for a sense of the progress made over the years. The buried valleys are then described in some detail, by subregion. Finally, the hydrologic characteristics of the aquifers are discussed. Chapter VIII presents information on current and planned research which is focused on the Buried Valley Aquifer Systems.

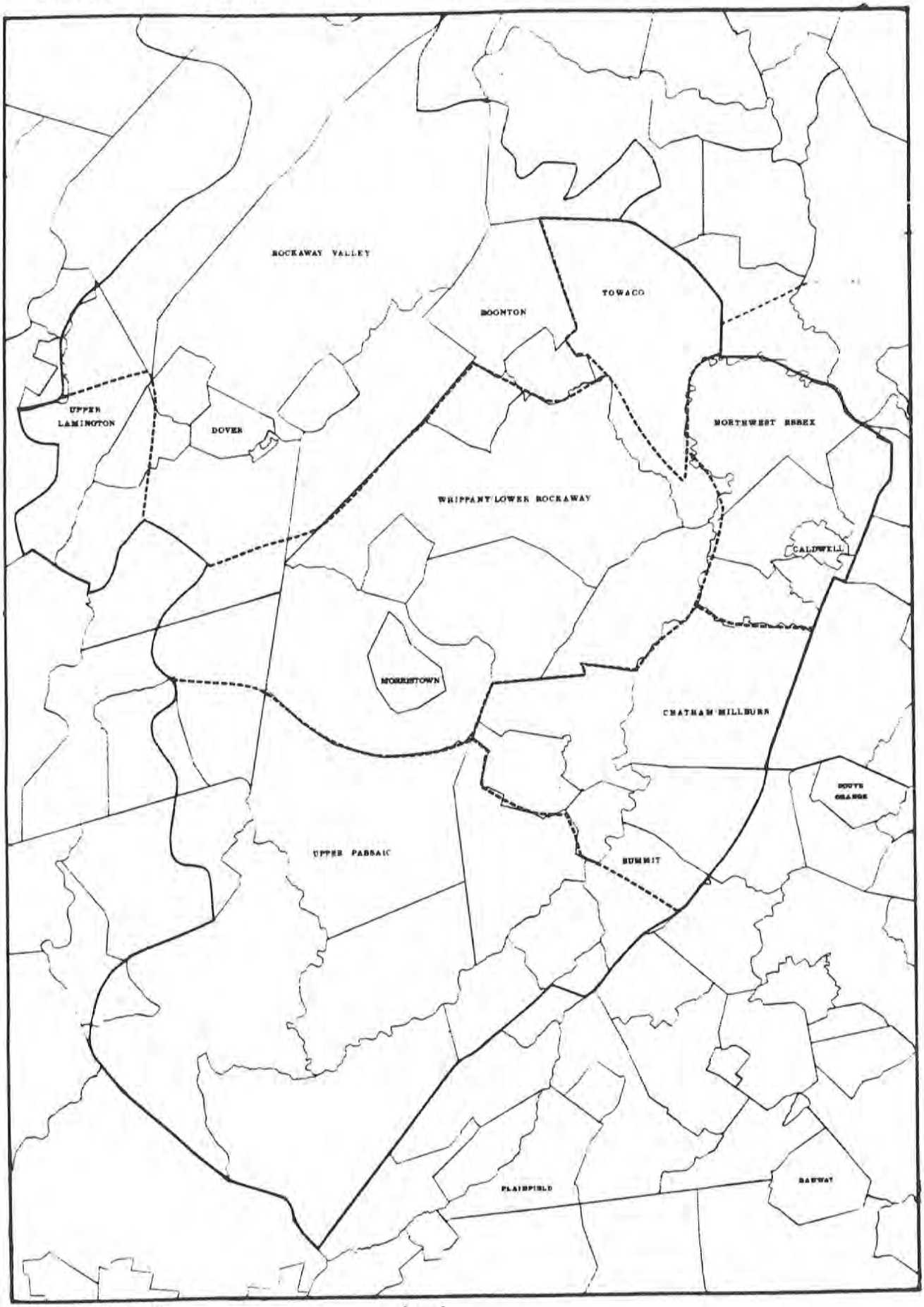
Subregions of the Aquifer Systems

Although evidence mounts that the entire valley-fill aquifer system of the Rockaway, Whippany and Passaic River watersheds are directly connected and therefore a single hydrologic system, a system of subregions is proposed for the purpose of focusing discussion (See Figure IV-1). The subregions of the Buried Valley Aquifer Systems are:

1) Rockaway Valley Aquifers--The entire Rockaway watershed upstream of the Jersey City Reservoir in Parsippany is considered as one system. From upstream to downstream, the municipalities of Jefferson, Rockaway Township, Wharton, Dover, Mine Hill, Roxbury, Randolph, Victory Gardens, Rockaway Borough, Denville, Boonton Town and Boonton Township are located within this subregion in part or in whole.

THE BURIED VALLEY AQUIFER SYSTEMS

FIGURE IV-1. SUBREGIONS OF THE STUDY AREA



2) Upper Lamington Aquifers--The Upper Lamington (or Black) River watershed includes aquifers tapped by the Morris County Municipal Utilities Authority and the Roxbury Water Company, in the municipalities of Mine Hill, Roxbury, Randolph and Chester Township. This subregion is considered separately from the Rockaway, though the aquifers are connected to the Rockaway system to the north.

3) Towaco Aquifer--The Towaco Buried Valley in Montville Township does not connect with the buried valley aquifers to the west, but may connect to the buried valleys of the Northwest Essex Subregion by way of the east through Lincoln Park, Wayne and Fairfield. The Towaco is considered as a separate subregion.

4) Northwest Essex Aquifers--The broad valley-fill sediments of Fairfield and the upgradient aquifers of the Caldwells, Essex Fells and Roseland comprise this subregion. The remaining municipalities of West Essex are included within the Chatham/Millburn Aquifers Subregion.

5) Whippany/Lower Rockaway Aquifers--The aquifer underlying the lower Rockaway River between Parsippany and Montville is apparently not connected to the upper Rockaway system, but rather connects to the south with deposits underlying the Whippany River watershed. Parsippany-Troy Hills is almost entirely within the Whippany watershed, as are Morristown, Morris Plains, Morris Township, Hanover, and western East Hanover. The Rockaway Valley subregion is apparently continuous with the major buried valley which traverses the Troy Brook watershed of Parsippany, but Parsippany is considered separately from the Rockaway Valley.

6) Chatham/Millburn Aquifers--This subregion with the longest history and greatest intensity of use is located just north of the terminal moraine in east-central Morris County and nearby portions of Essex County. The municipalities of Madison, Chatham Borough, Florham Park, Summit, Millburn, Livingston and eastern East Hanover comprise the subregion. The Chatham, Southern Millburn, Northern Millburn, Canoe Brook and Slough Brook Buried Valley Aquifers are within the area.

7) Upper Passaic--There are no major buried valley aquifers known in the Upper Passaic, located upstream (south) of the terminal moraine in Chatham Township, Passaic Township, Harding, Summit, Berkeley Heights, New Providence, Warren Township, Bernards Township, and portions of Mendham and Bernardsville. The subregion relies on ground water from shale and precambrian rocks, and contributes significantly to the base flow of the Passaic River.

Geologic and Hydrogeologic Investigations

Delineation and characterization of the Buried Valley Aquifers have come through decades of drilling, pumping and surface geophysical studies, most of which have occurred during this century. Much of this knowledge base is still quite general, though research of the aquifer system over the last twenty years has provided the general outlines and contours for most of the buried valleys and detailed lithologies for some valley segments. Still lacking are detailed, calibrated water budgets for each aquifer, detailed stratigraphies for most of the buried valleys, and data on the full role that bedrock aquifers play with respect to the buried valley aquifers.

Overview of Past Research

Most of the important research on the buried valleys has been done by the United States Geologic Survey (USGS) Water Resources Branch and Geology Division, the New Jersey Department of Environmental Protection (NJDEP), formerly the Department of Conservation and Economic Development, and various consulting firms which specialize in ground water resources.

Research on the buried valley aquifers has accelerated over the past decade. Prior to the late 1970's, research had focused primarily on the buried valleys of the Chatham-Millburn Valleys Subregion, beginning with the well fields in the Canoe Brook and Slough Brook Buried Valleys of Millburn and Livingston Townships and gradually expanding to embrace the Chatham, Millburn, and East Hanover Buried Valleys. Relatively little was known about the buried valleys in the Rockaway River watershed and Montville and Fairfield Townships until recently.

Initial research was performed by the New Jersey State Geologist and by the United States Geological Survey. Annual reports of the State Geologist in the 1890's reported information from the drilling of wells, to the extent that any information was available. The USGS prepared an important study on the Canoe and Slough Brook Buried Valleys in 1932, which for the first time compiled information about bedrock depths and surficial deposits to map buried valley aquifers in the region. A long hiatus ensued, with little work being done on the aquifers of the region. The drought of the early 1960's prompted a major research effort on the aquifers of eastern Morris County, to determine the location of additional ground water supplies. The USGS prepared studies

in 1966 and 1967, based on the drilling of test borings and test wells. Several potential well sites were discovered. A further study by the USGS, using all available well data, resulted in the mapping of bedrock contours for much of western Essex and eastern Morris Counties in the known areas of buried valleys. This 1968 map represented the farthest advance of buried valley delineation for many years.

The Rockaway Buried Valley was little known or mapped, though industries and municipalities diverted ground water from wells placed near the Rockaway River and its tributaries for many years. However, the connection of these well fields through a single aquifer system was not fully established until the 1970's. Four studies were commissioned by Morris County for the municipalities of Montville, Boonton, Boonton Township, Mountain Lakes and Denville. The studies, prepared in 1978 and 1979, mapped the main aquifers in the five towns, suggested future well sites and recommended aquifer management principles.

It was not until the early 1980's when another drought resulted in research by the NJ Geological Survey to delineate the Rockaway Buried Valley west of Denville and east of Mountain Lakes. The first study, published in 1983, firmly established the connection of the Rockaway Buried Valley with the glacial aquifers of the Upper Lamington River. The second study, as yet unpublished, has radically revised maps of the buried valley aquifer system by determining the location of the lower Rockaway Buried Valley from Mountain Lakes through Parsippany-Troy Hills Township. The USGS has also been active in the Rockaway watershed, with two major studies on aquifer/surface water relationships.

The important studies of the past 55 years are summarized in this section. More detailed information is available from the reports.

Thompson Study (1932)--Early attention focused on the well fields utilized by the City of East Orange and the Commonwealth Water Company in the vicinity of Millburn Township, Essex County. Three additional well fields existing at that time (1932) belonged to the Chatham and Madison Water Departments and the Normandy Water Company (Figure IV-2).

Formation logs from the Commonwealth and East Orange well fields were plotted, resulting in the geologic cross-sections of Figures IV-3 and IV-4. Figure IV-3 clearly shows the existence of two buried valleys separated by a trap rock (basalt) ridge, while Figure IV-4 shows a series of three valleys. Thompson plotted bedrock elevations based on the well logs, resulting in Figure IV-2 where the three valley areas are shown in plan view. One valley follows underneath Canoe Brook and is

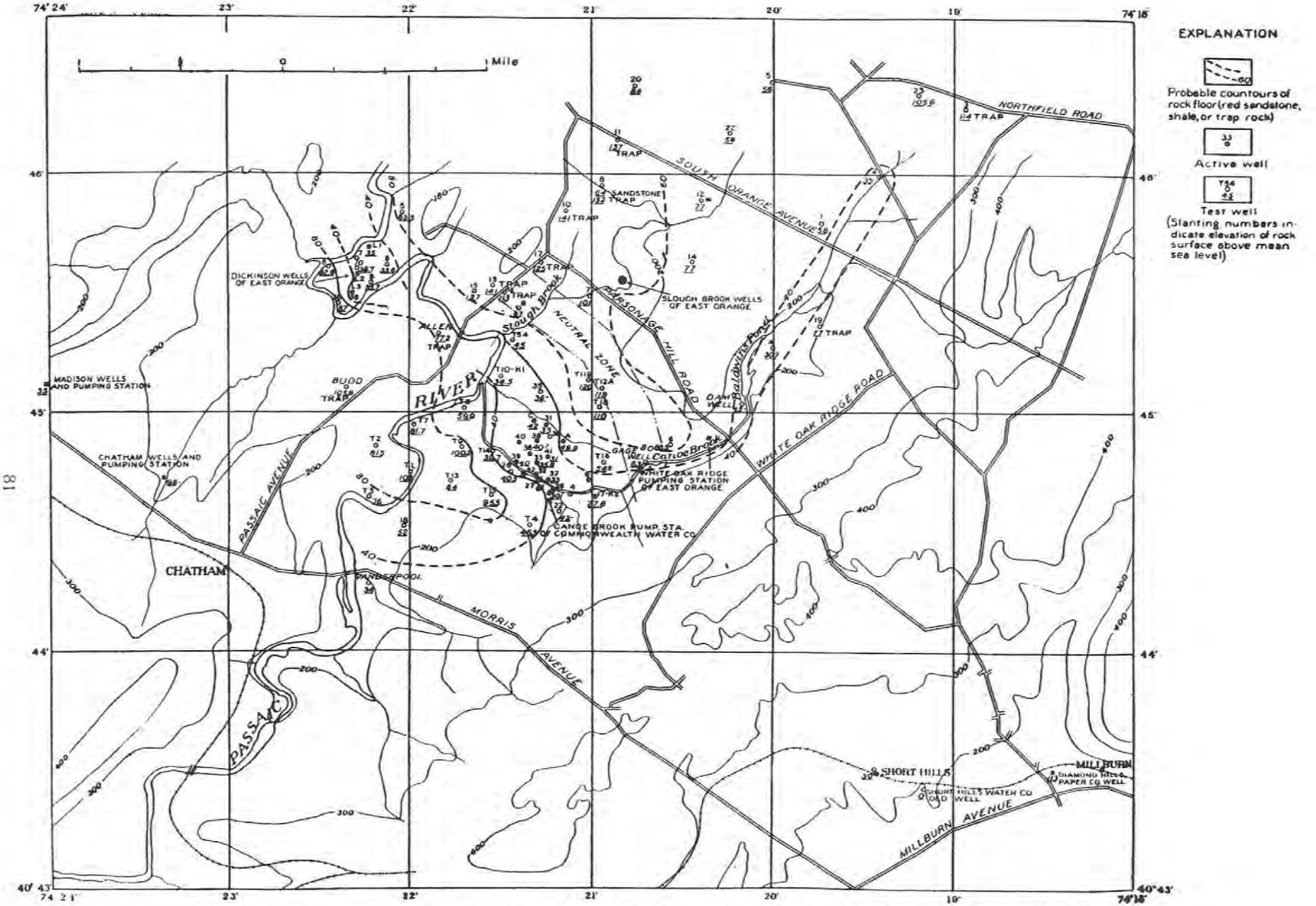


Figure IV-2. Passaic River Valley, near Chatham, Showing the Location of Well Fields and Contours of Bedrock Surface

Source: Thompson, 1932

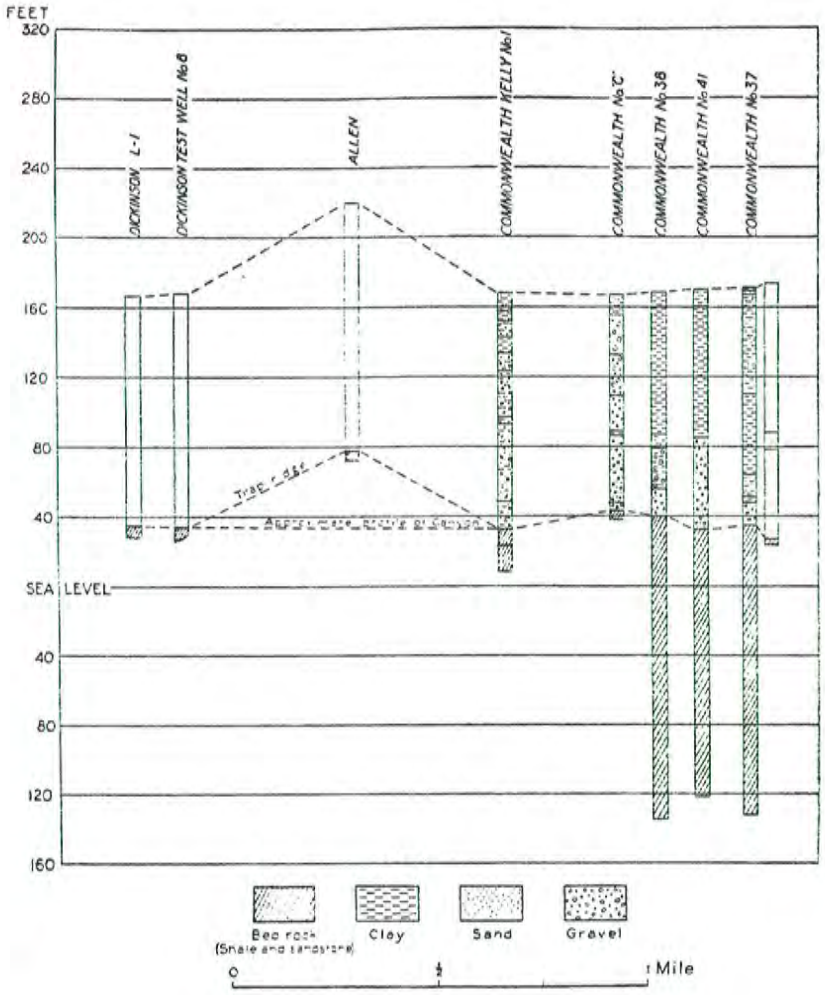


Figure IV-3 Logs of Wells Along a Line Through Canoe Brook and Dickinson Well Fields

Source: Thompson, 1932.

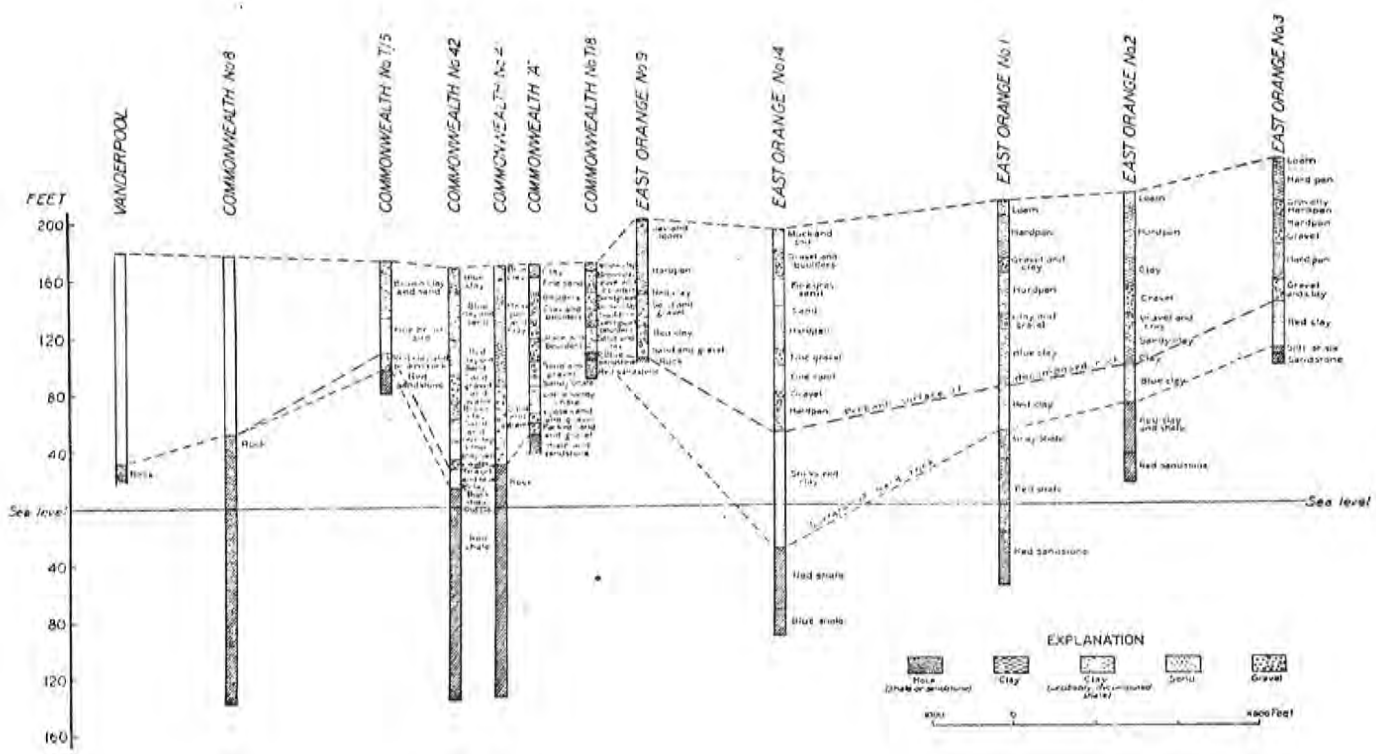


Figure IV-4 Logs of Wells Along a Line Through the Canoe Brook and White Oak Ridge Well Fields[a]

Source: Thompson, 1932.

[a] "The wells have been drilled by several different drillers, and different methods have been used. A study of the logs shows that the use of terms has not been uniform, and the interpretation of the logs is uncertain " (Thompson, 1932).

called the Canoe Brook Buried Valley. A second valley underlies the upper portion of Slough Brook and is called the Slough Brook Buried Valley. A third valley, at the southern limit of the area along Morris Avenue, is hinted at by the 40' elevation. Well data at the Chatham and Madison well fields also indicated deep deposits of stratified sand and gravel deposits. Thompson could not verify the connection of these deposits to the buried valley along Morris Avenue. A fourth buried valley area underlies the Dickinson well field along the Passaic River. Thompson postulated a connection of this area with the Slough Brook Valley or with Chatham and Madison.

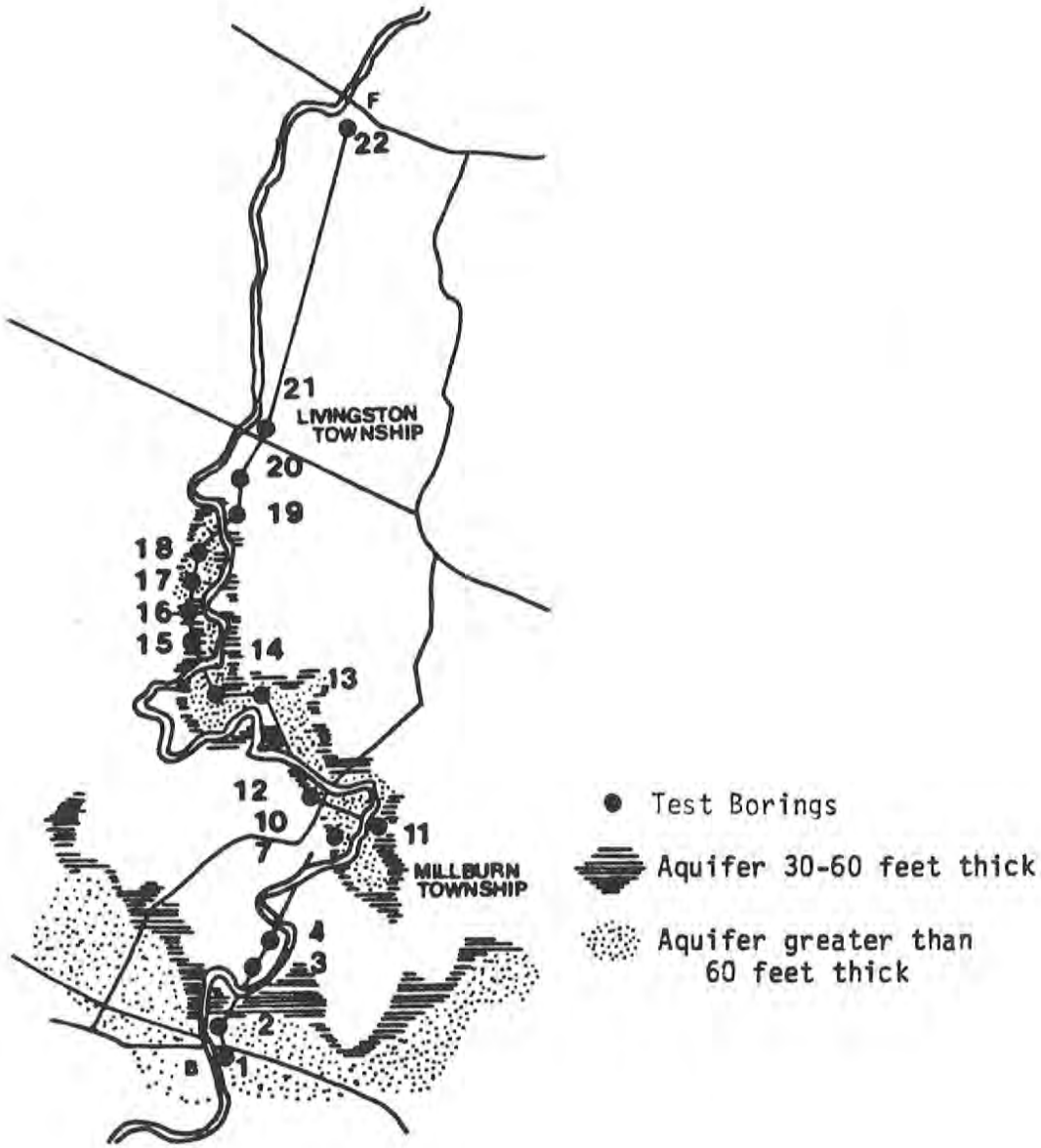
In each case, Thompson noted that the buried valleys were not wide, though their total length could not be determined. The Canoe Brook Valley, for instance, is approximately 3/4 mile wide.

Vecchioli and Gill (1962)--The same set of buried valleys were the concern of this unpublished USGS study for the U.S. Army Corps of Engineers. Several geologic logs were made along the Passaic River from the Chatham Borough to Cooks Bridge at Route 10 in Livingston (Figure IV-5 shows locations of the study sites). The geologic cross-section (Figure IV-6) indicates the buried valley at Chatham at the southern edge of the traverse, followed by a ridge (thought to be a buried part of Long Hill, a southwest-northeast basalt ridge in southern Morris County which dips below ground level just south of Chatham) and then a long buried valley underlying the present course of the Passaic River for some distance. The assumption made was that the cross-section traversed the northern buried valley lengthwise, indicating a north-south orientation for the buried valley itself.

Drought-Disaster and Water Supply Studies--A major acceleration of research on ground water resources and water-bearing geologic structures occurred in the 1960's. This interest was spurred by the record drought early in the decade and an acceleration in the growth of the area. The State published reports on the ground water resources located within the boundaries of Morris County (Gill and Vecchioli, 1965) and Essex County (Nichols, 1968a). The reports were essentially collections of existing data presented in more usable forms.

In 1966 and 1967, the USGS implemented a drought-disaster drilling program in the buried valley aquifer system (Vecchioli and Nichols, 1966; Vecchioli, Nichols and Nemickas, 1967). The drilling program was intended to determine new sources of emergency-use ground water supplies, distinct from existing well fields which were experiencing heavy use yet accessible to existing transmission lines. Test well holes

Figure IV-5 Location of Logs Shown in Figure IV-6 and Areas Where Thick Permeable Deposits Are Found



Source: Vecchioli and Gill, 1962

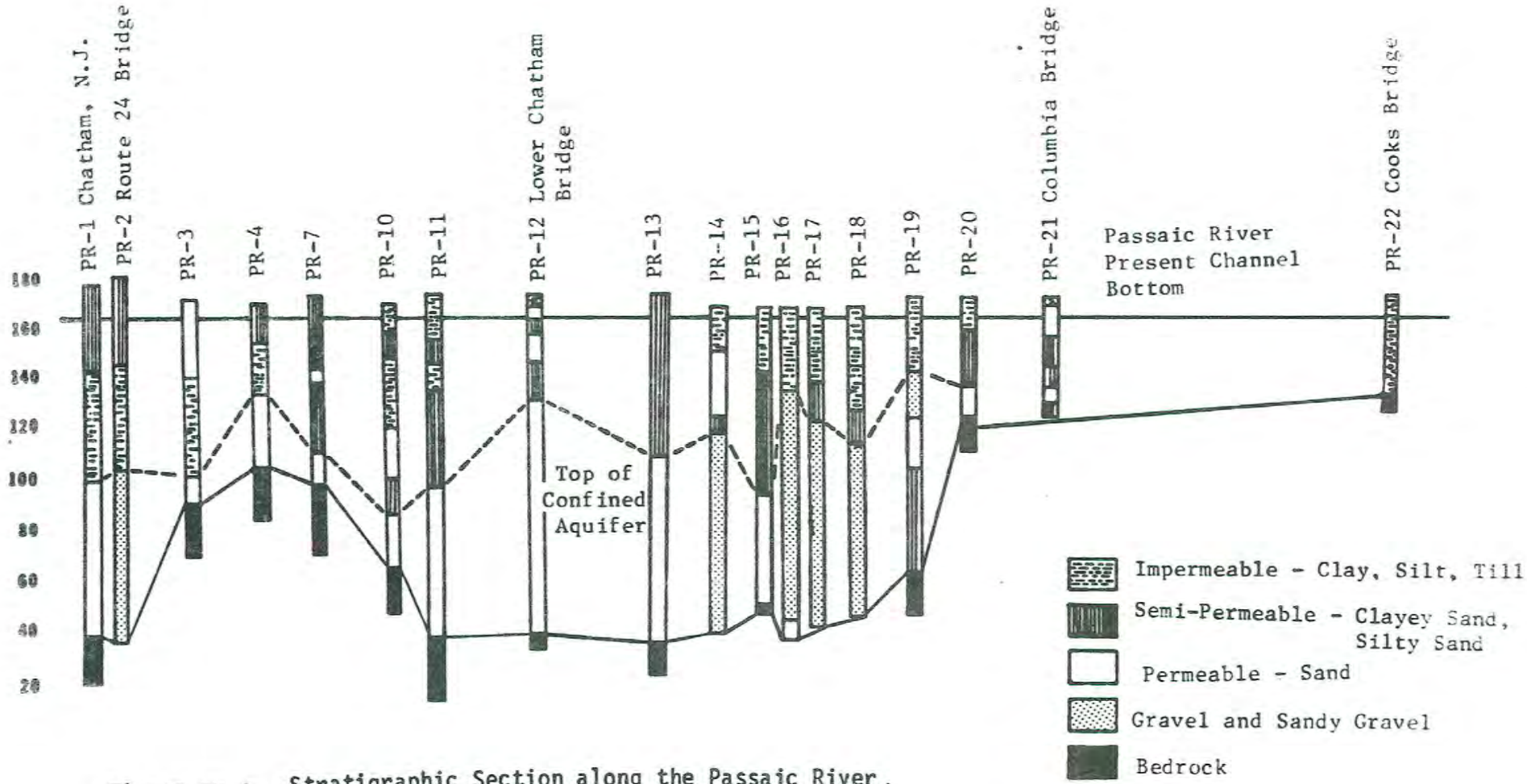


Figure IV-6. Stratigraphic Section along the Passaic River, Chatham to Cook Bridge (Route 10)

Source: Vecchioli and Gill, 1962

were drilled in five areas during the first year of study. During the second year, fourteen test well holes were drilled over a broad area in Chatham, Madison and Florham Park Boroughs (to explore for new resources capable of accommodating major production of wells) (Figure IV-7).

Area 1 was located along the eastern edge of Black Meadows in Florham Park Borough, Hanover Township and East Hanover Township. This area was the most productive of the area tested because of the existence of a very permeable sand and gravel aquifer extending nearly 100 feet in depth. The deepest deposits and thickest productive strata underlie OEP (Office of Emergency Preparedness) test wells 1, 2, and 3 along Black Brook (Figure IV-8). A cross-section through this area is shown in Figure IV-9. The various sediment sequences, although generally similar, illustrate the complexity of glacial deposition (Vecchioli and Nichols, 1966). The logs of existing wells in the area show that the majority have layers of coarse sand and/or gravel that serve as productive aquifers.

Area 2 was located along the western edge of Troy Meadows in Parsippany-Troy Hills Township (Figure IV-10). This area also has a permeable sand and gravel aquifer in the location of the two test wells, where the thickness ranges from 20 to 50 feet. A cross-section of this area is shown in Figure IV-11. While neither test hole 1 nor 2 showed any permeable materials, Production Well 5 (Figure IV-10) located near test hole 3 is very productive. The relationship of Production Well 5 to other parts of the buried valley system was not known (Vecchioli and Nichols, 1966). Existing well logs around Area 2 also show the water-bearing sand and gravel sediments which provide abundant supplies of ground water. The bedrock contours of this area were not well defined.

Area 3 was located along the west side of Interstate 287, north of State Route 10, and south of Lake Parsippany in Hanover and Parsippany-Troy Hills Townships (Figure IV-12). The test holes failed to indicate permeable materials that were thick enough or well enough sorted to serve as aquifers. It was believed unlikely, based on those test holes, that the area had a major buried valley aquifer.

Area 4 also was located in Parsippany-Troy Hills (Figure IV-13). Two test holes were drilled in this area, and one of these was completed as a test well. Neither was completed to bedrock. These tests show that moderately permeable sand and gravel deposits occur to depths of at least 100 feet, under very leaky artesian conditions. Well logs of the three existing public supply wells also show thick layers of sand and gravel.

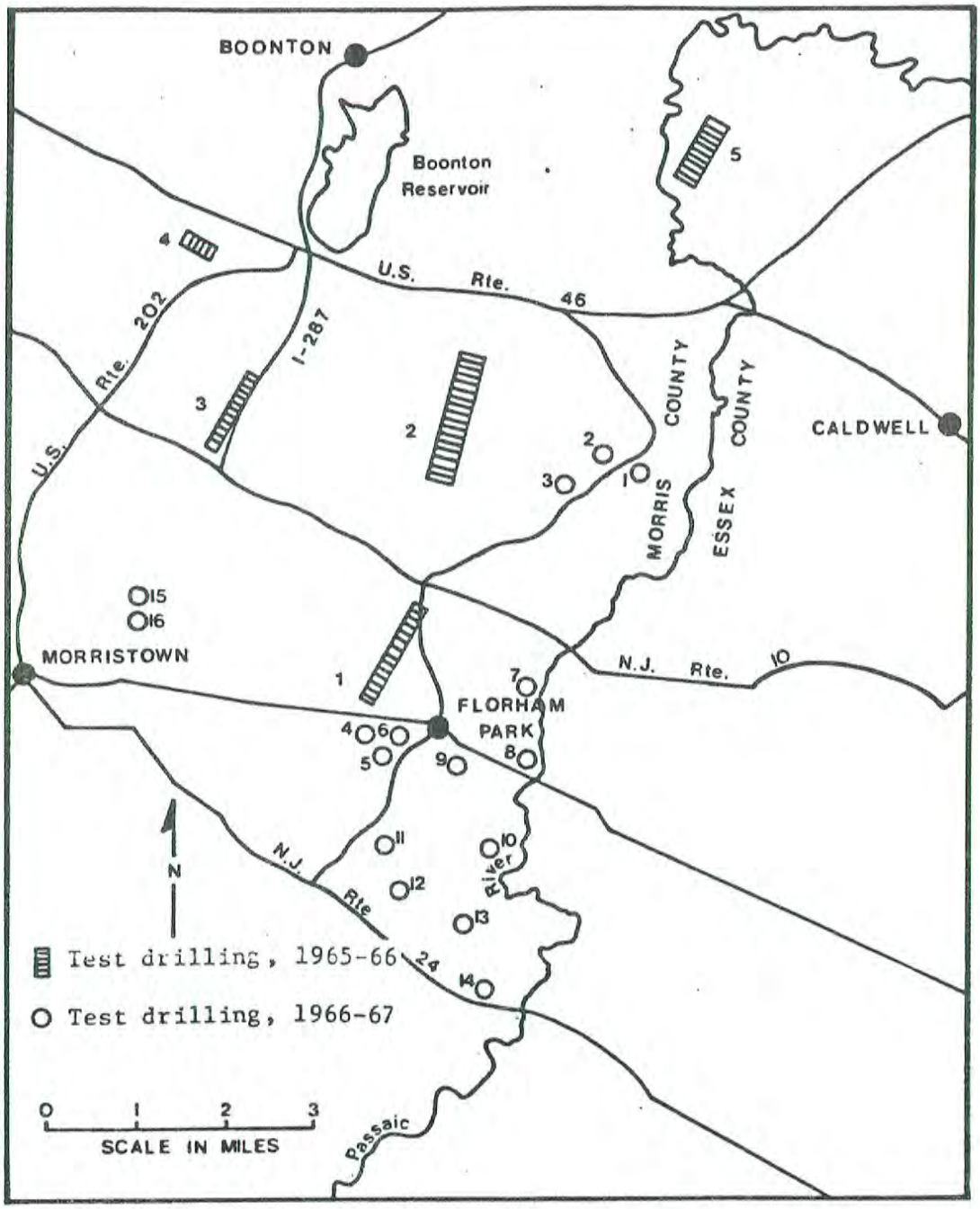


Figure IV-7 Drought Drilling Sites in Morris and Essex Counties, 1965-67

Source: Vecchioli, Nichols, and Nemickas, 1967.

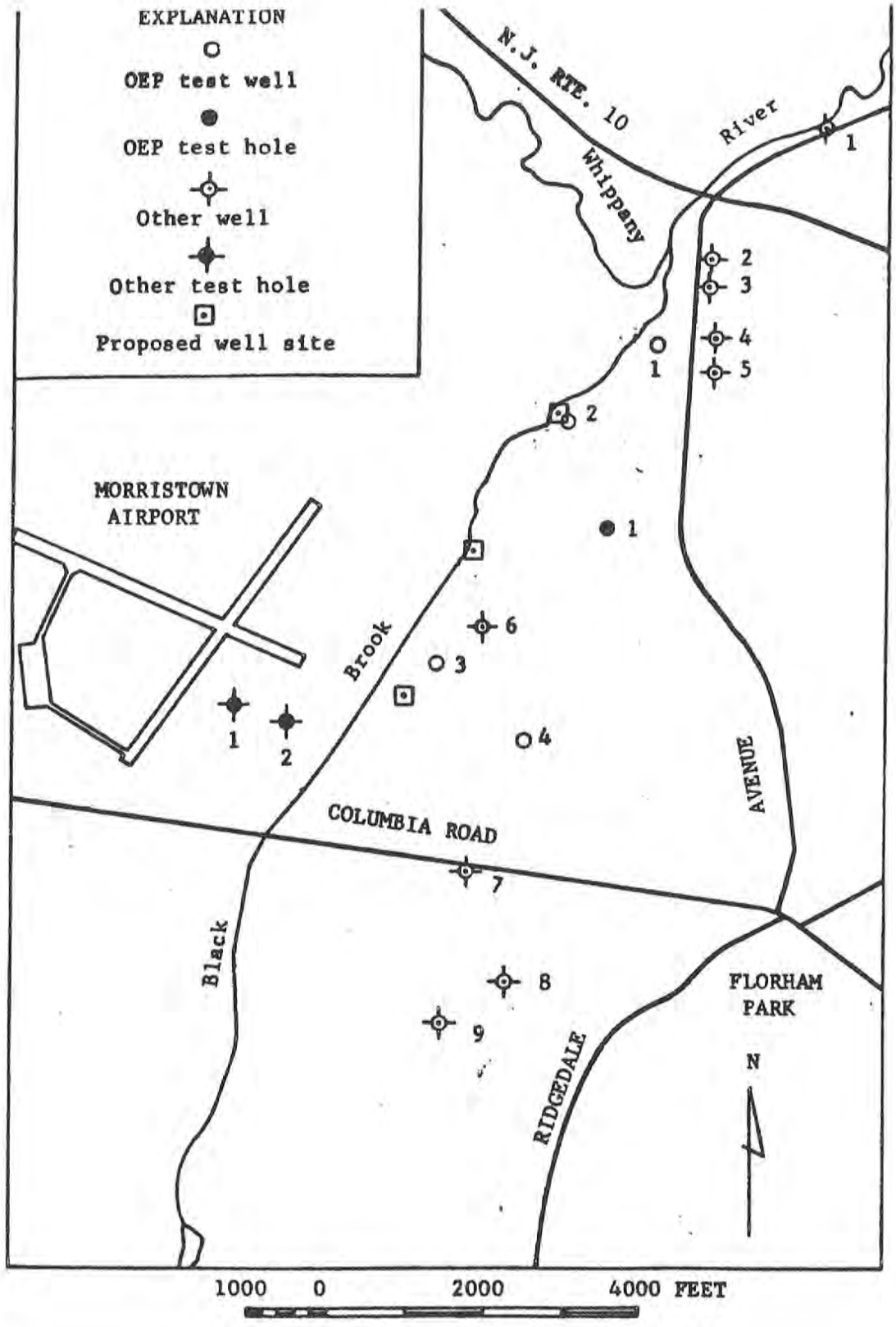


Figure IV-8 Locations of Test Holes and Wells in Area 1

Source: Vecchioli and Gill, 1966.

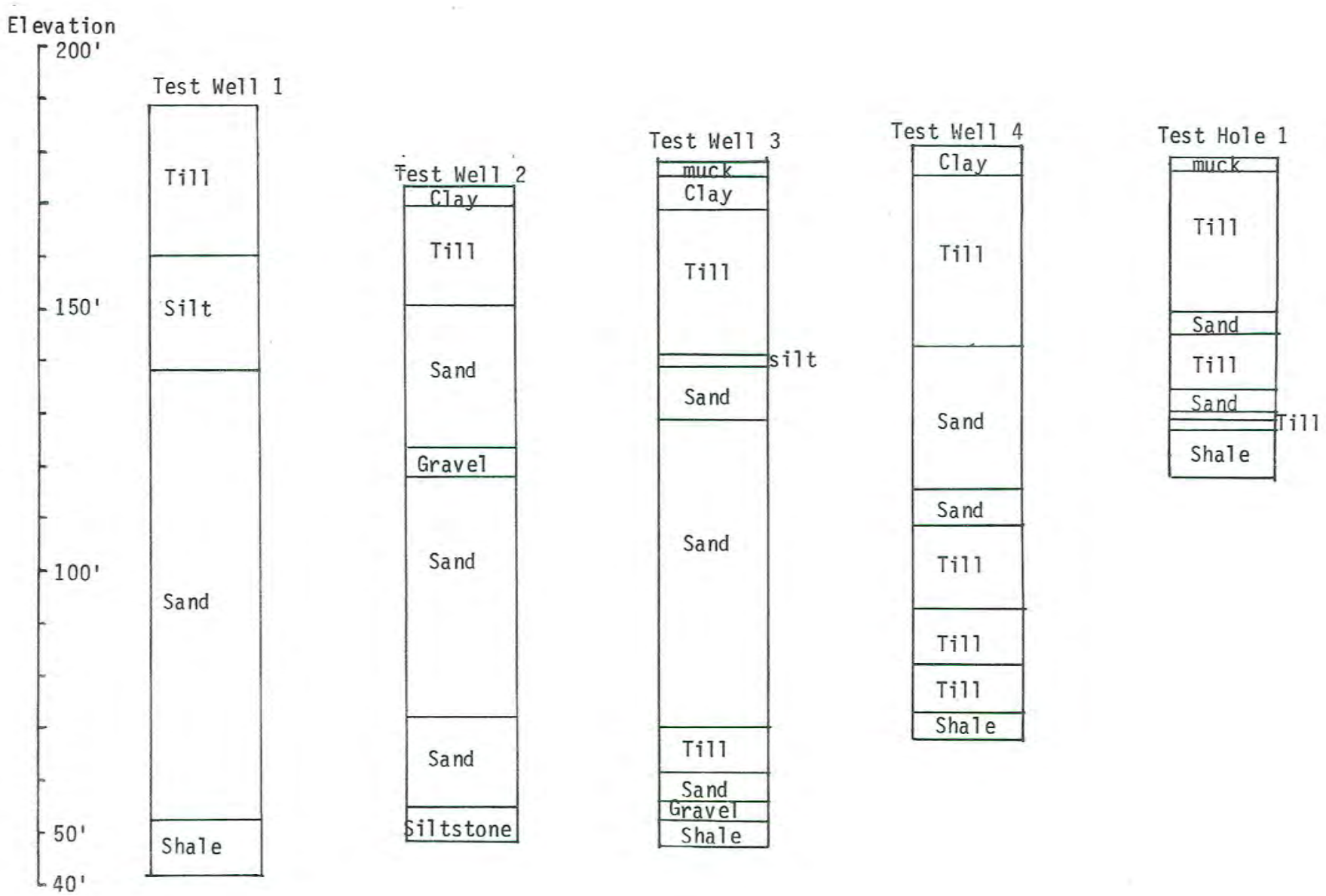


Figure IV-9 Well Logs Through Area 1

Source: Vecchioli and Gill, 1966.

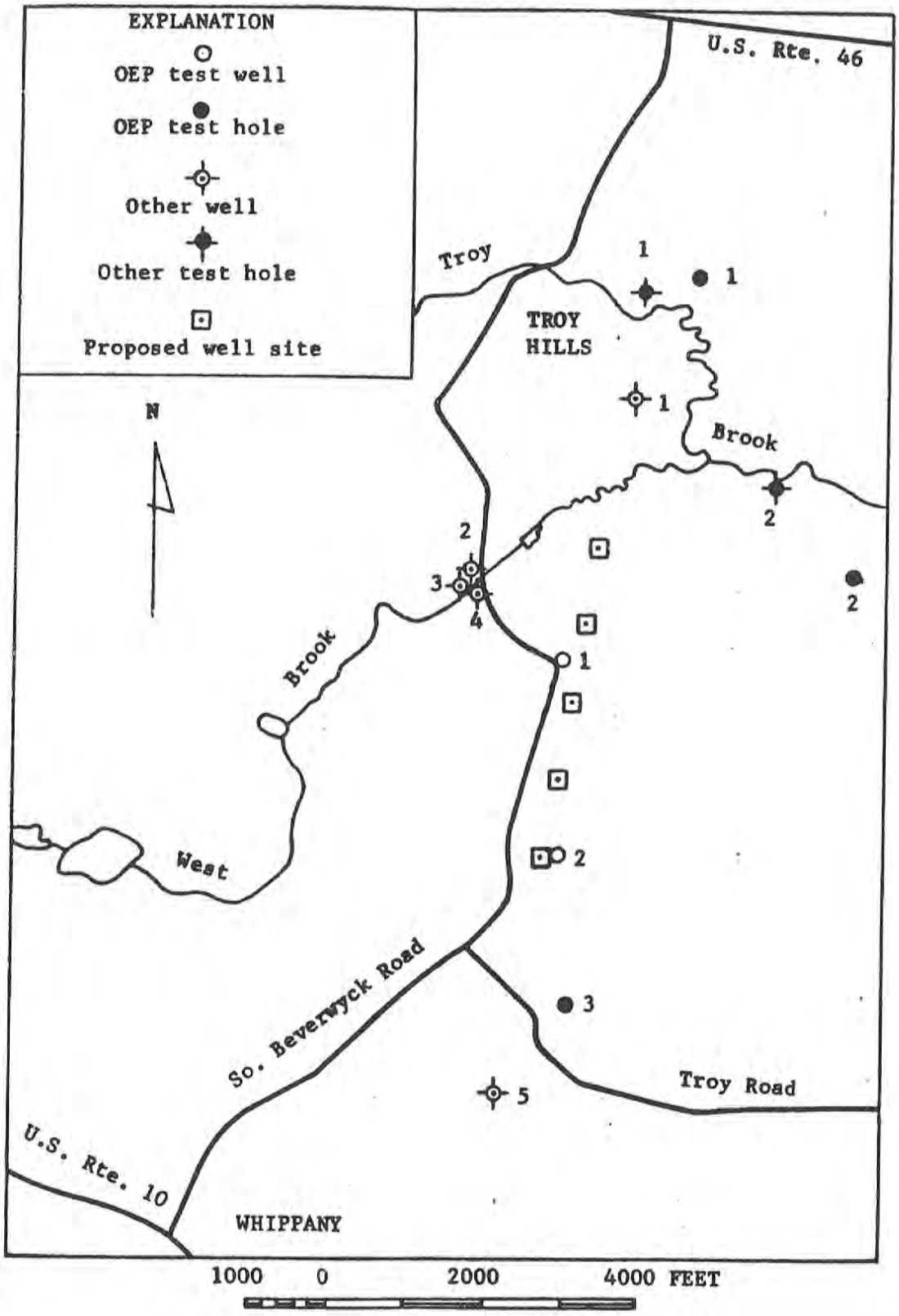


Figure IV-10 Locations of Test Holes and Wells in Area 2

Source: Vecchioli and Gill, 1966.

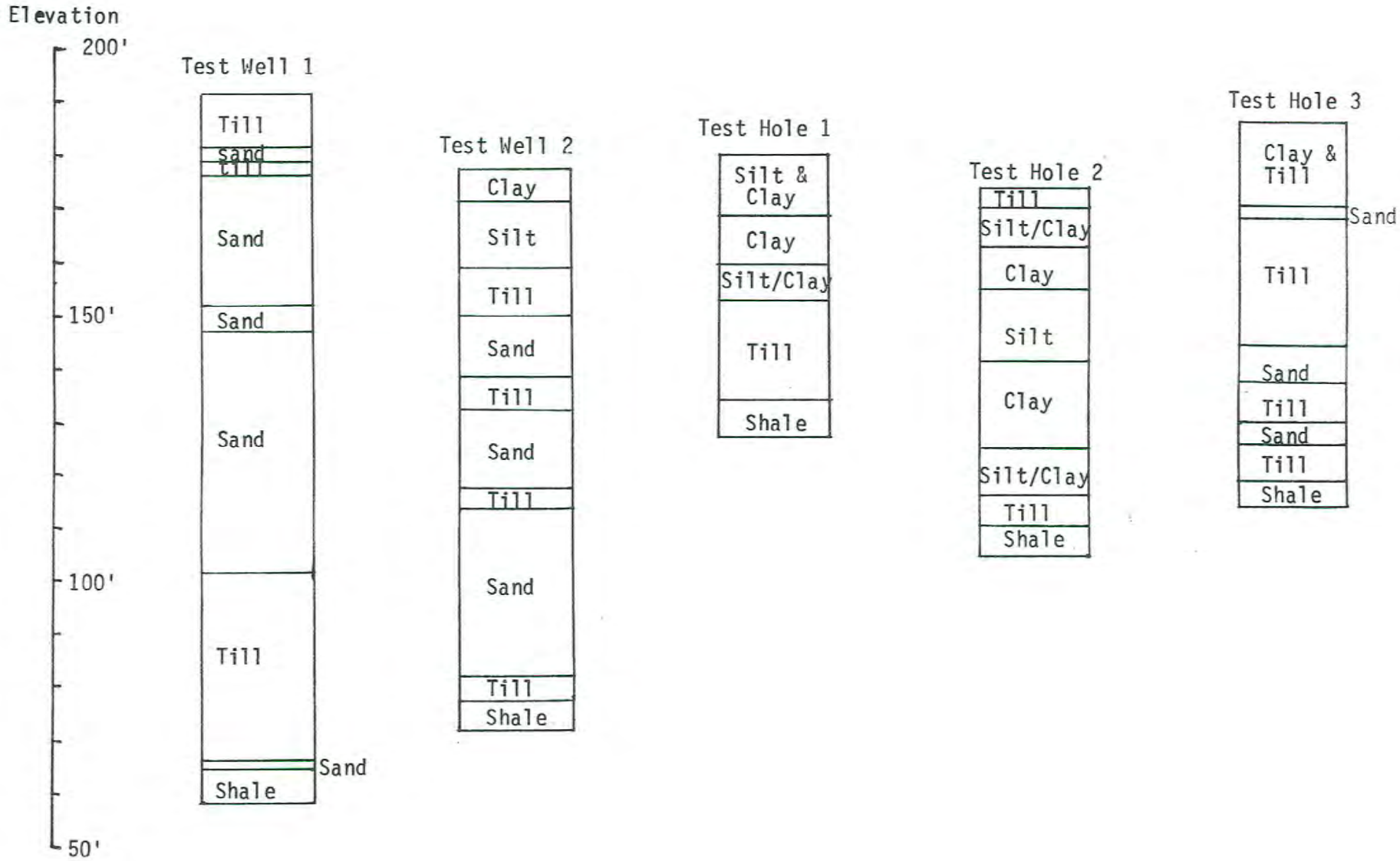


Figure IV-11 Well Logs Through Area 2

Source: Vecchioli and Gill, 1966.

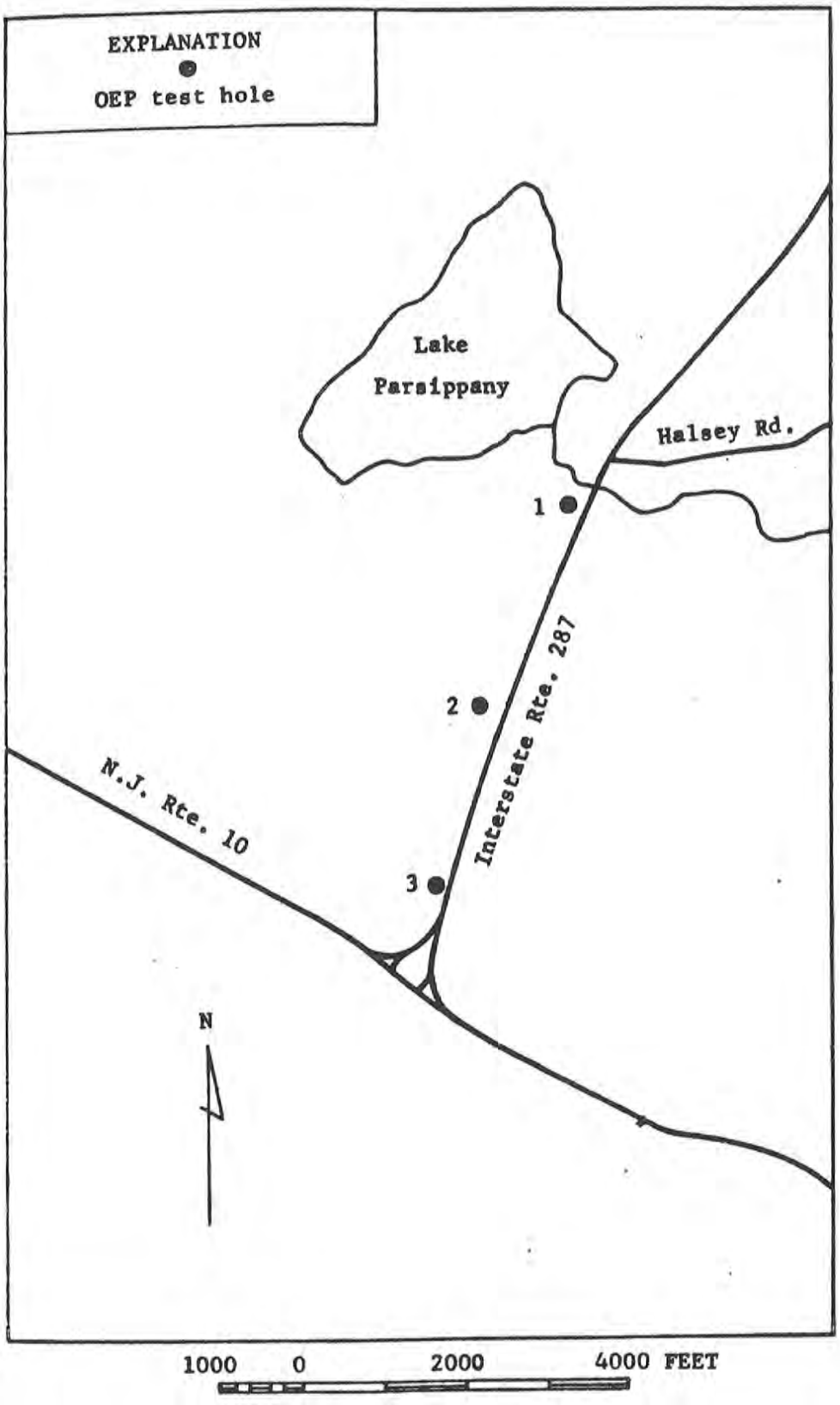


Figure IV-12 Locations of Test Holes in Area 3

Source: Vecchioli and Gill, 1966.

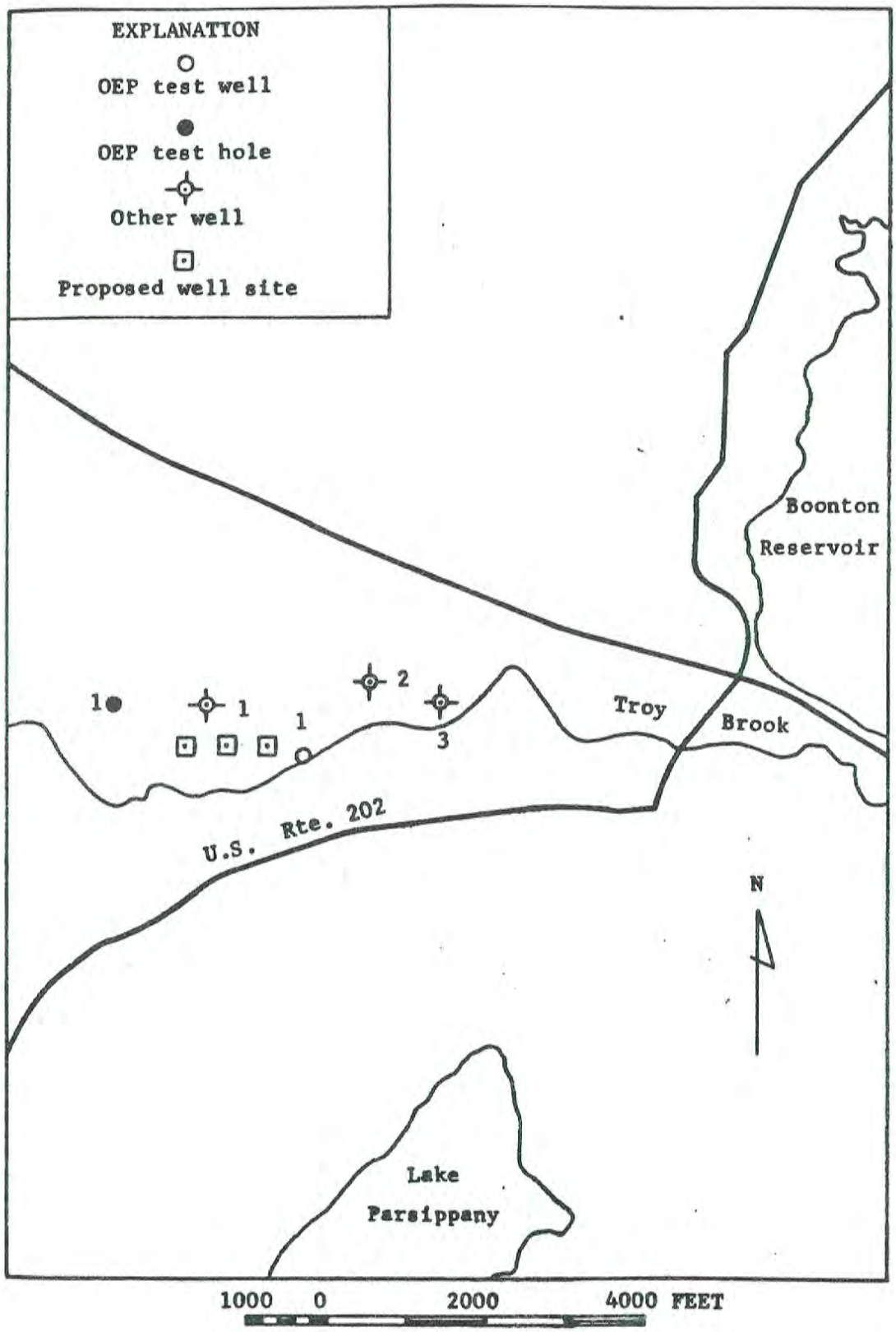


Figure IV-13 Locations of Test Holes and Wells in Area 4

Source: Vecchioli and Gill, 1966.

Area 5 was located in Great Piece Meadows, Fairfield Township, Essex County. Less was known about this area's buried valley than those of other areas. Therefore, a seismic refraction survey was conducted to delineate the deepest parts of the valley.[1] Based on the results of this study, as shown in Figure IV-14, two test hole sites were chosen, but only one was drilled. This test hole did indicate a buried valley, but the materials were relatively impermeable clay and silt (Vecchioli and Nichols, 1966). Wells existing along the eastern portion of Great Piece Meadows, however, are quite productive, indicating the existence of permeable layers in the buried valley channel. In addition, a cross-section from the southern tip of Hook (Towakhow) Mountain across Hanover Neck (Figure IV-15) shows sand and gravel beds with a thickness of approximately 60-100 feet thick.

Of the second year drilling, holes 2 and 3 penetrated thick permeable sand layers, assumed continuous with Area 1 of the 1966 study. As shown in Figure IV-16, the buried valley in East Hanover connects with that of Hanover and Florham Park, with only the segment underlying Route 10 in doubt. The buried valley in Hanover Township was located by the wells in Area 1 of the 1966 tests and further delineated by test hole 4 of the 1967 tests. The findings from test hole 4 also confirmed a connection between the Hanover-Florham Park segment and the major Chatham Buried Valley, which runs southeast to the Passaic River and the well fields in Millburn Township.

Earlier work had assumed a connection between the buried valley underlying the Passaic River (near the Dickinson and Braidburn well fields of East Orange) and that of Hanover-Florham Park (Gill, Vecchioli, and Bonini, 1965). However, test hole 6 from the 1967 study showed no buried valley to exist through that area.

Cross-sections through the area studied by Vecchioli, Nichols, and Nemickas (1967) are shown in Figures IV-17 and IV-18, using production and test wells and test holes. The routes of these cross-sections are shown in Figure IV-16. Figure IV-17 is a cross-section through Florham Park, Madison, Chatham, and Millburn. Figure IV-18 shows a cross-section through East Hanover and Florham Park. Each of these figures shows the elevations of the land surface, the top and bottom of the

[1] The seismic refraction method involves the propagation of seismic waves (eg. through detonation of an explosive charge) and analysis of the velocities of these waves as they travel through various earth materials. The geophysicist can interpret the seismic data and construct a profile of the area in question (Dobrin, 1976).

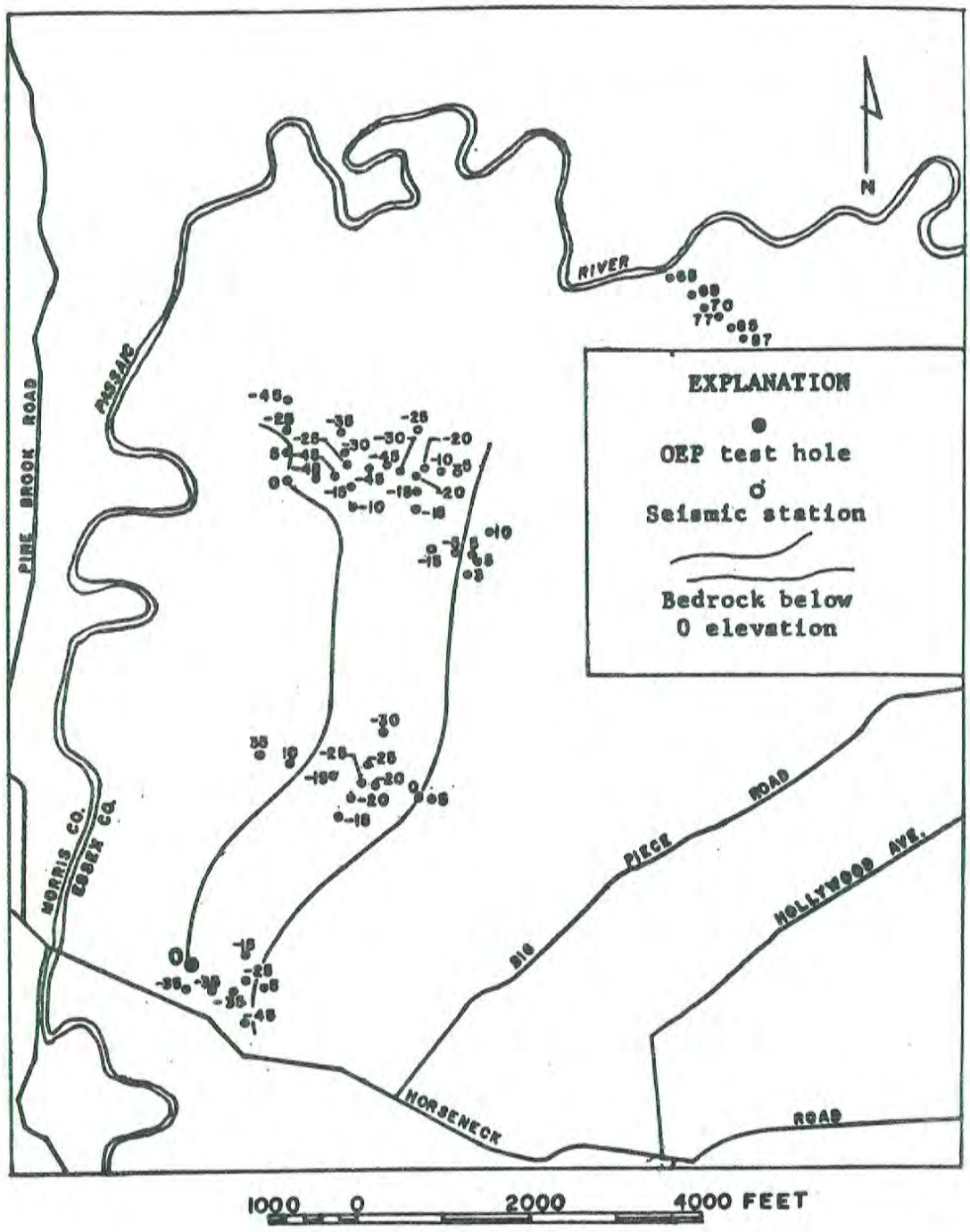


Figure IV-14. Locations of Test Hole and Elevations of Bedrock Determined by the Seismic Refraction Survey in Area 5

Source: Vecchioli and Nichols, 1966.

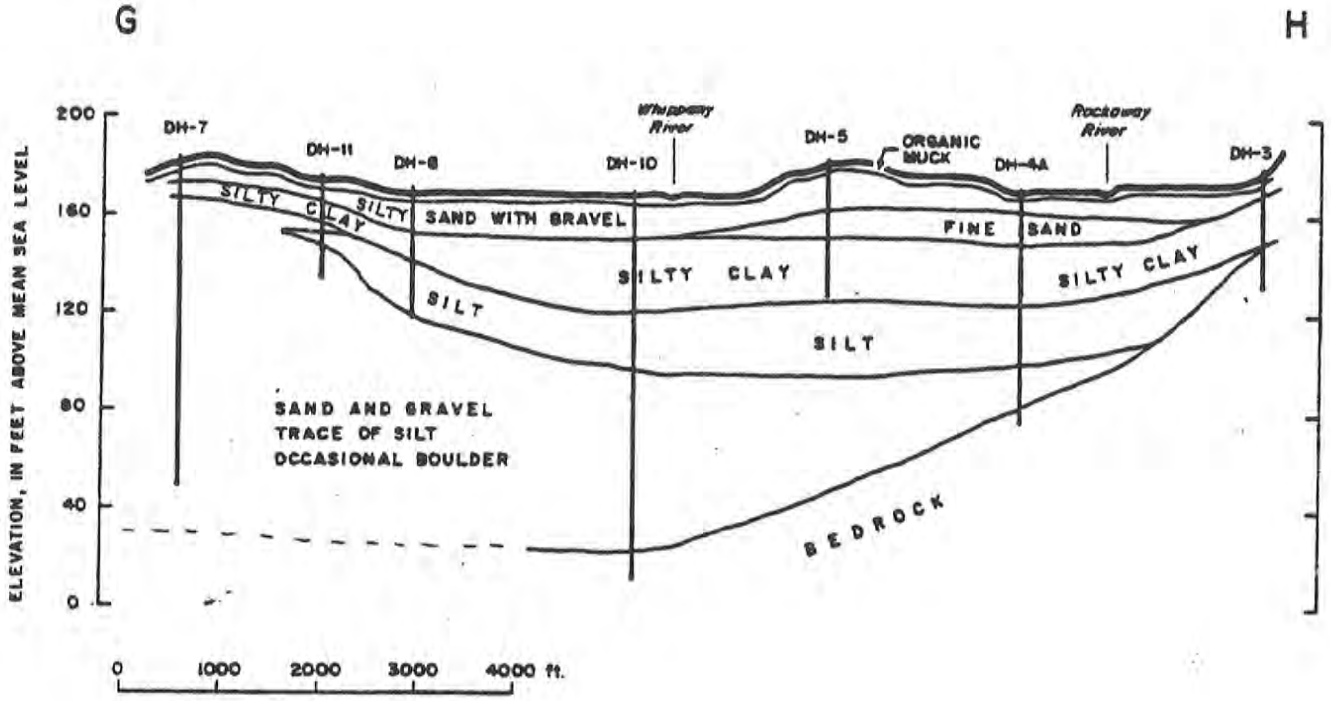


Figure IV-15 Generalized Geologic Section of Valley-Fill Deposits from Hanover Neck to Pine Brook, Morris County

Source: U. S. Army Corps of Engineers, 1979.

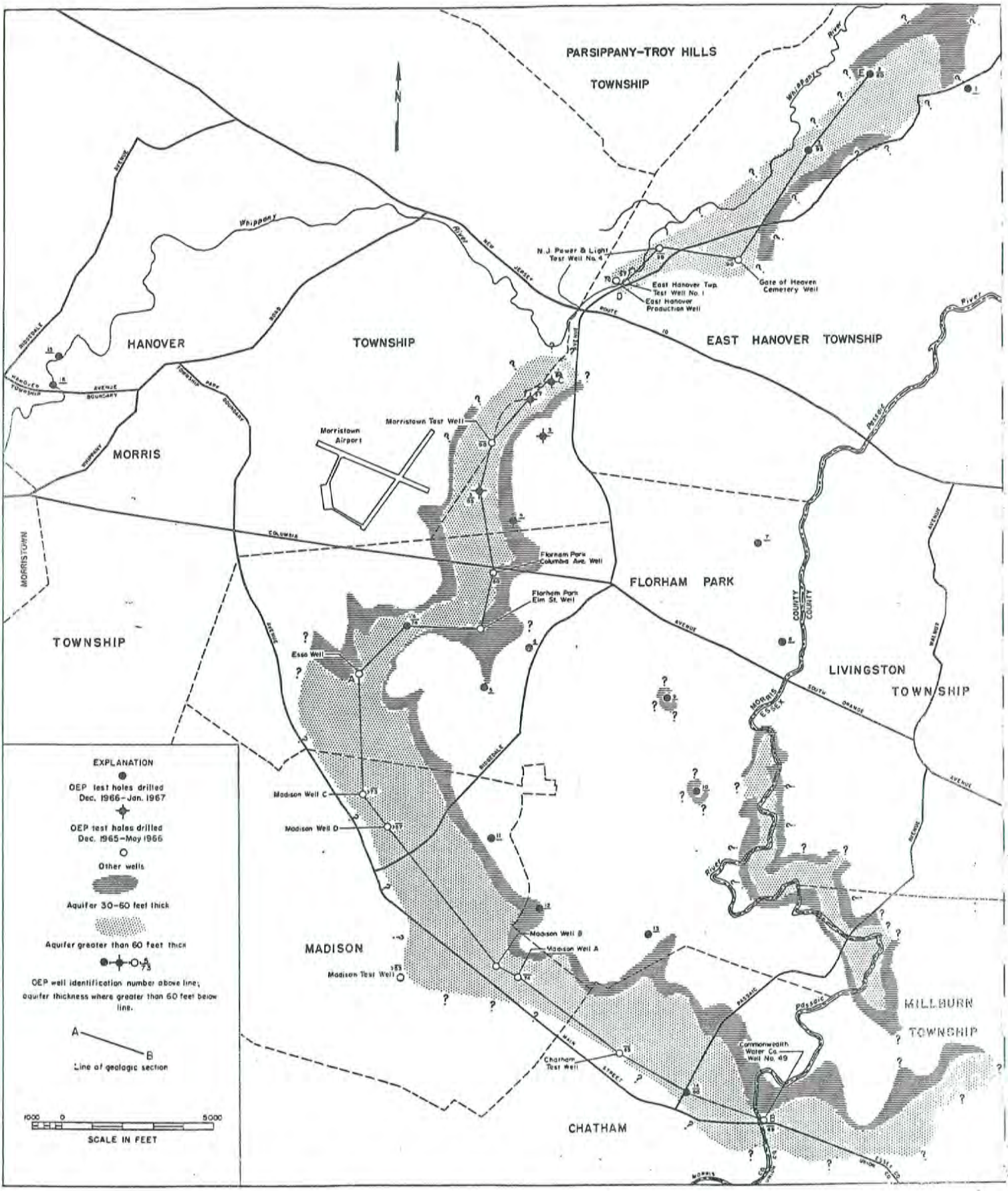


Figure IV-16 Buried Valley Aquifer in Drought Disaster Drilling Area

Source: Vecchioli, Nichols and Nemickas, 1967.

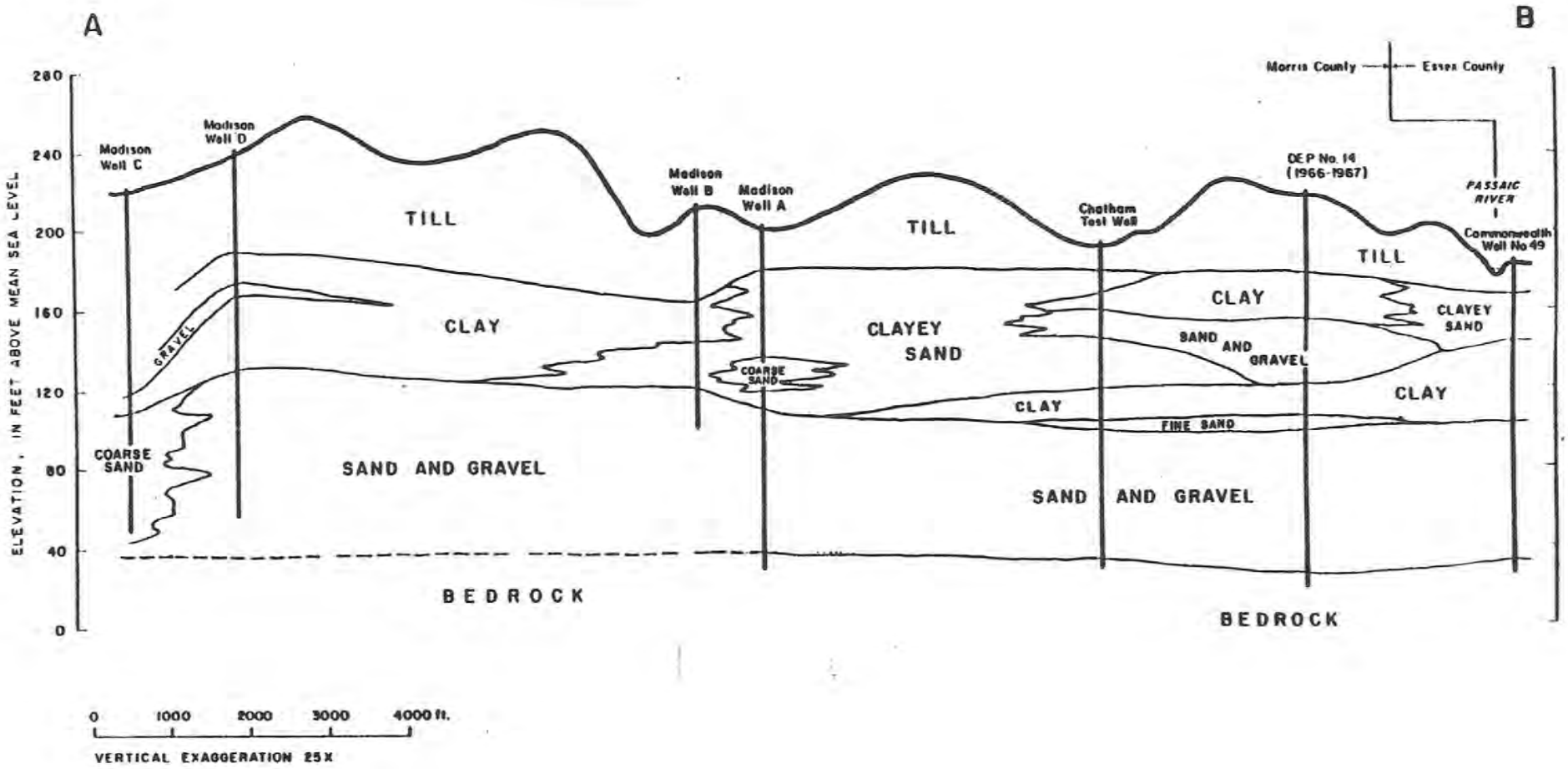


Figure IV-17 Generalized Geologic Section of Valley-Fill Aquifer through Chatham Valley, Morris and Essex Counties

Source: Adapted from Vecchioli, Nichols and Nemickas, 1967, by U. S. Army Corps of Engineers, 1979.

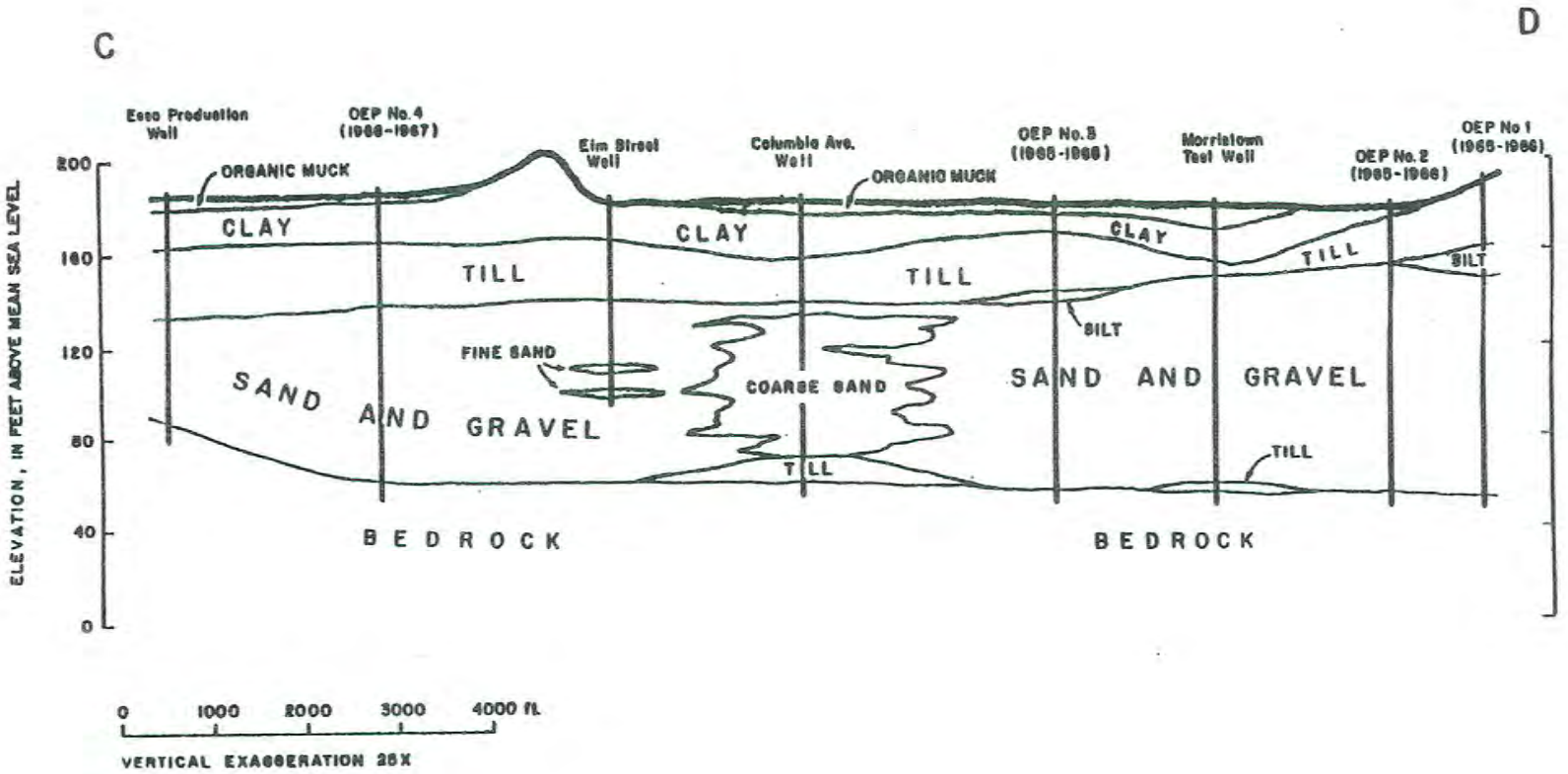


Figure IV-18 Generalized Geologic Section of Valley-Fill Aquifers through the Southern Portion of East Hanover Valley, Morris County

Source: Adapted from Vecchioli, Nichols and Nemickas, 1967, by U. S. Army Corps of Engineers, 1979.

aquifer, the bedrock surface when known, and the type of material penetrated by the test holes and wells. The distribution patterns of the various unconsolidated materials is interesting as well as being instructive of the geologic history of the area. The distribution of glacial till in the logs is especially peculiar: in some areas it overlies bedrock, in others it lies at the surface only, and in others the surface till is overlaid by clay and by clay and swamp muck. In the Morristown test well in Figure IV-18, till is nearly absent.

Nichols map--Nichols (1968b) combined all available data to produce a map of bedrock depth to delineate the extent of several buried valleys, some of which had been named. The Chatham, Millburn, East Hanover, Canoe Brook, and Slough Brook Buried Valleys, and a series of buried valleys in Great Piece Meadows are shown in Figure IV-19.

Meisler study--Figure IV-19 relies in part on a study by Meisler (1976), who used a variety of studies, including Nichols (1968b), to develop a generalized delineation of the buried valleys (Figure IV-20). While the valleys themselves may be delineated with some precision, it is very important to note that the deposits within them vary widely, at times extremely. Few generalizations can be made about the stratigraphy of the buried valley deposits that will apply well to any specific locations. The Meisler study did not include new information on the buried valleys, but did present a USGS computer model developed for the purpose of projecting the available yields from the buried valleys and the effects of increased ground water diversions on the system.

East Orange Water Reserve analysis--Another study on the main body of buried valleys was completed by Geraghty and Miller (1976), involving a water resources inventory and management study for the City of East Orange Water Reserve in Livingston, Millburn and Florham Park. The Reserve is the largest tract of public property in the area that is dedicated to protection of ground water resources. The study further refined the delineations of the buried valleys, developed generalized hydrogeologic sections for the Canoe Brook and Braidburn-Dickinson well fields (Figures IV-21 and IV-22), and proposed a water budget for the system.

Rockaway Valley Research--Until the late 1970's, very little was known about the buried valleys north and west of the areas discussed previously. In 1978 and 1979 Denville, Boonton Township, the Town of Boonton, Montville and Mountain Lakes commissioned four studies of the aquifers in those municipalities. Two major buried valleys were delineated - the Towaco Buried Valley in Montville and the Rockaway

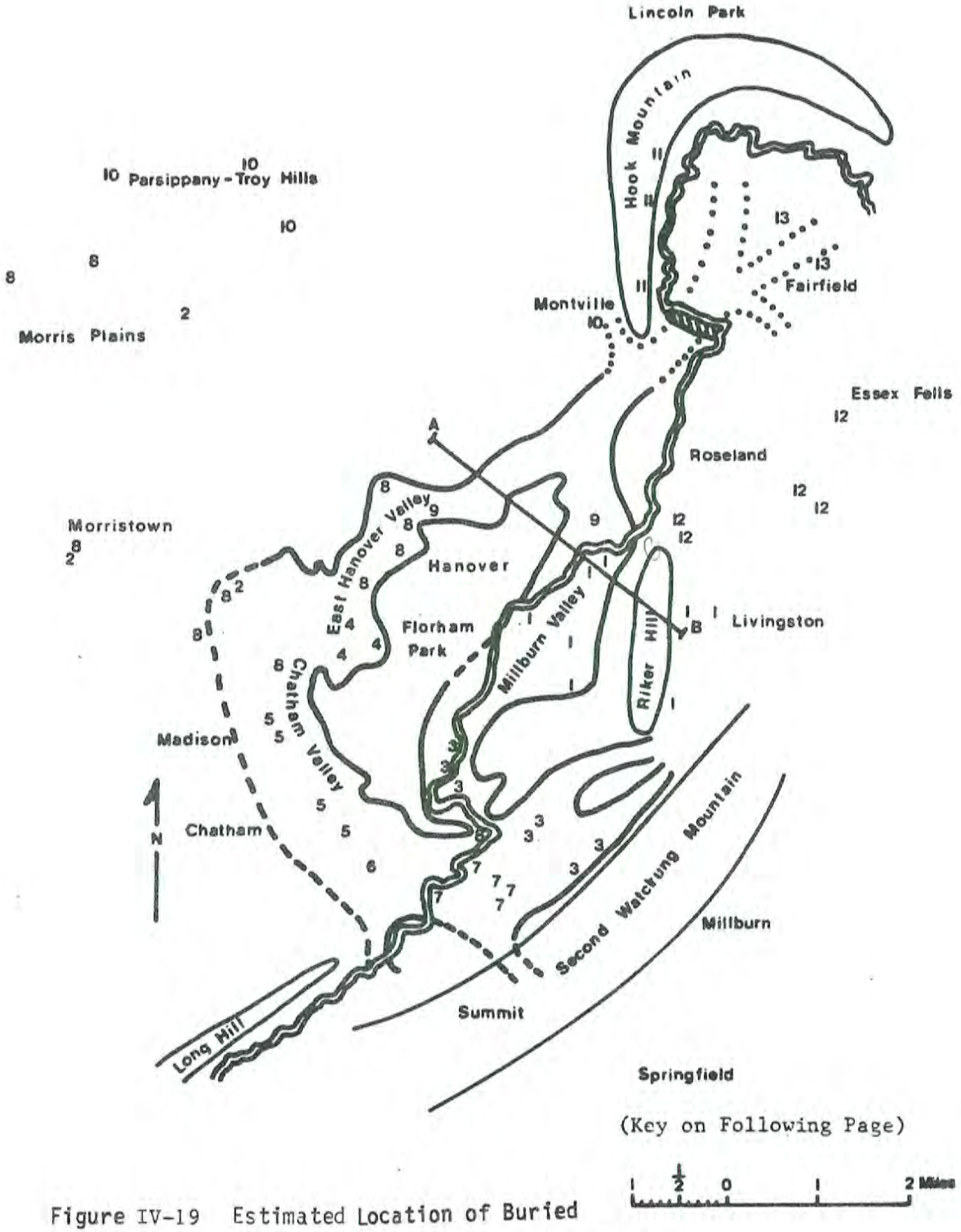


Figure IV-19 Estimated Location of Buried Valley Aquifers, with Well Locations

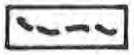
Source: Adapted from:
Meisler, 1976; Nichols, 1968b; Geraghty and Miller, 1978.

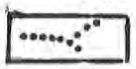
Key to Figure IV-19

(Numbers on map correspond to locations and owners of public supply and industrial wells)

1 Livingston Township Water Department
2 Southeast Morris County Municipal Utilities Authority
3 East Orange Water Department
4 Florham Park Water Department
5 Madison Water Department
6 Chatham Borough Water Department
7 Commonwealth Water Company
8 Industrial Wells[a]
9 East Hanover Water Department
10 Parsippany-Troy Hills Water Department
11 Montville Water Department
12 Essex Fells Water Department
13 Fairfield Water Department

Boundary of Valley-Fill Deposits


Inferred Boundary of Valley-Fill Deposits


Nichols, 1968b- continuation of the buried valley deposits inferred from bedrock topography

Geraghty and Miller, Inc., 1978 - potential recovery of .5 to 1.0 mgd from stratified drift deposits. Should be protected from development until further studies are completed.

Cross-Section Area

Passaic River

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[a] Industrial and private well owners are as follows:

Suburban Propane Gas Corporation, Sandoz Incorporated, Wilbur B. Driver Incorporated, Allied Chemical Corporation, Orange Products Incorporated, Exxon Research and Engineering, Morris County Golf Club.
(Note other well owners may exist but are not listed here.)

Source: Meisler, 1976; Nichols, 1968b; Geraghty and Miller, 1978

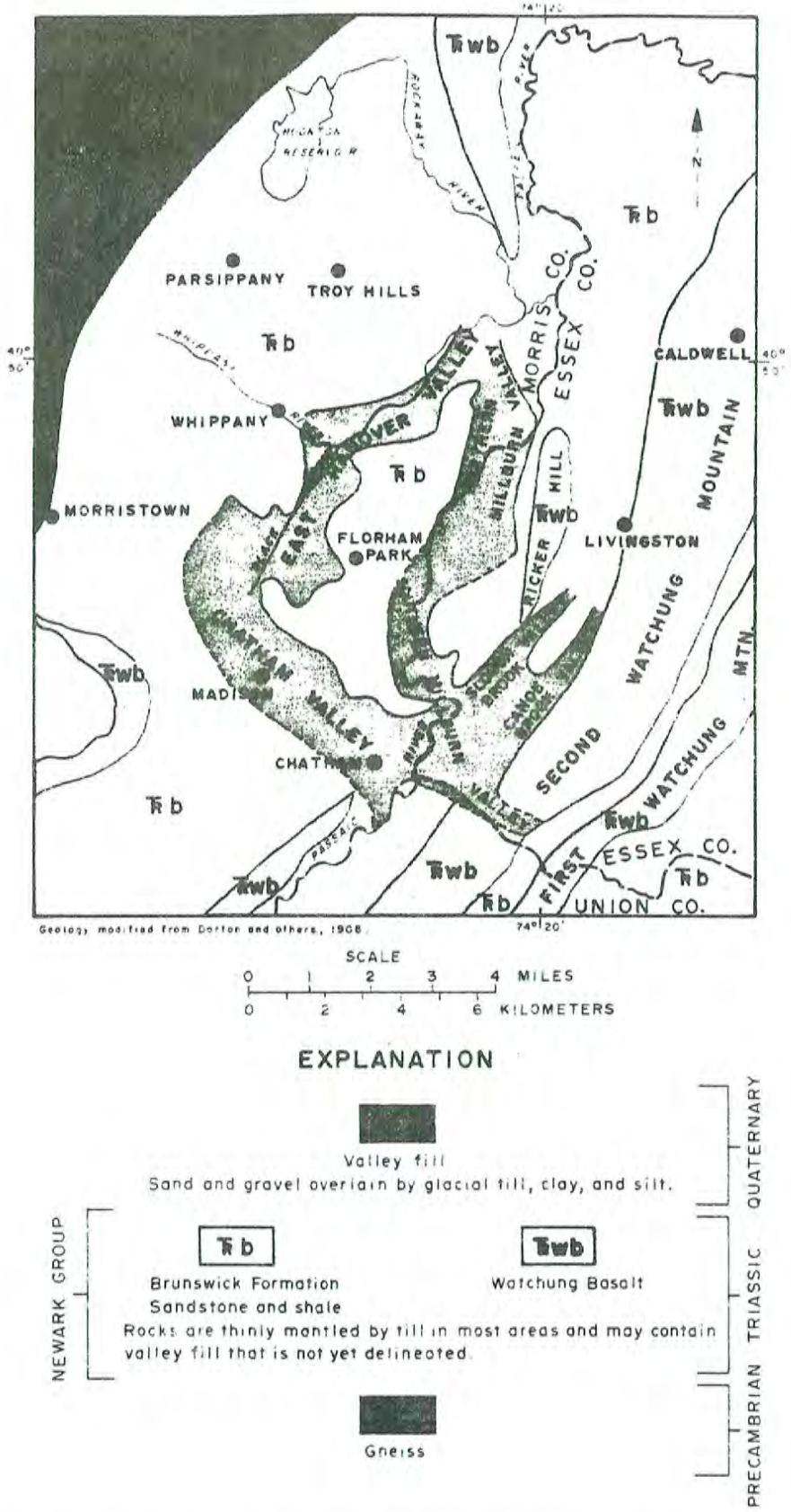
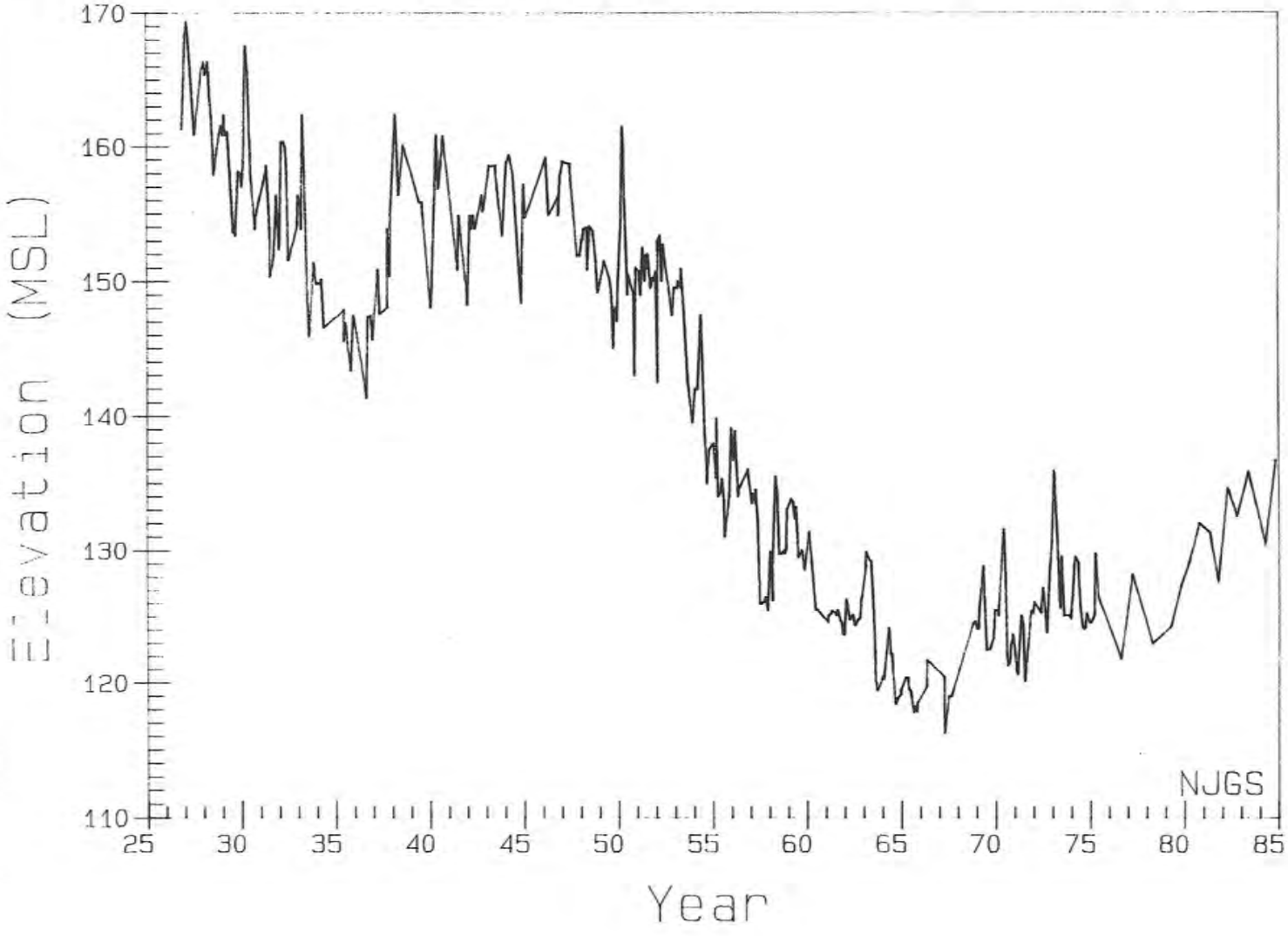


Figure IV-20 Generalized Geologic Map of Southwestern Essex and Southeastern Morris Counties

Source: Meisler, 1976.

Figure V-8. Hydrograph of USGS Observation Well No. 13-14, Neutral Zone Site, Millburn

Source: N.J. Geological Survey, 1986



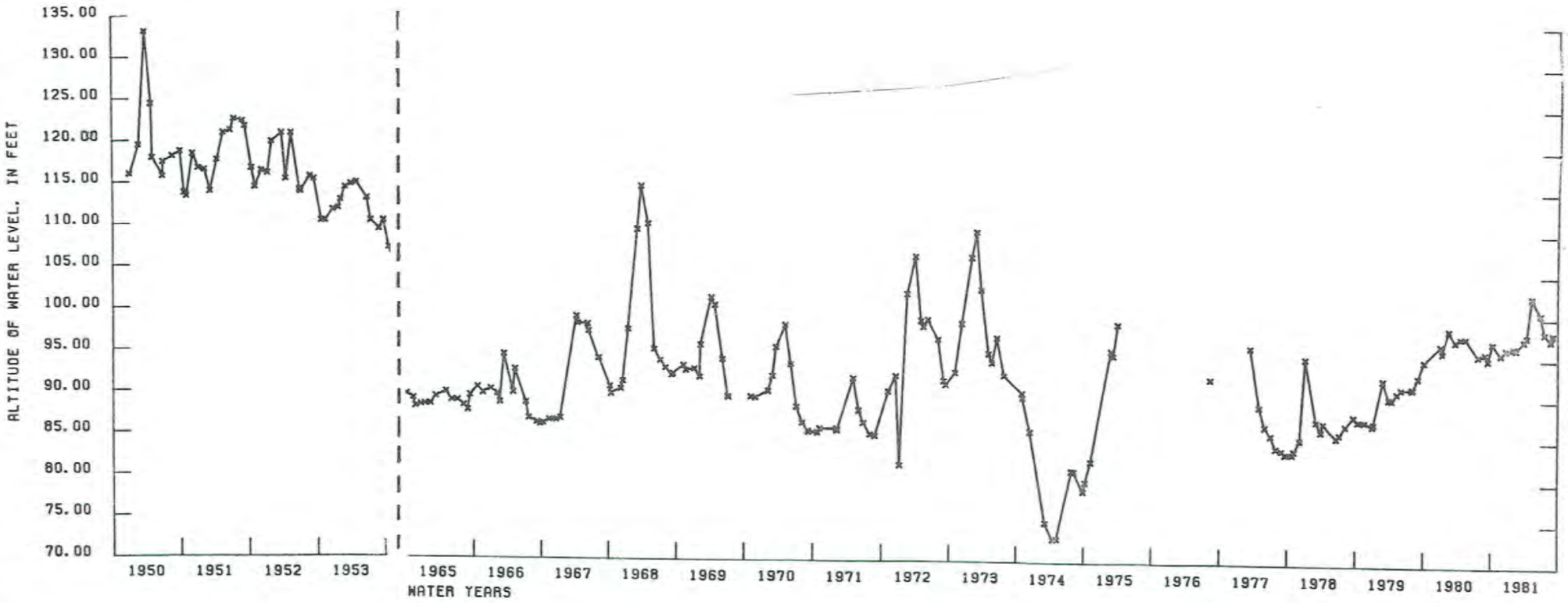


Figure V-9. Hydrograph of USGS Observation Well No. 13-13, Canoe Brook Aquifer

Source: U.S. Geological Survey, 1982.

Braidburn well field still flowed at the surface as late as 1959. A related point is that wetlands in the Water Reserve are supported by surface water and ground water perched at the surface, not by ground water seepage. Given the history of the area, it is likely that the wetlands at one time were supported by ground water.

Considerable interference exists within each well field. Adjacent wells are not pumped simultaneously. Interference with wells outside of the Water Reserve is not a problem, due to the large size of the Reserve. The NJDEP has found that the drawdown on the nearest well from the Canoe Brook and Slough Brook well fields is only 2 feet. The radius of influence for East Orange's wells is quite large, from 1000 feet to over 4000 feet, reflecting the confined conditions of the aquifer and the slower flow of water to rock wells than would tend to occur for wells in the glacial deposits.

In Livingston Township, the Fox (1974) report recommended that no further wells be developed in the Canoe Brook/Slough Brook area, as existing wells plus new East Orange wells would create demands over 5 MGD which might exceed the dependable yield of the area. Monitoring systems were advised to determine dependable yields. Fox recommended development of new wells west of Rikers Hill in the Brunswick Formation near the Passaic River, generally near Eisenhower Parkway. Under ideal recharge conditions, 10 wells yielding a total of 2 MGD were thought possible, with lower effective yields likely. The glacial sediments in Livingston were considered fully developed.

Livingston's static water level records are accurate from 1971 to the present. The static levels trended down through 1982, and then up in 1983-84 and very high despite the drought during the 1984-85 period. Interference effects are show between Wells 1 and 11, Wells 3 and 5, and possibly Wells 9 and 7, though these induce recharge from the river and are less likely to show interference effects. Well 12 interferes with East Orange's wells during drought episodes.

Southern Millburn Buried Valley--According to Thompson (1932), this valley is closely connected hydraulically with the Canoe Brook and Slough Brook Buried Valleys. The Dickinson and Braidburn well fields of East Orange are located here along the Passaic River, north of Chatham. Pumpage from the three valleys is often cited as a single value. The Southern Millburn Buried Valley, however, has a much higher withdrawal capacity. By 1972, over 15 mgd were withdrawn from this buried valley. Meisler (1976) concluded that a slight surplus existed for years of average pumping and normal precipitation, indicated in hydrographs by

increasing water levels since 1971, but warned that the balance was precarious.

Northern Millburn Buried Valley--Less research has been done on this buried valley than the others. However, Meisler (1976) conducted a first-approximation modeling of the aquifer, showing that a probable overpumpage exists (Table V-10). Livingston's wells in this area apparently induce recharge from the Passaic River, which would increase the yields available.

Chatham Buried Valley--Chatham and Madison have long used this valley as an excellent source of water with wells that initially flowed to 100 gpm (State Geologist, 1899). Meisler (1976) estimated that use of the Chatham Buried Valley could almost quadruple to 12 mgd from its 1972-73 use of 3.3 mgd. Hydrographs for the Chatham Buried Valley show the effects of pumping during the drought years with a later rebound (Figures V-10 and V-11).

No water budget exists for the Chatham Buried Valley well fields. The NJDEP does not believe the Chatham Buried Valley to be overstressed, though both Morristown and the southern portion of the East Hanover Buried Valley may be near or over their dependable yields. Static level trends reflect a long-term decline from the original wells, which flowed at ground level, with a recent incline which may reflect a stabilization of the aquifer and ground water demands.

Because of the location of Commonwealth Water Company's well field at the nexus of the Chatham, Millburn, Canoe Brook and Slough Brook valleys, plus the existence of the Passaic River as a source of induced recharge, determination of the water budget will be extremely difficult. If ground water does flow through the Hobart Gap to the Rahway River basin, then water budget calculations will be more complex.

NJDEP notes that the static water levels in the Commonwealth field have been rising recently, indicating some replenishment of the field. The field had declined a total of 53 feet between 1930 and 1965, then rose nearly 20 feet by 1985. Each of the well fields exhibits interference among the wells of that field. Commonwealth is attempting to maximize the productivity of its well fields, especially the Canoe Brook field, through an analysis of interference patterns to establish a pumping protocol.

A study was prepared for Florham Park in 1978 with regard to the development of a new well, but did not extensively analyze the aquifer.

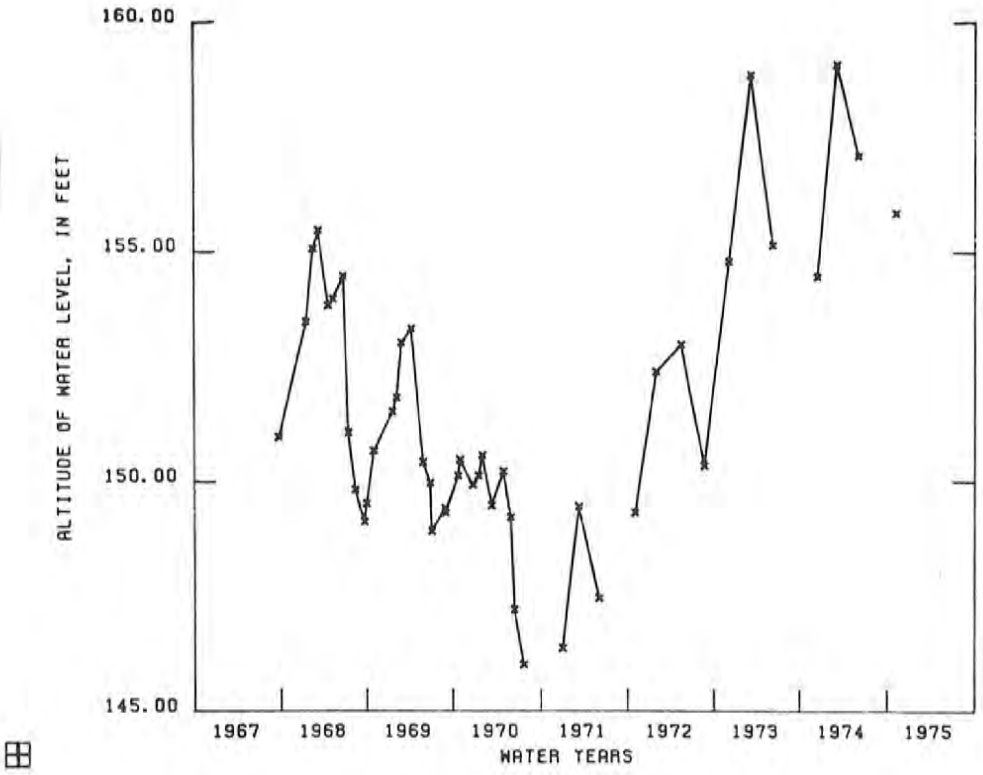


Figure V-10 Hydrograph of USGS Observation Well No. 27-8, Greenhouse Site
Source: United States Geological Survey, 1982

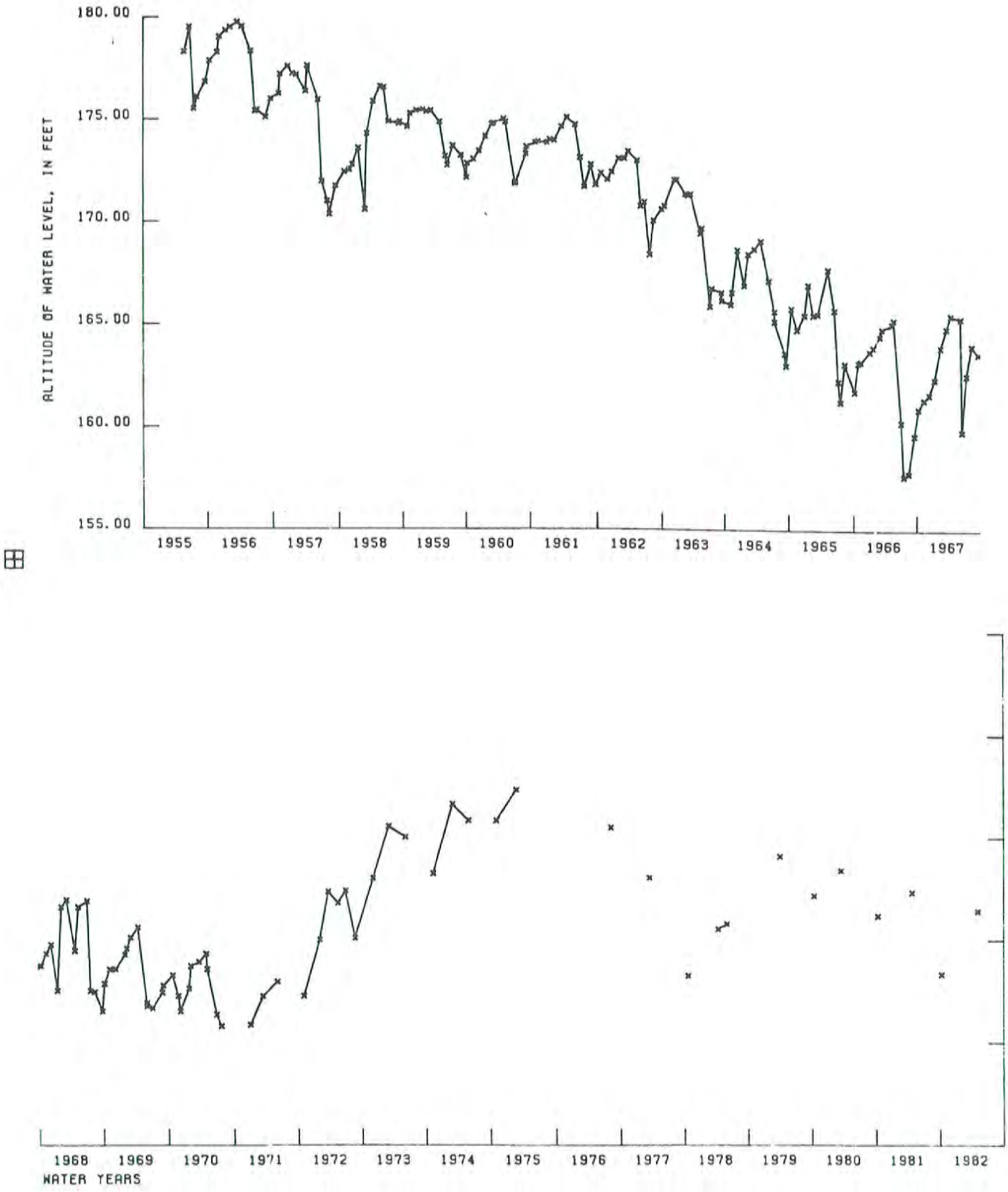


Figure V-11 Hydrograph of USGS Observation Well No 27-17, Madison 4 Site

Source: United States Geological Survey, 1982.

Florham Park has identified a loss in static level of perhaps 1 foot over 10 years, which the NJDEP considers insignificant. Despite an unusually large radius of influence for Well 4 (15,000 feet), no significant interference effects have been noted. Data for Well 4 do indicate drawdown effects of up to 5 feet upon nearby wells during maximum pumping.

The three wells of Chatham Borough, existing as they do in close proximity, interfere with one another but not excessively. No other interference effects are known despite the close proximity of wells owned by Madison Borough (0.5 miles), East Orange (1 mile) and Commonwealth Water Company (1 mile). Static levels in the Madison Borough wells have dropped since the first wells were developed in the 1890's. The first production well, Well 1, flowed to about five feet above the ground level. The old wells were grouped no more than 2000 feet apart on the Station Road property. Recent static water levels for Wells A, B, C and D were 11, 12, 21 and 44 feet below grade. Well E currently has a static level of 54 feet below grade. The NJDEP has not noted any concerns with the long-term static level trends. Madison Borough's records indicate that the static levels had returned to pre-drought levels by 1985 but began to drop again in 1986.

The Madison Borough wells exhibit some mutual interference due to their close proximity. Florham Park recently drilled its Well near Madison Well C which drew down Well C by 1 to 1.5 feet. The Exxon Research & Engineering well is also near Well C.

Recharge of Well Fields

Very little research has been attempted to define the recharge areas of public water supply wells. In most instances, assumptions based on a basic knowledge of the area's geology are the only guide to determining recharge areas. In a few sites, more detailed hydrogeologic work has eliminated potential recharge sites (i.e. where major clay lenses impede the percolation of ground water) or has identified some of the better recharge areas (as in portions of the East Orange Water Reserve). It is reasonable to say, however, that the total knowledge of recharge and recharge areas for well fields is very poor, and that most development actions in the Buried Valley Aquifer Systems have taken place with no acknowledgement of or concern for aquifer recharge.

Rockaway Valley Subregion

Recharge areas in the subregion have not been identified specifically, but the assumed recharge locations include the hillsides on both sides of the river and outcroppings of the valley-fill aquifer where it is not confined as in Boonton's well field and other areas.

Some recharge may occur from the river, up to 50 percent in some systems with shallow wells next to the Rockaway River. Water quality tests taken by Boonton in the 1960's apparently did not show a significant correlation between surface and ground waters, indicating minimal induced recharge. Boonton did artificially recharge the aquifer through a recharge pit located between two wells, using river water. This practice was ended in the 1970's when pumping costs became prohibitive and the reservoir became the primary water source. Boonton has not noticed a detrimental impact on static water levels in the aquifer.

Induced recharge from the Rockaway River is apparently an important source of recharge to wells located adjacent to the river in Denville, Dover, and Wharton, according to various studies.

Ground water moving within the aquifer will recharge well fields, and may be the primary direct recharge source in many areas. However, recharge within the aquifer necessarily derives from surface recharge.

In the Beaver Brook Buried Valley, recharge is assumed to derive from direct infiltration through unconfined northern portions of the aquifer (though these areas are mostly active wetlands, indicating that the water table is too high for percolation), subsurface and fractured bedrock flow from the hillsides, movement through the buried valley aquifer itself, and recharge from the unconfined sediments east of the buried valley channel.

Upper Lamington Subregion

The determination of recharge areas is complicated by the lack of congruity between surface water divides and ground water divides. The limestone formation apparently bridges the Lamington/Rockaway Rivers surface water divide and may in fact discharge in the Rockaway River watershed. The stratified drift deposits may also bridge into the Rockaway River watershed and either discharge to the Rockaway River, to the Lamington River, or both, but the ground water divide may not match the surface water divide. In addition, the upper and lower aquifers may

not have the same ground water divides. The Woodward-Clyde report indicates that bedrock slopes upward toward the north, while the NJGS report indicated that the ancestral valley of the Rockaway River flowed north from the present Upper Lamington watershed. This appears to be a fundamental conflict which must await further investigations.

Despite these unknowns, recharge to the aquifers does occur from the surface within the Upper Lamington watershed, especially along the sandy soils at the valley floor and in low slope areas. Recharge of each aquifer also likely occurs from the overlying aquifers. Recharge of the Alamatong well field also occurs from the lateral flow of ground water through the aquifers utilized by the five wells.

Towaco Valley Subregion

All of the recharge areas for the Towaco Aquifer are entirely within the valley and the surrounding watershed, which limits the yield of the well field. The surrounding watershed is primarily sloped with a basalt or gneiss bedrock, while the valley floor itself has mostly sandy soils.

Northwest Essex Subregion

Little is known about recharge to the aquifers. The glacial deposits are probably contiguous to the underlying bedrock. Recharge from percolation to fractured bedrock along the slope of the Watchung Ridge is likely the major source of recharge. There is some possibility of recharge along fracture lines between shale and basalt which enters the aquifer on the east side of the ridge and passes underneath the crest to the west. Recharge of the aquifer in Fairfield is assumed to derive from higher ground of the Watchung Ridge. Some recharge does occur through surficial deposits in Fairfield itself.

Whippany-Lower Rockaway Subregion

In the East Hanover Buried Valley north of Route 10, the aquifer does not derive significant recharge from the Whippany River, according to an analysis by Geraghty & Miller (1986), due to the clay layer which separates the river from the underlying aquifer. Also due to the clay layer, the radius of influence for all three East Hanover wells is expected to extend under the Whippany River. (This same clay strata has been mapped at the confluence of the Whippany and Rockaway Rivers at the

Sharkey Landfill Superfund site.) Recharge to the aquifer is most likely due to the infiltration of precipitation in the stratified deposits within the area.

Most of the recharge in Mountain Lakes probably is from the flow of ground water downgradient along the Rockaway buried valley. Some recharge occurs through the soils and stratified drift deposits within the Borough. Recharge of Parsippany's wells derives from different sources according to the well location. The infiltration of precipitation is likely an important source, considering Parsippany's large area (25 square miles). The Troy Brook Buried Valley probably receives substantial recharge from lateral flow through the buried valley aquifer, if the connection with the Rockaway Buried Valley proves correct. The buried valleys probably also receive recharge from the underlying bedrock.

In the well field areas of the Southeast Morris County MUA, recharge for the semi-confined buried valley aquifers is assumed to be primarily from the adjacent bedrock aquifers, flow from along the hillsides leading to the valleys, and flow from upgradient portions of the aquifers. The Triassic aquifers are primarily recharged from direct infiltration of precipitation.

Chatham-Millburn Valleys Subregion

Recharge for the wells of Chatham Borough and Madison is assumed to be from the terminal moraine area to the south and regionally from the bedrock and Chatham Buried Valley.

The City of East Orange has conducted some research on recharge areas within its water reserve. These areas may also serve to recharge the aquifers tapped by Commonwealth. Significant recharge probably occurs on the slopes of the Watchung Ridge. The shale/basalt interface is likely to be shattered and permeable. Induced recharge from the Passaic River and the flow of water through the buried valleys to the well fields also are significant sources. It is generally assumed that the aquifers (glacial and Brunswick) are contiguous and exchange water based on the location of wells or the natural hydraulic gradient. While generally true, some of East Orange's wells encountered confined shale aquifers and dramatic water quality changes (i.e. higher sulfur or lower hardness). Finally, recharge within the Reserve does occur through sand outcroppings and less permeable deposits. Extensive clay lenses exist, slowing water movement, but the large area makes extensive recharge

possible. The relative contributions of these sources to recharge are not known.

The Slough Brook Buried Valley cuts north to south through the middle of Livingston and supports five Livingston wells before it enters the East Orange Water Reserve. Recharge is most likely from the underlying fractured bedrock, which in turn recharges from upgradient areas along the Second Watchung Ridge. As Roseland tends to slope toward the northwest and Livingston's streams slope southwest, it would seem that the contributing area is confined to the central, northern and western portions of Livingston and some of southern Roseland. Fox (1974) concurs, stating that most of Livingston's recharge results from infiltration within Township boundaries. Most of the valley and lower slope area is already developed, primarily for residences on sewers. The undeveloped crest of the Second Watchung is owned by the Kean family (Northfield Ave to Route 10, east of Shrewsbury Road) and development corporations (Route 10 to Roseland, east of Shrewsbury Road). Both are active targets for development.

The Canoe Brook Buried Valley and the Brunswick aquifer appear to be hydraulically connected, unlike the shale and glacial deposits along the Passaic River sediments, according to Fox. The Southern Millburn Buried Valley under the Passaic River is probably recharged mostly by the river and somewhat from the side slopes in East Hanover and Livingston.

Drought Impacts in the Buried Valley Aquifers

Droughts of Recent Decades

As discussed in Chapter III, the effect of droughts is different on aquifers than on surface water reservoirs. The slow flow of ground water, the existence of aquifers under pressure and the large reservoirs of ground water (relative to the diversions) result in slowed reactions to droughts. Unless a large well is located in a small aquifer, static water levels tend to remain stable during the initial periods of a drought (often for over one year in the buried valleys) and only then to decline in relative proportion to the severity of the drought. Recovery periods express a similar lag and occur in proportion to the bounty of new precipitation. The drought of record for the Buried Valley Aquifer Systems is (as for surface water) the drought of 1960-65. Hydrographs from monitor wells in the region clearly show the declining levels during and after that period. The 1970's were generally a period of

high rainfall. Two relatively small droughts have occurred recently in 1980-81 and 1984-85. Declines in static water levels were moderate compared to the 1960's drought, in locations where static levels were recorded during both droughts.

Long term comparisons of the lag effects of well fields affected by droughts could have assisted researchers in determining changes in the recharge and capacity of aquifers over time, due to development and other actions. Unfortunately, very few major wells were monitored even as far back as the early 1970's and almost none were monitored in the 1960's and before.

Effects on Major Wells

Many of the public water supply systems lacked procedures to monitor static water levels regularly during the drought of the early 1960's. Only the relatively minor and short-lived droughts of the early 1980's have been monitored in the large portion of the region. Based on discussions with personnel and consultants, this section explores the effect of prolonged precipitation reductions (droughts) on public supply wells in the Buried Valley Aquifer Systems.

Rockaway Valley Subregion--Static water level records have been collected by Boonton only since enactment of the 1981 Water Supply Management Act. During the 1980-81 drought, no significant water level changes were noticed in the well field. A voluntary ban on outdoor water uses plus water conservation requests were implemented by Boonton to reduce demand upon the reservoir and well field. Denville reports that static level changes in its wells during the 1980-81 drought were minimal. Dover also reports that its well field is not significantly affected by drought conditions. It may be that the well field is more reliant on induced recharge from the Rockaway River during these periods. The same may be true of Rockaway Borough, which reports that no major drought effects have been seen.

Small drought effects have been documented for the Rockaway Township well field, with up to 10 feet of drawdown and then quick recovery after precipitation resumes normal levels. During the same drought period the NJDEP drew 2 MGD from deep mines in Rockaway Township to supply flow to the Rockaway River. The withdrawals caused a mine shaft drawdown to 1200 feet below grade, 1000 feet of which was recovered in the next 4-5 years after pumping ceased. The net effect on the aquifer is unknown.

In Wharton Borough, static water levels recede as the river flow reduces during droughts. The effect occurs slowly and is not extreme. The 1960's drought resulted in a drop of 5 to 7 feet in static water level, in the presence of reduced pumping. Recovery is achieved in a matter of weeks after river flow increases.

Upper Lamington Subregion--Drought impacts have been recognized within the Alamatong well field. The effects were especially notable for point wells drilled in the surficial aquifer for private residences. The drawdown from the two shallow MCMUA wells caused the most shallow residential point wells to lose capacity during drought periods. MCMUA has redrilled some wells and has connected other residences to public water to compensate for the drawdown effects. Wells 1 and 2 initially had static water levels of 10 feet below grade, and now have static levels of 18 to 21 feet. These are the shallowest wells and most affected by drought. The deeper wells, however, do track the trends of the shallow wells for static level increases and decreases. Well 4 is least affected (there are no long-term data for Well 5). The NJDEP requires that the MCMUA draw preferentially from the lower aquifers when stream flow in the Lamington River is low, to reduce the impacts of drought in the shallow aquifers.

Roxbury Water Company did not monitor its static water levels until very recently, and therefore no record exists to determine drought impacts on the well field.

Towaco Valley Subregion--Montville experienced some supply problems during the 1984-85 drought and implemented a low-intensity water conservation program. Wells 9 and 10 are close together but do not interfere with one another, however, they require redevelopment, having lost gpm yield due to aging. Redevelopment is anticipated in 1986 and 1987. Well 11, developed in 1985 as a complementary supply, is expected to eliminate drought problems.

Northwest Essex Subregion--Unlike most systems, Essex Fells has twenty years of static water level data. Droughts effectively foreclose the use of the West Caldwell wells, and also Well 2 (in the golf course) which has a very small recharge area and limited storage capacity. Otherwise, drought impacts are seen but the wells recover after each drought period. Records from the severe 1960's drought indicate that the well system (when no wells are off-line due to contamination) can produce sufficient water during a drought.

In Fairfield, drought effects are limited, with a slight drawdown in a couple of wells and no significant drawdown otherwise, over ten years of recorded data. Fairfield is located farthest down the gradient from the Watchung Ridge and reaps the advantage of its favorable aquifer location.

Whippany-Lower Rockaway Subregion--Mountain Lakes Borough reports that drought effects on its wells are minimal. A similar situation exists in East Hanover, where Well 5, the smaller of the two wells, exhibits very little drawdown during drought periods and Well 2 shows no drought effects.

In Parsippany-Troy Hills Township, drought effects on the wells are minimal, except for Well 3 which apparently draws from an isolated pocket of glacial sediments. When local recharge is limited by drought, Well 3 yields decline significantly. Sufficient capacity exists from non-sensitive wells to make up for the loss of yield.

The Southeast Morris County MUA has identified drought effects for its rock wells, which must be pumped less during drought periods. The result is low pressure during some days, but has not caused a supply problem. The Triassic aquifer wells apparently are not very useful during the summer due to drawdown effects, and the smaller wells can also run dry in the winter if pumped continuously for 12 to 24 hours. The wells in glacial drift are less prone to drought effects.

Chatham-Millburn Valleys Subregion--Chatham Borough reports significant changes in static levels during major droughts. The static levels have risen by ten feet from the drought period in 1966 to late 1985, but had fallen three feet by August 1985.

Commonwealth Water Company's observation wells located within the Canoe Brook/Passaic River well field indicate that static water levels dropped as much as 20 feet during the 1960's drought, but rebounded after the drought ended. Records from 1982 through 1985 indicate generally stable levels with static levels that remained high during most of the drought, a drop of less than 10 feet during mid-1985 and then recovery after the drought ended. Commonwealth plans to install continuous recorders in three or four observation wells, along with monitoring systems for the pumping wells. The Baltusrol well field has exhibited stable static levels over the last fifteen years, while the Short Hills well field has also been stable for the last ten years.

East Orange Water Reserve reports, based on extensive static water level records, that drought impacts during the 1980's have been minimal, with

no restrictions on use in the 1980-81 or 1984-85 droughts. The 1960's drought, the most severe recorded, produced significant decreases in static levels. Since that time, East Orange's demand has reduced due to the loss of several neighborhoods when Interstate 280 was constructed.

The Florham Park well field does react to droughts, with a loss of head equaling approximately 7 feet or so. Well 4, the largest producer, is also the most sensitive to drought and production is reduced in Well 4 during drought periods. The wells recover from drought in less than one year, based on data from the 1980-81 drought.

Livingston's wells also were affected during the 1980-81 drought. They rebounded considerably during 1983-84 with record rains and the 1984-85 drought did not affect them greatly. In 1980-81 the well drawdown was severe, very close to limits of the system. All 11 wells were run constantly, several at reduced yields to keep water levels above the pumps. The total system yielded approximately 3.5 mgd, which is assumed to be the dependable yield of the well system.

Livingston Well 1 is drawn down below pumping levels by continuous pumping of Well 11. Therefore, Livingston usually rests Well 11 in winter, and runs it during peak demand periods. The well maintains high static level for 3-4 weeks, then drops drastically. Wells 11, 4, and 10 showed the greatest drought effects. Wells 2 and 8 were fairly constant producers, while Well 6 was affected very severely. The Passaic River wells were affected much less than the others and served as the major supply during drought. Well 12 showed a more pronounced interference effect with East Orange's Hobart Gap Road well during the drought.

The quick rebound from the 1980-81 drought and the severe drawdown in the Slough Brook wells during the drought indicate a small contributing drainage area for the Slough Brook wells. The effects on Well 11 seem to indicate a supply of ready water in the overburden, with a major drawdown into the fractured rock once the overburden water is used. A repeat of the 60's drought would probably show much worse results. The effects of a record drought on the Passaic River wells is less clear. 1985 static levels in all wells approximate the levels of the early 1970's when records began.

Madison Borough's wells show little drought effects for almost a year after rains are sub-normal. Decline of the static level may reach as much as fifteen feet, with a faster recovery period of five or six months between renewed rains and recovery of the static levels. The

drought effects indicate considerable water stored in the aquifer system and relatively good connection between recharge areas and the aquifer.

Water Use Management Programs

The NJDEP requires with all water allocation permits for public water supply systems that a water conservation plan be developed and implemented within the service area. The plan must be submitted annually to the department for review. However, the department has not formulated substantive standards by which to judge these plans, and so the thoroughness of the plans and the resources provided to implement them vary widely. Many public water supply systems are openly critical of efforts to conserve water when supplies are plentiful, given the loss of revenues to the system. Nearly all supply systems do acknowledge the need for water conservation in drought periods and when estimates of dependable yields indicate that conservation is required.

Alternate Supplies for Ground Water Users

A few of the public water supply systems have access to surface water supplies. The Town of Boonton has a reservoir, as does the Southeast Morris County MUA. Commonwealth Water Company derives a large portion of its supplies from surface waters, mostly through bulk purchases of water from other supply systems. Most public water supply systems in the Buried Valley Aquifer Systems do not have recourse to surface water supplies, though, and must remain heavily reliant on ground water. Surface water diversion rights are primarily allocated to major water supplies serving the cities of northeast New Jersey, including the Jersey City Water Department and the Passaic Valley Water Commission. In the event of well contamination, the only option for most areas is treatment of the contaminated supply. This lack of alternate water supplies for ground water users is one of the major criteria which led to the designation of the Buried Valley Aquifer Systems as a "sole source aquifer" by the federal government.

Diversion of Ground Water to Surface Waters

Most of the ground water which is pumped by private and public supplies eventually finds its way to the surface water systems of the region. The bulk is treated in the wastewater treatment facilities of the area. Table V-11 lists the current capacities and average flows for the wastewater treatment facilities in the region. Public sewer service areas are shown in Figure G-8.

The diversion of ground water to surface water has important implications for water budgets. For instance, the 12 MGD facility operated by the Rockaway Valley Regional Sewerage Authority will result in over 12 MGD being diverted from the aquifers of the Rockaway Valley Subregion (a percentage of water pumped is not treated at RVRSA but rather is used for lawns, etc.), with up to 12 MGD piped downstream of the Jersey City Reservoir, treated at the RVRSA facility and released into the lower Rockaway River. In the process, the ground water withdrawals could reduce the base flow of the Rockaway River during drought periods and reduce the safe yield of the reservoir. Conversely, the fact that ground water is withdrawn from aquifers during droughts (when base flow normally would not occur at such rates), treated and released will improve flows of the Passaic River so that the Passaic Valley Water Commission has more water available for diversion and treatment at Little Falls.

The implications of ground water diversions to surface waters will be more important as development of the region increases. The increased runoff to streams from developed areas, which translates into less ground water recharge, is also a diversion of ground water to surface waters but has far fewer benefits as it cuts the dependable yields of aquifers during droughts. Land use policies in the region have not yet faced or dealt with the ground water implications of growth.

TABLE V-11

PUBLIC WASTEWATER TREATMENT FACILITIES IN THE BURIED VALLEY AQUIFER SYSTEMS

Facility and Location	Permit Flow (MGD)
Berkeley Heights Sewage Treatment Plant Slough Brook, Berkeley Heights	3.10
Bernards Township Sewage Treatment Plant Dead River, Bernards	
Caldwell Regional Sewage Treatment Plant Passaic River, West Caldwell	4.50
Chatham Township Pollution Control Plant Black Brook, Chatham Township	0.75
Florham Park Sewerage Authority Passaic River, Florham Park	1.00
Hanover Sewerage Authority Whippany River, Hanover	3.00
Jefferson Township Municipal Utilities Authority White Rock Lake, Jefferson	0.129
Joint Meeting of Essex and Union Counties Effluent disposed out of study area	50.00*
Livingston Township Sewage Treatment Plant Passaic River, Livingston	3.00
Madison-Chatham Joint Meeting Passaic River, Chatham Borough	4.00
Montville Township Municipal Utilities Authority Three small facilities Crooked Brook and Passaic River	0.044
Morris-Butterworth Sewage Treatment Plant Whippany River, Morris Township	2.00
Morris-Woodland Sewage Treatment Plant Loantaka Brook, Morris Township	2.00
Morristown Sewage Treatment Plant Whippany River, Hanover	3.45

TABLE V-11 (Cont'd)

Facility and Location	Permit Flow (MGD)
New Providence Sewage Treatment Plant Passaic River, New Providence	1.50
Parsippany-Troy Hills Sewer Utility Whippany River, Parsippany-Troy Hills	16.00
Passaic Township Sewage Treatment Plant Passaic River, Stirling	0.65
Pequannock, Lincoln Park and Fairfield Sewerage Authority Pompton River, Lincoln Park	7.50
Rockaway Valley Regional Sewerage Authority Rockaway River, Parsippany-Troy Hills	12.00
Roxbury-Ajax Sewage Treatment Plant Black (Lamington) River, Roxbury	1.00
Warren Township Stage IV and Stage V Sewage Treatment Plants Dead River, Warren	0.93

*The Joint Meeting of Essex and Union Counties provides sewerage for Millburn, Summit and a portion of East Orange. Most of the flow to the sewage treatment plant is not derived from ground water in the study area.

Sources: Camp, Dresser & McKee, 1985; NJDEP, 1978.

CHAPTER VI

GROUND WATER POLLUTION

What is Pollution?

Definition of Pollution

Lewis Carroll fans would like the word "pollution." The meaning varies according to the focus of the user. With the advent of myriad laws and regulations on pollution, two general usages have been developed. The first is anthropocentric, defining pollution as the existence of substances in the environment which prevent the use of an environmental resource (ground water, for the purpose of this study) by humans for agriculture, industry, and domestic uses. The second usage focuses more on the effect of the substances on the natural environment. Regulations controlling ground water pollution frequently focus on the human effects of contamination rather than the ecological effects. Part of the cause for the dichotomy relates to past views of ground waters and surface waters as separate hydrologic systems. New realizations that the two are closely related have led to more encompassing definitions of ground water pollution, or contamination, and its effects. For instance, the NJDEP uses policies for ground water quality standards which specifically include the effects of contaminated ground water on surface waters and ecosystems.

Categorizing Pollution

Ground water contamination may be categorized according to several systems that variously describe its location, origin and effects. The distinctions are important, as they form the basis for decisions about what contaminants should be regulated, who should be regulated, and what method of regulation should be used (if any). The following basic categories may be used in desribing ground water contamination.

Ground Water Regime--Aquifers contain ground water in sufficient quantities and accessibility as to be economically withdrawn, but ground water occurs in more locations than aquifers alone. The unsaturated zone between the ground surface and the top of the aquifer may have a considerable quantity of ground water which is held to the soils and rocks by adsorption and capillary action or is passing through, percolating to the aquifer. The saturated zones of the ground may be aquifers, but they also may be confining or semi-confining strata that are saturated with ground water yet do not allow the ready flow of the water. Finally, there are deep zones which are saturated with ground water but do not serve as aquifers because of the cost of recovery, limits on quantity, or poor quality. In each case, ground water contaminants will behave differently and pose different policy concerns.

Natural vs Introduced (Anthropogenic)--Ground water has chemical constituents which are naturally occurring and may pose limitations on human use. These contaminants may also affect ecosystems, creating special environments such as hot springs and mud pots. Common natural contaminants of ground water include salt, sulphur, iron and manganese. The latter two are common in the glacial aquifers of this region, while sulphur is sometimes found at depths in the Triassic aquifers.

Contaminants may also be introduced by human action (anthropogenic). Such contaminants include landfill leachate, volatile organic chemicals, salt, etc. In certain circumstances, human action such as pumping wells may induce natural pollution of an aquifer. This is the situation where manganese from surface water sediments is drawn into aquifers by pumping (Lyford, et al., 1984). Obviously, the existence of contaminants as a natural occurrence raises significantly different management options than anthropogenic contaminants.

Health Effects--A common concern of ground water policies is the effect of contamination on public health and welfare. Public health standards for nitrates, salt, and bacteria in drinking water have existed for decades for this reason. More recently, general standards were developed with reference to VOCs, often requiring wells to be shut down when any one VOC was found above 50 ppb or the total VOC load exceeded 100 ppb. More recent laws and research are refining standards to reflect medical estimates of health effects from short-term and long-term exposures. Contaminants with health effects are often called "toxic substances" or "toxics." The former is misleading while the latter is improper. A better general term is "hazardous," and the term "hazardous contaminant" is now dominant in regulations. Hazardous

substances may be explosive, flammable, toxic (acute or chronic), or genotoxic. The latter category includes carcinogens (cause cancer), mutagens (cause mutations in genetic material), onconogens (cause tumors), embryotoxicity (causes toxic effects in a developing fetus) and teratogens (causes birth defects). Standards are developed in a different manner for each health concern.

Cause and Culpability--The direct cause of contamination is important in ground water management, as different causes are subject to different means of control. Accidental discharges and spills cannot be regulated through permit programs, but rather are avoided in part through good housekeeping and safety standards and remediated when necessary through emergency responses. Leaking underground storage tanks are detected and controlled differently than above ground tanks. Industrial sources also vary according to the industry involved and the nature of the contaminants or hazardous wastes. Some contamination results from deliberate actions, such as the underground injection of wastes, which have unintended results.

Another important factor in ground water contamination, and a means of categorizing discharges, is the level of culpability. Laws and regulations treat accidental discharges differently than "midnight dumpers." In the first instance, the result may be a cleanup order and perhaps fines for poor safety practices. In the case of deliberate, illegal discharges the result may be criminal prosecution. Under the current hazardous waste cleanup laws, each responsible party may be held liable for all cleanup costs; the costs are split according to the relative contribution of each known party to the contamination. If a responsible party refuses to fund the cleanup in advance, though, that party may be charged for three times their normal contribution as a punitive penalty. Those responsible parties which provide funding in advance therefore avoid a potentially overwhelming surcharge. Through such measures that penalize the more culpable and less cooperative responsible parties, pollution laws attempt to spur cooperation as the least expensive course of action.

Sources of Pollution

Chapter VII discusses in some depth the sources of contamination within the Buried Valley Aquifer Systems. Table VI-1 indicates some of the potential ground water contamination sources identified by the Office of Technology Assessment (1984). Six major categories are used, according to the degree to which the discharge is a function of the land use or of

Table VI-1. Sources of Ground Water Contamination

Source: Office of Technology Assessment, 1984

Category I—Sources designed to discharge substances
Subsurface percolation (e.g., septic tanks and cesspools)
Injection wells
  Hazardous waste
  Non-hazardous waste (e.g., brine disposal and drainage)
  Non-waste (e.g., enhanced recovery, artificial recharge, solution mining, and in-situ mining)
Land application
  Wastewater (e.g., spray irrigation)
  Wastewater byproducts (e.g., sludge)
  Hazardous waste
  Non-hazardous waste

Category II—Sources designed to store, treat, and/or dispose of substances; discharge through unplanned release
Landfills
  Industrial hazardous waste
  Industrial non-hazardous waste
  Municipal sanitary
Open dumps, including illegal dumping (waste)
Residential (or local) disposal (waste)
Surface impoundments
  Hazardous waste
  Non-hazardous waste
Waste tailings
Waste piles
  Hazardous waste
  Non-hazardous waste
Materials stockpiles (non-waste)
Graveyards
Animal burial
Aboveground storage tanks
  Hazardous waste
  Non-hazardous waste
  Non-waste
Underground storage tanks
  Hazardous waste
  Non-hazardous waste
  Non-waste
Containers
  Hazardous waste
  Non-hazardous waste
  Non-waste
Open burning and detonation sites
Radioactive disposal sites

Category III—Sources designed to retain substances during transport or transmission
Pipelines
  Hazardous waste
  Non-hazardous waste
  Non-waste
Materials transport and transfer operations
  Hazardous waste
  Non-hazardous waste
  Non-waste

Category IV—Sources discharging substances as consequence of other planned activities
Irrigation practices (e.g., return flow)
Pesticide applications
Fertilizer applications
Animal feeding operations
De-icing salts applications
Urban runoff
Percolation of atmospheric pollutants
Mining and mine drainage
  Surface mine-related
  Underground mine-related

Category V—Sources providing conduit or inducing discharge through altered flow patterns
Production wells
  Oil (and gas) wells
  Geothermal and heat recovery wells
  Water supply wells
Other wells (non-waste)
  Monitoring wells
  Exploration wells
Construction excavation

Category VI—Naturally occurring sources whose discharge is created and/or exacerbated by human activity
Groundwater—surface water interactions
Natural leaching
Salt-water intrusion/brackish water upconing (or intrusion of other poor-quality natural water)

SOURCE: Office of Technology Assessment.

other factors. Figure VI-1 illustrates some of the common contaminant sources such as agricultural chemicals, septic systems, landfills, road salts, leaking underground storage tanks and industrial wastes. Prior to controls by the State, New Jersey had many instances of ground water contamination from road salt piles left uncovered near well sites (Figure VI-2). Septic systems are still a common cause of nitrate, bacterial, virus and suspended solids pollution on a localized basis (Figure VI-3). Septic systems generally cause problems where the soil allows excessive percolation or, conversely, not enough percolation, and where the ground water table is too close to the leach field lines. Many private wells have been contaminated by septic systems discharging nearby, especially when the wells are shallow. Leaking underground storage tanks are a common threat to aquifers, including the Buried Valley Aquifer Systems. Some fluids, such as gasoline, pose a double threat to ground water. As shown in Figure VI-4, the gasoline product floats on top of the water table toward the well. Soluble constituents such as benzene, toluene and xylene (often called BTX) move into the aquifer itself, so that both the free floating product and the contaminated ground water must be cleansed. Costs for complete cleanup can range from tens to hundreds of thousands of dollars, and sometimes in the millions of dollars if public water supply wells are contaminated.

Until recently, industrial wastes were often disposed of in surface lagoons and seepage pits which usually had no liner or treatment system. Several public wells in the Buried Valley Aquifer Systems have been withdrawn from service due to contamination from such sources. Contaminants from lagoons penetrate to ground water and move with the general flow toward discharge points, such as rivers (Figure VI-5), potentially contaminating two water resources. A less noticed source of ground water contamination results from sewer lines in collection systems and large mains. While most attention was focused on the infiltration of ground water into the lines, overburdening sewage treatment plants, the possibility that sewage was flowing out of lines into aquifers (Figure VI-6) has hardly been addressed. In 1974, the USEPA rated the relative contribution of contamination sources to regional ground water quality problems (Table VI-2). Buried pipelines and storage tanks were rated as regional concerns, along with then-common industrial disposal practices, septic tanks, and spills.

Contamination and Health Effects

One of the most difficult questions facing environmental agencies, industry and citizens today is the risk of health effects that humans

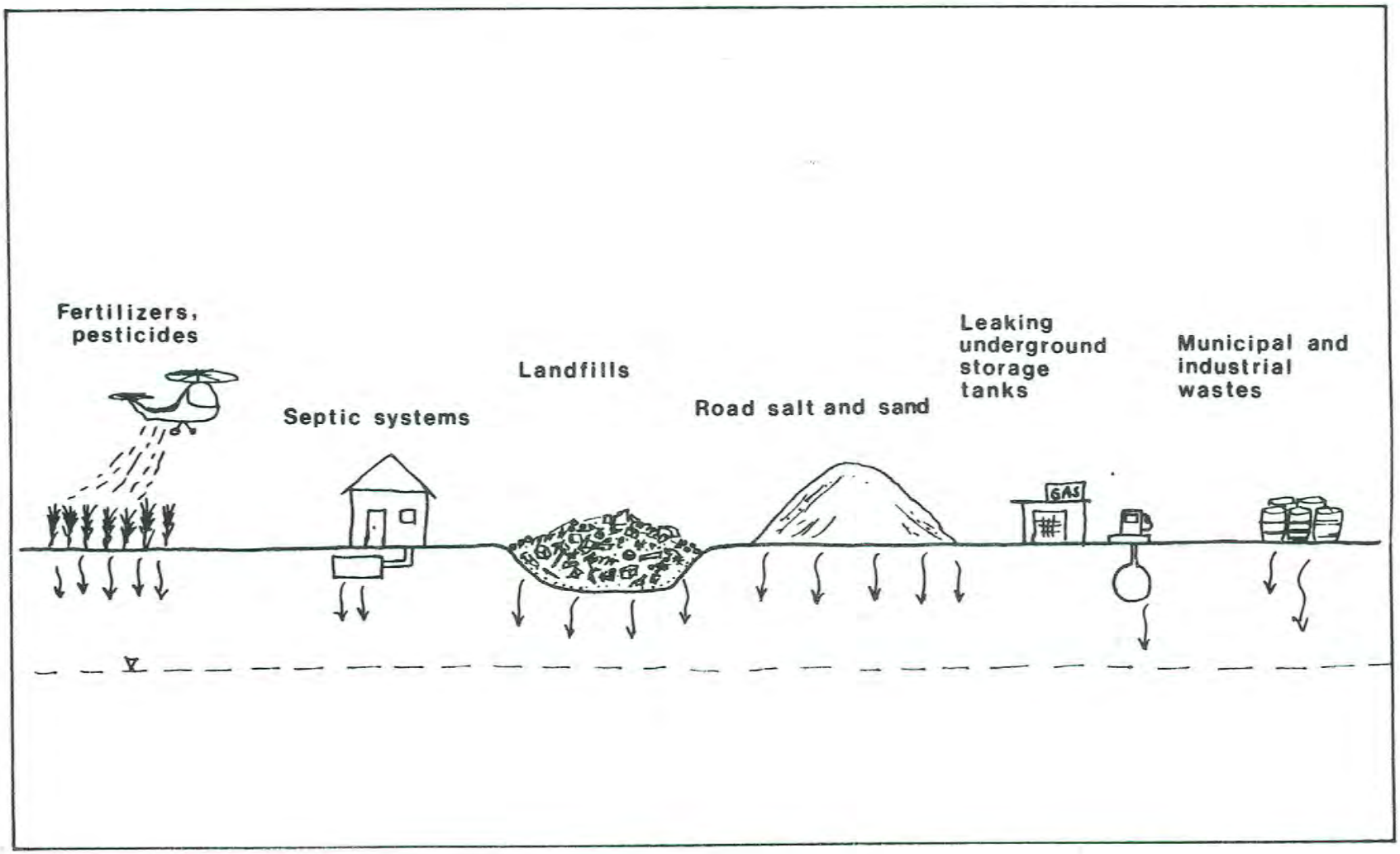


Figure VI-1. Common Sources of Ground Water Contamination

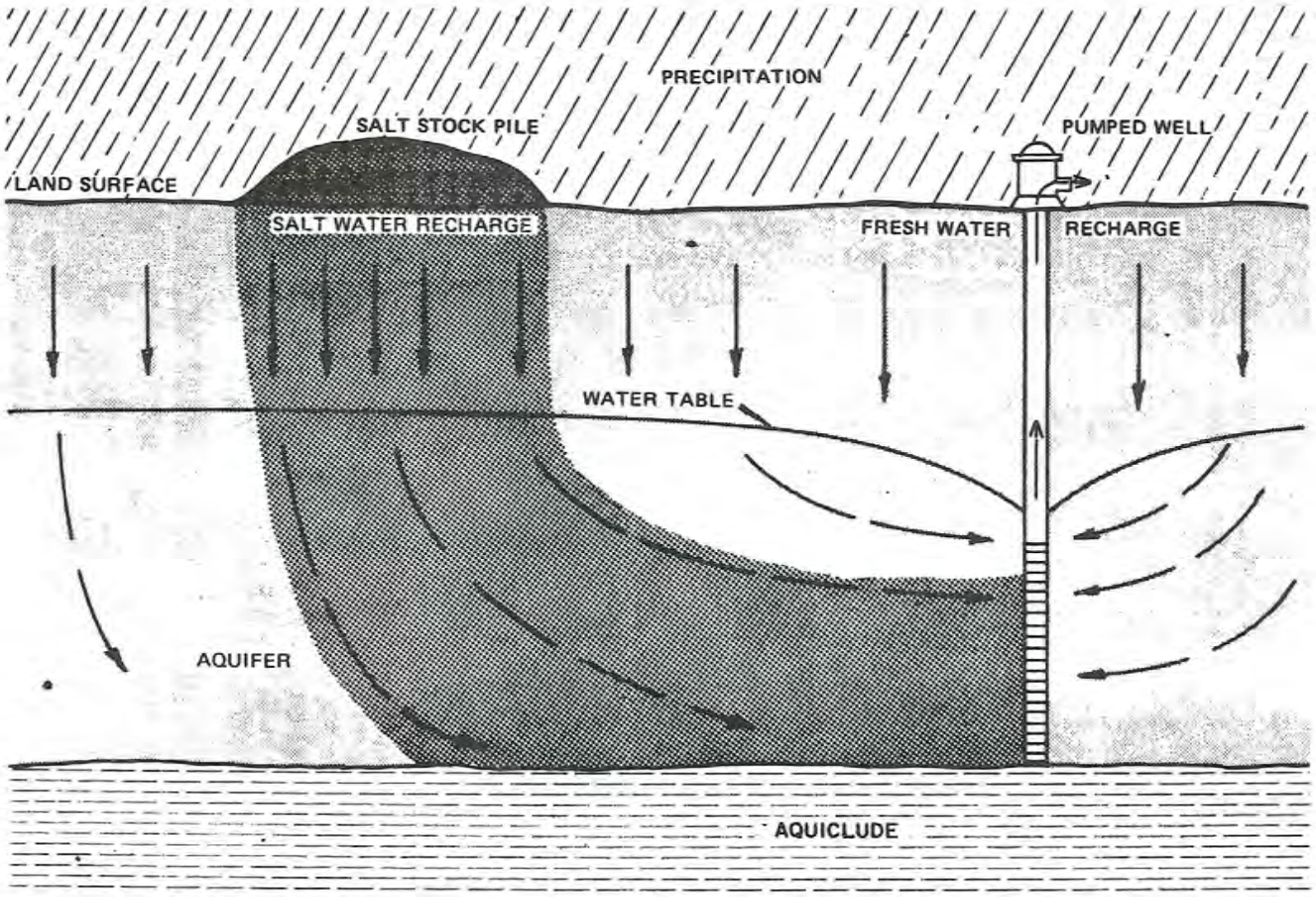


Figure VI-2. Contamination from Salt Stockpile

Source: U.S. Environmental Protection Agency, 1974

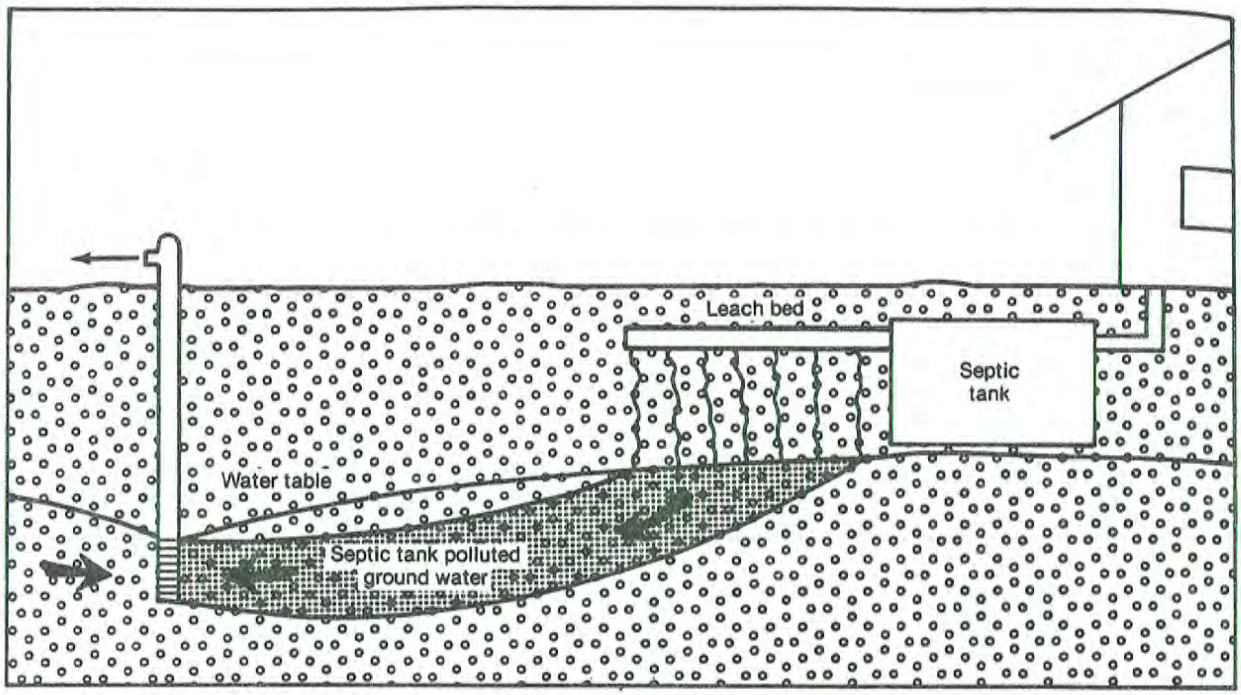


Figure VI-3. Contamination from Septic Systems

Source: U.S. Environmental Protection Agency, 1985

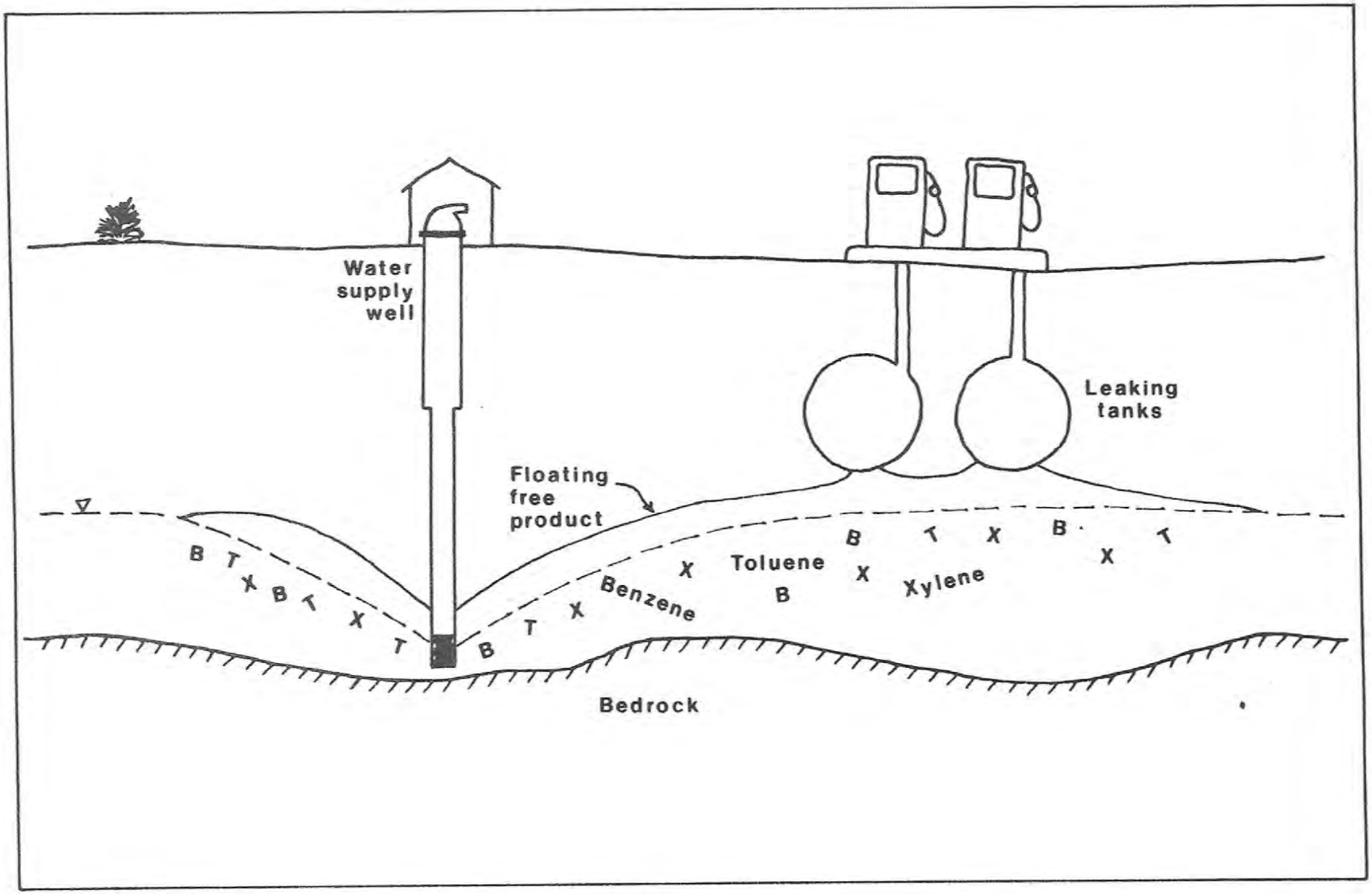


Figure VI-4. Leaking Underground Storage Tanks

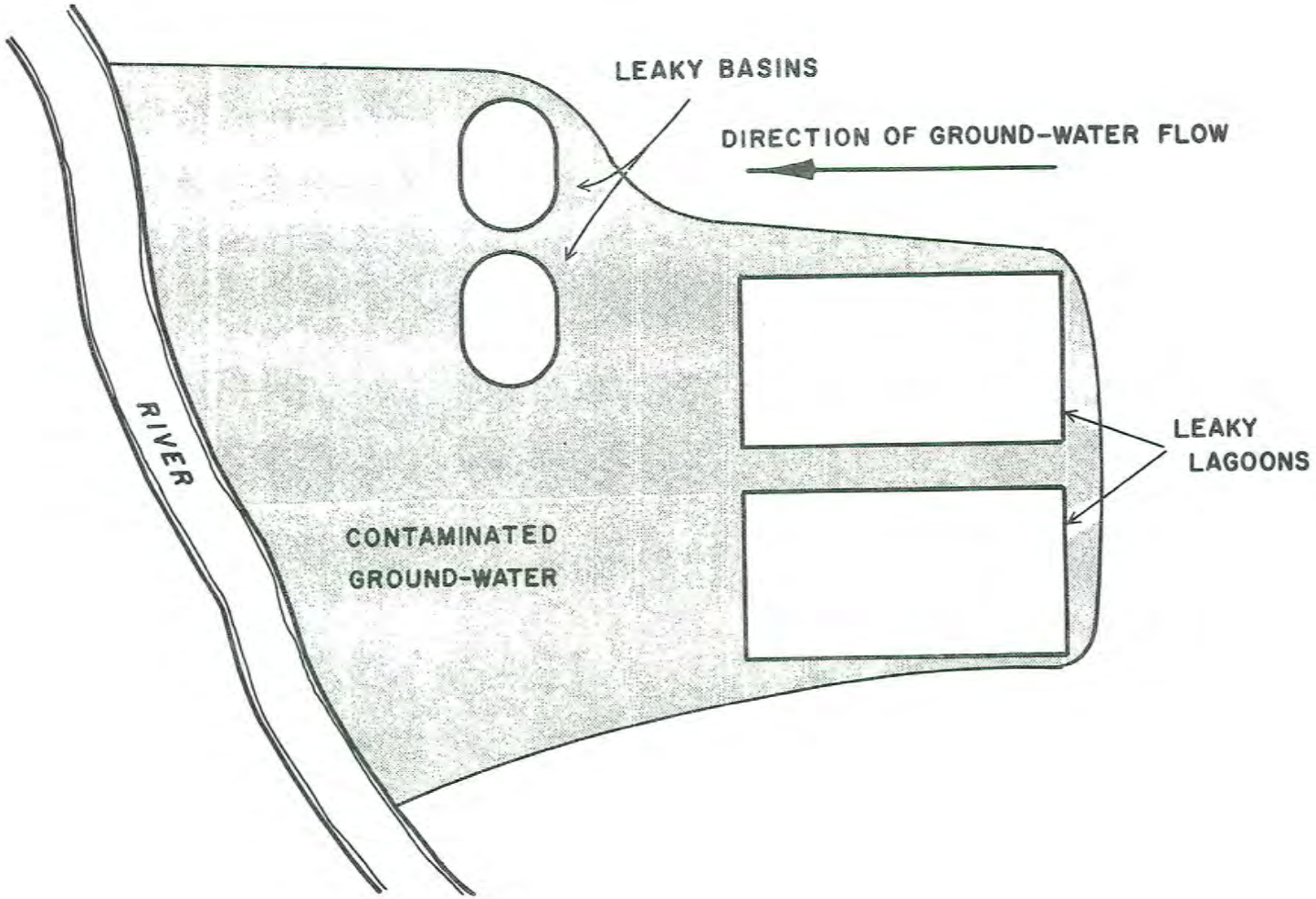


Figure VI-5. Contamination Plume from Industrial Waste Lagoons

Source: U.S. Environmental Protection Agency, 1974

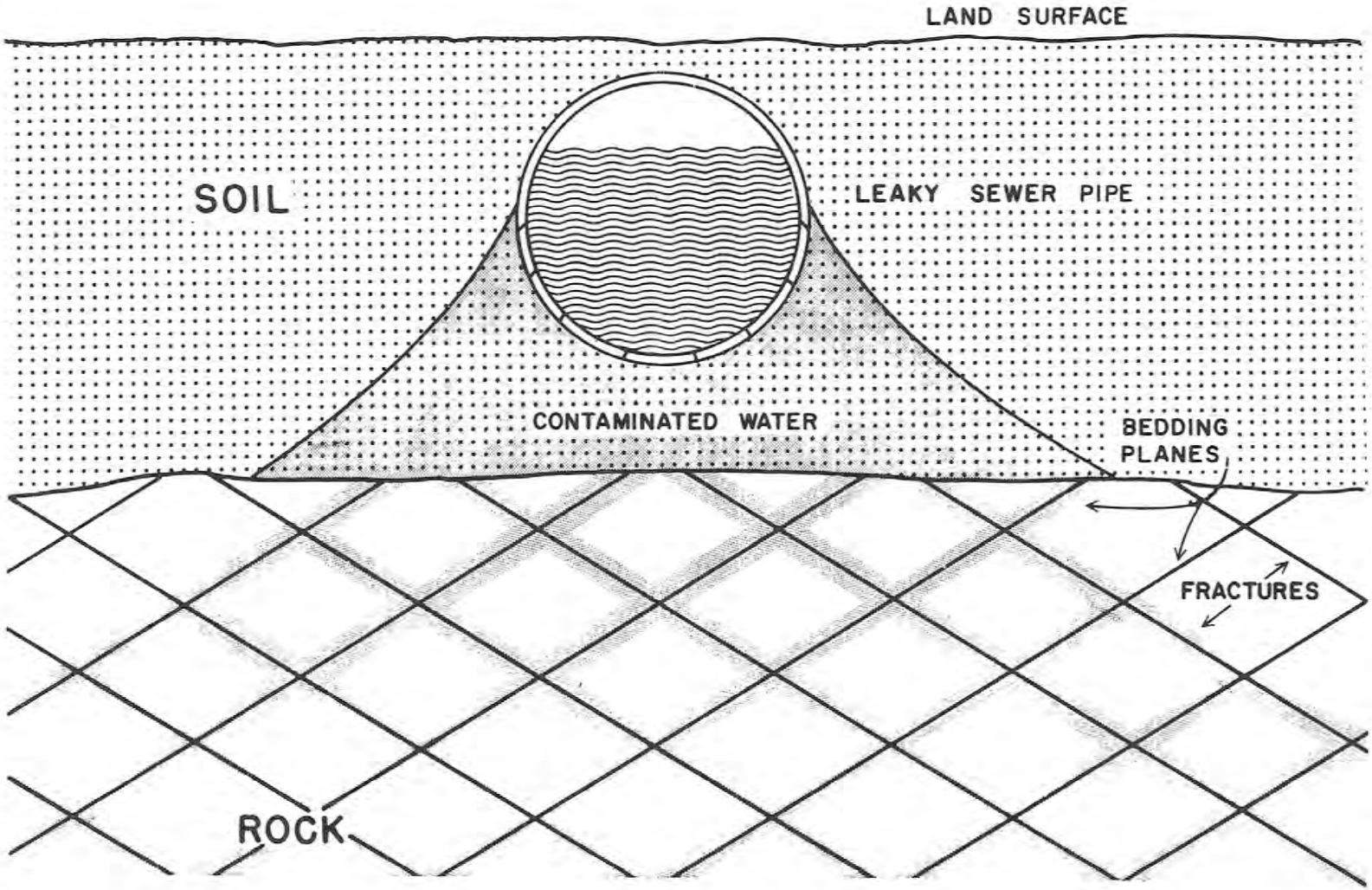


Figure VI-6. Contamination from Sewer Lines

Source: U.S. Environmental Protection Agency, 1974

Table VI-2. Principle Sources of Ground Water Contamination and Their Relative Impact in the Northeast

Sources	Relative importance to region [a]	Typical size of area affected [b]	Estimated future trend in rate of new occurrences [c]
Septic tanks and cesspools	I	II	I
Buried pipelines and storage tanks	I	II	II
Application and storage of highway deicing salts	I	II	II
Landfills	I	III	I
Surface impoundments	I	III	III
Spills and surface discharge	I	III	II
Mining activity	II	II	II
Petroleum exploration and development	II	II	II
Salt-water intrusion	III	I	III
River infiltration	III	IV	I
Underground storage and artificial recharge of waste water	III	III	I
Water wells	III	IV	II
Agricultural activities	III	II	III

a) I - High
II - Moderate
III - Low

b) I - Regional
II - Point source but can be regional in nature due to high density of individual occurrences
III - Can affect adjacent properties
IV - Effects usually contained within the boundaries of one property

c) I - Increase
II - No significant change
III - Decrease

Source: U.S. Environmental Protection Agency, 1974

should be exposed to by way of environmental contaminants. The issue is compounded in complexity by the relatively limited medical knowledge available on many of the contaminants found in ground water. Testing of contaminants is most often accomplished using laboratory animals and extrapolating data to estimate the consequences of human exposure. Testing using humans is out of the question, and inadvertent exposures of humans are often so mixed with exposures to other substances that a definitive link of exposure to disease is difficult. Still, the USEPA (and the NJDEP more recently) have been charged with the responsibility of establishing maximum contamination levels for site cleanups and drinking water standards based on health effects.

The Office of Technology Assessment in 1984 compiled a listing of substances which are known to be found in ground water, with information on the various health effects known or suspected to be caused by each. Two tables are located in Appendix E which provide the information. One table lists each substance, its range of detected concentration, examples of uses, and qualitative estimates of the carcinogenic potency and noncarcinogenic toxicity. The second table again lists the substances along with a breakdown of 24 health effects according to the organ effected by toxicity, teratogenicity, mutagenicity and carcinogenicity. A relative guide to potential health effects is provided by the two tables in combination, though more recent medical information may have become available in the three years since the data were compiled.

Substances Found in the Buried Valley Aquifer Systems--The case studies of contamination sites in the study area (Appendix F) include information on the specific, major contaminants found in each site. This information has been compiled as Table VI-3, listing the compounds in alphabetical order. By far the most frequent compounds found in the aquifer systems are trichloroethylene (TCE), tetrachloroethylene (PCE), 1,1,1 trichloroethane (1,1,1 TCEA), methylene chloride, toluene, xylene and various benzene and chlorobenzene compounds. Many of these compounds are solvents used in industrial and commercial processes, often as degreasing agents. Table VI-3 is not a complete listing of substances, but it covers all of the more common contaminants.

Known or Suspect Health Effects--The USEPA and the NJDEP have established mandatory or recommended Maximum Contaminant Levels (MCLs or RMCLs) for many common ground water contaminants, based upon the current state of understanding with regard to health effects, environmental effects, etc., and the requirements of the federal and New Jersey Safe Drinking Water Acts. Current MCLs, RMCLs and Interim Guidelines have

TABLE VI-3

GROUND WATER CONTAMINANTS OF THE
BURIED VALLEY AQUIFER SYSTEMS

Chemical Name	Chemical Name
Acetone	Isoproponol
Arsenic	Lead
Bromoform	Mercury
Cadmium	Methanol
Carbon tetrachloride	Methylene chloride
Chloride	Naphthalene
Chlorobenzene	Nickel
Chloroform	Phenols
Chromium	bis(2-ethylhexyl)phthalate
Copper	Polychlorinated biphenyls
Cyanide	Radium
Dibromochloromethane	Selenium
Dichlorobenzene	Silver
1,1 dichloroethane	Sulfates
1,2 dichloroethane	Tetrachloroethylene
1,1 dichloroethylene	1,2,3 trichlorobenzene
1,2 dichloroethylene	Trichloroethylene
Trans-1,2 dichloroethylene	1,1,2,2 tetrachloroethane
Dichloromethane	1,1,1 trichloroethane
Diethylphthalate	1,1,2 trichloroethane
Ethanol	1,1,2 trichloroethylene
Ethyl acetate	Trichlorofluoromethane
Ethylene dichloride	Trifluorotoluene
Ethylbenzene	Toluene
Freon-113	Vinyl chloride
Hexane	Xylene
Isophorone	Zinc

Source: Passaic River Coalition.

been compiled in Table VI-4, for many of the chemicals of Table VI-3 and some additional hazardous contaminants. Generally, RMCLs are established by the USEPA based on no expected adverse impact upon sensitive populations (for substances that are not carcinogenic) or are based on no exposure for carcinogens (a zero RMCL). The "zero limit" for carcinogens is required in the RMCLs by law, reflecting the theory that no threshold exists for carcinogens. However, the Safe Drinking Water Act requires the USEPA to set the mandatory MCL for carcinogens according to the practicable limits of water treatment technology. The NJDEP is required to set limits for non-carcinogens in a similar manner to federal law, but sets MCLs for carcinogens based on an expected occurrence of one cancer per million population at the MCL standard. The Interim Guidelines are not actually law, but serve as guidelines for use by the NJDEP and water purveyors in response to contamination discovered in water systems.

Although not all of the contaminants in Table VI-3 are actually found in drinking water, the high demand for ground water in the region results in a sizable risk that every contaminant in the area will eventually find its way to a pumping well if the contamination is not fully treated or kept to the site. Information in Appendix E is provided on known or probable human carcinogens, as well as contaminants capable of producing toxic effects on key organs such as the liver, kidney or nervous system. The information in Appendix E is qualitative, not quantitative. The drinking water standards generally refer to lifetime exposures, so no immediate inference is possible between the existence of contaminants and health effects for any one person. Standards provide a relative scale of potential health effects, rather than a a statement of absolute risks. Given that caveat, it is generally assumed that higher concentrations and greater numbers of contaminants both increase the probability of health impairment.

Economic, Environmental and Social Impacts--Although most recent concern has focused on the health effects of ground water contaminants, there are other concerns as well. The economic consequences of ground water contamination, both for preventive and corrective actions, can be large. Environmental impairment can also be major, especially where the contamination can damage biota in surface water ecosystems. Finally, the psychological impacts must not be ignored. People can be as badly affected by fear as by contamination of ground water. Government agencies must always contend with the difficult choice between a presentation of full information and a desire to minimize public fears due to false impressions or panic. Table VI-5 provides a listing of some major economic, environmental and social impacts from contamination.

TABLE VI-4

DRINKING WATER CONTAMINANT
REGULATIONS AND GUIDANCE
(milligrams per liter, mg/l)

Chemical	NJDEP Interim	MCL~ Primary	RMCL~ Proposed	Secondary Standard
Acetone*				
Acrylamide			0**	
Alachlor			0	
Aldicarb			0.009	
Arsenic*		0.005		
Barium		1.0		
Benzene	+	0.005		
Bromoform* (THM)				
Cadmium*		0.010		
Carbofuran			0.036	
Carbon tetrachloride*	+	0.005		
Chlordane	+		0	
Chloride*				250.0
Chlorobenzene*				
Chloroform* (THM)				
Chromium*		0.05		
cis-1,2-dichloroethylene			0.07	
Copper*				1.0
Cyanide*				
DBCP			0	
Dibromochloromethane* (THM)				
o-dichlorobenzene			0.62	
Dichlorobenzene*	+			
1,1 dichloroethane*		0.007		
1,2 dichloroethane*	+	0.005		
1,1 dichloroethylene*	+			
1,2 dichloroethylene*				
Dichloromethane*				
1,2 dichloropropane			0.006	
Diethylphthalate*				
Endrin		0.0002		
Epichlorohydrin			0	
Ethanol*				
Ethyl acetate*				
Ethyl benzene			0.68	
Ethylene dibromide (EDB)			0	
Ethylene dichloride*				

TABLE VI-4 (Cont'd)

Chemical	NJDEP Interim	MCL Primary	RMCL Proposed	Secondary Standard
Ethylbenzene*				
Freon-113*				
Hardness				250.0
Heptachlor			0	
Heptachlor epoxide			0	
Hexane*				
Iron				0.3
Isophorone*				
Isoproponol*				
Lead*		0.05		
Lindane		0.004	0.0002	
Manganese				0.05
Mercury*		0.002		
Methanol*				
Methoxychlor		0.1	0.34	
Methylene chloride*	+			
Monochlorobenzene			0.06	
Naphthalene*				
Nickel*				
Nitrate (as N)		10.0		
p-Dichlorobenzene		0.75		
Pentachlorophenol			0.22	
Phenols*				
bis(2-ethylhexyl)phthalate*				
Polychlorinated biphenyls*	+		0	
Radium* (Ra-226 and Ra-228)		5 pCi/1		
Selenium*		0.01		
Silver*		0.05		
Styrene			0.14	
Sulfates*				250.0
Tetrachloroethylene*	+			
Toluene*			2.0	
Total Dissolved Solids (TDS)				500.0
Total Trihalomethanes (THM)*		0.10		
Toxaphene		0.005	0	
Trans-1,2 dichloroethylene*	+		0.07	
1,2,3 trichlorobenzene*				
Trichloroethylene*	+	0.005		
1,1,2,2 tetrachloroethane*				
1,1,1 trichloroethane*		0.20		
1,1,2 trichloroethane*				
1,1,2 trichloroethylene*				
Trichlorofluoromethane*				
Trifluorotoluene*				
Vinyl chloride*	+	0.001		
Xylene*	+		0.44	
Zinc*				5.0
2,4-D		0.1	0.07	
2,4,5-TP Silvex		0.01	0.052	

TABLE VI-4 (Cont'd)

* Substances found in ground water within the Buried Valley Aquifer Systems, either in drinking water or at contamination sites.

** The Safe Drinking Water Act requires that a RMCL of zero be set for all chemicals which are possible, probable or known human carcinogens. MCLs are set for these substances according to the best available treatment and detection methods. A level of 0.005 or 0.001 mg/l (5 or 1 ppb) is commonly selected as the MCL for possible carcinogens.

+ The NJDEP has developed interim action levels for these chemicals. See Table VI-9 for the four levels of concern for each chemical.

~ MCL - Maximum Contaminant Level, a mandatory standard.
RMCL - Recommended Maximum Contaminant Level.

Sources: 40 CFR 141 (Primary and Secondary Drinking Water Regulations); 50 FR 219:46904 (MCLs for Volatile Organic Chemicals); and 50 FR 219:46982 (RMCLs for Synthethic Organic Chemicals); NJDEP-Division of Water Resources, "Interim Action Levels and Recommendations for Response for Selected Organics in Drinking Water," January 1986.

Table VI-5. Examples of Economic, Environmental and Social Impacts Resulting from Ground Water Contamination

Source: Office of Technology Assessment, 1984.

Economic impacts	
Industry	Higher operation/maintenance or capital costs (e.g., for accelerated repair or replacement of damaged equipment or materials)
	Lost output from downtime during repairs, during the search for alternative water supplies, and during relocation
	Relocation costs
	Decreases in property value
	Decreases in revenue if quantity of products sold or their prices fall as a result of lower product quality
	Secondary costs (e.g., incurred by suppliers to inputs to the industry or by receivers of the output such as by processors or marketing agents)
	Legal and administrative costs
	Costs of detection, correction, and prevention activities
Agriculture	Higher operation/maintenance or capital costs (e.g., for accelerated repair or replacement of damaged equipment or materials)
	Loss of output due to damage to productivity of land (also reflected in decreases in property value)
	Lost revenue from discarding of food products unsuitable for consumption
	Loss of output due to injury or death to perennial plants and trees
	Decreases in livestock productivity, including illness and death
	Secondary costs (e.g., incurred by suppliers of inputs to agriculture or by receivers of output)
	Legal and administrative costs
	Costs of detection, correction, and prevention activities
Households	Higher operation/maintenance or capital costs (e.g., for cleaning, replacement, and/or rehabilitation of damaged pipes, plumbing, appliances)
	Decreased value of residential property
	Relocation expenses, including search costs, higher purchase prices, higher interest rates and fees, and moving costs
	Secondary costs (e.g., contraction or expansion of commercial activities)
	Loss of income due to sickness
	Legal costs
	Costs of detection, correction, and prevention activities (e.g., pre-treatment and purchase of bottled water)
Municipalities	Lost receipts from property, sales, or income taxes
	Re-allocation of additional resources to provide emergency services
	Costs of procuring alternative supplies
	Legal and administrative costs
	Detection, correction, and prevention activities
Environmental impacts	
Aesthetics	Odor
	Taste
	Appearance
Surface water contamination by groundwater	
Biota	Damage to vegetation, waterfowl, and aquatic life
	Contamination of fish
Air pollution	
Soil contamination	
Social impacts	
Psychological stress	
Inconvenience	
Social disruption	

SOURCE: Office of Technology Assessment.

Drinking Water Quality Policies and Programs

The national and state programs involved with ground water contamination have three major thrusts - prevention, site cleanup, and maintenance of drinking water quality. Each is important in its own right and as part of comprehensive responses to the issue of contamination, but the quality of drinking water is the most direct effect of contamination upon people. For that reason, public and governmental reaction to the contamination of drinking water supplies generally leads to more rapid and direct action than other concerns about contamination.

Major State and National Issues

The primary national and state issue in drinking water quality has been addressed indirectly above. How much contamination is safe or can be tolerated as public policy? Risk analysis is used as an analytical tool, combined with whatever medical knowledge exists, to answer these questions and present the answers in terms of regulations. In every case, the desire of public laws and regulations is to establish standards which protect the public health reasonably well. However, insufficient knowledge of health effects for single contaminants is compounded by the presence of multiple contaminants in some drinking water supplies. Multiple contaminants may have synergistic effects, where two compounds together cause more damage than the sum of effects from the two as independent agents.

The technology exists, for the most part, to cleanse contaminated drinking waters to what are currently considered "safe" levels. The continuing problem will be that of defining "safe" for people of various ages and states of health.

Safe Drinking Water Standards

The Safe Drinking Water Act of 1974, as amended in 1986, provides for the development of maximum recommended levels of a variety of contaminants by the US Environmental Protection Agency. Implementation of this act has been slowed by a variety of factors. Prompted by a concern for the quality of drinking water in New Jersey, the Legislature in 1982 decided to move forward on drinking water standards independent of the federal efforts. The result was a bill known as A-280, which amended the Safe Drinking Water Act of 1977 (P.L. 1977, c. 224, C.

58:12A-1 et seq.). The NJDEP was required to have standards at least as stringent as federal regulations, so that the net affect of federal law on New Jersey is now indirect. The primary authority for drinking water quality in New Jersey is the NJDEP.

A-280 established a Drinking Water Quality Institute to advise the NJDEP on maximum contaminant levels for 22 initial chemicals (the 2(a) List) and for any additional pesticides and related compounds, metals, base/neutral extractable organic compounds and acid extractable organic compounds which, "within the limits of medical, scientific and technological feasibility...may be found in drinking water and the presence of which above maximum contaminant levels in drinking water, upon ingestion or assimilation, may, on the basis of the best information available...cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunction (including malfunctions in reproduction) or physical deformity..." The additional contaminants are also known as the 2(b) List compounds. The NJDEP was charged with setting the 2(a) list standards within 18 months of the effective date of the act, and with setting the 2(b) list standards within 24 months.

A-280 (also known as P.L. 1983, c. 433) established a requirement for all public community water supplies - defined as having over 15 service connections for year-round residents or regularly serving at least 25 year-round residents - to test their water for the 2(a) list of chemicals within 12 months and semiannually thereafter. Public community water supplies must also test for the 2(b) list of chemicals within 12 months of the list's promulgation by the NJDEP and annually thereafter. The NJDEP may increase or decrease the testing schedule for both lists.

Implementation of the A-280 program did not progress as quickly as required by the Legislature, but the first round of tests for the 2(a) list was required by January 9, 1985. The 2(a) list is given in Table VI-6. Not all of the 2(a) list has proven testing methodologies, and so several chemicals were not tested. Table VI-7 provides the results of the first round of tests, for systems within the Buried Valley Aquifer Systems. None of the systems found contamination reaching Levels III or IV, requiring immediate action for treatment or shutdown of the well, except for the carbon tetrachloride result for Denville (the presence of carbon tetrachloride was disputed by Denville, but the installment of a water treatment system in 1986 has rendered the debate moot). Table VI-8 lists the four levels of recommended response to the presence of contaminants in drinking water.

TABLE VI-6

DRINKING WATER CONTAMINANTS:
THE 2(A) LIST

Trichloroethylene
Tetrachloroethylene
Carbon Tetrachloride
1,1,1 Trichloroethane
1,2 Dichloroethane
Vinyl Chloride
Methylene Chloride
Benzene
Chlorobenzene
Dichlorobenzene(s)
Trichlorobenzene(s)
1,1 dichloroethylene
cis-1,2 dichloroethylene*
trans-1,2 dichloroethylene
Polychlorinated biphenyls (PCBs)
Xylenes
Ethylene Glycol*
Chlordane
Kerosene*
Formaldehyde*
n-hexane*
methyl ethyl ketone*

*Not tested during initial testing rounds. Requirement imposed to test within six months after the NJDEP promulgated interim test methodologies for each chemical.

Source: P.L. 1983, c. 443, Section 2(a); N.J.A.C. 7:10-14.

TABLE VI-7

RESULTS OF A-280 TESTING IN THE
BURIED VALLEY AQUIFER SYSTEMS

Water Supply	Sample Type*	Date	Contaminant**	Level (ppb)
Essex County				
Caldwell Water Dept (WD)	IS	84/12/22	TCE	4.20
East Orange WD	VS	85/07/02	None detected	0.00
	IS	85/01/07	TCE	0.80
	IS	85/01/07	PCE	3.00
Essex Fells	IS	84/12/19	TCE	3.50
	IS	84/12/19	TCE	2.40
Livingston WD	IS	85/01/07	TCE	0.30
	IS	85/01/07	PCE	1.30
	IS	85/01/07	Trans-1,2 DCE	0.20
North Caldwell WD	IS	84/12/19	TCE	4.10
Roseland Public Works	IS	84/12/19	TCE	3.10
Morris County				
Boonton WD	IS	85/01/07	1,1,1 TCEA	1.50
Denville Twp WD	IS	85/01/02	1,1,1 TCEA	2.00
	IS	85/01/02	PCE	8.00
	IS	85/01/02	1,1,1 TCEA	40.00
	VS	85/03/14	PCE	9.00
	VS	85/03/14	1,1,1 TCEA	40.00
	VS	85/03/14	PCE	10.00
	VS	85/03/14	1,1,1 TCEA	43.00
Dover WD	IS	85/01/08	TCE	1.50
	IS	85/01/08	1,1,1 TCEA	10.00
East Hanover WD	IS	85/01/08	TCE	10.00
	VS	85/03/14	1,1 dichloroethane	3.00
	VS	85/03/14	TCE	2.00
	VS	85/03/14	TCE	7.00
	VS	85/03/14	Trans-1,2-DCE	2.00
Mountain Lakes WD	IS	85/01/04	1,1,1 TCEA	2.40
NJ Psychiatric Inst.	IS	85/05/29	PCE	32.00
Greystone Hosp.	VS	85/06/12	PCE	34.00
	VS	85/06/12	PCE	34.00
Rockaway WD	VS	85/07/02	None detected	0.00
	IS	85/01/16	TCE	3.20
	IS	85/01/16	PCE	2.70
Hercules, Inc.	IS	85/02/14	TCE	2.00
	IS	85/02/14	1,1,1 TCEA	1.20
Roxbury Water Co.	IS	85/01/07	TCE	2.00
	IS	85/01/07	Trans-1,2-DCE	3.00
	IS	85/01/07	PCE	37.00
	VS	85/03/15	TCE	2.00
	VS	85/03/15	Trans-1,2-DCE	2.00
	VS	85/03/15	PCE	20.00

TABLE VI-7

Water Supply	Sample Type	Date	Contaminant	ppb Level
Roxbury Water Co. (Cont'd)	VS	85/03/15	TCE	4.00
	VS	85/03/15	Trans-1,2-DCE	4.00
	VS	85/03/15	PCE	39.00
Roxbury WCo-Shore Hills	IS	85/01/07	1,1,1 TCEA	4.30

*Sample types are IS (Initial Sample) and VS (Verification Sample).

**Abbreviations for chemical names are as follows:

TCE	Trichloroethylene
PCE	Tetrachloroethylene
1,1,1 TCEA	1,1,1 Trichloroethylene
Trans-1,2-DCE	Trans-1,2-dichloroethylene

Source: NJ Department of Environmental Protection, Final Report: Results of Initial Testing for Hazardous Contaminants in Public Water Supplies Under Assembly Bill A-280 Through January 9, 1985, February 20, 1986.

TABLE VI-8

RECOMMENDATIONS FOR RESPONSES FOR
SELECTED ORGANICS IN DRINKING WATER

Level I

No recommended action at these concentrations. However, the N.J. Department of Environmental Protection (the Department) will spot check a random sample of representative Level I results submitted by public community water systems pursuant to the Act.

Level II

The Department shall obtain confirmation of sampling results by additional testing of the water distribution system and raw water sources which may have contributed to the original sampling results. Upon confirmation of Level II concentrations, the Department shall require that the water supply system monitor its water supply sources and delivered water at intervals and for a duration determined by the Department on a case-by-case basis. The Department will also recommend investigation by the water system of alternative water sources and development of appropriate treatment techniques.

Level III

The Department shall obtain confirmation of sampling results by additional testing of the water distribution system and raw water sources which may have contributed to the original sampling results. Upon confirmation of Level III concentrations, the Department shall require that the public community water system conduct monthly monitoring of its water supply sources and delivered water for a specified time period. Also, the Department shall require within one year that a public community water system develop adequate treatment facilities or alternative water sources. (Note: blending of water supply sources, if possible, may be allowed by the Department on a case-by-case basis provided delivered water continues to be acceptable to the Department.) The Department shall recommend that within one year a nonpublic or public noncommunity water system with confirmed Level III concentrations and/or an appropriate local health agency take one or more of the following remedial actions: extend an existing public community water system; develop a new public community water system; develop point-of-use treatment; or conduct any other appropriate remedial actions. The Department shall require quarterly progress reports from public community water systems. The Department shall require appropriate progress reports on a case-by-case basis from public noncommunity and nonpublic water systems. The Department shall initiate additional enforcement action based upon unsatisfactory progress reports.

TABLE VI-8 (Cont'd)

Level IV

The Department shall obtain confirmation of sampling results by additional testing of the water distribution system and raw water sources which may have contributed to the original sampling results. Upon confirmation of Level IV concentrations, the Department shall take all necessary actions to require immediate remedial efforts on a case-by-case basis depending upon the actual confirmed concentration of hazardous contaminant. Such formal enforcement action by the Department may include directive letters, administrative orders or appropriate court actions. The Department may require remedial action in the form of sealing potable water wells, developing alternative water supplies, developing appropriate treatment techniques, restricting types of water usage, and initiating any other appropriate actions.

Source: NJ Department of Environmental Protection, Division of Water Resources, Drinking Water Guidance, "Interim Action Levels and Recommendations for Responses for Selected Organics in Drinking Water," January, 1986.

The Drinking Water Quality Institute also was slow in being formed and implemented. The full membership was not confirmed until more than a year after passage of A-280. The Institute consists of 15 members, comprised of the Commissioner of the NJDEP, the Commissioner of Health, the Chairman of the Water Supply Advisory Council, the Director of the NJDEP-Division of Water Resources, the Director of the NJDEP-Office of Science and Research, the Director of the Office of Occupational and Environmental Health in the Department of Health, and nine appointed members. The appointees are split evenly between representatives of water purveyors (at least one relying on ground water), the academic scientific community, and the public. The public representatives must all have backgrounds in environmental health issues. The Institute works with staff members of the NJDEP and NJ Department of Health to develop recommendations for contaminants to test under the 2(b) list, maximum contaminant levels, appropriate testing techniques, testing frequencies, and general activities under the Act. The first set of recommended maximum contaminant levels are expected to be released late in 1986. For carcinogens, the Institute must devise standards that result in a probability of cancer equalling no more than 1 in 1 million over a lifetime exposure. For non-carcinogenic chemicals the Institute must devise standards which eliminate to the greatest extent feasible all harmful effects. In all cases, the limits set by the USEPA are the highest levels the NJDEP may adopt. No maximum contaminant levels are set by the NJDEP in the absence of evidence that the hazardous contaminant exists in drinking water.

In addition to the regulatory mechanism establishing the testing methodologies and schedules and maximum contaminant levels, A-280 also requires that all laboratories used for water quality testing under the act be certified by the NJDEP for their ability to correctly analyze for the 2(a) list contaminants and other contaminants required to be tested by the NJDEP. By certifying laboratories, the act intends to ensure that samples from the same source and sent for analysis to different laboratories will have the same analytical results.

Given the lack of maximum contaminant levels under A-280, and the need to set immediate guidelines for public community water systems which found contaminants in their drinking water, the NJDEP-Division of Water Resources in early 1986 released a "Drinking Water Guidance" which sets recommended contaminant levels to trigger the four action levels described in Table VI-8. An Interim Action Level is established for each recommended response levels. The NJDEP has used the drinking water guidance in prescribing responses from water systems. Table VI-9 provides the interim action levels for 14 chemicals from the 2(a) list.

TABLE VI-9

INTERIM ACTION LEVELS (ug/1) FOR SELECTED
ORGANICS IN DRINKING WATER
JANUARY 1986

Contaminant	Group*	Level I	Level II	Level III	Level IV
Benzene	A	0-0.68	0.68-6.8	6.8-68	>68
Carbon Tetrachloride	A	0-0.27	0.27-2.7	2.7-27	>27
Chlordane	B	0-0.8	0.8-32	32-63	>63
Dichlorobenzene(s)	C	0-94	94-425	425-750	>750
1,2 Dichloroethane	A	0-0.7	0.7-7	7-70	>70
1,1 Dichloroethylene	B	0-7	7-53	53-100	>100
trans-1,2 Dichloroethylene	C	0-27	27-148	148-270	>270
Methylene Chloride	A	0-4.8	4.8-47	47-479	>479
Polychlorinated Biphenyls	A	0-0.007	0.007-0.07	0.07-0.7	>0.7
Tetrachloroethylene	A	0-0.67	0.67-6.6	6.6-66	>66
1,1,1 Trichloroethane	B	0-20	20-110	110-200	>200
Trichloroethylene	A	0-3.1	3.1-30	30-309	>309
Vinyl Chloride	A	0-0.015	0.015-0.15	0.15-1.5	>1.5
Xylene(s)	C	0-100	100-550	550-1200	>1200

All units in Levels I, II, III and IV are presented in micrograms per liter (ug/1) which also equals parts per billion (ppb). For all but Level 4, the ranges should be read as meaning from above the lower number to less than or equal to the higher number.

*The column titled "Group" represents categorization of the listed hazardous contaminants based upon the weight of evidence of its carcinogenicity. For example, Group A refers to known or probable human carcinogens, Group B refers to possible human carcinogens and Group C refers to insufficient or negative data available on carcinaogenicity.

Source: NJ Department of Environmental Protection, Division of Water Resources, Drinking Water Guidance, "Interim Action Levels and Recommendations for Responses for Selected Organics in Drinking Water," January, 1986.

Control and Cleanup of Contaminant Discharges to Ground Water

Effluent Limitations for Discharges to Ground Water

The federal government has established ground water discharge standards for certain classes of activities, such as hazardous waste facilities, solid waste facilities, and underground injection facilities. However, no overarching federal regulations control the discharge of effluents to ground water. New Jersey does have a program, modelled after the federal program for surface waters, which regulates facilities discharging effluents (other than domestic septic wastes) to ground water.

Federal Clean Water Act--The Water Pollution Control Act of 1965, as amended in 1972 and 1977, is commonly called the "Clean Water Act" after the name of the 1977 amendments. In its broad scope of controls over the discharge of contaminants into water, the Clean Water Act offers very little protection to ground water. The act empowers the USEPA to implement the National Pollution Discharge Elimination System (NPDES) to control the discharge of pollutants into "the waters of the United States." The difficulty lies in the definition of those waters. Although the USEPA has jurisdiction over pollution discharges to essentially all surface waters, ground waters are not included in the NPDES program. The NPDES program was first enacted in the 1972 amendments and may have had the unintentional effect of encouraging industries to avoid the NPDES program by switching their effluent discharges from surface waters to ground waters. This effect might especially be true for small facilities which discharge relatively small effluent streams. The only major provision of the Clean Water Act used to improve ground water protection is Section 208, which provides funds to states to prepare regional Water Quality Management Plans. Some regions have used '208' funding in part to plan for the protection of ground water supplies from surface water and other effluent discharges.

NJ Water Pollution Control Act--The New Jersey Legislature passed the Water Pollution Control Act in 1981, so that the NJDEP could assume jurisdiction of the federal Clean Water Act in the state. Along with the NPDES program for effluent discharges to surface water, the Legislature added a similar program for discharges to ground water. New Jersey was a lead state in developing such a program. The new program is referred to as NJPDES-GW (New Jersey Pollution Discharge Elimination System-Ground Water). The NJDEP promulgated NJPDES-GW regulations in

1981 and has since that time proceeded to require permits for classes of ground water discharges (N.J.A.C. 7:14A-6).

The NJPDES-GW regulations set forth monitoring, evaluation and response requirements for "all discharges, past or present, actual or potential, of pollutants, including hazardous and non-hazardous waste...to ground water or onto land which might flow or drain into the waters of the State. A new source shall not discharge to groundwater prior to installing a groundwater monitoring system..." (N.J.A.C. 7:14A-6.1(a)1). Under the regulations, the NJDEP has the authority to require monitoring systems at such diverse facilities as sludge drying lagoons in sewage treatment plants, inactive landfills, and hazardous waste facilities. Under the NJPDES-GW program, the NJDEP has taken an aggressive posture on the requirements for ground water monitoring at closed landfills to determine the extent and nature of ground water contamination, so as to develop data to direct mitigation or cleanup activities. The site owners become responsible, then, for providing the data that the NJDEP will use for enforcement actions. To distinguish these information-gathering permits from normal permits to discharge to ground water, the NJDEP has developed a class of NJDPES-GW "Initial Interim Permits" which mandate monitoring but do not confer a right to discharge contaminants.

The requirements for monitoring vary according to the proposed, actual, or past activity and the relative threat to ground water quality. At least one monitoring well is generally required upgradient of the site to develop data on the background ground water quality. At least two wells (three for hazardous waste disposal sites) are usually required downgradient of the site to allow a comparison of ground water quality before and after the ground water reaches the site. The constituents for which ground water must be analyzed also vary according to the site. Where specific compounds are used at the site, monitoring may be more focused than for other sites where an unknown variety of chemicals may be present. Generally, more monitoring wells are required as the size of the site, the complexity of the site geology, the variability of waste disposal circumstances and the nature of hazard posed by the discharge increase. The NJDEP has wide latitude in its requirements for monitoring systems.

Further requirements are placed on site owners or operators if the initial monitoring system and sampling program indicate that a contamination problem related to the site has occurred. For hazardous waste facilities, a new monitoring plan must be submitted which will lead to a determination of the rate and extent of migration of the hazardous waste and the concentration of all hazardous constituents.

Findings that significant contamination exists will lead to cleanup actions. The requirements for monitoring of non-hazardous waste facilities are less stringent in nature than for hazardous waste facilities, but the steps required and actions followed in response to indications of ground water contamination are essentially the same. For certain constituents in both cases, the threshold for action is set at the natural background level for the constituent. Otherwise, the action threshold is set according to specific ground water quality standards promulgated by the NJDEP in N.J.A.C. 7:9-6. The advanced monitoring program must remain in effect until the NJDEP agrees that ground water has not been contaminated (in the case of false positive readings) or that corrective actions have been taken to the Department's satisfaction. In addition to the analysis of ground water samples, the permit holder also must collect a considerable amount of hydrogeologic data which is used in the development of corrective actions and the placement of further monitoring wells (if needed).

Ground water quality standards have been adopted by the NJDEP in N.J.A.C. 7:9-6. The standards are preceded by a series of policy statements. Several of the policies are important to note:

1) Water is vital to life...
2) It is the policy of the Department not to permit the introduction of pollutants into the ground waters of the State in concentrations which are known to be carcinogenic, mutagenic or teratogenic.
3) Existing and potential uses of ground water be shall maintained and protected. Where existing quality is inadequate to support designated uses, the quality shall be upgraded...
4) The purpose of these rules is to protect the ground waters of the State for use as agricultural, industrial and potable water supplies and other reasonable uses, and as a supplement to surface waters...
5) Existing ground water quality which exceeds those levels to support designated uses shall be maintained and protected unless the State chooses to allow lower quality as a result of necessary and justifiable economic and social development. In no event, however, may degradation of water quality interfere with or become injurious to existing designated uses. Additionally, no degradation shall be allowed in ground waters which constitute an outstanding National resource such as ground waters of National and State Parks, wildlife refuges and wildlife management areas and ground waters of exceptional ecological significance.

Among other effects of these policies, the NJDEP may cause new NJPDES-GW permit applicants, and existing discharges who propose to modify their discharge, to meet higher ground water standards than those promulgated by regulation if the normal ground water quality is significantly higher than the permitted standards. However, the applicant also may demonstrate that the higher standard is not reasonable.

The NJPDES-GW program is a major step toward controlling point discharges to ground water, and works in concert with the Underground Injection Control program described below. However, the application of the standards to drinking water supplies, where those supplies are of pristine or near-pristine quality, has not always aimed toward the maintenance of that quality. The NJDEP has, on several occasions in the Buried Valley Aquifer Systems, withdrawn and substantially revised draft NJPDES-GW permits based on local desires for more stringent standards which reflect current ground water quality. Therefore, the flexibility of the system provides both for potential problems and significant gains in the protection of ground water from contamination by point discharges.

Septic System Design and Construction Controls--The NJDEP is responsible for the promulgation of standards for septic systems under what is known as Chapter 199 (N.J.S.A. 58:11-23). An existing set of regulations is now being revised to reflect the different design standards necessary to protect ground water from contamination. The new standards are intended to make the septic system standards more responsive to differences in the soils types, percolation rates, effluent loading, etc. A second purpose is to increase the ability of applicants to design septic systems according to specific standards set forth in the regulations and eliminate some of the need for administrative interpretation of the regulations on a case-by-case basis.

Resource Conservation and Recovery Act--RCRA was passed in 1976 as a complete overhaul of the Solid Waste Disposal Act of 1965. RCRA was then amended by the Solid and Hazardous Waste Act Amendments of 1984. RCRA established the primary authority for the USEPA to regulate both solid waste and hazardous waste facilities in the country. Both portions of the regulatory program may be delegated to states which establish programs of equal or greater stringency.

As many solid and hazardous waste facilities pose the potential for ground water contamination, RCRA is extremely significant for ground water protection. The 1984 amendments, which established a national program for controlling underground storage tanks and reduced the amount

of hazardous wastes which may be disposed of at sanitary landfills, have increased the importance of RCRA. The major portions of RCRA are contained within Subtitles C (hazardous waste facilities) and D (solid waste facilities).

Subtitle C established a system for tracking hazardous wastes from their point of origin to the final disposal facility. With the 1984 changes, the manifest system now covers the vast majority of hazardous waste by volume and by generator. Subtitle C also establishes a permit system for all owners and operators of hazardous waste treatment, storage and disposal (TSD) facilities, both existing and new. Existing facilities were required to submit applications for interim status; that is, they are treated as permitted facilities until such time as the USEPA (or the state) considers their application for a permanent facility permit. Approximately 10,000 interim-status facilities exist in the country (Pye, Patrick and Quarles, 1983). Such facilities must meet technical and non-technical standards for operations while awaiting final permit review (40 CFR 265). The technical standards impose specific design, operating and maintenance standards for each specific type of TSD facility that are oriented toward minimizing the specific environmental threats posed by those facilities. The non-technical standards apply to all interim-status facilities and include waste analysis, inspection, financial responsibility, and ground water monitoring requirements.

The standards for permitting facilities (both new and existing) are contained within 40 CFR 264. The two basic thrusts of the standards involve a "liquids-management strategy" and a "groundwater-monitoring and response program." The first focuses on minimizing the production of leachate and its migration toward ground water and other discharge points. The liquids-management strategy includes requirements such as liners and leachate-collection systems as part of new surface impoundments, waste piles and landfills. The groundwater-monitoring and response program involves requirements for monitoring of contaminant movement and the removal of contaminants from ground water if levels at the border of the waste pile exceed set standards. The third, and very important, part of the permitting process requires that facilities have sufficient financial ability to close the facility properly at the end of its active life and provide for post-closure care.

Subtitle D sets forth a program for federal involvement with solid waste (domestic, commercial and industrial waste that is not liquid and is not regulated under Subtitle C). USEPA has a weaker role in Subtitle D than in Subtitle C, perhaps reflecting the lesser concern for the effects of solid waste facilities. The regulations are found in 40 CFR 257. All

states are required to develop plans for the management of solid wastes. In New Jersey, the Solid Waste Management Act of 1975 gives the responsibility for solid waste planning to the counties and responsibility for the regulation of facilities to the NJDEP, which also prepares the plans required by RCRA. The state plans are subject to USEPA review and continuous review and revision.

Under RCRA, solid waste facilities are either "sanitary landfills" or "open dumps." Sanitary landfills are so classified "only if there is no reasonable probability of adverse effects on health or the environment from the disposal of solid waste at such facility." Open dumps are all other facilities and must be upgraded to sanitary landfill standards or closed. In New Jersey, hundreds of open dumps have been closed over the last ten years, including many municipal dumps. "Adverse affect" is tied to ground water contamination criteria. Contamination exists when the concentration of any contaminant at the boundary of the solid waste pile exceeds any National Interim Primary Drinking Water Standards in an aquifer that is or is capable of being used as a source of drinking water. The entire Buried Valley Aquifer Systems meets the aquifer designation except for pockets of deep ground water which have high natural contaminant concentrations. Few national drinking water standards have been set, though the USEPA proposed new standards for some organic chemicals in November, 1985.

Safe Drinking Water Act: Underground Injection Control--The Safe Drinking Water Act of 1974 includes a program to control the injection of fluids into the ground through injection wells. The USEPA established standards to be used by the states in developing their own programs for USEPA review and approval. New Jersey has an approved program for Underground Injection Control (UIC). The program regulates five classes of wells (Table VI-10). All owners or operators of injection wells must have valid permits if they are to continue operating such wells. No well may be granted a permit if the injected fluids will move into an underground source of drinking water (USDW) and either violate any primary drinking water standard or otherwise impair human health (Gordon, 1984).

The New Jersey UIC program has been incorporated within the NJPDES program of the NJDEP-Division of Water Resources. The UIC program regulates all fluids placed underground, including the underground storage of fluids for later retrieval and the injection of water. The program regulates "any septic tank, seepage pit, or cesspool used by generators of hazardous waste, or by owners or operators of hazardous waste management facilities, to dispose of fluids containing hazardous

TABLE VI-10

CLASSIFICATION OF INJECTION WELLS

Class	Criteria
I	Industrial and municipal disposal wells that inject fluids beneath formations containing Underground Sources of Drinking Water (USDW) within one quarter mile of the well site. Also includes wells injecting hazardous wastes (other than Class IV wells).
II	Includes wells that inject fluids brought to the surface in conventional oil and natural gas production, for enhanced recovery of oil and natural gas and for storage of liquid hydrocarbons.
III	Includes wells that inject for extraction of minerals or energy.
IV	Includes wells used by hazardous or radioactive waste management facilities to dispose of hazardous or radioactive wastes into or above a formation which contains a USDW within one quarter mile of the well site. In primacy states (such as New Jersey), existing Class IV wells used to inject wastes directly into a drinking water aquifer are to be eliminated over a period of six months, and new Class IV wells of this type are to be prohibited.
V	Injection wells not included in Classes I-IV.

Source: USEPA regulations pursuant to the Safe Drinking Water Act, Section 1421.

waste" and "any septic tank, seepage pit, cesspool or other well used by a multiple dwelling, community or regional system for the injection of wastes" (N.J.A.C. 7-14A-5.1(b)1.iii and 1.iv). Individual septic systems are controlled under separate regulations of the NJDEP. In the case of New Jersey, Class V wells specifically include air conditioning return flow wells, cooling water return flow wells, storm water drainage wells, aquifer recharge wells, and septic tank systems other than for single family residences.

UIC permits are not allowed where a Class I, II or III well results in the movement of any contaminant in underground sources of drinking water or where a Class IV or V well results in the movement of contaminants in a USDW that may cause a violation of any primary drinking water standard set by the NJDEP or USEPA. Monitoring systems may be required. Individual permits are not generally required for Class V wells, but may be required if the well may cause the violation of any primary drinking water standard. Most of the injection wells in the Buried Valley Aquifer Systems are Class V wells. The NJDEP may require corrective action as necessary to prevent the contamination or continued contamination of a USDW. All wells are subject to construction, operation and maintenance, and record keeping requirements. The full set of regulations are available under N.J.A.C. 7-14A-5.

Contamination Mitigation Programs

Several major programs exist which lead to the investigation and correction of ground water contamination from spills and discharges. The NJDEP-Division of Water Resources is responsible for most activities under the NJ Water Pollution Control Act, including site investigations and enforcement where ground water supplies have been impaired. The Superfund program effects investigations and cleanups at National Priority List sites, through cooperative actions of the USEPA and the NJDEP. The NJDEP has a variety of programs for funding site cleanups, including the Spill Fund, a bond fund, and USEPA grants under Superfund. Under the Spill Compensation and Control Act, Superfund and the new ECRA program, responsible parties may also be required to clean up sites to which they have contributed contaminants. The information in this sections is derived from a variety of sources, but a primary source for hazardous waste site management information is NJDEP-DWM (1985).

NJ Water Pollution Control Act--The NJDEP-Division of Water Resources is responsible for several programs under this act that may lead to site cleanup actions. Under the NJPDES-GW program, facilities

with permits must report violations of the permit standards, or site inspections by the NJDEP may discover violations. Enforcement actions may result, including the correction of any resulting ground water contamination. Facilities without permits may also face enforcement actions under the Act if they have discharged hazardous contaminants to ground water. Records of the NJDEP show that many facilities continue to be discovered which have not received or applied for NPDES-GW permits despite operating active discharges to ground water. The nature of NJDEP enforcement actions is discussed in greater detail in Chapter VII. Two enforcement regions of the NJDEP cover the Buried Valley Aquifer Systems. Most of the area is within the Northern Region (field office based Parsippany), while the Essex and Union County municipalities are within the Metropolitan Region (field office based in West Orange). In both cases, the enforcement staffs for the Division of Water Resources and other NJDEP divisions occupy common quarters to improve communications on cases which bridge the responsibilities of various divisions (as ground water contamination cases often do).

Superfund (CERCLA)--The Superfund program, as it is commonly known, was established by the Comprehensive Environmental Response, Compensation, and Liability Act, P.L. 96-510, enacted in 1980. Primary responsibility for implementation of CERCLA rests with the USEPA. The program was authorized for five years and funded with $1.6 billion, most of which is derived from an industry tax. The Congress has extended the funding authority somewhat while considering the reauthorization of CERCLA in 1986. Under the Superfund program, the USEPA may respond to releases or threatened releases of hazardous contaminants that may endanger public health or welfare. The existence of the fund allows immediate action; the USEPA may bring legal action against responsible parties which refuse to take action to recover site investigation and cleanup costs. The cost to responsible parties may be as much as three times the government's costs, as a punitive measure to encourage private compliance with USEPA requirements for action.

Superfund is operated under a "National Contingency Plan," a regulation which provides for the method by which sites are analyzed for inclusion in the Superfund program (the National Priority List), investigated, and cleaned up. The USEPA (or cooperating state agencies) may take direct, immediate action if a site poses an imminent threat to the public health or welfare or to the environment. Intermediate steps to reduce the threats may be taken, as well. To address long-term site concerns, remedial investigations and feasibility studies analyze the nature of the site contamination, the potential for harm to the public and the environment, alternatives which might address the site concerns, and the

preferred alternative for site cleanup. The final step involves the implementation of site cleanup plans and recovery of costs (if the responsible party(ies) does not provide the funding).

Under Superfund, the federal government pays 90 percent of site costs and the states 10 percent. If the site was owned by a state or local government, the ratio is 50:50. Of course, if a responsible party pays for the work, only administrative costs are incurred by government agencies. USEPA attempts to reduce total costs by putting a priority on cleanup options which use containment or cleanup on site (rather than excavation and removal for treatment), and by considering all possible alternatives in light of their economic, technical and environmental factors.

Public involvement in the Superfund program is relatively limited. Essentially, the USEPA (or the NJDEP, if control for a site has been contracted to the state by the USEPA) must hold at least one public meeting at the beginning of the Remedial Investigation/Feasibility Study and at the conclusion of the RI/FS. The first meeting is to acquaint the public and officials with the nature of the perceived site concerns and the RI/FS. The RI/FS contract has already been signed by the time the public meeting is held. Public input, especially information about the history of the site and the location and quantities of hazardous wastes, is solicited at the first meeting. The second meeting is held to present the results of the RI/FS, which is always available in nearby repositories for public review prior to the meeting. Input from the public is then requested on the most acceptable alternative to address the site concerns, especially in response to a "preferred alternative" selected by the USEPA or by the NJDEP in cooperation with the USEPA.

NJ Spill Compensation and Control Act--This legislation was enacted in 1977 in response to the need for controls over major facilities which store petroleum and other hazardous substances. The "Spill Act", as it is known, also required the NJDEP to develop standards for responses and cleanup actions for any spills and discharges of petroleum and other hazardous substances which are not permitted by the NJDEP or USEPA under established regulatory programs. Liability standards for damages to natural resources and State costs in responding to discharges were also established along with a "Spill Fund" used by the Department to respond to incidents. The Spill Fund generates approximately $10 to $15 million per year.

The Spill Act was amended in 1980 to respond to discharges which are not active (such as abandoned sites), allowing the use of funds to address

public health threats from such sites. The 1977 act had only applied to current discharges. The Spill Act now provides for a ceiling of $3 million to be spent on any site which was not actively discharging as of the date of enactment. No limit applies to post-Act sites, where the discharge is continuing either by continued addition of materials to the site or by leakage of previously placed materials from the site. The new laws and interpretations provide additional flexibility for the NJDEP in its responsibilities.

The Spill Fund is used for cleanups at sites which are not on the National Priority List of the Superfund program, for emergency responses to current discharges, and for State matching funds for Superfund and other sites which receive federal funds. The Spill Act is implemented by the NJDEP-Division of Hazardous Site Management (regulation of major facilities), the Division of Hazardous Site Mitigation (site cleanups), the Division of Environmental Quality (emergency responses), and the Division of Water Resources (responses to contaminated drinking water supplies, both public and private, to provide treatment or replacement supplies). Claims for costs due to contaminated water supplies must be submitted by the owners of contaminated wells to the NJDEP within one year of the discovery of damages. This requirement can cause some difficulties for private homeowners and municipalities which have missed deadlines due to a lack of knowledge of the program. For private wells, the program is triggered either by direct contamination or by inclusion within a "well restriction area" based on an actual or potential threat of contamination. The NJDEP has the power to force well owners to seal their wells according to State standards in "well restriction areas" (N.J.S.A. 58:4A-4.1).

NJ Hazardous Discharge Bond Act of 1981--A $100 million bond fund was approved by voters in 1981 for the identification, cleanup and removal of hazardous discharges. The bond fund supplements the Spill Fund and has recently been used to advance money to the federal Superfund program so that progress at New Jersey sites will not lag due to the delay in Superfund reauthorization. The bond fund is expected to be exhausted even with reauthorization of Superfund in 1986, and additional funding may be approved by the Legislature and voters.

Environmental Cleanup Responsibility Act--ECRA was enacted in 1983 as N.J.S.A. 13:1K-6 et seq., P.L. 1983, c. 330). It is one of the first laws in the country which requires the owners of most classes of industrial property to notify the NJDEP-Division of Hazardous Site Management of the impending sale of real property or a decision to close the business. In each case a "negative declaration" or cleanup plan

must be approved by the NJDEP, so that the facility does not pose a threat to the public health or welfare at the time of sale, transfer or closure. ECRA applies to firms which are involved in the generation and disposal of hazardous substances or hazardous waste. The law applies to sites on which such activities have taken place even if current uses of the property are not covered.

The intent of ECRA is to ensure that the costs of site cleanup fall to the owner of the property rather than to the public. By placing the requirement for notification at the time of transfer, a major economic incentive exists for industrial facility owners to move quickly toward site cleanup with NJDEP approval. The program is still in its early years, with considerable backlogs of property transfer approvals and difficulties in implementation.

Implementation--The NJDEP operates its hazardous site cleanup program under the umbrella of a "Management Plan for Hazardous Waste Site Cleanups." The first plan covered the years from 1983 to 1986. The plan deals with all sites for which cleanups are eligible for public funding, though some of the sites will actually be cleaned by responsible private parties. Additional cleanup activities take place through enforcement actions by the Divisions of Water Resources, Hazardous Site Mitigation, Hazardous Site Management and Solid Waste. The ECRA program also involves numerous site cleanups, but the action is undertaken as part of the regulatory process rather than as an action by enforcement elements of the NJDEP.

Additional information on programs of the NJDEP which address hazardous substance cleanups is available in a report prepared by the NJDEP, A Status Report on the Hazardous Waste Cleanup Program in New Jersey. The first report (submitted to the Legislature) was released in April 1985 and the second report is due in the fall of 1986. The Division of Hazardous Waste Management is responsible for Department-wide program analysis of hazardous waste cleanup actions.

Technologies--The range of technologies currently in use for ground water investigations and site remediation are so many that this study cannot provide more than a cursory overview. Many books and reports have been published on the topic of hydrogeologic and cleanup technologies. Some of these references are listed in the bibliography. For those interested in an overview of pollution control, the Office of Technology Assessment prepared a very useful report called Protecting the Nation's Groundwater From Contamination in 1984. The USEPA published a seminar report, Protection of Public Water Supplies from

Ground-Water Contamination, which provides a more readily understandable presentation of the topic. Finally, the U.S. Geological Survey prepared a well-presented handbook, Basic Ground-Water Hydrology, which presents considerable information on the theory and practice of hydrogeology as it applies both to water supply and contamination issues, and which uses excellent graphics to illustrate the text's points.

The first step in all ground water contamination cases is to halt the addition of contaminants to the aquifer by eliminating the contaminant source. This step may be as simple as removing a few leaking barrels or as complex as redesigning an entire disposal system. Some contaminant sources, such as inactive landfills, cannot readily be prevented from putting additional contaminants into the aquifer.

Hydrogeologic investigations are the touchstone of remedial work. Detailed information about the site geology and hydrogeology, the nature and concentrations of contaminants, and the extent and flow rate of the contaminant plume is critical to proper site cleanup. Hydrogeologic investigations provide the data which, with proper analysis, provide the information necessary to plan remedial actions. Table VI-11, from the 1984 report by the Office of Technology Assessment, provides an overview of hydrogeologic investigation techniques, their uses and the constraints and limitations posed by the techniques themselves and by site characteristics. The techniques range from indirect to direct, from inexpensive to very expensive. The importance of proper site investigations is clearly shown by Figure VI-7, where reliance on deep monitoring wells near the contamination source or shallow wells distant from the site would not have detected the contamination plume. Ground water contamination does tend to move in plumes, and is diluted primarily in the direction of travel (as some contaminants move slower than the rate of ground water flow) rather than away from the flow. Contaminants may tend to float on the water table, sink to the bottom of an aquifer, or dissolve within the ground water, but in each case the plume will tend to be a discrete presence within the aquifer.

Once the hydrogeology and contamination of a site has been determined, a range of remedial alternatives will be feasible. A decision-making process will lead to conclusions about which techniques combine the optimum results from public health, environmental and economic viewpoints. Table VI-12 presents an overview of remedial action alternatives available for the correction of ground water contamination. The three most common sets of alternatives revolve around containment, withdrawal, and treatment of the contaminants. Containment means that the contaminants are physically isolated within the ground water

Table VI-11. Techniques for Hydrogeologic Investigations

Source: Office of Technology Assessment, 1984

Techniques	Information	Major site contraints				Other constraints
		Subsurface geology	Subsurface hydrology	Water quality	Surface conditions	
1. Unpublished and published information	To identify geologic, hydrologic, hydrogeologic, water quality, topographic, and climatic conditions.	Type of geologic formation: May not be sufficiently detailed for complex geologic settings.	Complexity of subsurface conditions: Usually data are unavailable for specific sites, but some regional hydrogeologic information may be useful, particularly in simple, uniform hydrogeologic settings.	Not a constraint.	Not a constraint.	Proprietary data may limit availability.
2. Mapping	To delineate surface geologic, soil, or topographic conditions.	Not a constraint.	Not a constraint.	Not a constraint.	Site access: Inaccessible terrain may be problematic during ground surveys.	Nonsite-specific information often adequate; represents separate cost. May require a relatively long time to complete (days to months).
3. Remote sensing (aerial photography and thermal, infrared, and radar satellite imagery)	To assess indirectly geologic, hydrologic, hydrogeologic, or water quality characteristics of the earth's surface. A reconnaissance tool to optimize surface field studies.	Depth: Techniques generally provide information on only face features but some techniques may provide some information on shallow groundwater flow and/or contaminant seepage within 10 feet of the land surface. Type of geologic formation: Some techniques can penetrate the surface and provide information on contaminants if under thin alluvium or sand.	Saturation conditions: Some techniques (e.g., radar) to detect presence of contamination are applicable only in unsaturated areas where there is a moisture difference between contaminated and uncontaminated areas. Flow system: Detectable contamination limited to discharge areas with techniques other than radar.	Nature of Chemical Compounds: Contaminant distribution can be detected by various techniques if chemicals stress vegetation, cause tonal changes in surface water, or thermal anomalies.	Climate: Some techniques are weather dependent; cloud cover interferes with all techniques except radar. Timing: Some techniques are accomplished best at different times of day (e.g., predawn or midday) and seasons.	Nonsite-specific information often adequate; represents separate cost.
4. Excavations and drilling	To access directly the subsurface environment for the purpose of geologic sampling, geophysical logging, water quality sampling, and fluid potential measurements.	Depth: Excavations generally only done at less than 20 feet. Applicability of different drilling techniques varies with depth; however, with use of proper equipment, holes can be drilled to virtually any depth. Type of geologic formation: Some drilling techniques can be used in only certain types of materials (soil versus rock, consolidated versus unconsolidated, prone to caving versus non-caving).	Not a constraint.	Nature of chemical compounds: Presence of certain contaminants may limit use of some drilling fluids to avoid sample contamination. Variations in contamination with depth may limit use of certain techniques to avoid cross-contamination.	Scale: Excavations can cover larger areas than drilling. Site access: It may be difficult to reach some sites (e.g., steep or marshy) with steep or marshy) with some types of equipment.	Property access: May require a relatively long time to complete (days to months). Relatively high cost to implement.

Table VI-11 (Cont'd)

Techniques	Information	Major site contraints: Subsurface geology	Subsurface hydrology	Water quality	Surface conditions	Other constraints
5. Geologic sampling	To identify directly stratigraphy and geologic structure and to obtain geologic samples for laboratory testing of hydraulic and soil characteristics.	Depth: Type of sample that can be obtained depends on the depth and penetration capability of drill rig and/or sampling equipment. Depth is not a limiting factor for obtaining either undisturbed samples from some unconsolidated materials, or representative and non-representative samples from any type of materials.[b] Type of geologic formation: Some limitations depending on whether consolidated or unconsolidated. See Depth.	Not a constraint.	Not a constraint.	Not a constraint.	May require a relatively long time to complete (days to months).
6. Hydrometeorological measurements	To quantify temperature, precipitation, evapotranspiration, and infiltration at the earth's surface.	Not a constraint.	Not a constraint.	Not a constraint.	Not a constraint.	Field techniques to measure transpiration are difficult to apply, so estimates are usually made. Nonsite-specific information often adequate; represents separate cost.
7. Surface hydrology (hydraulic measurements; surface water sampling)	To identify flow and water quality characteristics of surface water.	Not a constraint.	Not a constraint.	Nature of chemical compounds: Difficult to obtain samples of many organic compounds that are only slightly water-soluble.	Not a constraint.	Nonsite-specific information often adequate; represents separate cost.
8. Subsurface Hydrology a. Potential measurements	To measure subsurface water level or pressure for evaluating direction of flow and to calculate flow rates within and between hydrologic units in both the unsaturated and saturated zones.	Depth: Depth is a limiting factor for some techniques (e.g., some tensiometers and drill stem tests). However, techniques are available to obtain measurements at any depth, provided specially designed wells are drilled. Type of geologic formation: Fine-grained, low permeability material limits the use of certain techniques (e.g., standpipes). However,	Saturation conditions: Choice of techniques depends on whether measurement is required for the saturated or unsaturated zone.	Not a constraint.	Not a constraint.	Not a constraint.

Table VI-11 (Cont'd)

Techniques	Information	Major site contraints: Subsurface geology	Subsurface hydrology	Water quality	Surface conditions	Other constraints
d. Water quality sampling (cont'd)		before sample collection, which may in turn limit selection of the most effective sampling equipment for particular constituents.		Design constraints of multiple completion wells (e.g., small diameter) may may limit use of most effective sampling equipment for some chemical parameters. Proper disposal of evacuation water prior to sampling is dependent on its quality. Techniques used to evacuate wells and obtain samples may result in incorrect measures of some compounds (especially dissolved gases and volatile organics). Also, the presence of some constituents (e.g., sediment) may damage some types of equipment. Some techniques allow excessive exposure to the atmosphere or other gases that might influence the measurement of specific parameters.		
9. Hydrogeologic system analysis (modeling; geostatistics)	To simulate or predict the behavior of subsurface hydrogeologic units, including groundwater flow and solute transport; or to estimate the values of hydrogeologic phenomena at unmeasured points.	Not a constraint.	Complexity of subsurface conditions: choice of modeling technique (i.e., analytic or numeric) depends on complexity of problem. Modeling complex systems limited by cost of obtaining data. Most geostatistical methods require that the sample population be normally distributed; thus if data represent complex subsurface conditions, geostatistical methods may be difficult or impossible to apply.	Not a constraint.	Not a constraint.	Relatively high cost to implement. May require a relatively long time to complete (weeks to months). Specialized skills required. Requires a clear definition of the hydrogeologic parameters used, including their variability in time and space.
10. Surface geophysics (electrical resistivity and electromagnetic conductivity; ground-penetrating radar; seismic refraction; shallow geothermic method)	To assess indirectly stratigraphy and extent of subsurface contamination to aid in placement of monitoring well sand to reduce number of wells.	Depth: Depth limitations are dependent on technique. Generally, techniques cannot be applied at depths greater than 500 feet. Type of geologic formation: Minimum detecta-	Complexity of subsurface conditions: Techniques applicable only in relatively simple stratigraphic conditions. Natural subsurface properties must be sufficiently uniform so as not to confuse or mask the effects of chemicals. Natural	Nature of chemical compounds: Chemicals of interest must be capable of both inducing a change in the subsurface parameter measured by the method and showing a different response than	Climate: Some techniques requiring electrode contact not applicable in frozen soils or in dry sandy areas (e.g., electrical conductivity). However, other techniques are applicable in these	Relatively high equipment cost; need for skilled personnel; may require a relatively long time to complete (weeks to months).

Table VI-11 (Cont'd)

Techniques	Information	Major site contraints				Other constraints
		Subsurface geology	Subsurface hydrology	Water quality	Surface conditions	
10. Surface geophysics (cont'd)		ble concentration strongly influenced by properties of subsurface materials. Conditions that may prevent good results include: naturally conductive brackish water, steep water table, crystalline rock, and karst or other environs where groundwater flow is concentrated along interconnected fractures in massive bedrock.	conditions that may be responsible for false detection or nondetection include: discontinous, thick layers of clay; hydrogeologic heterogeneity; variations in natural groundwater chemistry due to changes in geologic materials; and variations in surface topography. Some methods are more effective than others for detecting small fracture zones containing high contaminant concentrations (e.g., electromagnetic conductivity is better than electrical resistivity). Homogeneous subsurface environments having layers of increasing densities present interpretative difficulties for some techniques (e.g., seismic refraction). All techniques generally require subsurface drilling or monitoring for verification of results. Saturation conditions: Some techniques can be used to obtain some types of information only in the unsaturated zone (e.g., electrical resistivity can track contaminant movement in only the unsaturated zone).	surrounding subsurface conditions. Many techniques (e.g., resistivity and conductivity methods) generally are ineffective for defining organic contaminant plumes. However, the presence of organic chemicals and petroleum products may be delineated in sand or gravel aquifers at depths generally less than 25 feet with ground penetrating radar. Relatively high concentrations required by techniques for detection of contaminants. Techniques only provide gross information on concentrations of some individual constituents. Some techniques can be effective in delineating extent of high concentrations of inorganic contamination in suitable geologic environments.	conditions (e.g., electromagnetic conductivity). Nature of surface: Conductors (e.g., metal fences, overhead power lines, paved areas, buildings, storage tanks, and buried pipelines or wires) may impair use of some techniques. Sensitivity of different techniques to these features is variable. Bare rock, wetlands, shallow lakes, and dry sandy areas prevent use of techniques requiring electrode contact.	
11. Subsurface (borehole) geophysics (acoustical; electrical-magnetic; nuclear; flow; thermal; geochemical)	To measure direct physical properties of subsurface materials to evaluate lithology, geologic structure, hydraulic properties, water quality, and flow.	Depth: Not a limiting factor for most techniques provided an uncased borehole can be drilled. Type of geologic formation: Most techniques can be used only in uncased boreholes, and thus cannot be used in geologic formations that cave in when drilled. Exceptions include nuclear logs which can be used in cased boreholes. Some tech-	Saturation conditions: Some techniques (e.g., electrical-magnetic logging techniques) are applicable only in saturated zone. Some techniques can be used to provide certain types of information in the unsaturated zone, and other types of information in the saturated zone (e.g., neutron logs).	Nature of chemical compounds: Some techniques applicable only if constituents in groundwater have properties that will induce response from instruments (e.g., spontaneous potential logs). Some techniques can be used to detect particular contaminants (e.g., Draeger tubes can detect over 140 in-situ soil gases).	Not a constraint.	Relatively high cost to implement.

Table VI-11 (Cont'd)

Techniques	Information	Major site contraints: Subsurface geology	Subsurface hydrology	Water quality	Surface conditions	Other constraints
11. Subsurface (cont'd)		niques more suitable for obtaining information on particular types of geologic materials (e.g., natural gamma logs for obtaining clay unit properties).				
12. Hydrogeochemistry	To perform field testing of water samples to determine need for further laboratory chemical analysis and to analyze for unstable consituents.	Not a constraint.	Not a constraint.	Nature of chemical compounds: Field techniques available to obtain information on conductance, organic vapors, alkalinity, pH, Eh, DO, iron, and hydrocarbons. (See Subsurface Hydrology — Groundwater quality sampling, for additional constraints.)	Not a constraint.	Not a constraint.

[a]Based on Geotrans, Inc., 1983b.
[b]*Undisturbed sample*—An in-place specimen in which features such as structure, density, and moisture content are essentially preserved. Suitable for laboratory testing of properties of geologic structure.
Representative sample—A disturbed sample in which some features do not survive but grain size and gradation are preserved. Suitable for grain size gradation analyses and obtaining knowledge of subsurface stratigraphy.
Nonrepresentative sample—A sample that may consist only of drill cuttings or other incomplete or contaminated portions of subsurface materials. Generally not suitable for testing or analysis. Somewhat suitable for subsurface stratigraphy.

SOURCES: Office of Technology Assessment; Geotrans, Inc., 1983b.

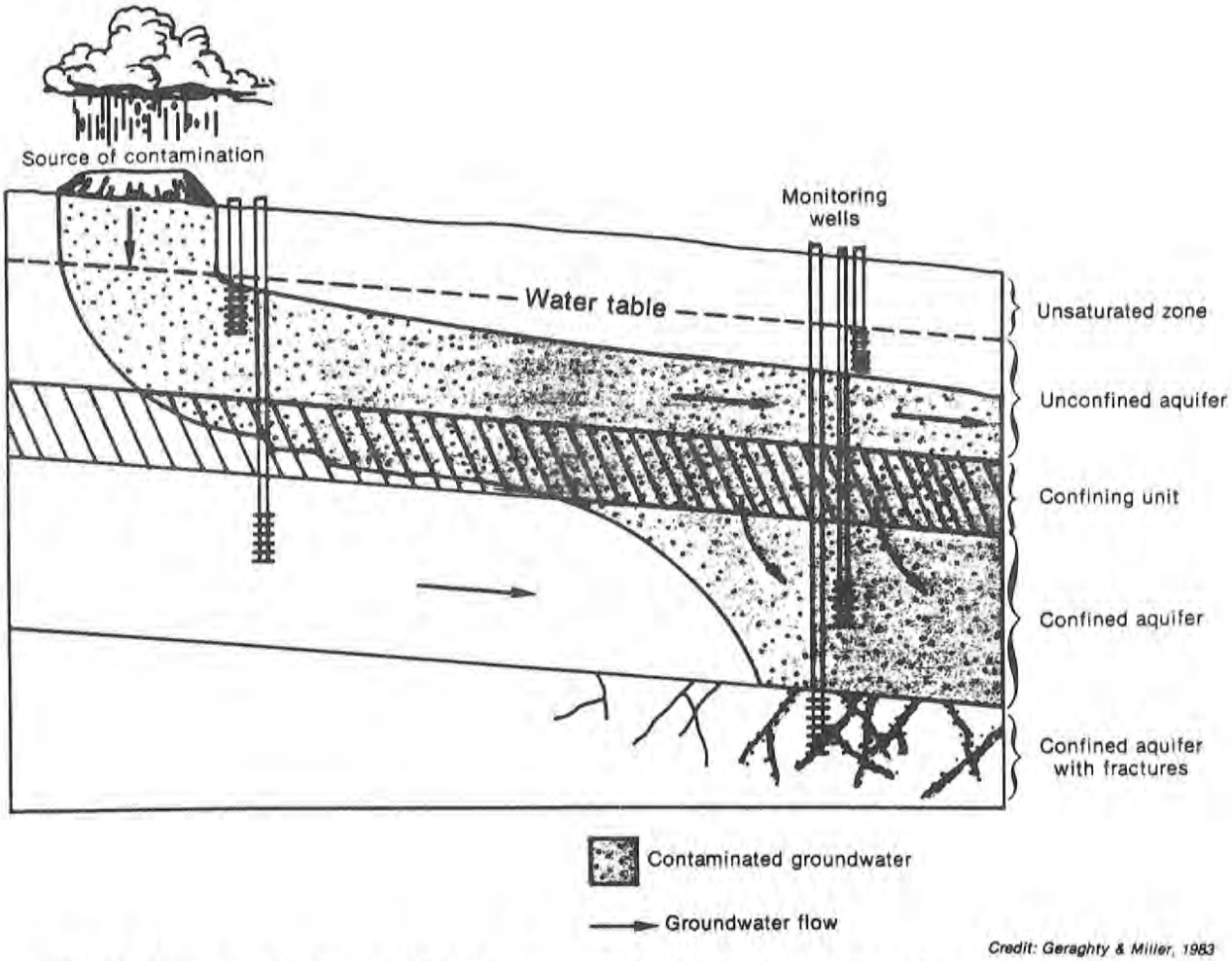


Figure VI-7. Sampling Wells for a Ground Water Contamination Plume

Source: Office of Technology Assessment, 1984

Table VI-12. Corrective Action Alternatives

Source: Office of Technology Assessment, 1984

I. ***Containment***: This category consists of geotechnical methods that act to limit the mobility and prevent the further spreading of contaminants. Contaminants are not actually removed from the subsurface but are contained or isolated from the rest of the environment—e.g., via physical barriers or hydrodynamic pressures. Techniques are applied in relation to either the contaminants or their source.

1. *Slurry Wall*: Consists of a material (slurry) barrier wall constructed in-place; is usually located below the water table and surrounding a site to limit the horizontal migration of contaminants in the saturated zone; is also used to reduce hydraulic gradients, facilitate withdrawal, or channelize groundwater flow.
2. *Sheet pile*: Consists of a material (e.g., concrete, steel, or wood) barrier wall inserted into place by driving or vibration; is usually located below the water table and around a site to limit the horizontal migration of contaminants in the saturated zone.
3. *Grouting*[b]: Consists of a material cutoff injected into voids of water-bearing strata either to cover, bottom seal, or bind together the subsurface materials at a site.
4. *Geomembrane cutoff*: Involves the insertion of synthetic sheeting into an open trench (combining aspects of both the slurry wall and sheet pile) to form a barrier wall; is used primarily to limit the horizontal migration of contaminants in the saturated zone.
5. *Clay (or other) cutoff*[c]: Clay (or other material, e.g., concrete) barrier wall; normally is constructed above the water table and downgradient of a site to limit the horizontal migration of contaminants in the unsaturated zone (which is commonly negligible).
6. *Liner*[d]: Consists of a material (e.g., clay or synthetic) barrier constructed or emplaced to isolate (e.g., cover or seal) contaminating sources in order to limit the vertical migration of contaminants; is often a facility design component.
7. *Natural containment*: Involves limitation of contaminant mobility by naturally occurring geochemical, geologic, and/or hydrologic conditions; is evaluated by analytical and/or empirical methods.
8. *Surface sealing*[d]: Is used as an infiltration control measure to limit the vertical migration of contaminants either by reducing leachate production and/or recharge.
9. *Diversion ditch*[d]: Is used as an infiltration control measure to limit surface runoff into a contamination management area (e.g., a slurry-walled area) by channelizing and diverting surface drainage.
10. *Hydrodynamic control*: Limits the horizontal migration of contaminants in the saturated zone through selective pumping and the subsequent creation of pressure troughs or pressure ridges.

II. ***Withdrawal***: Withdrawal options include methods for either directly removing or facilitating the removal of contaminated groundwater and/or contaminated soils from the subsurface. Techniques are principally applied in direct relation to the contaminants.

1. *Pumping*: Involves the removal of contaminated groundwater by pumping from wells or drains; controls the lateral (and in some cases, vertical) migration of contaminants; can be used for flushing (via artificial recharge).
2. *Gravity drainage*: Involves the removal of groundwater from the subsurface using the force of gravity (e.g., using sumps of French drains) instead of pumps; controls the lateral (and in some cases, vertical migration of contaminants.
3. *Withdrawal enhancement*: Enhances the ability to withdraw either groundwater or contaminants, typically by increasing contaminant solubility in water (e.g., by injecting steam or heat, bacteria or nutrients, or surfactants).
4. *Gas venting*: Removes gases associated with contamination (e.g., methane and petroleum-related products).
5. *Excavation*: Involves the direct removal of contaminated soil and/or groundwater resulting from source leakage.

III. ***Treatment***: This category includes physical and chemical/biological treatment methods for detoxifying contaminants found in groundwater. These methods presume that contaminants have already been withdrawn from the subsurface (e.g., via withdrawal methods) in the form of contaminated groundwater or contaminated soils. Treatment can be applied at the source, at the site of contamination (e.g., in on-site treatment units), prior to the distribution of groundwater for use (e.g., in municipal wastewater treatment facilities), and at the point of end use (e.g., at the tap).

a. Physical treatment

1. *Skimming*: Involves the removal of floating contaminants (e.g., oil, grease, and hydrocarbons) in a multi-layer solution.
2. *Filtration*: Involves the physical retention and subsequent removal of contaminants present as suspended solids.
3. *Ultrafiltration*: Involves the physical filtration, through semi-permeable membranes, of suspended and dissolved metals, emulsified hydrocarbons, and substances of high molecular weight.
4. *Reverse osmosis*: Involves the osmotic filtration, through semi-permeable membranes, of contaminants (e.g., metals and radioactive wastes) present as dissolved solids; operates at high pressures (up to 1,500 psig).
5. *Air stripping*: Uses air injection to facilitate the volatilization and removal to the atmosphere of contaminants (e.g., volatile organics and hydrogen sulfide) that are present in water as dissolved solids.
6. *Steam stripping*: Involves the fractional distillation of volatile organics or gases by heating.

b. Chemical/biological treatment

7. *Precipitation/clarification/coagulation*: Removes contaminants (e.g., suspended and colloidal solids, phosphates, and heavy metals) through the use of chemical additives such as coagulants and coagulant aids.
8. *Ion exchange*: Removes selected ions (primarily inorganic) via the exchange of ions between an insoluble solid salt ("ion exchanger") and a solution containing the ion(s) to be removed.
9. *Adsorption*: Removes contaminants (primarily organics) via their tendency to condense, concentrate,

Table VI-12 (Cont'd)

or adhere on the surface of another substance (e.g., granular activated carbon and synthetic resins) with which they come into contact.

10. *Electrodialysis*: Separates and removes positive or negative ions under the action of an electrical field.

1. *Chemical transformation*: Involves oxidation-reduction reactions for the chemical conversion of contaminants to less toxic substances (e.g., by ozone treatment, hydrogen peroxide treatment, ultraviolet photolysis, and chlorination).
12. *Biological transformation*: Involves the transformation and removal by micro-organisms of dissolved and colloidal biodegradable contaminants; includes both aerobic and anaerobic processes.
13. *Incineration*: Involves the high-temperature transformation of contaminants into constituent components; many types of thermal destruction systems are included.

IV. ***In-situ rehabilitation***: In-situ rehabilitation techniques are directed at immobilizing or otherwise detoxifying contaminants in place.

1. *Biological degradation*: Involves either stimulating the growth of native microflora or injecting specific organisms to consume or otherwise alter contaminants.
2. *Chemical degradation*: Involves the injection of specific chemicals that react with or otherwise alter contaminants.
3. *Water table adjustment*: Involves either the isolation of the contaminated zone (and creation of a detoxifying unsaturated environment) by lowering the water table or the artificial inducement of increased flushing action by raising the water table.
4. *Rehabilitation via natural processes*: Involves the natural degradation, dispersion, or detoxification of contaminated groundwater; is evaluated by analytical and/or empirical methods.

V. ***Management options***: Management options are usually applied either to prevent further contamination or to protect potential exposure points from contaminated groundwater. These methods thus focus on sources and exposure points rather than on the contaminants per se. The methods also tend to be institutionally-based rather than technology-based.

1. *Limit/terminate aquifer use*: Limits access or exposure of receptors to contaminated groundwater.
2. *Develop alternative water supply*: Involves the substitution of contaminated groundwater with alternative supplies (e.g., surface water diversions and/or storage, desalination, and new wells).
3. *Purchase alternative water supply*: Includes bottled water and water imports.
4. Source removal[e]: Involves the physical removal of the source of contamination and includes measures to eliminate, remove, or otherwise terminate source activities; could also include modification of a source's features (e.g., operations, location, or product) to reduce, eliminate, or otherwise prevent contamination.
5. *Monitoring*: Involves an active evaluation program with a "wait and see" orientation.
6. *Health advisories*: Involves the issuance of notifications about groundwater contamination to potential receptors.
7. *Accept increased risk*: Involves the decision to accept increased risk: is usually a "no action" alternative.

[a]Based on Woodward-Clyde Consultants, Inc., 1983. See this reference for a detailed bibliography on specific corrective action alternatives.
[b]Can be considered a form of chemical immobilization if injected directly into the plume of contamination.
[c]Physical barriers located above the water table will not affect the horizontal migration of contaminants in the saturated zone.
[d]Most often used in the context of either "source removal" or the prevention of recharge to the groundwater system, rather than as a containment option per se.
[e]Modification of a source's features is often an important element of corrective action in the context of preventing future groundwater contamination (i.e., reducing the need for future corrective action).

SOURCE: Office of Technology Assessment.

environment so that further spreading of the contaminants and their contact with humans are limited. Figure VI-8 shows one method of containment, where an actual barrier is built around the site. Barriers to flow also include drainage ditches and the creation of a cone of influence which directs the flow of ground water to the site. The latter method is called hydrodynamic control and is shown in Figure VI-9. Hydrodynamic control results in the diversion of contaminated water from the site, however, and must be linked with other control technologies.

Withdrawal of contaminants may also be used at contamination sites. Pumping is one possibility, while excavation of wastes is another. Any withdrawal, as with hydrodynamic controls, requires that the wastewater be treated or otherwise disposed of in an acceptable manner. Treatment options include the physical, chemical or biological removal of contaminants. Many of the contamination sites in the Buried Valley Aquifer Systems have volatile organic contaminants (VOCs) which can be removed effectively by granular activated carbon (GAC) treatment or air stripping. The two techniques vary in their ability to remove VOCs from water. Figure VI-10 shows the relative ease by which selected VOCs are removed by air stripping, while Figure VI-11 shows the relative ease of removal by GAC. In both figures, the higher numbers indicate more effective removal. As one example, 1,2,4-trichlorobenzene is relatively difficult to air-strip but relatively easy to remove using GAC.

The technologies used for investigation and remedial actions vary with each site, and are highly sensitive to the circumstances peculiar to the contaminants and the site history and geology. This section has attempted to present only the range of alternatives and should not be used to prescribe techniques for a particular site.

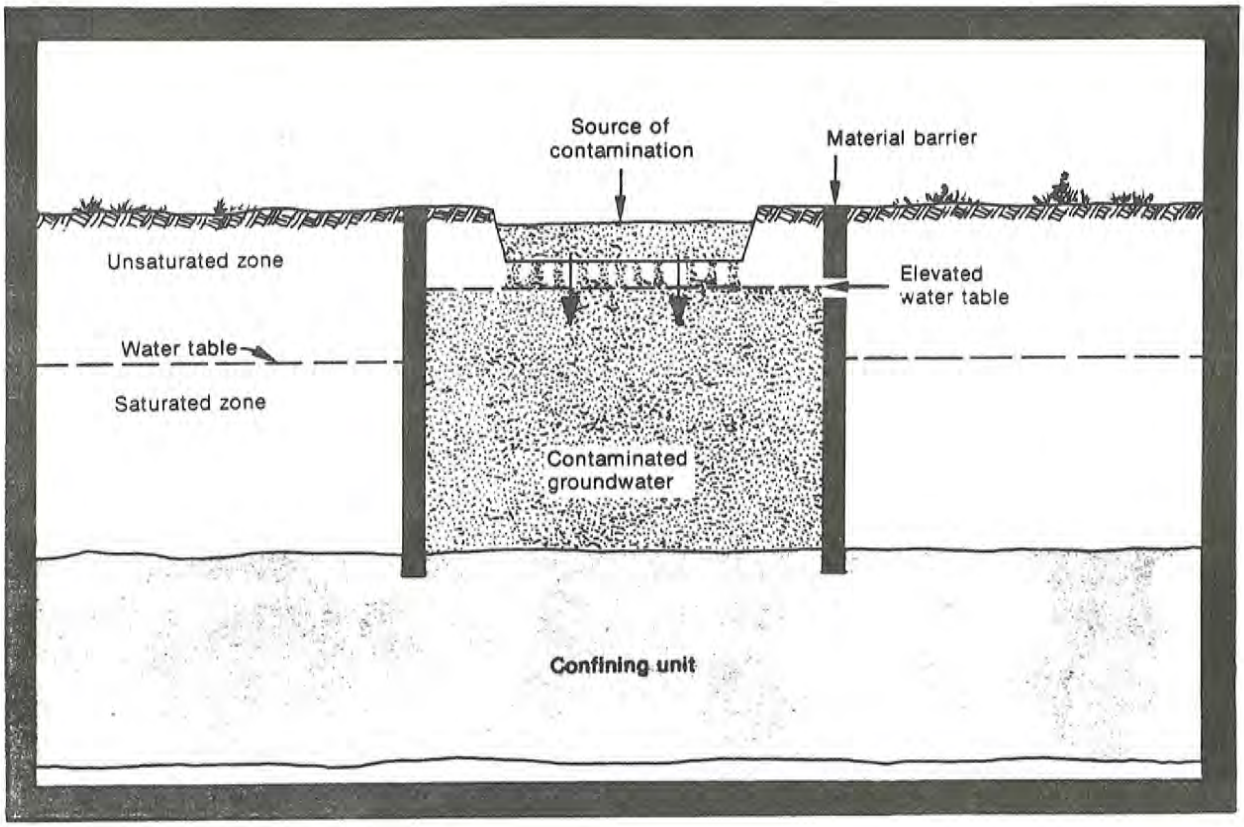


Figure VI-8. Containment of Ground Water Contamination

Source: Office of Technology Assessment, 1984

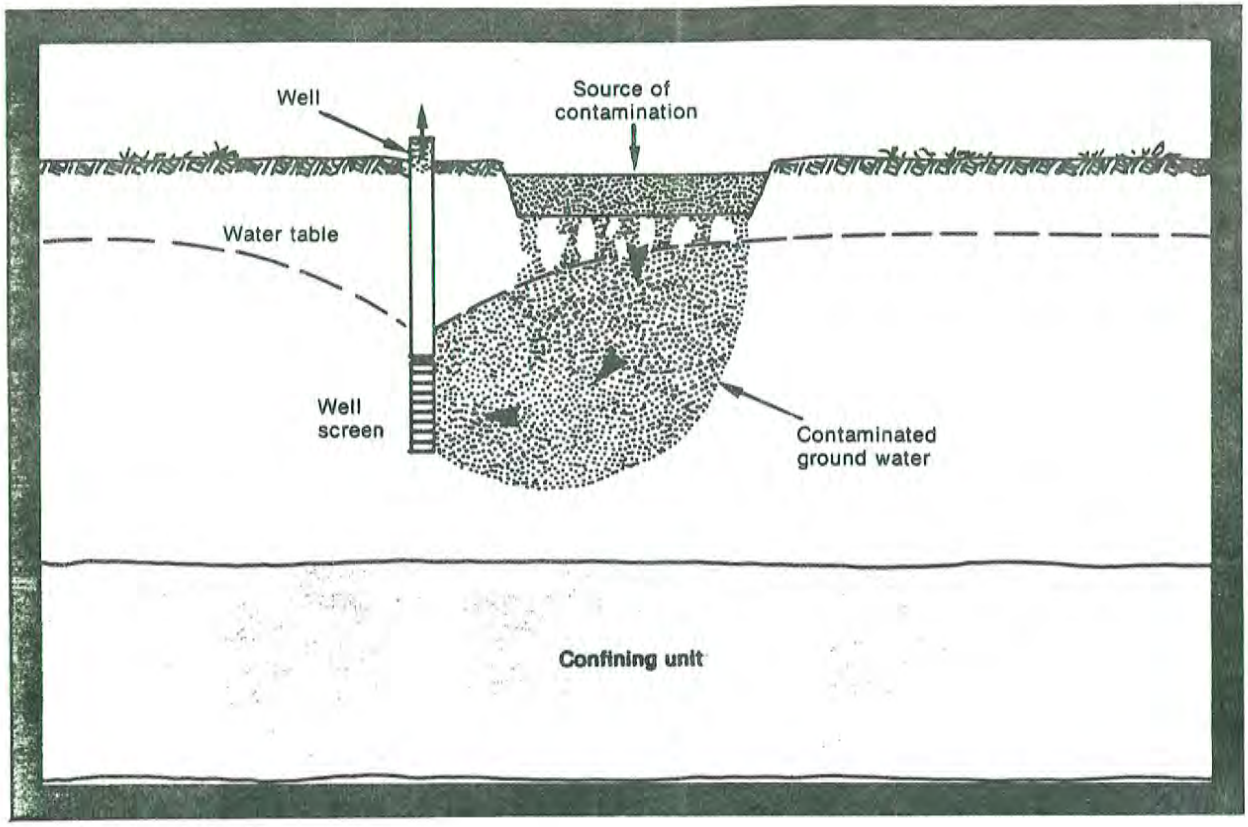


Figure VI-9. Hydrodynamic Control of Contamination Plumes

Source: Office of Technology Assessment, 1984

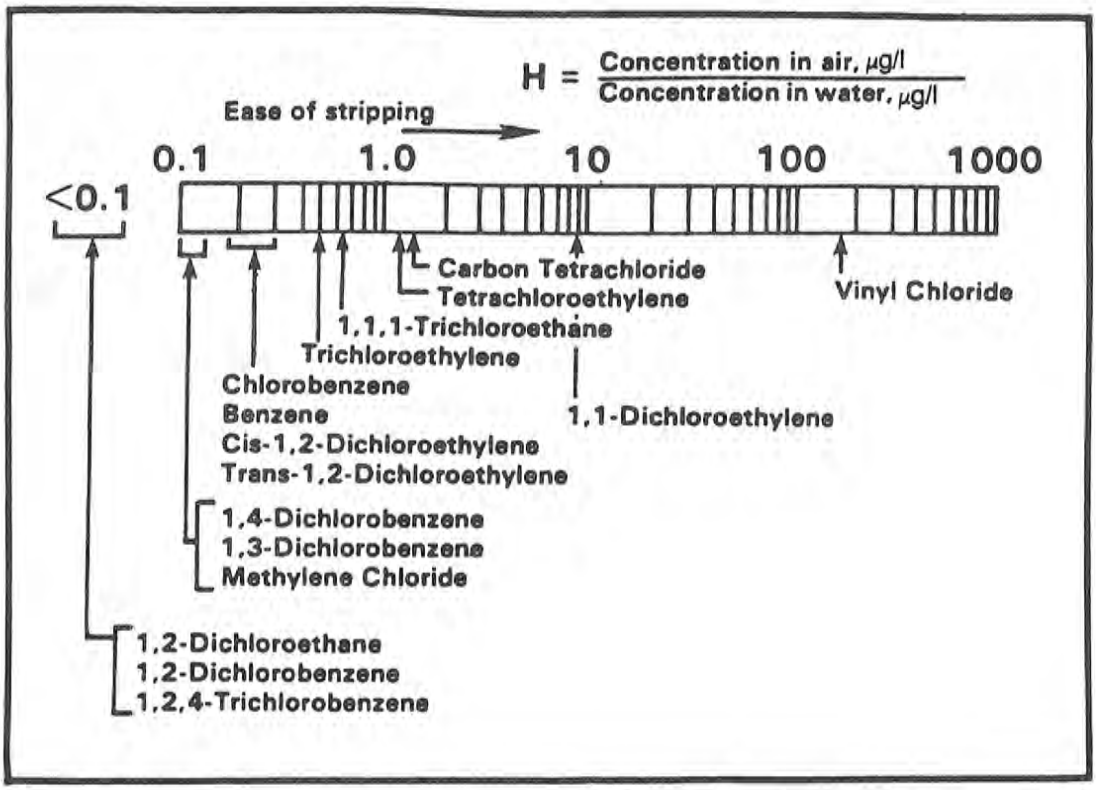


Figure VI-10. Relative Effectiveness of Treatment by Air Stripping

Source: U.S. Environmental Protection Agency, 1985.

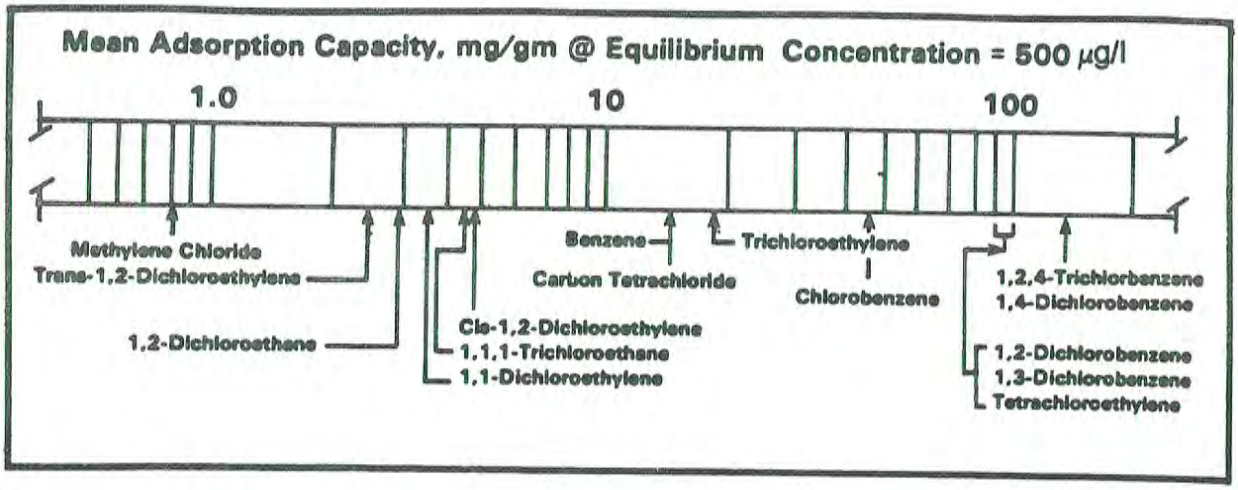


Figure VI-11. Relative Effectiveness of Treatment by Granular Activated Carbon

Source: U.S. Environmental Protection Agency, 1985

CHAPTER 7

REGIONAL GROUND WATER QUALITY

The Buried Valley Aquifer Systems are located in a suburban to rural area with some densely developed business centers such as Morristown, Dover, Boonton, Wharton, etc. Industries in the region include electronics, metal working and finishing, pharmaceuticals, specialty chemicals and aeronautics. Light industry abounds in the rapidly growing suburban areas, while heavier industry exists primarily in the Rockaway Valley area along the Rockaway River.

Public sewerage was not developed in much of the region until the 1960's and 1970's, with some densely developed areas receiving public sewerage only recently (e.g. East Hanover and Fairfield). Significant clusters of light industry, many of which used industrial solvents in their processes, made use of lagoons and septic systems for industrial waste disposal until public sewerage became available. Such waste disposal practices pose a major threat to ground water quality.

Underground storage tanks, essentially unregulated and unmonitored until 1985, also have posed a major threat to ground water quality. Most underground tanks installed over the past 40 years have been constructed of bare steel, unprotected from corrosion and lacking monitor systems to detect leakage. Tanks in the region include gasoline and diesel fuel facilities as well as a lesser number of process chemical and waste storage tanks at industrial sites.

Many ground water contamination sites exist within the region. The largest number of sites exist within the Rockaway Valley and the Whippany-Lower Rockaway subregions. However, each subregion of the Buried Valley Aquifer Systems has experienced some contamination. Not all of the sites pose major threats to potable water supplies. Many of the minor sites have been restored to acceptable quality under the supervision of the NJ Department of Environmental Protection. Of the more heavily contaminated sites, almost none have aquifer

decontamination programs in operation. Most have extensive enforcement histories during which hydrogeologic analyses were required of the involved parties to determine responsibility, feasibility of cleaning up the resource, and costs.

In a few instances, contamination from one site has been so severe and extensive as to contaminate large bodies of ground water off site. None of these "regional" contamination sites has a decontamination program in operation, though several may reach that stage within the next two years. A relatively large number of public supply wells have been affected by regional contamination incidents, in Denville, Dover, East Hanover, Fairfield, Rockaway Borough, Rockaway Township and Roseland.

While action on individual contamination sites is important from an enforcement perspective, decision makers involved in water supply planning and water quality management must consider contamination from a broader perspective. For that reason, information on contamination sites is presented in this chapter by subregion of the Buried Valley Aquifer Systems. Management of sites which have the potential for ground water contamination in the future is also a major concern for the region, and a section of the chapter discusses the categories of sites which lend themselves to contamination incidents by the nature of substances handled at the facilities. Local governments have taken actions to protect their water supplies in some cases, and these techniques are discussed generally. Finally, State and Federal policies and studies have recognized the importance of ground water pollution as a broad issue potentially affecting a vast number of people. A brief discussion of their findings concludes the chapter.

Major Studies of Ground Water Quality

The first synoptic assessment of ground water quality in New Jersey was prepared by Robert Tucker, Ph.D., of the N.J. Department of Environmental Protection, Office of Science and Cancer Research, during a study begun in 1978 and published in 1981. Most public supply wells were found to have no contamination (as is the case today) but some significant contamination incidents were discovered including the TCE contamination of the Rockaway Borough wells. Results are presented in Table VII-1, indicating the occurrence of VOCs in ground water. A total of 1118 samples from 670 wells were analyzed statewide in the study.

TABLE VII-1

VOLATILE ORGANIC COMPOUNDS WITH
WIDESPREAD OCCURRENCE IN GROUND WATER

Chemical	No. of Samples ≥ 10 ppb	No. of Wells ≥ 10 ppb	No. of Wells ≥ 100 ppb
Carbon tetrachloride	6	5	2
Chloroform	24	24	3
1,2-dichloroethane	22	18	0
Tetrachloroethylene	16	16	2
1,1,1 Trichloroethane	83	65	5
Trichloroethylene	52	27	12
Dichlorobenzene	8	8	2
Trichlorobenzene	4	4	1
	215	167	25
Actual Number of Wells*		111	21

*Numbers of wells are less than the totals in the columns because some wells have more than one contaminant.

Source: Tucker, Robert K. 1981. Groundwater Quality in New Jersey: An Investigation of Toxic Contaminants. Trenton, NJ: NJ Department of Environmental Protection, Office of Cancer and Toxic Substances Research: 5.

Additional cases of public supply contamination in New Jersey eventually led to legislation by Senator Raymond Lesniak which requires periodic testing of all public water supplies (surface and ground water) for a wide range of pollutants. In addition, the legislation created the Drinking Water Quality Institute which must establish drinking water quality standards for all public supplies in the State. A-280, the Water Quality Testing Act, completed its first round of testing in 1985. Most public supplies were found to be free of significant quantities of hazardous substances (supplies are tested at the consumer point, not prior to treatment). 93 per cent of all public water supply systems in New Jersey were deemed completely safe. However, this rosy picture applies only to the delivered water. Many supply systems in the Buried Valley Aquifer Systems have acceptable water because contaminated wells have been shut down or routed through sophisticated treatment systems to remove volatile organic compounds from the delivered water. Results of the A-280 testing rounds in 1985 and early 1986 are available to the public. Sample results from the Buried Valley Aquifer Systems are presented in Table VI-7.

The U.S. Geological Survey recently completed a synoptic survey of the surface and ground water regimes in the Upper Rockaway watershed, including ground water quality analyses. The raw data are available but the final report is not expected in 1986.

No other regional studies of ground water quality have been performed. Because of differences in testing technology and the increased sensitivity of such tests over time, long term trends for ground water quality do not exist for the region. The A-280 tests will not establish such trends either, due to the emphasis on testing finished rather than raw water. However, monitoring of contaminated wells is required. Unlike the measurement of ground water static levels through the USGS observation well system, the Buried Valley Aquifer Systems lacks even the most rudimentary system of water quality trend analysis. One of the greatest roadblocks to the development of such a system is the cost. Where ground water levels exhibit regional trends, ground water contamination is primarily exhibited in isolated plumes. Truly synoptic ground water quality analysis would require that all public supply wells, select private supply wells and an array of dedicated monitor wells be analyzed periodically throughout the region. The cost of the new monitor wells and of the water quality analysis may be prohibitive but the system could have considerable value.

Ground Water Contamination in the Region

As in Chapters IV and V, the Buried Valley Aquifer Systems will be considered as seven subregions for ease of understanding. However, the subregions are interconnected through the various buried valley deposits (except for the Towaco Valley in Montville) and sites near the borders of one subregion may be of concern in the next. The discussion is in relatively general terms. Detailed information on most of the contamination sites is available in Appendix F--Ground Water Contamination Sites: Case Studies. The designation of sites is according to the major source of the contamination. "A" indicates an Accidental discharge, "I" is Industrial, "D" is Dumping and "L" is Landfill. "ECRA" sites are those undergoing site evaluation prior to sale of industrial properties, under the provisions of the Environmental Cleanup Responsibility Act (ECRA) of 1984, a New Jersey law. "A-280" sites are public water systems which have exhibited contamination at actionable levels. The sites generally are numbered according the sequence by which they were received by the N.J. Geological Survey which advises NJDEP on hydrogeological matters.

Most of the information in Appendix E and this chapter exists in public records of the New Jersey Geological Survey. A few site profiles were generated from public records of the Bureau of Ground Water Quality Management of the NJDEP. The remaining information is anecdotal, provided by local water system supervisors, engineers and consultants during interviews. None of the information in Appendix E relies on this anecdotal information.

Rockaway Valley Subregion

A concentration of aging industries and newer light industry along the Rockaway River has resulted in a related concentration of ground water contamination incidents. Many public wells in the subregion have experienced significant contamination, including the entire well fields of Rockaway Borough and Rockaway Township, Denville Well 3, Dover Well 4 (and to a lesser extent Dover Wells 1, 3 and 5, and Wharton Well 3). Some private wells have also been contaminated, though much of the developed area relies on public water supplies. The sites in Table VII-2 exist within the subregion and either may or do involve significant ground water contamination. Table VII-3 lists some of the minor contamination cases which have either been closed or do not pose a major risk. A glossary for Tables VII-2 to VII-11 follows Table VII-2.

TABLE VII-2

MAJOR CONTAMINATION CASES
ROCKAWAY VALLEY SUBREGION

ID#	Site and Description	Status	NPL
A152	Shell Gasoline Station, Rockaway Township Extensive gasoline leakage. Contamination of the Rockaway Township well field. Shell Oil Company paid for a treatment system.	C/U	N
A155	Rockaway Township Well Field, Rockaway Township Contamination both by gasoline constituents and by TCE. Treatment by air stripping.	Spill	Y
A162	Rockaway Borough Municipal Wells, Rockaway Borough TCE and PCE contamination from unknown sources in all three wells, 1980. Activated carbon filtration used for treatment.	RI/FS	Y
A163	Dover Municipal Well 4, Dover Shut down from contamination with 1,1,1 TCA and PCE. Multiple contamination from local industries possible. Wells 1, 3, and 5 exhibit low levels of VOCs.	Spill	Y
A237	Community Transit (DAYCO), Dover Major 1984 oil spill being cleaned up. Industrial park adjacent to Dover Wells 1, 3, and 5, suspect source for VOCs.	C/U Inv.	N
A238	Towne & Country Gas, Rockaway Township Gasoline constituents in plume moving toward Rockaway Township well field. Scope of contamination not defined.	Inv.	N
A	Wharton Borough Well 3, Wharton Petroleum hydrocarbon odors from unknown source resulted in shutdown. Treatment system planned.	Local	N
A	Denville Township Wells 3 and 6, Denville VOC contamination, suspect sources include Howmet (Austenal) and NJ Natural Gas. Treatment system planned.	Inv.	N
I57	L.E. Carpenter, Wharton Industrial wastes disposed of in unlined sludge lagoon, extensive contamination with many VOCs. Some free product recovery achieved.	ACO	Y
I67	ARC Avionics/Cessna Co., Boonton Township Industrial waste discharges to unlined lagoon. VOC contamination plume extending off site.	Enf.	N

TABLE VII-2 (Cont'd)

ID#	Site and Description	Status	NPL
I68	Radio Frequency Labs, Inc., Boonton Township Industrial waste discharges to unlined lagoon. The site is next to ARC/Cessna.	Enf.	N
I90	New Jersey Natural Gas (GPU), Dover Heavy VOC contamination from former coal gasification facility in upper aquifer, some lower aquifer contamination 400 feet from Dover Well 4.	ACO	N
I125	Picatinny Arsenal, Rockaway Township Unlined lagoons with metal plating wastes, sanitary landfills. Aquifer contamination with VOCs and heavy metals in southern arsenal area.	C/U	N
I126	Radiation Technology, Rockaway Township Severe VOC contamination resulted in the loss of two wells at the site near Lake Denmark.	ACO	N
I141	Johanson Manufacturing Company, Boonton Township Industrial waste discharges to unlined lagoon. VOC contamination plume which may affect the ARC/Cessna property.	Enf.	N
I210	Howmet (Alloy Division), Dover Moderate levels of VOCs in ground water below the site, from buried drums and industrial waste discharges to lagoons and a septic system on site. Next to Howmet (Austenal).	Inv.	N
I211	Howmet (Austenal Division), Dover Extensive VOC contamination of upper and lower aquifers from industrial waste discharges to leaching field. Implicated in contamination of Denville Well 3 and possibly Dover Well 4.	Inv.	N
I	McWilliams Forge, Rockaway Borough High VOC contamination. Decontamination through pumping to treatment.	C/U	N

GLOSSARY OF TERMS USED IN TABLES VII-2 TO VII-11

A	Accidential Discharge
I	Industrial Source Discharge
D	Dumping
L	Landfill
ECRA	Environmental Cleanup and Responsibility Act
A280	Water Quality Testing Act
ACO	Administrative Consent Order
Closed	Closed Case
C/U	Clean Up of Site In Progress
Inv.	Investigation in Progress by NJDEP or USEPA
Local	Local Enforcement Case
N/A	Information on Status Not Available
NPL	National Priority List (No/Yes)
RI/FS	Remedial Investigation/Feasibility Study
Spill	Spill Fund Act
VOC	Volatile Organic Chemical

TABLE VII-3

MINOR CONTAMINATION CASES
ROCKAWAY VALLEY SUBREGION

ID#	Site and Description	Status	NPL
A90	Dover Christian Nursing Home, Dover Gasoline odors from underground tank leakage.	Closed	N
A93	Rockaway Valley Methodist Church Fuel oil in well.	Closed	N
A116	Exxon Station, Town of Boonton Gasoline tank leak.	Closed	N
A151	Jerry Jones Mack, Rockaway Township Oil spills.	Closed	N
A156	Steve's Getty, Dover Seepage pit behind station.	C/U	N
A171	Gulf Lake Telemark, Rockaway Township Gasoline tank leak.	C/U	N
A	Fernbrook School, Randolph Heating oil tank leak.	Closed	N
I42	Thatcher Glass, Wharton Phenol contamination.	Closed	N
I209	Garden State Transit, Rockaway Township Fuel oil leaks and discharge to a septic system.	Inv.	N
I241	Pacific Vegetable Oil, Boonton Tanks, drums and spillages.	Inv.	N
I249	Drew Chemical, Boonton Drums and spillages found on site.	Inv.	N
I250	Jersey Plating, Boonton Discharges to a cesspool.	N/A	N
I327	U.S. Gypsum, Boonton Downgradient of Drew Chemical.	Inv.	N
I	Boonton Coal Gas Facility, Boonton Some tar and oil deposits.	--	N
--	Boonton Town Well 6 Natural contamination with manganese. Treated.	--	N
--	Denville Township Well 6 Natural contamination with manganese.	--	N
--	Dover Wells 1, 3, and 5 Casting sand dump, no contamination known.	--	N
--	Rockaway Borough Failing septic systems in borough.	--	N
--	Rockaway Township Two municipal dump sites, closed, which require ground water monitoring under NJPDES.	Closed	N
--	Wharton Borough Chloride from former highway department salt pile. Well 3 had shown significant xylene several years ago, 100 ppb peak, dropped to none detected. Bleach dumping pit allegedly used by L.E. Carpenter near Well 3 (not active) has not apparently affected Well 3.		

Of the major contamination cases, the primary areas of concern are the Beaver Brook Buried Valley Aquifer in Rockaway Township (gasoline constituents and TCE) and the Rockaway Buried Valley Aquifer in Dover, Randolph Township and Rockaway Borough (various VOCs, including PCE, TCE and 1,1,1 TCEA). In both cases, contamination has been severe enough to close wells or force extensive treatment prior to potable use. Four sites in this subregion (L.E. Carpenter (DAYCO Corporation), the Rockaway Township well field, the Rockaway Borough well field and the Dover Well 4) are on the National Priority List of the Superfund program for cleanup. The two contamination sites are discussed in detail later in the chapter under Regional Contamination Issues.

The minor contamination sites mostly involve leaking underground storage tanks which released gasoline or fuel oil to ground water, resulting in nonpotable private wells or fumes in structures.

Upper Lamington Subregion

Relatively few contamination incidents have occurred in the Upper Lamington subregion, reflecting the lower density of development, the more residential character and the relative absence of industry. Minor contamination of one public well has been documented and a handful of private wells have been closed due to contamination. The cases in Table VII-4 show that the primary difficulties involve leaking underground storage tanks.

Towaco Valley Subregion

The Towaco subregion includes the Towaco Valley Aquifer, which is within a small watershed area, and the Towakhow (Hook) Mountain area of Montville. Few contamination incidents have occurred in the subregion, only one of which has any potential for contamination of the major aquifer. The cases for the region are indicated in Table VII-5. The Marotta Scientific Controls case is by far the largest, involving the contamination or closure of scores of private wells, but the Bellows Lane contamination is in the vicinity of the Montville well system.

TABLE VII-4

CONTAMINATION CASES
UPPER LAMINGTON SUBREGION

Major Cases

ID#	Site and Description	Status	NPL
A	Spartan Oil-Gulf Station, Roxbury Four facilities with underground storage tanks, including the Gulf station, are located in an area where ground water has been contaminated with gasoline constituents.	Inv.	N
I225	Ledgewood Baptist Church, Roxbury Very high VOC contaminants were discovered in several private wells including that of the church. The wells were sealed. No sources were confirmed but an auto body shop and a transmission repair shop are possible sources.	N/A	N

Minor and Closed Cases

I260	Hercules, Inc., Roxbury Violations of a surface water discharge permit led to studies to determine whether ground water contamination occurred, while improvement of the industrial waste treatment facility commenced.	Inv.	N
A-280	Roxbury Water Company Actionable levels of PCE were found in one well. The well was repaired, reducing the flow of PCE, but the source has not been identified.	A280	N

TABLE VII-5

CONTAMINATION CASES
TOWACO VALLEY SUBREGION

Major Cases

ID#	Site and Description	Status	NPL
A	Bellows Lane, Montville Fuel oil leakage has contaminated over 15 residential wells with petroleum hydrocarbons. A gasoline spill has contaminated private wells approximately one-half mile east of the fuel oil site. Public water is being provided.	Inv.	N
I158	Marotta Scientific Controls, Montville Extensive ground water contamination with VOCs (which also contaminated the Boonton Aqueduct) from industrial waste discharges. Over 55 homes are being connected to public water.	ACO	N

Minor and Closed Cases

I161	Penick Corporation, Montville Phenol contamination from dumping.	Closed	N
--	New Graphics, Montville Septic system, requires NJDPES permit.	--	N

Northwest Essex Subregion

Two of the largest contamination incidents are located within the Northwest Essex Subregion. Two of Fairfield's wells and over one square mile of aquifer (surface area) have been contaminated with VOCs. Essex Fells has three wells in two locations out of service due to VOCs. In addition, there are contamination incidents which have not affected major supply wells. Ground water contamination cases identified within the subregion are listed in Tables VII-6 and VII-7. The Fairfield and Essex Fells contamination cases are by far the most severe. The Fairfield case is a National Priority List site and is currently being studied under Superfund. In both cases, the major contamination threats are attributed to improper or illegal industrial waste disposal practices.

Whippany-Lower Rockaway Subregion

Extensive light industry, suburban residential and highway corridor development exists in this subregion. Along with the Rockaway Valley subregion, it has the greatest concentration of ground water contamination cases. One area, in East Hanover, has incurred regional contamination similar to the Fairfield or Roseland incidents. A second area north of Lake Intervale in Parsippany has significant contamination but no wells have been affected. Most of the other cases are localized or do not affect public supply wells. Cases in the Whippany-Lower Rockaway subregion are listed in Tables VII-8 and VII-9.

Of the major contamination cases, the greatest concern revolves around the two regional contamination sites in East Hanover. Both the Merry Lane area and the Ridgedale Avenue area are discussed in detail under Regional Contamination Issues in this chapter. East Hanover also has a contaminated well (currently treated before use) in a third location. Although the carbon tetrachloride problem at Allied-Signal and the TCE at Airtron and Mennen are significant incidents, current recovery systems are limiting the effects on other parties. As with the Northwest Essex Subregion, most of the major cases involve improper or illegal industrial waste disposal practices. Some sites are the result of accidental spills, poor housekeeping at manufacturing sites, or leaking underground storage tanks containing industrial chemicals.

Most of the minor sites involve either leaking underground storage tanks or minor industrial use of septic systems for waste discharges.

TABLE VII-6

MAJOR CONTAMINATION CASES
NORTHWEST ESSEX SUBREGION

ID#	Site and Description	Status	NPL
I37	Fairfield Township Regional Contamination Wells 2 and 7 shut down due to VOCs. Major plume from Caldwell Trucking, General Hose and others contaminated many private wells downgradient of public wells.	Inv.	N
I218	Caldwell Trucking, Fairfield Industrial and domestic septage discharged to unlined lagoon. Extensive plume, very high VOC levels on site and plume.	RI/FS	Y
I219	General Hose, Fairfield Solvents discharged to the ground. Partial cause of VOC plume with Caldwell Trucking.	Inv.	N
I313	Essex Fells Water Dept, Roseland and Essex Fells Two supply wells in Roseland shut down due to TCE contamination, as has a third well in Essex Fells. Several industries implicated in Roseland, one in Essex Fells. Treatment planned for Roseland wells.	Inv.	N
I344	McGraw-Edison/National Electric Coil, West Caldwell Solvent waste discharges to a septic system, high VOC levels in ground water. Upgradient of Fairfield Well 7, may be implicated.	Inv.	N
I348	Ketcham & McDougall, Roseland TCE waste discharges to unlined pits resulted in ground water contamination. Implicated in contamination of the Roseland wells.	Inv.	N
I349	Tri-County Asphalt, Roseland High levels of petroleum hydrocarbons and VOCs from asphalt operations. Possibly surficial only. Soils removal has occurred.	C/U	N
I352	Intedge, Roseland Extensive VOC contaminants in the septic system from industrial waste discharges. Possible ground water contamination, similar contaminants to those in the Roseland wells.	Inv.	N
I365	Resistoflex, Roseland Industrial waste discharges to the septic system and other contamination sources. High ground water levels of TCE and PCE. Implicated in Essex Fells well contamination.	Inv.	N

TABLE VII-7

MINOR CONTAMINATION CASES
NORTHWEST ESSEX SUBREGION

ID#	Site and Description	Status	NPL
I350	PSE&G Transmission Station, Roseland Fuel oil spill.	Closed	N
I351	Allied-Amphenol, Roseland Underground storage of hazardous wastes and mineral spirits led to local contamination of soils and the water table aquifer. The site is near the Roseland wells but might not be implicated.	Inv.	N
I364	Merrick Corporation, Roseland Abandoned underground storage tank and a former septic system.	Inv.	N
ECRA #85-603	Panelgraphic Corporation, West Caldwell Spills from drum storage areas and a floor drain led to moderate levels of VOCs in soils and ground water on the site.	ECRA	N
--	Caldwell Sewage Treatment Plant, West Caldwell Sludge with heavy metals dumped, removed.	Closed	N

TABLE VII-8

MAJOR CONTAMINATION CASES
WHIPPANY-LOWER ROCKAWAY SUBREGION

ID#	Site and Description	Status	NPL
L47	Sharkey Farms Landfill, Parsippany Allegedly received hazardous wastes from Ciba-Geigy, possible midnight dumping. Small plume.	RI/FS	Y
D15	Champion International, Morris Township Large spill of ink and solvents in 1978. Ground water contamination near a dry well receiving waste VOCs discovered in 1985.	Inv.	N
ECRA 85-17	Van Dyk Research, Hanover A sludge lagoon and radiologic wastes from a former U.S. Radium site heavily contaminated the site, migrating off site.	ECRA	N
ECRA 84-294	Norda, Inc., East Hanover Over 3,600 barrels were buried on site. High VOC levels in a ground water plume.	ECRA	N
ECRA 84-063	Lydo Precision Products, Mountain Lakes Discharge of industrial wastes to a septic system and to the ground. Ground water contamination flowing toward the Norda site.	ECRA	N
I28	Allied-Signal Corporation, Morris Township Carbon tetrachloride from an unknown source is being decontaminated through pumping of the ground water to passive air stripping.	C/U	N
I81	Airtron, Morris Plains Plating wastes discharged to unlined lagoons. High TCE plume flowing to Mennen Co. wells.	Inv.	N
I152	Norda, Boonton Very high VOC levels discovered at the Synthatron site, downgradient of Norda, essentially matching substances used and stored at Norda.	Inv.	N
I162	Royal Lubricants, East Hanover An unlined lagoon and a septic system received VOC and other industrial wastes.	Inv.	N
I163	Dorine Industrial Park, East Hanover VOCs and a dye discharged to septic systems. Private well contaminated with VOCs and several wells had the nontoxic dye.	Inv.	N

TABLE VII-8 (Cont'd)

ID#	Site and Description	Status	NPL
I171	Boonton Electronics, Parsippany Extensive dumping of waste solvents created an extensive plume of VOCs, gradient toward the Parsippany well on Halsey Road.	C/U	N
I229	Synthatron Corp., Parsippany Very high VOC levels from upgradient sources. Arsenic, chloride and sulfate contamination implicate Synthatron's arsine gas production.	Inv.	N
I239	Chemical Components, East Hanover 25 drums, a former waste lagoon and high VOC levels in a septic system. Implicated in the regional pollution near Ridgedale Avenue.	Inv.	N
I262	Weiss-Aug, East Hanover Industrial waste discharges to septic system. Implicated in contamination near Merry Lane.	Inv.	N
I298	Bronner Manufacturing and Tool Co., East Hanover Industrial waste discharges to the ground and septic system, contamination plume with very high VOC levels affecting many private wells. Implicated as a major source of the regional contamination near Ridgedale Road.	Inv.	N
I308	Pine Brook Well Contamination, Montville Waste PCE from dry cleaning store closed six private wells. Public water being supplied.	Inv.	N
I315	Sidmak, East Hanover Septic system with very high VOCs from laboratory discharges. May be implicated in regional contamination near Ridgedale Road.	Inv.	N
I317	Triangle Industrial Park, East Hanover High VOC levels found in septic system, source unknown. VOC contamination found in nearby private wells. May be implicated in the regional contamination near Ridgedale Road.	Inv.	N
I362	East Hanover Well #2, East Hanover Moderate levels of VOCs, primarily TCE, water treatment system installed. Two closed landfills and industrial septic systems are possible sources.	Inv.	N
I	Mennen Company, Morris Plains Former septic system and contaminated soils removed from the site. Airtron TCE being pumped for irrigation use.	C/U	N

TABLE VII-8 (Cont'd)

ID#	Site and Description	Status	NPL
I	G&F Industrial Park, East Hanover Moderate VOCs and high PCBs found in the septic system. May be implicated in the East Hanover Well 2 contamination.	Inv.	N

TABLE VII-9

MINOR CONTAMINATION CASES
WHIPPANY-LOWER ROCKAWAY SUBREGION

ID#	Site and Description	Status	NPL
A22	Amoco, Morristown Gasoline tank leak.	Closed	N
A153	Shell Gasoline Station, Lake Hiawatha, Parsippany Gasoline tank leak.	Closed	N
A186	Mobil Gasoline Station, Hanover Gasoline tank leak.	C/U	N
A242	Van Winkle Gulf, Montville Petroleum ethers in private well.	Inv.	N
ECRA 85-300	C.G. Winans Company, Hanover Contaminated soils near two tanks removed.	ECRA	N
ECRA 84-310	Whippany Soap Products, Hanover Soil contamination with petroleum hydrocarbons.	ECRA	N
ECRA 85-319	Rowe International, Hanover Soil contamination with petroleum hydrocarbons.	ECRA	N
I69	Colloid Chemical, Hanover Phenol discharges to surface water.	Closed	N
I123	Bell Laboratories, AT&T, Hanover Ground water contamination detected, but previously suspected causes not implicated.	Inv.	N
I172	Boonton Electronics, Hanover Soil contamination from solvents.	C/U	N
I220	Ballantine Laboratories, Inc., Parsippany Elevated VOCs in septic system, cleaned out.	Closed	N
I280	Whippany Paperboard Company, Hanover Fuel oil sprayed on activated sludge to reduce odors. Lagoons have VOCs.	Inv.	N
I314	Ell-Bee Chemical, East Hanover Elevated VOCs in septic system, cleaned out.	Inv.	N
I316	Foster-Wheeler, East Hanover Elevated VOCs in septic system, cleaned out.	Inv.	N
I338	DeForest Investment, East Hanover Elevated VOC levels in the septic system, cleaned out. VOCs also found in stormwater pond from floor drains at a garage.	Inv.	N
I360	Chemcoat, East Hanover Elevated VOC levels in the septic system, cleaned out and use discontinued.	Inv.	N
I	East Hanover Regional Contamination Four industries with septic systems. Three had minor contamination. The fourth, Prime Fabricators on DeForest Avenue, had ground water contamination with high VOCs but has not been definitely implicated in the regional contamination near Ridgedale Avenue.	Inv.	N
--	Parsippany-Troy Hills Well 7 Alleged odor in well from shaving lotion.	--	N
--	Southeast Morris Water Authority, Hanover Twp Manganese and iron in Black Brook wells, treated.	--	N

Chatham-Millburn Valleys Subregion

Despite the long history of ground water use in this subregion, very few contamination cases have been identified. The Chatham Valley, lower East Hanover Valley, Millburn Valleys, Canoe Brook Valley and Slough Brook Valley supply a large percentage of the total ground water withdrawals in the Buried Valley Aquifer Systems. Contamination of this water resource would affect more individuals than similar contamination in any other subregion. The known cases are listed in Table VII-10.

Both Livingston and Madison have experienced low level contamination with VOCs. However, the sources and extent of contamination are unknown in both cases.

Upper Passaic Subregion

The Upper Passaic area relies primarily on bedrock wells. No major buried valley or stratified drift aquifers exist within the subregion. The area is predominantly rural and suburban with few industries, though office building development has accelerated. Contamination incidents tend to be few and localized. However, a high reliance on private wells and the lack of public water systems in many areas result in a high cost of supply replacement where contamination occurs. Cases identified within the Upper Passaic subregion include those in Table VII-11. Almost every case involves a leaking underground storage tank, usually at gasoline stations. The two exceptions are Millmaster Onyx and the Millington Asbestos dumps. Neither appears to threaten any major ground water resources due to their proximity to the Passaic River, toward which surficial ground water from the sites would flow.

Regional Contamination Issues

Seven ground water contamination sites in the Buried Valley Aquifer Systems exhibit such extensive contamination that they may be considered "regional" in nature. These regional contamination sites are:

1) Dover/Rockaway Borough/Denville well fields
2) Rockaway Township well field
3) Parsippany-Troy Hills Township, Lake Intervale area
4) Fairfield Township
5) Essex Fells Water Department, Roseland wells
6) East Hanover Township, Ridgedale Avenue area
7) East Hanover Township, Merry Lane area

TABLE VII-10

CONTAMINATION CASES
CHATHAM-MILLBURN VALLEYS SUBREGION

Major Cases

ID#	Site and Description	Status	NPL
A	Madison Car Care Exxon, Madison Exxon discovered a loss of over 1,000 gallons. Gasoline floating on the water table exceeded three feet in places, and may also be contributed by any of three gasoline station at the same intersection. Site is upgradient of the Madison public supply wells.	Inv.	N
A-280	Livingston Township Water Department Actionable levels of VOCs were discovered in finished water and traced to Well 4 which is undergoing redevelopment. Testing will occur before use.	Inv.	N
A-280	Madison Borough Three wells in two locations have low levels of VOCs. Monthly monitoring is in place and two of the wells have voluntarily been taken out of service at the present time.	Inv.	N

Minor and Closed Cases

ECRA 84-595	Warren Communications, Livingston PCE spill to soils.	ECRA	N
ECRA 85-263	Paper Mart, Inc., Livingston Leaking underground fuel tank.	ECRA	N
--	Chatham Borough Waste fluids dumped by furniture stripping business, cleaned up under NJDEP order.	--	N
--	East Orange Water Reserve, Millburn Millburn leaf composting area may contribute nitrates. East Orange Golf Course may contribute fertilizers.	--	N
--	Florham Park Wells 2 and 3 High manganese levels. Treated.	--	N
--	Livingston Township Waste cutting oil pit near Well 9 closed, cleaned and monitored--no plume.	--	N
--	Madison Borough PCB transformers stored and leaked at Station Road facility near Wells A, B, and E. Two old wells sealed, soil removal planned for 1986. Also, Dodge Field pond filled in 1920's and 1930's with cars, coal ash, etc.	--	N

TABLE VII-11

CONTAMINATION CASES
UPPER PASSAIC SUBREGION

Major Cases

ID#	Site and Description	Status	NPL
A17	Mohawk Oil (Sunoco), Harding Between 2,000 and 6,000 gallons of gasoline lost, several hundreds of gallons recovered. Four private wells contaminated and redrilled to below the contamination.	Hold	N
A228	Washington Valley Auto, Warren Township Leakage from gasoline tanks contaminated over two dozen private wells. The wells have been replaced with public water.	Inv.	N
ECRA	Millmaster Onyx, Berkeley Heights Extensive contamination of soils with PCBs and of ground water with petroleum hydrocarbons and benzenes exist on site. Contamination of the deep aquifer also exists but may have a different source.	ECRA	N

Minor and Closed Cases

A123	Exxon Gasoline Station, Bernardsville Gasoline tank leak.	Closed	N
A	Green Village Sunoco, Chatham Township Gasoline tank leak.	Inv.	N
I297	Millington Asbestos Dumps Waste asbestos was dumped on the bank of the Passaic River and several locations in the Great Swamp. Methyl mercury dumped into the Passaic River site. Ground water contamination unlikely but surface water a concern.	RI/FS	Y

The Airtron Corporation/Mennen Company site in the Whippany/Lower Rockaway subregion could be considered regional in nature, but the single source (Airtron) and the effect of Mennen's wells in drawing substantially all of the contamination from the Airtron site has limited the scope of the contamination.

All of the regional contamination sites have multiple sources, affect more than one property, and exhibit high to very high VOC levels. Volatile organic chemicals tend to be more mobile than other chemicals which do not dissolve in ground water, and their use in industrial processes for degreasing is ubiquitous. TCE is the most common contaminant in the regional sites, affecting each of the seven areas. Many of the affected areas did not have public sewerage until recently, forcing industries to rely on unlined lagoons and septic systems for industrial waste disposal. Many industries only began to ship their wastes off site for disposal after the enactment of federal statutes regulating the storage and disposal of hazardous wastes, such as the Resource Conservation and Recovery Act of 1976. The regional contamination sites are the legacy of decades of unwitting disposal practices which have now impaired ground water quality in large areas.

Case studies of the seven regional contamination sites provide a good overview of the methods by which contamination occurs, the difficulties in proving responsibility and the greater difficulties of determining and funding aquifer restoration. Unlike contamination incidents in which a single source may be identified, the regional cases may involve many responsible parties, each having discharged wastes of varying character over decades (sometimes with several owners of a single site having discharged to ground water in sequence) which have impaired the aquifers to differing degrees. Aquifer restoration efforts for a regional site may exceed $1 million just for analysis, with costs for implementation greatly exceeding the study costs. Potentially responsible parties must weigh the costs of their share of a cleanup if they accept responsibility with the possibilities that other parties may be identified and forced to assume a share of the cost, that costs will rise or fall as the contamination plume spreads or attenuates, and that a blow to their public image may result from delay. They also may be held liable for assessments of up to triple the analysis and cleanup costs if public funds are used where responsible parties did not assume the costs of cleanup.

The seven regional contamination areas constitute the most critical and severe incidents in the Buried Valley Aquifer Systems. The success or failure of government efforts to achieve aquifer restoration in these

areas will, at least for the Buried Valley region, indicate whether present laws and enforcement systems are sufficient to protect the public health and safety.

1) Dover/Denville/Rockaway Borough--The Rockaway Buried Valley Aquifer is closely aligned with the Rockaway River from Jefferson Township to Denville Township (see Figure G-1). The three municipalities of Dover, Denville and Rockaway Borough have experienced significant levels of VOC contamination in wells in the Rockaway Buried Valley Aquifer. Dover Well 4 has been closed, Dover Wells 1, 3 and 5 are less contaminated but are affected, Denville's Well 3 requires treatment, and Rockaway Borough's three wells were shut down in 1981 and then placed back in service with treatment (see Figure VII-1). No final conclusions are available on whether the wells have the same contamination sources or have been impaired by more local sources. The likelihood is that many individual contamination sites are responsible, but the net effect is essentially that of an impaired aquifer at least from the Dover well field to the Rockaway Borough wells. The NJDEP has identified several sites which are suspected or confirmed sources of ground water contamination. The relative contribution of each site and the full extent of the contamination, by source and regionally, is under investigation. However, Wharton's Wells 1 and 2 and Denville's wells 1, 4 and 5 are west and east of the contamination area, respectively, and have not shown VOC levels of concern. The set of contaminated wells is considered as one regional contamination site, as the movement of contaminated ground water through the aquifer from Dover to Rockaway Borough is possible. The Rockaway Township well field is considered separately because of its location in the Beaver Brook Buried Valley.

The **Princeton Avenue well field** in Dover contains three wells which supply all of the town's current water supply. Wells 1, 3 and 5 exhibit levels of VOCs at approximately 10 to 20 ppb, with similar contaminants which may have a common source. Contaminated sites nearby include L.E. Carpenter (a subsidiary of DAYCO) upstream in Wharton, and an industrial area owned by DAYCO which is next to the well field.

The area geology consists of alluvial soil over glacial material, primarily stratified deposits north of the Rockaway River and morainal material to the south, within a valley of Precambrian gneiss bedrock. Up to 40 feet of clay lies on the valley floor beneath the glacial deposits. The NJDEP is concerned that contamination of the deep aquifer could result in flow of contaminants along the buried valley without regard to the river itself as a hydraulic boundary. Public wells near L.E. Carpenter include Dover Wells 1, 3, and 5 (5,500 feet downstream),

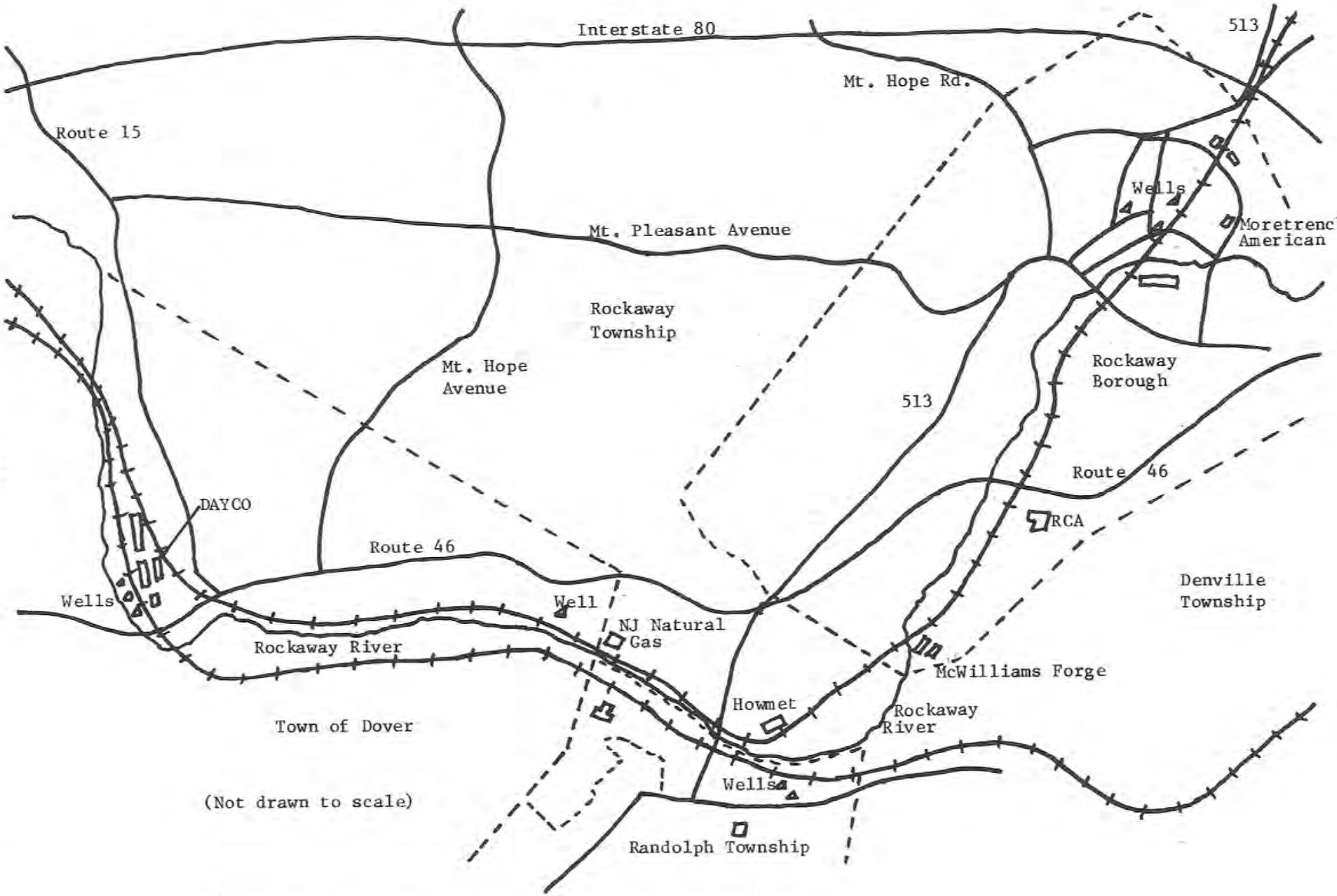


Figure VII-1. Rockaway Buried Valley Contamination Area

Wharton Wells 1 and 2 (4,000 feet upstream) and Wharton Well 3 (4,500 feet downstream). Wells next to the Rockaway River apparently draw a maximum of 50 per cent of their recharge from the river when shallow and a maximum of 20 per cent when deep. Therefore, the deeper wells have a greater potential for inducing the long distance migration of contamination in the buried valley aquifer. The ground water velocity is approximately 7 feet/day in the aquifer, with a transmissivity of 80,000 gpd/ft and hydraulic conductivity of 420 ft/day. The high velocity further encourages the migration of dissolved constituents from a site.

L.E. Carpenter produces vinyl wall coverings. Wastes including polyvinyl chloride were discharged both to a surface impoundment and to a subsurface disposal system between 1963 and 1970. 1979 NJDEP inspections found very poor waste management practices. An abandoned supply well near the river could provide a conduit for contamination to migrate to the lower aquifer. Buried drums also existed on site along with a former sludge lagoon, a filter bed, a long trench with waste liquids, many pits, film on the river banks, old storage tanks, evident tank spillage and three discharge pipes to the river. L.E. Carpenter in 1979 suggested that former tenants were primarily responsible and also suggested only removing the lagoon sludge and not implementing a ground water monitoring or recovery program. L.E. Carpenter is considered a known and sole source for the site contamination by the NJDEP.

NJDEP samples of a surface impoundment revealed several heavy metals and a wide variety of dissolved organic compounds. Ground water samples contained both free floating product, dissolved organic contaminants and several heavy metals, all of which are known discharges from L.E. Carpenter. Total VOCs ranged up to 11 ppm. In addition, up to 16.8 ppm of PCBs were found in ground water. 1986 monitor well samples show maximum contamination levels of more than 100,000 ppb of VOCs. Free product floating on the water table exceeded 10 feet in places during 1984, with over 55,000 square feet coverage of free product. The contamination became evident when consultants to the Rockaway Valley Regional Sewerage Authority began work on the main sewer interceptor through the property.

An Administrative Consent Order (ACO) was signed in 1982 based on a 1975 site inspection and continuing investigations begun in 1979. The ACO called for a ground water monitoring plan and removal of all solid and liquid wastes. An amendment to the ACO was signed in 1983 to define the contamination, remove any free product, and decontaminate the site. 4,000 cubic yards of sludge were removed from the impoundment in 1982,

and the removal of free product began and resulted in 2,833 gallons removed by early 1986, with up to 2 feet of product remaining. The other steps were not taken, nor was removal of free product completed by 1986. A directive for L.E. Carpenter to sign a third ACO was issued in 1986. The new Administrative Consent Order, once acted upon, requires L.E. Carpenter to conduct a Remedial Investigation, Feasibility Study, Remedial Action Plan and site cleanup under a strict schedule, with financial assurances from the company allowing the NJDEP to complete the work if the company reneges. The NJDEP has committed to using public cleanup funds if L.E. Carpenter does not sign the new ACO, and would then seek reimbursement for triple damages from the firm. The site also was placed on the National Priority List in 1985 over the objections of L.E. Carpenter.

A second industrial property owned by DAYCO is the Richboynton Road Industrial Complex in Dover, adjacent to and east of the Dover Water Works Park. A commercial tenant, Community Transit, was responsible for a loss of 6,000 gallons of diesel fuel from an above ground tank 400 feet from the Dover Princeton Avenue well field. 4,000 gallons were recovered initially. The remainder created a plume with product up to one foot in depth on the water table aquifer. The site also exhibits low levels of VOCs similar to the contamination in the Dover Wells 1, 3 and 5 (2 to 10 ppb of VOCs, considerably lower than the 1981 levels of 20 to 80 ppb), consisting of TCE and 1,1,1 trichloroethane. The DAYCO wells show levels of VOCs at 170 ppb, including 105 ppb 1,1,1 TCEA.

The industrial park was occupied by DAYCO-Hose Division through 1981, then L.E. Carpenter and five other lessees. Community Transit leased property during 1984.

The oil plume is limited to the DAYCO property, extending west in a plume under a building toward (but not reaching) the Dover well field. The contamination site is more readily affected by Well 5 pumping than by Well 3. Local ground water flow is to the west toward the well field and the Rockaway River when Well 5 is pumping, and southwest when Well 5 is off. The full extent of the VOC contamination is not known. The wells are set in the upper strata of the buried valley aquifer. Because of the high ground water velocity, VOCs may migrate from the site quickly. The oil spill and the VOC contamination are not connected.

Seven monitor wells and a fuel oil recovery well were installed and are in operation. Recovery is complicated by the presence of a building and foundation. These actions were taken by DAYCO when Community Transit delayed action. The tank itself was emptied. Dover Well 3 has been

used only intermittently during summer months since the spill. The recovery well acts to contain the spill and plume from further progress toward the well field by creating a cone of depression and removing oil from the ground. The DAYCO oil spill investigation is completed. The investigation for sources of the VOC contamination had not begun as of early 1986.

The **Dover Well 4** on Hooey Street (now named Rutan Drive) had 118 ppb of 1,1,1 trichloroethane and 122 ppb of PCE in 1981. Sampling of nearby wells indicated that the contamination might have a local cause. An industrial survey found no active user or discharger of the contaminant. Well 4 is a National Priority List site through Superfund, but investigations through the Superfund program have not begun. However, NJ Natural Gas and Howmet have agreed to split the $700,000 cost of an RI/FS for Dover Well 4. The Well 4 contamination is similar to that of Denville Well 3, which may have drawn the plume affecting Dover Well 4 once the Well 4 was shut down. in 1981 VOC levels at Well 4 dropped from 170 ppb to 70 ppb by 1985, indicating that the plume may have moved.

New Jersey Natural Gas owns property adjacent to Well 4 which was used for coal gasification. Significant pollution on site makes NJ Natural Gas a probable contributor to the contamination of Well 4, according to the NJDEP. Howmet (Dover Casting Division) is also in the near vicinity. McWilliams Forge may also be within the radius of influence of the well.

McWilliams Forge was found to have ground water contamination of up to 1700 ppb of TCE in the shallow aquifer and had been pumping over 1 MGD from shallow and deep aquifers without an allocation permit. An administrative consent order from the NJDEP has required the installation of monitor wells and a water treatment system to remove the TCE. The site contamination has apparently dropped to 10 ppb of TCE. McWilliams Forge is on the east side of the Rockaway River downstream of Denville. The site was subject to dewatering for a period during 1985 to allow the construction of a new building foundation.

The New Jersey Natural Gas site (owned by General Public Utilities) was formerly used to manufacture illuminating gas from coal. Recent hydrogeologic studies show that the site's soils and ground water are contaminated by coal gasification wastes. The ground water contamination extends off-site. NJ Natural Gas is very close to Dover's Well 4. NJ Natural Gas operated the facility for coal gasification from the 1900's to the 1950's. Coal tar was created as a byproduct. Samples

of coal tar yield benzene at levels of 420,000 ppb, toluene at 1,100,000 ppb, and also ethylbenzene, naphthalene, and acenaphthene. The site is no longer actively used for coal gasification and has not been for decades.

Extensive contamination with benzene, PCE and toluene exists. The total VOC level exceeds 10,000 ppb in some locations. An on-site well exhibited significant benzene and naphthalene contamination in 1983. Off-site contamination includes soil contamination on the banks of the Rockaway River, nearby. Negotiations are underway between the owner and the NJDEP to establish a decontamination plan for the site. The possibility of public funds being used for decontamination exists, with eventual assessment of costs to the property owner. NJ Natural Gas is contributing toward the RI/FS for Dover Well #4.

The site consists of fill over unsorted glacial till, a silty, fine sand, a thick, semi-confining silt, and sand. When Well 4 is not pumping, there is an upward hydraulic gradient. Surficial ground water flow is south-southwest toward the Rockaway River, explaining the bank contamination. Although the semi-confining layer exists, the potential for flow from the contaminated upper aquifer to the lower aquifer, which is used by the Dover Well 4 only 400 feet away, could occur, especially if Well 4 is put back on line. A 1985 pump test of Well 4 caused a significant drawdown of the deep monitor well. NJDEP noted that an on-site abandoned deep well could also allow the penetration of pollutants. The only deep monitor well exhibited contamination of the lower aquifer in excess of 100 ppb total VOCs. NJDEP has required further definition of the lower aquifer contamination. Contamination of the river is anticipated due to the flow of heavily contaminated ground water.

The **Denville Wells 3 and 6** have been contaminated by relatively low levels of PCE (up to 19 ppb) and 1,1,1 TCEA (up to 50 ppb), first discovered in 1981. Possible sources include Howmet Turbine Components Corporation (Dover Casting Division), NJ Natural Gas, and McWilliams Forge. Denville has installed a treatment system while helping the NJDEP investigate the source(s) of the contamination. Howmet has agreed to help fund the treatment system, with no acknowledgment of responsibility for the contamination. The wells are located near the southwestern corner of Denville in Randolph Township next to Dover. No source for the Denville contamination has been confirmed as of early 1986. Consultants to Denville conducted a pumping test to help define the aquifer and determine the potential for induced flow of contaminated ground water to the wells.

The primary chemical of concern is PCE, which has a lower recommended maximum contamination level for potable water than 1,1,1 TCEA. Denville took Well 6 off-line voluntarily until the treatment system is installed (Well 3 has not been in use). September 1985 levels included 11 ppb of PCE and 34 ppb of 1,1,1 TCEA. One sample in 1985 also exhibited 4.5 ppb of carbon tetrachloride which has not been replicated as of early 1986. In a high flow pump test, the level of VOCs was below 40 ppb.

The full extent of contamination is not known. The geology in the area consists of a surface aquifer and a confined aquifer separated by an aquitard of clay and silt. The confined conditions extend to the Dover Well 4 site to the south, according to Denville's consultant. The aquitard is thick in the Denville well area but changes to a complex layering/lensing downstream (north) at the narrow valley where the Rockaway Borough Well 4 is located. A pumping test of Denville Well 3 led Denville's consultants to exclude McWilliams Forge as a likely contaminant source, though the 4,000 radius of influence observed did reach to the McWilliams Forge property in the deep aquifer. Denville's consultant concluded that the Howmet site surface aquifer is fully connected to the deep aquifer pumped by Well 3, based on the same test. Average transmissivity of the aquifer was measured at 40,930 gpd/ft, with a storage coefficient of 3.1 X 10-4.

Howmet (Dover Casting) has confirmed over 19 VOCs in excess of 100 ppb and 4 in excess of 1,000 ppb in the surface aquifer. The latter are 1,1 dichloroethylene, 1,1 dichloroethane, p-dichlorobenzene and 1,1,1 trichloroethane (15,970 ppb). The contaminants found in Denville Well 3 are also in test pits and both the shallow and deep aquifer at Howmet. The upper aquifer is contaminated with VOCs and heavy metals (e.g. lead, nickel, manganese, hexavalent chromium and total chromium above drinking water or ground water standards). The deep aquifer has VOC levels of 500 ppb, including 1,1,1 TCEA, TCE and PCE. A tentative conclusion exists that pumping of Well 3 induces recharge of the deep aquifer from the surface aquifer at Howmet with Howmet as a probable source of contamination. The contaminants also correlate with Dover Well 4, located 3,500 feet from Howmet. Contamination of that well includes 1,1,1 TCEA, PCE and TCE in declining order.

Howmet (Dover Casting) makes nickel and cobalt based engine parts for Rockaway Township industries. Three leaching fields were used for wastewater disposal. At Howmet, buried drums were found during the course of a sewer line inspection. Subsequent investigation showed that illegal discharges of industrial wastes had occurred through septic leaching systems. The most concentrated single contaminant was 1,1,1

TCEA. Howmet consultants have claimed that a ground water divide exists between Howmet and the Denville Well 3 due to simultaneous pumping of wells at both sites, but this is not confirmed or accepted by the NJDEP. The NJDEP concluded in 1985 that Howmet contributed at least partially to contamination of both the Dover Well 4 and the Denville Well 3, immediately across the Rockaway River. The NJDEP has approved a remedial plan based on further investigation by Howmet, which plan Howmet began implementing late in 1985. The program must include a remedial investigation, feasibility study, remedial action plan and implementation. Howmet is contributing to the RI/FS for Dover Well #4.

Rockaway Borough's wells have been contaminated by organic chemicals to varying degrees. The borough installed a granulated activated carbon filtration system to bring the water to potable standards, after closing the system for four months in 1981. The wells were placed on the Superfund National Priority List in December, 1982. The Remedial Investigation/Feasibility Study under the Superfund program began in 1985 and was released for public review in August 1986. Decontamination is continuing through pumpage to the treatment system. The Rockaway Borough wells are located in the northeastern quadrant of the borough, north of the Rockaway River. There are three wells, numbered 1, 5 and 6. Well 1 and Well 6 are the most severely affected of the wells. The contaminants include TCE, PCE, 1,1,2,2 tetrachloroethane, chlorobenzene and methylene chloride. TCE levels have been at or below 26.7 ppb. The PCE levels range from 10.2 ppb in Well 1 to 147 ppb in Well 6, though the peak level measured in Well 6 was 650 ppb. The remaining contaminants are less concentrated. As there are only three private wells in the borough, the main concern lies with the borough wells. Contamination of surface water in the Rockaway River and tributaries has not been identified except for methylene chloride at or less than 13.8 ppb.

The borough wells are located in an area of glacial sediments consisting of 50 feet of clay-rich till over 40 feet or more of stratified drift. NUS Corporation (a consultant to the USEPA) locates the borough in the middle of the terminal moraine, but geological evidence suggests that morainal material overlays valley-fill deposits from an earlier southward movement of the Wisconsin glacier. The till provides some protection for the lower aquifer. Well 5 draws from the lower aquifer and was a flowing artesian well when drilled. Wells 1 and 6 apparently are recharged partially by the river. Tetra Tech in 1979 defined the Rockaway River as gaining water from the aquifer in the borough and losing water to the aquifer downstream. Ground water movement, therefore, may be toward Wells 1 and 6 from the river, but more

generally toward the river and also downgradient (to the east) within the lower aquifer. The full extent of the contaminated aquifer is not yet known. Wells 1 and 6 have a radius of influence of up to one-half mile, while Well 5 has a radius of influence exceeding one mile (indicating that Well 5 draws from a more confined aquifer). As Wells 1 and 6 show the greatest contamination, the sources are most likely to be found within one-half mile.

There are no confirmed sources of pollution, though the RI/FS identified some probable source areas. Many possible sources exist, none of which is currently active according to a borough industrial survey. It is possible that sites with proven contamination may be victims of the regional contamination rather than causes. Further investigations will attempt to confirm suspects. The sites under investigation include an old dump 1,800 feet north of the wells, which supposedly only accepted domestic and commercial wastes and has since been developed for housing; dye pits, long inactive and covered, once operated by Liondale Dye Plant; the Moretrench American facility, which once manufactured pumps and likely used solvents for metal degreasing; the A & A Fuel Oil Company fuel storage tanks; Pettit Paint Company which mixes and packages marine paints and has underground and mixing tanks on the property (prior to acquisition of the property by Pettit Paint, Thiokol manufactured jet engines and ballistics beginning in the mid-1950's during which time the use of solvents was likely, and Rolling Mill, a foundry, used the site prior to Thiokol); the Borough garage which has handled a nominal amount of organic solvents and drums; a drum dump site behind the A & A Fuel Oil Company; the Stiles Rubber Company which had test results showing TCE contamination of 77.5 ppb and PCE contamination of 128 ppb in 1985; an industrial area 1,000 to 2,000 feet northeast of the wells which includes some of the above sites; and sources of the Rockaway Township contamination which could be implicated in Rockaway Borough's contamination if the Beaver Brook Aquifer is hydraulically connected to the Rockaway Valley Aquifer and ground water flows toward Rockaway Borough.

The RI/FS for the Rockaway Borough Well Field identified the general area contaminated by PCE and TCE through the use of soil gas concentration surveys. The results of the PCE soil gas concentration survey are shown in Figure VII-2. Based on the surveys, monitor wells were installed to sample the ground water. The results were used to develop Figure VII-3, a cross-section of the aquifer showing the inferred area of contamination. Finally, the combined results of all testing led to a designation of primary and secondary source areas for the TCE and PCE contamination (Figure VII-4) where research will occur.

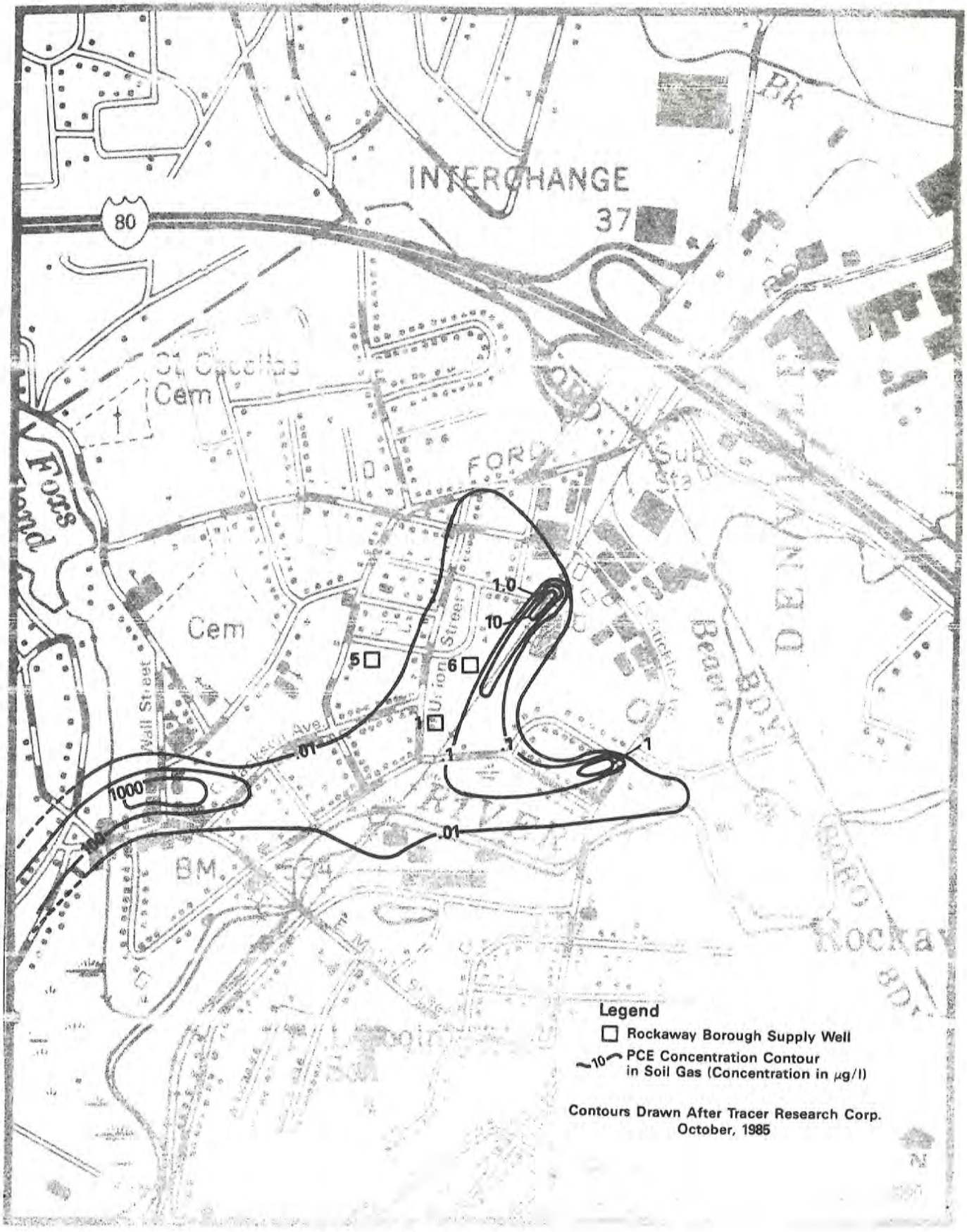


Figure VII-2. Rockaway Borough Well Field -
Soil Gas Concentration Contours for PCE

Source: Science Applications International Corporation, 1986.

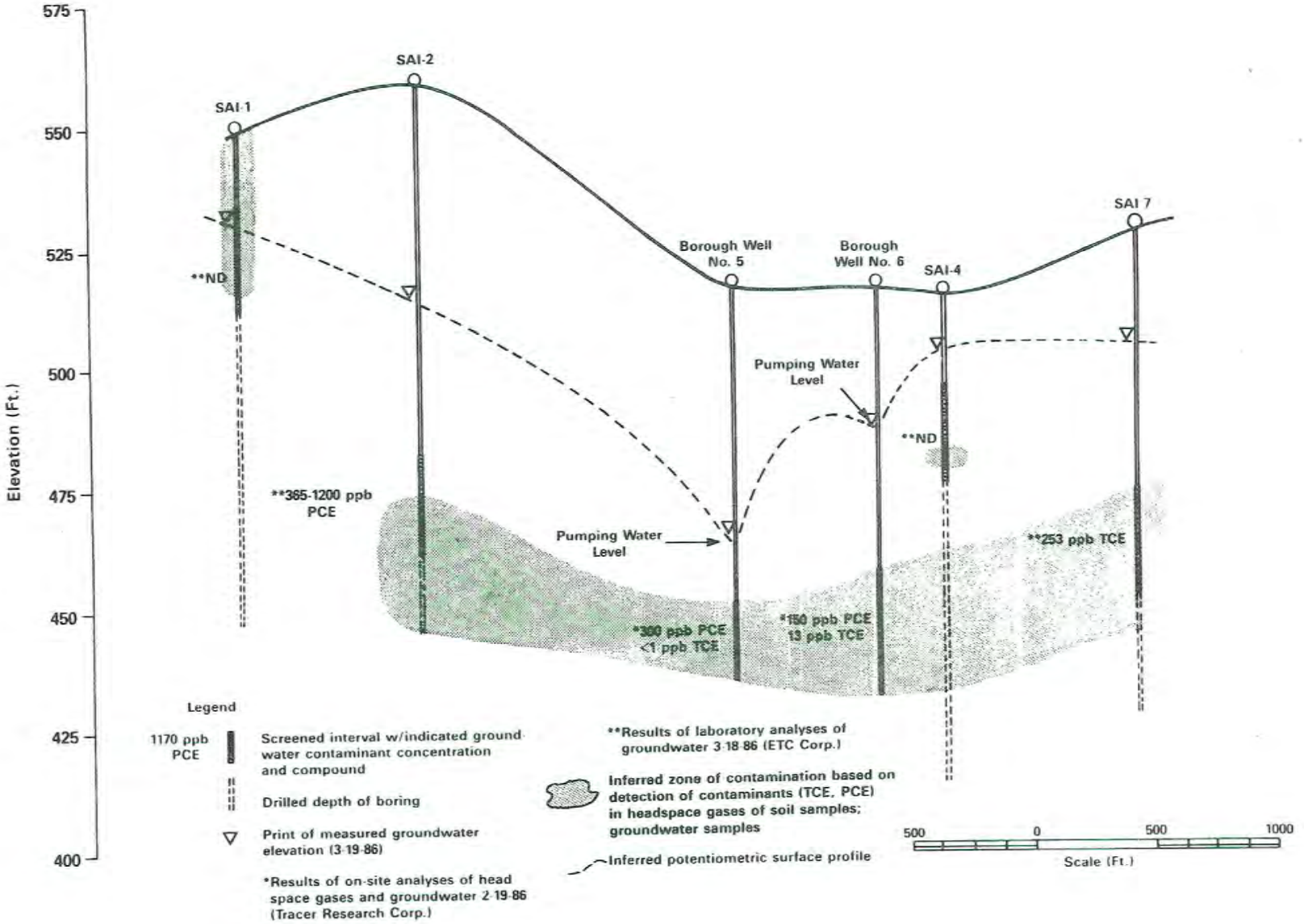


Figure VII - 3: Cross-Section of Rockaway Borough Well Field with Inferred Area of Contamination

Source: Science Applications International Corporation, 1986.

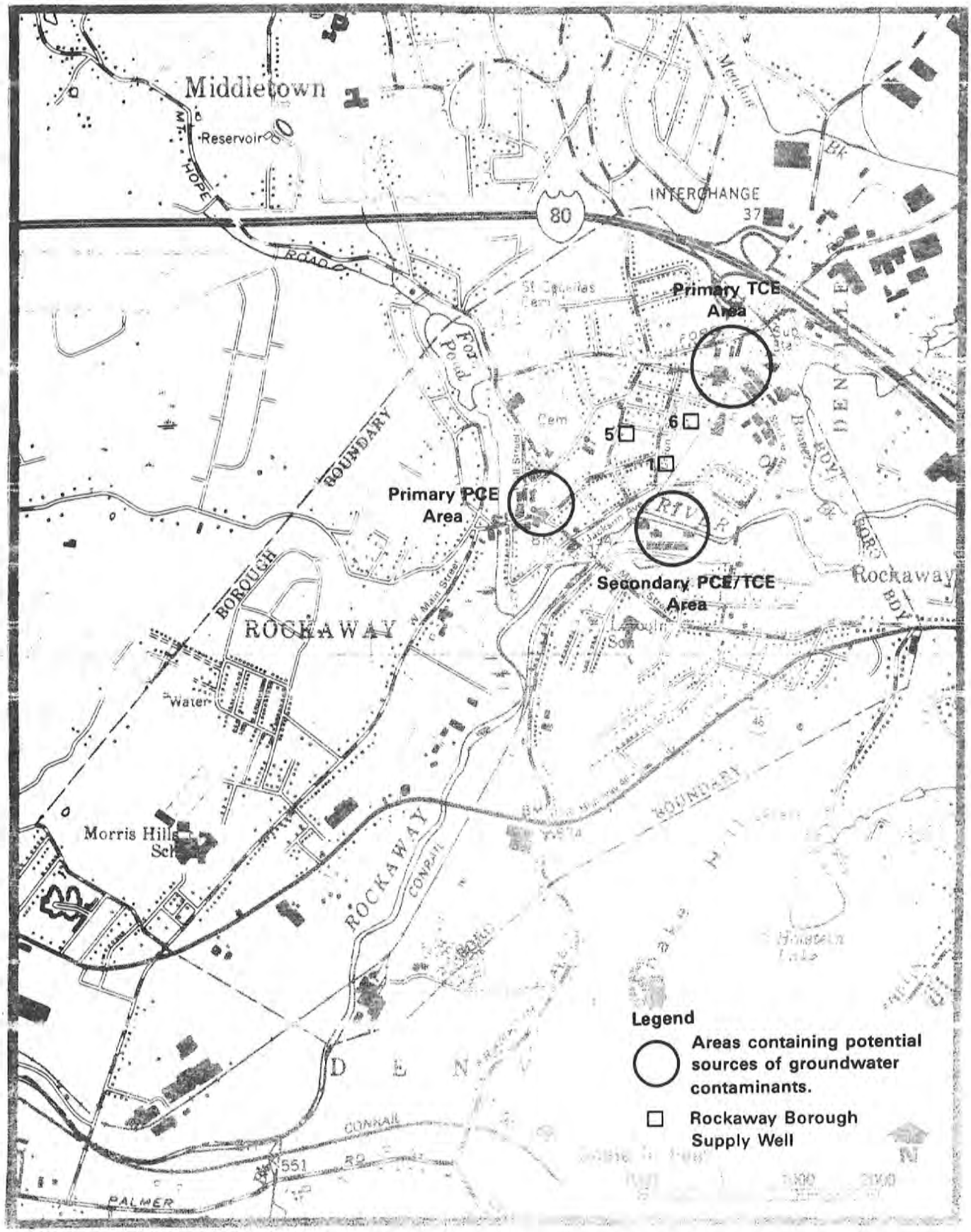


Figure VII - 4. Areas That May Contain Sources of Contaminants Affecting Affecting the Rockaway Borough Well Field

Source: Science Applications International Corporation, 1986.

The source is assumed to be inactive (no additional materials being added to the source site), based on industrial surveys by the borough and the NJDEP. Therefore, there is no apparent source to close. Mitigation primarily has involved treatment of the public water supply, which simultaneously protects the residents and decontaminates the aquifer. The treatment system is highly effective. The Rockaway Borough contamination problem indicates the difficulty of discovering and isolating contamination causes. Even extensive hydrogeologic studies may not determine the full cause due to the possibly lengthy time between introduction of the contaminants to the aquifer and detection within the water supply system.

2) Rockaway Township Well Field--The three wells operated by Rockaway Township are located on the western edge of the Beaver Brook Buried Valley near Green Pond Road, north of Interstate 80 (see Figure VII-5). All of the township's public water supply is derived from the wells. The Beaver Brook Buried Valley Aquifer has been contaminated by various volatile organic compounds, including gasoline constituents and TCE. The well water is successfully treated by a granular activated carbon and air stripping system, and the site was listed under the Superfund program in December, 1982. All three of the Rockaway Township wells have been contaminated. Essentially the entire southern Beaver Brook Buried Valley Aquifer in the area is considered contaminated to nonpotable levels, requiring extensive treatment prior to consumption.

The Beaver Brook Buried Valley consists of three Wisconsonan glacial deposits. The deepest is a productive glacial aquifer with up to 80 feet of coarse sand and gravel and high permeability, in which the township wells are set. The second layer is clay deposited by a glacial lake which serves as an aquitard in the center of the buried valley. The clays are up to 60 feet thick but thin out on both sides of the valley. The surface layer is a sand and gravel water table aquifer up to 30 feet thick. The buried valley is approximately 170 feet deep at maximum depth.

The water table in the upper aquifer lies 20 to 30 feet below the surface, with a flow toward Beaver Brook and Meadow Brook. Under pumping conditions the deep aquifer flows toward the well system from the north, west and southeast. Regional flow is assumed to be from north to south along the line of the buried valley aquifer, and toward the valley from side slopes. Ford Road approximates the eastern boundary of the deepest portion of the buried valley, but glacial sediments continue east into Denville. However, the clay aquitard

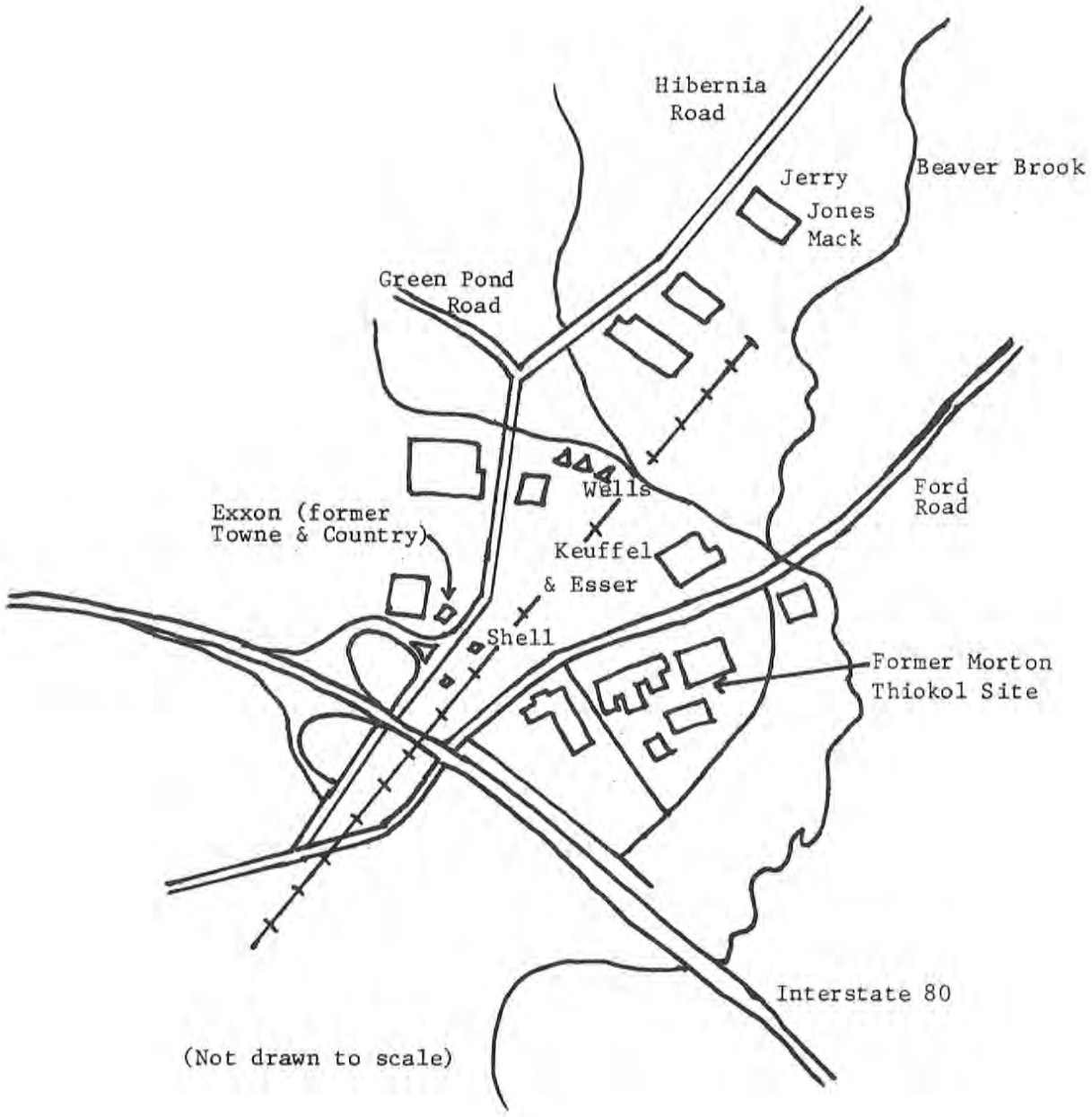


Figure VII-5. Beaver Brook Buried Valley Contamination Area

disappears east of Ford Road, leaving a single, unconfined aquifer from Ford Road east and allowing easy movement of pollutants to the confined aquifer where the township wells are located. The wells may influence ground water flow across the entire buried valley.

There are several suspected sources for the well contamination. A Shell Oil station on the east side of Green Pond Road next to Interstate 80 leaked an unknown amount of gasoline which affected the ground water near the station. Monitor wells were installed. Samples indicated dissolved volatile hydrocarbons and industrial solvents. The extent of the contamination indicated a connection with the township's supply wells. Although the normal gradient of the ground water flow is apparently southeast toward the Beaver Brook valley-fill aquifer, the township wells have pulled the contamination northeast. Shell Oil has cooperated with township authorities and installed a treatment system using granular activated carbon and air-stripping for the township water system, and may be considered a confirmed source.

One additional source of gasoline contamination may be the Towne & Country station on the western edge of the buried valley across Green Pond Road from the Shell station. The station was leased by Exxon which discovered gasoline contamination. No free product was discovered but high VOC levels existed in the ground water. The plume has traveled off-site to the northeast, toward the well field, but it is not yet known whether the contaminants have reached the wells. The Shell Station across Green Pond Road exhibits similar contaminants. The site is on the edge of the buried valley and lacks the three-part structure of the valley center. The bedrock is greater than 60 feet below grade under fine sands. The NJDEP suspects prior gasoline contamination from the Towne & Country station. The gasoline tanks were excavated and removed by Exxon in 1984 and found to be sound. Towne & Country denies responsibility and has raised the possibility of excursions of contamination from the Shell site to the Towne & Country site. However, sampling from monitor wells indicates low VOCs upgradient of the site, high VOCs directly downgradient and somewhat lower levels between the site and the Shell Station, suggesting two separate causes.

Two other sites have been identified which have petroleum contamination, but neither is suspected of having any major affect on the aquifer. Garden State Transit was found to have discharged wastewater containing petroleum hydrocarbons and VOCs into its septic system. Frequent diesel fuel spills occurred as well. Garden State Transit is just north of Interstate 80 and due south of the Rockaway Township well field. Ground water flow is assumed to be toward the east and Beaver Brook.

Jerry Jones Mack, located northeast of the well field on Hibernia Road, had an oil spill which contaminated soils on site. Water samples showed slight water degradation adjacent to the spill. Soils were removed from the site.

A former Morton Thiokol facility is just east of Ford Road at the edge of the buried valley. Monitor well samples show that contamination is higher to the east of Ford Road than to the west (2,500 ppb TCE versus 600 ppb TCE), indicating an eastern source of the contamination given the ground water flow to the northwest toward the well field. Keuffel & Esser Company, north and northwest of the Thiokol site along Ford Road, has discovered solvent contamination of the sediments above the confining layer, but the extent of contribution to the lower aquifer pollution, if any, is not known. Monitor wells at the Thiokol and Keuffel & Esser sites have TCE and chloroform contamination and show ground water flow toward the municipal wells.

As of early 1986, the only mitigation actions were the removal of underground tanks at the two gasoline stations and implementation of the treatment system. Only one source of contamination, the Shell station, can be considered a verified source. The pumping and air-stripping of the township wells constitute decontamination, but the higher concentration levels east of Ford Road indicate that the pumping may actually pull more contamination to the wells. Meanwhile, Rockaway Township has been forced to look elsewhere for additional sources of public water supply, rather than use the contaminated aquifer with an expanded treatment system.

3) Parsippany-Troy Hills Township, Lake Intervale--A grouping of industries along Fanny Road north of Lake Intervale has extensive ground water contamination. The three major industries are Norda, Inc., Synthatron and Lydo Precision Products. The site is at the border between Parsippany, Boonton and Mountain Lakes (see Figure VII-6). Existence of the site became known when contamination of a dewatering well used in construction of a sewer line near Lake Intervale (1,000 feet southwest of the site) was discovered in 1979. Contaminants included high levels of benzene and toluene. Contamination was found at Norda and then at Synthatron to the southwest of Norda. Lydo Precision Products also has ground water contamination at less high levels. Ballantine Laboratories, which manufactures electrical equipment on a site adjacent to Norda and Synthatron, found elevated levels of VOCs in its septic system. The source of ground water contamination on the site appears to be upgradient of Ballantine.

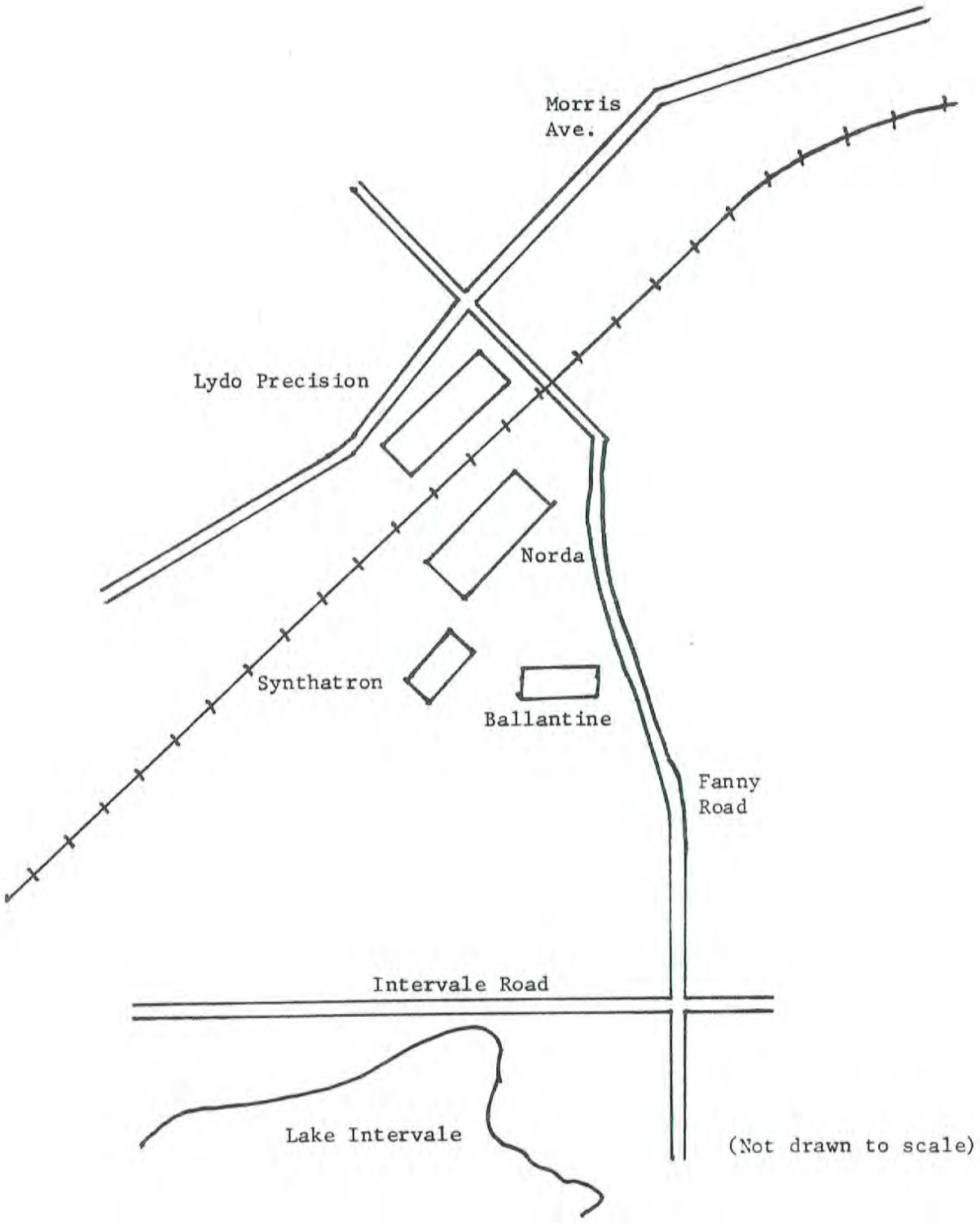


Figure VII-6. Lake Intervale Contamination Area

Synthatron and Norda are located over glacial deposits approximately 135 feet thick, consisting of fine sediments with lenses of coarse outwash and sand in the upper 70 feet which are permeable. Lydo Precision is sited over more than 65 feet of glacial sediments tentatively identified as till. The ground water flow through Norda and Synthatron is southwest toward Lake Intervale, while flow from Lydo Precision is believed to be south. (The Lydo Precision site is less well known than the Norda/Synthatron area.) The contamination has affected the Norda and Synthatron sites and the downgradient area to Lake Intervale. Although no private, potable wells are nearby and the nearest public well is 1.5 miles (Parsippany's wells near Troy Brook), the connection of the glacial sediments with the aquifer tapped by the public wells has caused concern. The contaminant plume appears to be moving off site to the southwest. The bedrock is Triassic sandstone.

Norda's septic systems showed low-level contamination. The downgradient monitor wells had moderate VOC contamination. The highest levels of contamination in the area are apparently not on the Norda or Lydo Precision sites, which have moderate VOC contamination, but on the Synthatron property and areas to the southwest which have extremely high VOC levels, arsenic, sulfate and pH problems. Norda is an old flavor and fragrance plant with underground storage, waste and septic tanks. Synthatron, now closed, produced arsine gas and purified gases. An electromagnetic conductivity survey by the NJ Geological Survey (NJGS) indicated that the contamination at Synthatron came from the Norda property at least in part. Many of the compounds in a Synthatron well were stored in underground tanks at Norda (tanks were used for hexane, acetone, toluene, isopropyl, methanol, fuel oil, etc.) or were found in septic systems at Norda. The benzene apparently could arise as a breakdown product of toluene or as an impurity. Synthatron handled chemicals which could cause the arsenic, chloride, sulfate, total dissolved solids and pH contamination. Synthatron had basement sumps tied to the septic system, receiving wastes from sinks, etc. In addition, a railroad siding is located upgradient of both sites and has been suggested as a possible source by consultants to both industries. The NJGS concluded in 1983 that all of the investigations indicate that Norda was likely to be the source of the majority of the ground water contamination in the Lake Intervale area, with contribution of some contaminants by Synthatron.

At Lydo Precision, on the upgradient side of the railroad, a septic field on the site received industrial wastes. A drum storage area was periodically washed and the runoff went to a storm sewer which became contaminated with waste oils from the area and solvents. An underground

storage tank existed on site. Water based cutting oil wastes with metal chips were dumped by hand near the railroad bed, substantiating claims by the other industries about contamination near the railroad. Lydo Precision uses cutting oils and solvents in its facility which manufactures precision medical parts. Although the contamination does exist, the levels are much lower than those at Synthatron and do not correspond well with the most common contaminants in the major plume.

Much has yet to be learned about the hydrogeology and contamination history of the Fanny Road industrial area. Few mitigation actions have taken place. Decontamination has not begun. The plume has not been fully defined, and its southerly limits are unknown. No private or public wells exist in the area, resulting in the use of monitor wells for plume definition. Synthatron is closed as the result of a court suit by Parsippany against the industry. Synthatron has suggested that it is the victim of pollution passing through its property from upgradient. The NJDEP had decided in 1983 that Synthatron was a possible source of the arsenic and other non-VOC contaminants and that Norda was most likely a major source of VOC contamination. Both Synthatron and Norda suggest the railroad and upgradient sources as the cause. Considerable efforts are required to assess and cleanup the area.

4) Fairfield Township--Two public wells and many private wells have been closed due to high levels of volatile organic chemicals. The private wells are located within a contamination plume beneath an extensive area of eastern Fairfield Township. The contaminated area is between the North Caldwell boundary with Fairfield and Route 46, from near the western end of the Caldwell Wright Airport northeast to the Passaic River. The total contaminated area exceeds one square mile. The major plume (over 10 ppm) is approximately 1,250 feet wide and 4,000 feet long (see Figure VII-7). Private wells in the center of the plume have VOC levels which exceed 10,000 ppb. At least two contamination sources have contributed to this plume, Caldwell Trucking and General Hose. The Caldwell Trucking site is a National Priority List site under Superfund with an ongoing Superfund investigation in addition to a NJDEP investigation. Contaminants within the plume include TCE, 1,1,1 TCEA, carbon tetrachloride, PCE, 1,2 dichloroethane and methylene chloride. The presence of carbon tetrachloride in the plume is disputed. The two public wells are located upgradient of the Caldwell Trucking site and may have different sources of contamination from the plume and each other. Fairfield Well 7 has had a maximum VOC level of 670 ppb, while Well 2 has a maximum of 200 ppb (TCE and 1,1,1 TCEA). Well 7 contains carbon tetrachloride while Well 2 does not.

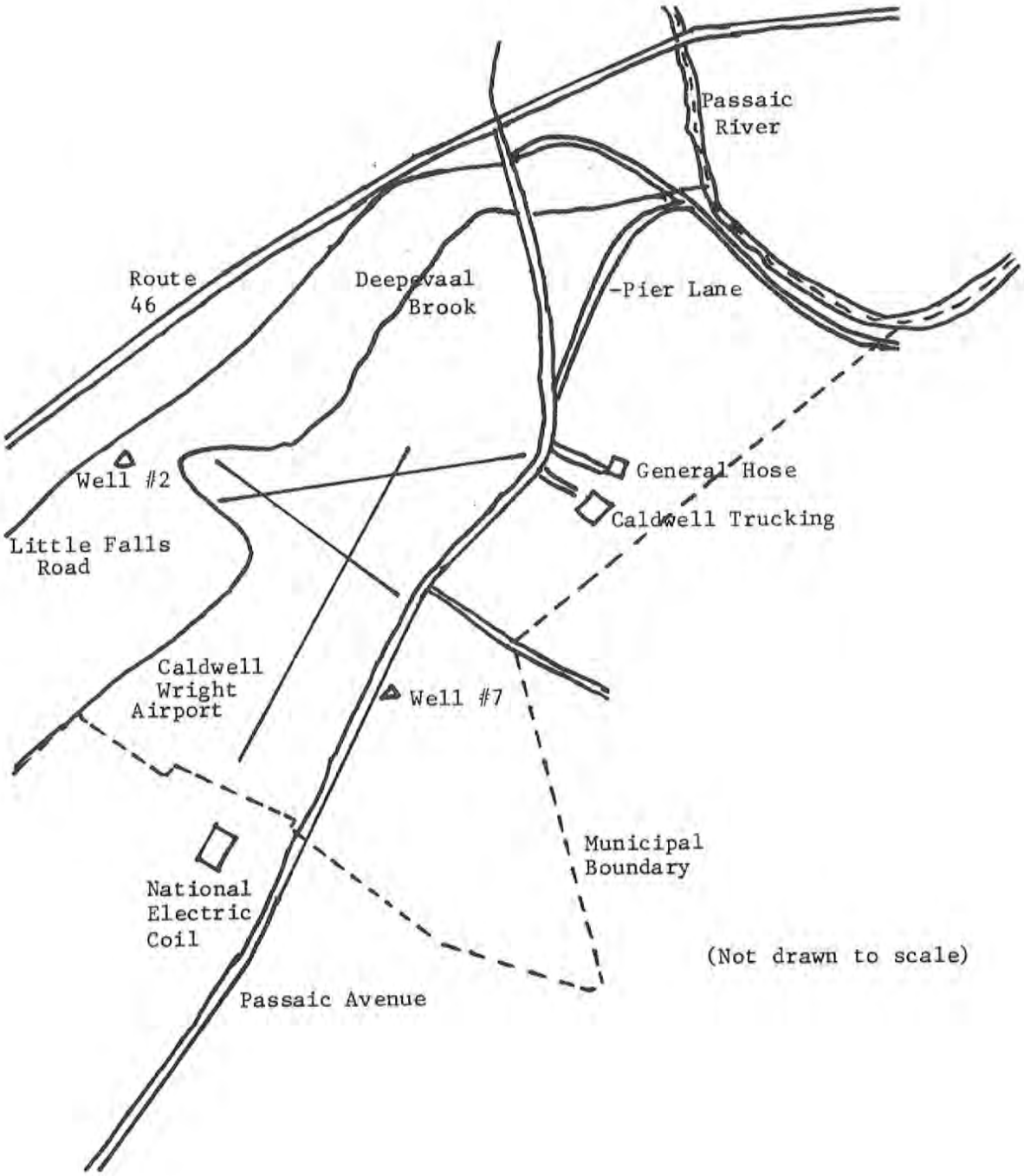


Figure VII-7. Fairfield Regional Contamination Area

Ground water flow in the entire area is toward the Passaic River along a northeast gradient. The geology of the area consists of basalt bedrock sloping down toward the northwest from the Caldwells, meeting with shale along a fault line. Glacial sediments increase in thickness from east to west, ranging up to 150 feet deep and consisting of a thick layer of low permeability deposits over a layer of stratified drift. Percolation of contaminants from the surface to the deep glacial and shale aquifers is expected to be slow except when major wells nearby are pumping. In addition to the glacial aquifer, a bedrock aquifer exists at between 150 and 230 feet below the surface (sloping at 10 degrees to the west) along a contact metamorphic zone between the basalt and a shale layer. The contact zone is highly fractured. Ground water flow in the bedrock is to the north-northeast under static conditions. The glacial aquifer flow is in the same direction under static conditions.

The glacial sediments are less thick in the area of the Caldwell Trucking and General Hose site than at the Fairfield wells. At Caldwell Trucking, the site geology consists of basalt bedrock near the surface on the southeast corner of the site and sloping below the surface to the northwest to a depth of 50 to 75 feet. The surface deposits consist of sandy gravels and silty sands over sands and silty sands. To the west and northwest of the site, a clay aquitard lies over a sand and gravel aquifer. At General Hose, to the north of Caldwell Trucking, the site geology consists of glacial deposits to approximately 27 feet in depth and then weathered basalt bedrock. Ground water flow is to the northwest on the site, apparently due to a ground water mound.

When Fairfield Well 7 (to the southwest) is pumped, the gradient in both the glacial and bedrock aquifers shift. The potential exists for flow from Caldwell Trucking to Well 7 through the glacial aquifer and possibly through the bedrock aquifer as well. Well 7 draws from the bedrock below the glacial aquifer. The bedrock and the glacial aquifer are hydraulically connected, allowing the flow of water between them. In static conditions water flows from the bedrock aquifer to the glacial aquifer, perhaps limiting contamination of the bedrock. However, the gradient reverses during the pumping of Well 7.

Caldwell Trucking and General Hose are known contaminant sources and have been considered major sources since 1976 and 1981, respectively, with Caldwell Trucking considered by far the larger source. General Hose also was a customer of Caldwell Trucking (a septage disposal firm) for several years. During pumping conditions Caldwell Trucking is considered to contribute to the pollution of Well 7 also, through

induced flow, but it may not be the only or original source and the route of flow apparently is not direct.

Caldwell Trucking (see Figure VII-8) hauled septage waste to an unlined lagoon on their property until 1973. Caldwell Trucking has been ordered to clean up the site and initiate ground water contamination. The site is on the National Priority List for Superfund cleanup in connection with the contamination, and a Superfund investigation is in progress. Sludge samples from the property contained extremely high concentrations of TCE, 1,1,1 TCEA, PCBs, lead and chromium. Ground water from the plume area contains very high levels of TCE, methylene chloride, trans-1,2 dichloroethylene, 1,1,1 TCEA, vinyl chloride, chloroform, PCE, 1,1 dichloroethane, and other chemicals, with total VOC levels as high as 580 ppm (580,000 ppb). Caldwell Trucking received an administrative order from the NJDEP in 1982 requiring that all discharges to the soil and ground water be ceased and that a plan for delineation of the plume and decontamination of the ground water be prepared.

General Hose has leaked solvents into the ground and contaminated the soil. Monitor wells confirmed severe ground water contamination. The site has total VOC contamination levels up to 43 ppm, including TCE, 1,1,1 TCEA, 1,2-dichloroethylene, chloroform, PCE and other chemicals (descending order). A highly contaminated well at a nearby industry led to NJDEP investigations. General Hose had leaking waste storage tanks at the east side of its building (with extremely high soil concentrations of TCE, benzene, PCE, 1,1,1 TCEA, cymene and dichlorobenzene) and used a series of connected septic tanks for industrial wastewater disposal until 1980. General Hose used TCE and 1,1,1 TCEA. Spillage was found in the storage areas. The septic tanks revealed chloroform, TCE and 1,1,1 TCEA, which also were found in the water supply well. NJDEP required the installation of monitor wells in 1981, and later served a penalty against General Hose along with an Administrative Compliance Order. A second ACO with fine was delivered in 1986. No mitigation actions have occurred.

Well 2 has evidently been polluted by separate sources. National Electric Coil has been identified as a major discharge source to ground water upgradient of both Well 7 and Well 2, with contaminants similar to both wells except for the carbon tetrachloride in Well 7. Investigations under consideration may determine whether National Electric Coil should be considered a contributor to the Well 7 or Well 2 contamination.

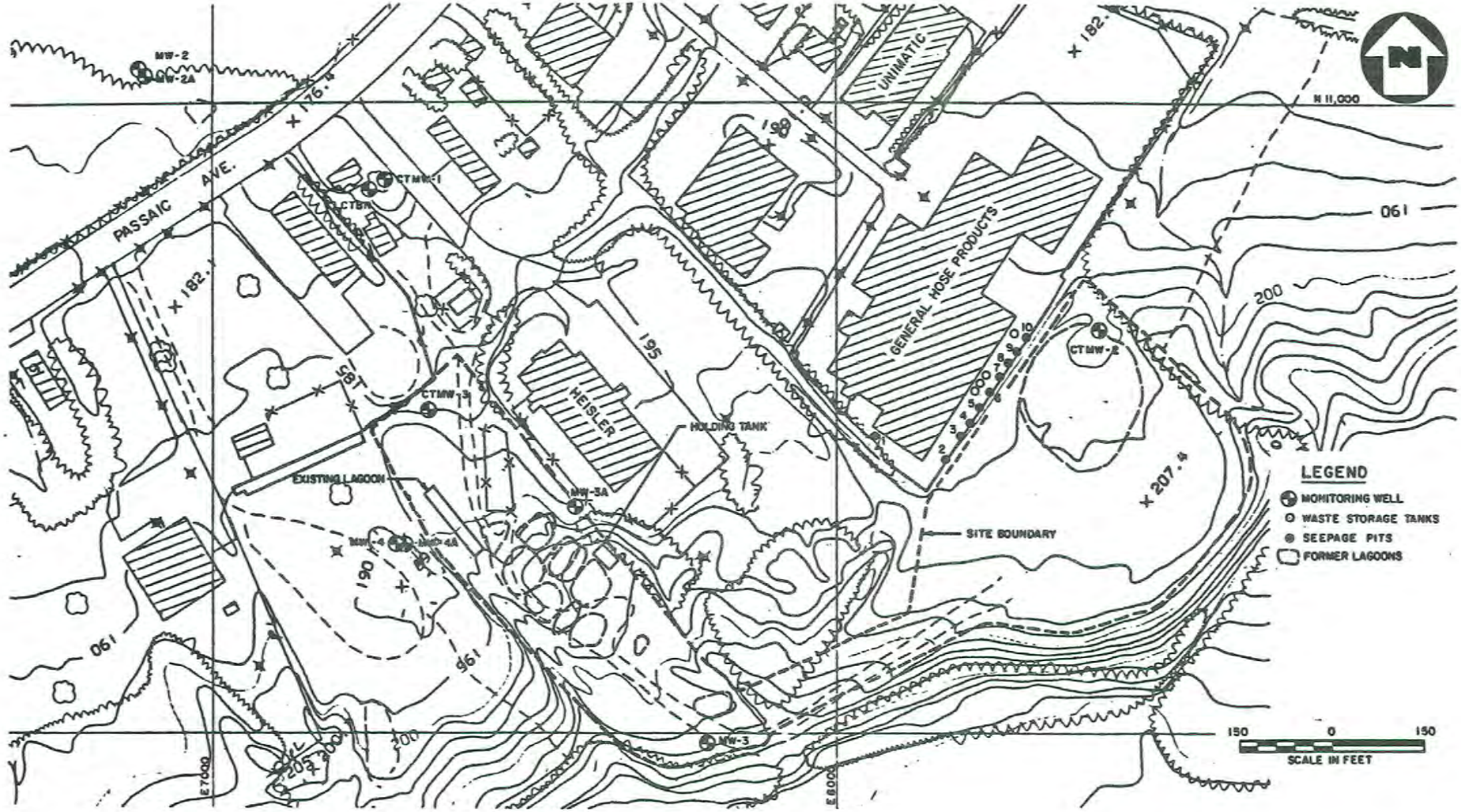


Figure VII-8. Caldwell Trucking Superfund Site

Source: U.S. Environmental Protection Agency, 1986

McGraw-Edison/National Electric Coil refurbishes used electric motors, using solvent sprays for equipment cleaning at a site near the Fairfield airport, southwest of Well 7. Waste solvents were at one time discharged to septic systems creating high levels of soil and ground water contamination. Monitor wells indicate ground water contamination with TCE, PCE, chloroform and trans-1,2 dichloroethylene, 1,1,1 TCEA, and other VOCS to total concentrations of over 13,000 ppb. The downgradient monitor wells have an almost total correlation with the contaminants in Fairfield Wells 2 and 7. The septic system had higher levels of the same contaminants. Soil contamination is confined to the site but vertical contamination has not been defined. The regional ground water flow is expected to be northeast toward the Passaic River. Fairfield Well 7 is less than 3,000 feet northeast of the site, while Fairfield Well 2 is less than 1 mile north of the site. Both wells exhibit contamination with similar substances as found on the National Electric Coil (NEC) site. Ground water from the site flows northeast. Whether the plume has reached either of the wells or is not an existing source of their contamination has yet to be determined.

NEC attempted to remove contaminated soil from near the septic systems but failed due to high ground water in the pit. The two septic disposal basin were removed and waste discharges halted.

Fairfield Wells 7 and 2 were shut down in 1981 and 1982, respectively. Fairfield attempted to use Well 7 for golf course irrigation under a NJDEP permit in 1981, hoping that the level of contamination would reduce. Continued high levels led to discontinuation of the pumping and current knowledge of induced flow from Caldwell Trucking makes pumping of Well 7 untenable. The contaminated private wells have been replaced with public water. Unimatic Corporation was directed to cease pumping contaminated water for cooling water, as this water was later discharged to a stream. The NJDEP will require a broad study from Fairfield Township if any new wells are proposed, to ensure that the contamination is not diverted to them.

Fairfield installed sewers to much of the township in the late 1970's but has not sewered all areas. Prior to sewering, all industries and residences used septic systems or cesspools. Many of the industries use contaminants found in the ground water and may have discharged them to septic systems prior to installation of the sewers, though Caldwell Trucking and General Hose were the only active sources found. Industrial discharges to septic systems have been a significant contamination source, in fact, in five of the seven regional contamination cases.

A good level of cooperation has existed between Fairfield Township and the NJDEP in pursuing the investigation and enforcement of the pollution case. Fairfield Township hired a consultant in 1982 to assess the contamination and its effects on Fairfield's water supplies. The NJDEP is investigating potential contamination sources for both Fairfield wells. The NJDEP first investigated pollution in the area in 1976 and cited knowledge of contamination as early as 1974 when a water analysis cited foul odors "that would be considered foreign to potable waters" in certain private wells. The NJDEP investigation began in earnest in 1980. The Caldwell Trucking and General Hose sites are the subject of a Superfund investigation. Differences existed between the USEPA (lead agency) and the NJDEP on the extent of the investigation, especially with regard to the contamination of Well 7 and its treatment. The National Electric Coil investigation is handled by the NJDEP. NEC instituted a sampling plan in 1985 with NJDEP approval which must define the ground water regime and aquifer contamination. Further data will be developed by NEC along with immediate development of a recovery well as a short-term remedial action.

5) Essex Fells Water Department, Roseland Wells--Three wells of the Essex Fells Water Department have been closed due to contamination with TCE. Wells 10 and 12 are located in the western section of Roseland south of Eagle Rock Avenue and east of Eisenhower Parkway, while Well 8 is located in southwest Essex Fells. The contamination of Wells 10 and 12 may have multiple sources and broader implications than the Well 8 pollution, as ground water near Wells 10 and 12 flows toward the buried valley aquifer under the Passaic River. Ground water flow is approximately northwest in the Well 10 and 12 area.

The Essex Fells water system was delivering finished water with 30 to 50 ppb of VOCs, mostly TCE, in 1983 and part of 1984. When Wells 10 and 12 were taken off line, the levels dropped to less than 10 ppb. When Well 8 was taken off line, the levels dropped to 2.5 ppb. Well 10 had over 110 ppb when shut down late in 1983, but 5 to 15 ppb later. Well 12 had 300 to 350 ppb when shut down in October of 1983, dropping to approximately 150 ppb in 1984 and 90 ppb in 1985. Potential sources of the Well 10 and Well 12 contamination, based on industrial surveys, included Ketcham & McDougall, Tri-County Asphalt, Public Service Electric & Gas, Allied (Amphenol Products Co., Severna facility), Merrick Corporation and Intedge (see Figure VII-9). PSE&G has been eliminated as a contributing source, as may others as further data are developed.

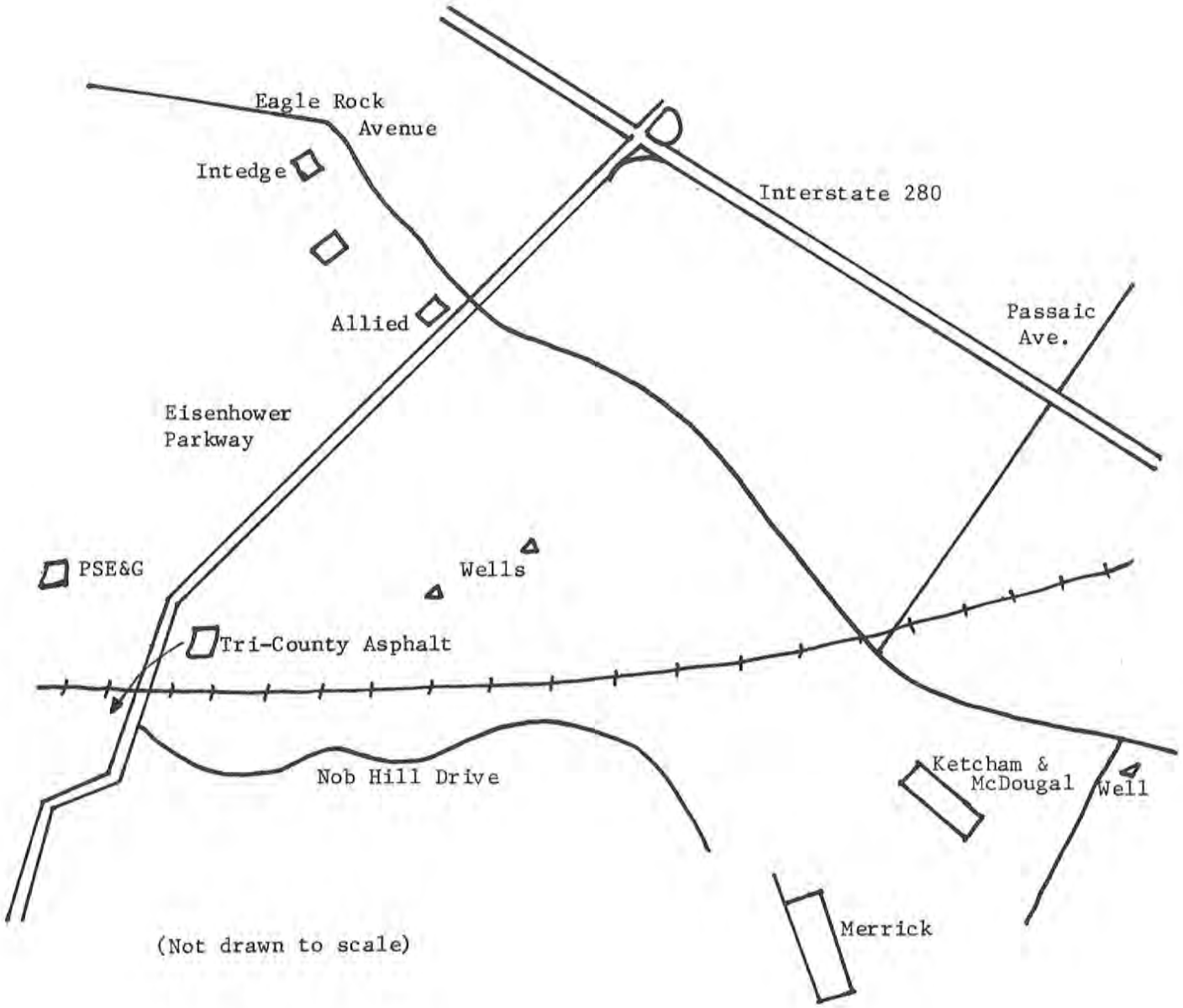


Figure VII-9. Roseland Wells Contamination Area

All three wells were shut down and none are pumping to waste or treatment. Each of the industries identified as potential sources have conducted site investigations and short-term cleanup operations to minimize ground water contamination. More extensive cleanups will be required at some sites. Essex Fells Water Department intends to install a water treatment unit for Wells 10 and 12. Funding is expected to come from the NJ Spill Fund or corporations which accept responsibility for contributing to the contamination.

The site geology consists of bedrock up to 80 feet below the surface in some locations near Essex Fells Well 11 and Ketcham & McDougall. Upper strata include unstratified glacial deposits, clays and stratified sand and gravel deposits. The aquifer in the shale bedrock follows bedding planes (which dip to the northwest) and fractures. The site geology at Merrick Corporation is not fully known. Consultants to Merrick indicate that the site is mapped as glacial moraine but that the nearby Ketcham & McDougall site has permeable sand and gravel and a gravel pit exists near the Merrick site. The bedrock is shale over basalt. Ground water flow is assumed to be toward the north.

The Essex Fells bedrock wells (Wells 10 and 12) were artesian when drilled but are now significantly lower. The overlying glacial deposits are a principal recharge source through leakage in the fractures (oriented north-northeast). Well 10 has only 30 feet of glacial overburden, considerably less than at the Ketcham & McDougall site is 80 feet. The glacial deposits at Essex Fells Well 11 and Ketcham & McDougall (very close together) are relatively permeable, while the deposits at Wells 10 and 12 have more clay and silt. Regional ground water flow under static conditions is north-northwest toward Foulertons Brook and Hatfield Swamp. The flow from the Ketcham & McDougall site is therefore perpendicular to the direction to Wells 10 and 12. However, it is believed that during pumping conditions Wells 10 and 12 draw water along the bedding planes and divert the normal plume. Well 10 and 12 both exhibit contamination trends which support the theory of a diverted plume. Contamination levels are lower after extended rest periods, but climb rapidly in Well 12 after prolonged pumping and less rapidly in Well 10.

The site geology at Allied-Amphenol consists of glacial till from the surface to 13 to 28 feet in depth, stratified glacial deposits of 5 to 16 feet thick, and then weathered and intact bedrock. A shallow water table aquifer and a deep aquifer (flowing artesian) exist. Ground water flow is to the northwest (away from Essex Fells Wells 10 and 12) with a very slow velocity. The Intedge site geology is inferred to be similar

to the Allied-Amphenol site, as Intedge is just west of the Allied facility.

Ketcham & McDougall was found to have discharged industrial effluent from its marine products manufacturing facility to unlined open pits. High levels of TCE were found in the area. The pits were closed and pumped. Investigations are attempting to determine the relative contribution of each suspect industry to the contamination. Monitor wells have been installed. The full extent of ground water contamination in the area is not known. However, Ketcham & McDougall is cooperating with hydrogeologic studies at the site to determine the ground water regime and plume contours. A recent pumping test of Well 12 resulted in measurable drawdown at Ketcham & McDougall. Ketcham & McDougall is located approximately 400 feet from the Wells 10 and 12.

Ketcham & McDougall maintained two large seepage pits, one inside the building and one outside, which were connected and used for cooling water and waste TCE. TCE discharges had essentially ceased by 1984, but the NJDEP water sample indicated TCE levels of 400 ppm, 1,2-dichloroethylene of 70 ppm, and 1,1,1 TCEA of 1.5 ppm. Sludge samples showed TCE at 6.7 per cent, 0.5 per cent 1,2-dichloroethylene and 11,000 ppb of PCE. The discharge was halted in 1984. Later water samples from the pits showed markedly lower TCE levels with a high of 490 ppb. Ketcham & McDougall has removed the sludges from the pits and ceased use of the discharge pits entirely. Under an Administrative Consent Order of 1984, Ketcham & McDougall was to agree to pay for the remediation of ground water contamination for which it is proven responsible, but did not sign the ACO. Additional monitor wells were installed in early 1986 to further define the contamination plume.

Merrick Corporation is located near the Ketcham & McDougall facility, 1,000 feet upgradient of Essex Fells Well 11. Well 11 is contaminated with TCE to a lesser extent than Wells 10 and 12. It is not known whether Merrick Corporation has contributed to the contamination of Wells 10, 11 or 12. Merrick Corporation has occupied the site since 1980. Prior to that time, Babcock & Wilcox owned the site from 1970 to 1980, and Walter J. Kidde Corporation prior to 1970. Under a proposed ECRA sampling plan, the existence of an abandoned underground storage tank was noted. In addition, a former septic field existed on or near the site, but may have been demolished for a townhouse project. Due to the regional TCE contamination, the NJDEP has asked for ground water investigations.

Allied-Amphenol manufactures precision plastic products. Amphenol maintained a mineral spirits underground storage tank on site. Overfilling and spillage of the tank led to some contamination. In addition, the tank had been used for storing liquid hazardous wastes without a RCRA permit. NJDEP required that Amphenol end use of the underground tank for storing liquid hazardous wastes, in compliance with federal and state law. A closure plan must be prepared. In addition, Amphenol took part in a pump test to determine whether ground water may flow to the Essex Fells wells. Ground water contamination in monitor wells installed at Amphenol exists at low levels. Soil samples were highly contaminated with PCE, ethylbenzene, methylene chloride and toluene, up to 23 ppm.

The extent of Amphenol's contribution to the regional ground water contamination is under investigation. Consultants to Amphenol indicate that no TCE (the pollutant in the Essex Fells wells) has been used or found at Amphenol. Natural ground water flow is apparently northwest toward the Passaic River, but pumping from the Essex Fells Wells 10 and 12 are suspected to influence local flow patterns. In addition, the hydraulic upwelling at the site is suspected to have limited downward migration of the soil contaminants.

Intedge is a food service firm located just west of Amphenol. Intedge had a floor drain near its oil and solvent (1,1,1 TCEA) storage which drained to a seepage pit. Intedge removed the liquid and sludge contents of the seepage pit in 1985 under NJDEP order. Liquid samples from a seepage pit on the east side of the facility showed a wide variety of benzenes and VOCs, with a total VOC level of 83 ppm. Included were carbon tetrachloride at 14 ppm, chlorobenzene at 9 ppm, TCE at 8 ppm, etc. However, the contribution of Intedge, if any, to the regional ground water contamination is not known.

Tri-County Corporation (Tri-County Asphalt) had an oil rack area, eight underground storage tanks, and the gravel packing around a Livingston Township trunk sewer line which were suspected contaminated areas. All were either operated by or affected by Tri-County Asphalt. High levels of petroleum hydrocarbons (up to 5.8 per cent of the soil samples) with attendant ethylbenzene, toluene and methylene chloride contamination (up to 1,500 ppb total VOC), were found on site. No VOCs were found in the 212 foot deep well onsite. The benzene and toluene derive from the oil, while the methylene chloride may be a breakdown product from the VOC used to test asphalt. The petroleum hydrocarbon contamination affected several areas of the site, including gravel packing around a Livingston sewer line.

Tri-County removed two underground storage tanks and the contaminated soil from the oil rack area. The possibility of ground water contamination which has not reached the deep well has not been explored. The site geology consists of bedrock to very near the surface. Ground water flow patterns are not known.

6) East Hanover, Ridgedale Avenue--At least two and probably several more industries have contributed to a wide contamination plume in the area of Ridgedale and DeForest Avenues affecting over 50 private wells and the proposed site of a new public supply well (Figure VII-10).

East Hanover is bounded by the Northern Millburn and East Hanover buried valley aquifers. The East Hanover Valley is the primary aquifer used by East Hanover Township. The township itself consists of a low hill between the two buried valley aquifers. The hill is comprised generally of glacial sediments over bedrock. Ground water flows toward the two rivers from the area in between. A ground water divide exists between the two buried valley aquifers, possibly in the area of West Street.

Ridgedale Avenue and DeForest Avenue join in the west-central portion of the township. The area has an upper layer of fine till with cobbles and boulders, while the lower layer is a gravelly glacial outwash and the primary aquifer for private wells. The two layers total 100 to 120 feet thick under Ridgedale Avenue, Triangle Industrial Park and West Street. The water table is 30 to 40 feet below the surface. The direction of flow has not been confirmed, but is predicted to be northwest toward the Whippany River. The aquifer has a high transmissivity, allowing easy flow of contaminants. Toward the East Hanover Buried Valley, in the Ridgedale Avenue area, clay lenses begin to appear which may cause perched water tables. The clay lenses thicken to the west to form a 20 foot thick layer over the buried valley. The clay layer may prevent vertical movement of water but the aquifer is not confined in some areas (Geraghty & Miller, 1968).

Until 1984, the Township of East Hanover did not have public sewerage available to the industries in the Ridgedale-DeForest Avenues area. Many industries disposed of at least small quantities of solvents and other industrial chemicals to on-site septic systems. Industries confirmed as having industrial contaminants in septic systems include Chemical Components, Bronner Manufacturing and Tool Co., Sidmak, Triangle Industrial Park, Ell-Bee Chemical, Foster-Wheeler, DeForest Investment, Chemcoat, Prime Fabricators and several others. The first four industries had the most significant levels of VOCs. Most of the

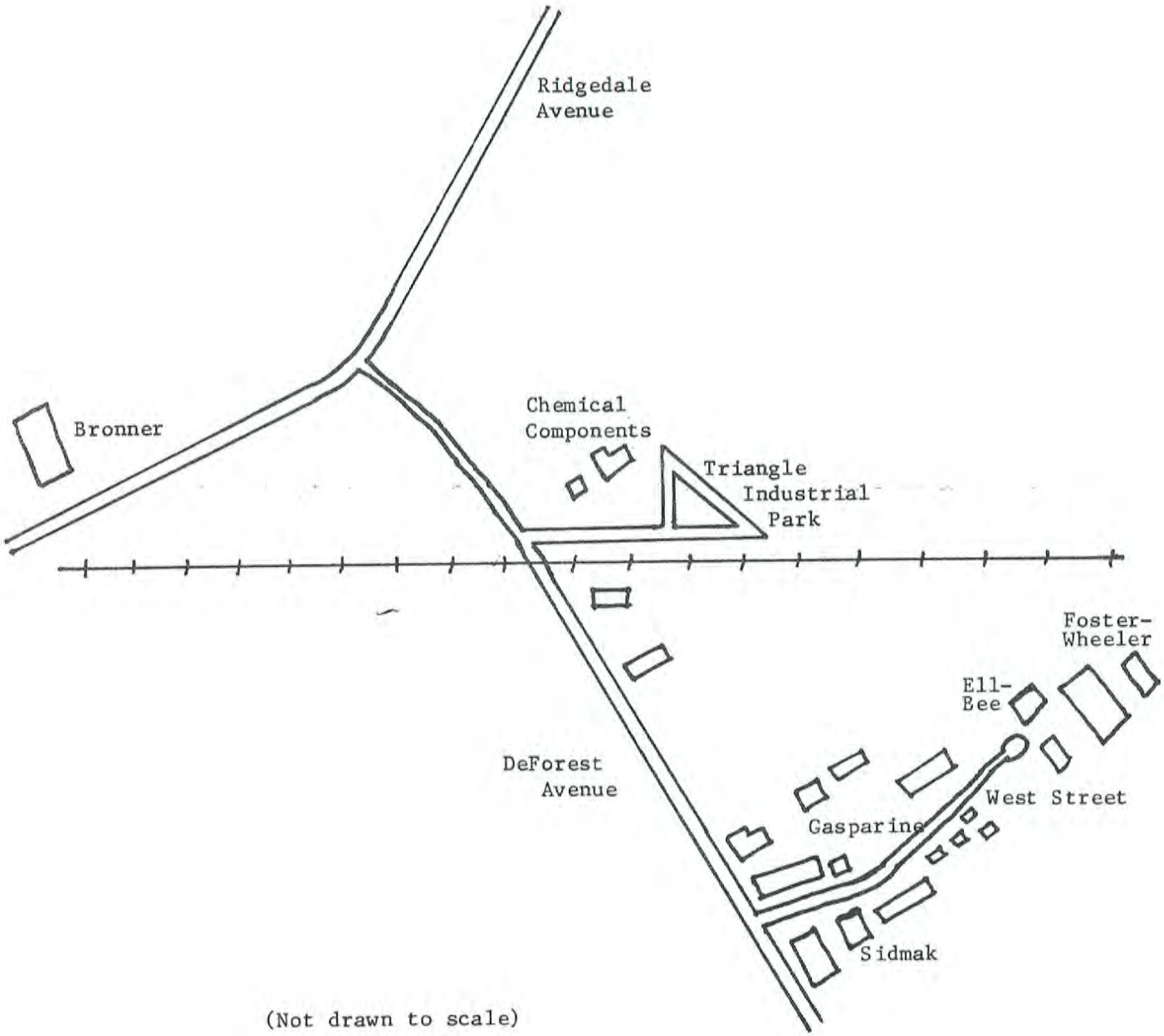


Figure VII-10. Ridgedale Avenue Contamination Area

industries were required to install monitor wells and all were required to cease industrial discharges to and clean out their septic systems.

Samples from the monitor wells and nearby private wells revealed a major contamination plume consisting of TCE, methylene chloride, 1,1 dichloroethane, PCE, 1,1,1 trichloroethane and trans-1,2 dichloroethane. Well contamination reached levels of up to 1,700 ppb of total VOCs. The industrial septic systems frequently contained similar chemicals. The plume is apparently moving northwest through a residential subdivision west of Ridgedale Avenue and north of its intersection with DeForest Avenue. Many private wells have been sealed or removed from use as potable supply wells. The difficulty lies in confirming and determining the relative contribution of each industry to the contamination plume.

Chemical Components had extensive contamination of its septic system, a lagoon which had been filled, and 25 buried drums. The firm manufactures and blends specialty chemicals. The septic system received non-domestic wastes from lab sinks and drains in the facility. NJDEP characterizes the site as an extensive threat to ground water. The septic system contents were removed and sources of contamination to the septic systems eliminated. The drums were excavated and removed.

Bronner Manufacturing and Tool Co. was discovered to have an illegal discharge of very high VOCs and petroleum hydrocarbons through a garden hose to the ground. A septic tank was contaminated with similar VOCs though at a somewhat lower concentration. Also, a fuel oil tank was abandoned in 1976 after it leaked, condition unknown. Citizen complaints of the liquid discharges to the ground led to an investigation by the East Hanover Health Department. The East Hanover enforcement survey called the site an imminent health hazard, with existing contamination of several private wells nearby. Many of East Hanover's private wells are located between Bronner and the Whippany River. The illegal discharge to the ground from the hose was stopped. Bronner was required to hire a ground water consultant and remove the septic system contents.

The septic system at Sidmak Laboratories was found to contain VOCs at high levels. Several of the contaminants with the highest levels were also found in the affected private wells. Floor drains received daily wash water from the laboratory which went to the septic system. Sidmak used all of the chemicals found in its septic system. Use of the septic system has been discontinued. The site is considered a significant threat to ground water.

Triangle Industrial Park has a number of industrial and commercial tenants. The septic system at Triangle was found to contain VOCs at high levels, including several chemicals found in the contamination plume. Ground water under the site has high TCE levels. A survey of tenants found none which currently used the substances found in the septic system, and the difference in concentration between the septic tank and the seepage pit also indicates a past source. The septic system has been pumped out and the industrial park is connected to public sewers.

The East Hanover Health Department has worked very closely with the NJDEP to test private wells and conduct industrial surveys. Many of the contaminated septic systems were found as a result of the surveys. The private well testing has two purposes. Wells with significant levels of contamination may be removed from use for potable supplies and replaced with public water. The results also help define the contamination plume and the variation in contamination levels.

A major policy question facing the NJDEP and East Hanover relates to the East Hanover Well 6 which has been drilled but not connected to the public supply system. The well is in direct line with the expected direction of plume movement, making the contamination of that supply likely. The NJDEP must determine whether the well should be used, whether treatment should be required immediately or after contamination is shown, which parties should pay for the treatment system if required, and whether an aquifer restoration plan might be devised which could safeguard the new well.

Each of the major industries implicated in the regional contamination by way of their septic system contamination is required to develop ground water analyses to determine the extent of their contribution to ground water contamination, if any, and steps to restore the aquifer. The analyses began in 1985 and 1986. In addition, a NJDEP analysis of the entire region is in progress to determine bedrock levels as an aid in determining plume flow.

No aquifer decontamination has occurred to halt movement of the plume or reduce the concentration of contaminants. Each of the sources identified has been corrected or eliminated, which should prevent growth of the plume but will not prevent its further movement. None of the industries have accepted responsibility for the contamination plume or the loss of the private wells in the area.

7) East Hanover, Merry Lane--The Merry Lane contamination site is the smallest and apparently least harmful of the regional sites, but the plume is also moving toward the buried valley under the Passaic River (Figure VII-11).

Three industrial sites have been implicated in the Merry Lane contamination. All three sites are east of the ground water divide between the East Hanover and Northern Millburn Buried Valleys. Ground water flow is south-southeast toward the Passaic River and the Northern Millburn Buried Valley. The depth of sediments and layering of aquifers is not as well known for the Merry Lane area as for the Ridgedale Avenue area. Contamination levels are generally much lower and occupy a smaller plume area than the Ridgedale Avenue plume.

Dorine Industrial Park came under scrutiny when a household well was found to have water which had turned green and had a chemical taste from fluorescein dye, benzene, and 1,1 dichloroethane. Several septic systems in Dorine Industrial Park and nearby were sampled and found to contain organic chemicals. Contamination levels were as high as 1,110 ppb of chloroform and total VOCs of 1,500 ppb. NJDEP ordered that the septic systems be cleaned out and sealed from non-sanitary waste discharges. Monitor wells have been installed. The homeowner has been tied into the public water system. The fluorescein dye (nontoxic) was eventually found in several private, residential wells. VOC analyses revealed contamination of the same wells with 1,1,1 TCEA, benzene, and other VOCs to a maximum of 163 ppb.

The ground water flow moves through Dorine Industrial Park toward the Passaic River at the southeast. The line of flow extends through ChemServices to Weiss-Aug (both located in the industrial park) and beyond. ChemServices' septic system contained VOCs of the same nature as the contamination. ChemServices also sealed a discharge point, floor drains and a collection pit. ChemServices is considered the source of the fluorescein dye and has embarked on a remedial program.

Weiss-Aug found ethylene dichloride and 1,1,1 TCEA in monitor wells downgradient of its septic system. Wash water discarded to a sink was identified as the cause of the septic system contamination. The plume contains total VOCs up to approximately 700 ppb.

Royal Lubricants had an unlined lagoon which was found to contain organic chemicals which may be contaminating ground water. The lagoon has five feet of sand over approximately 25 feet of clay which limits percolation. The lagoon received floor drain and stormwater effluent.

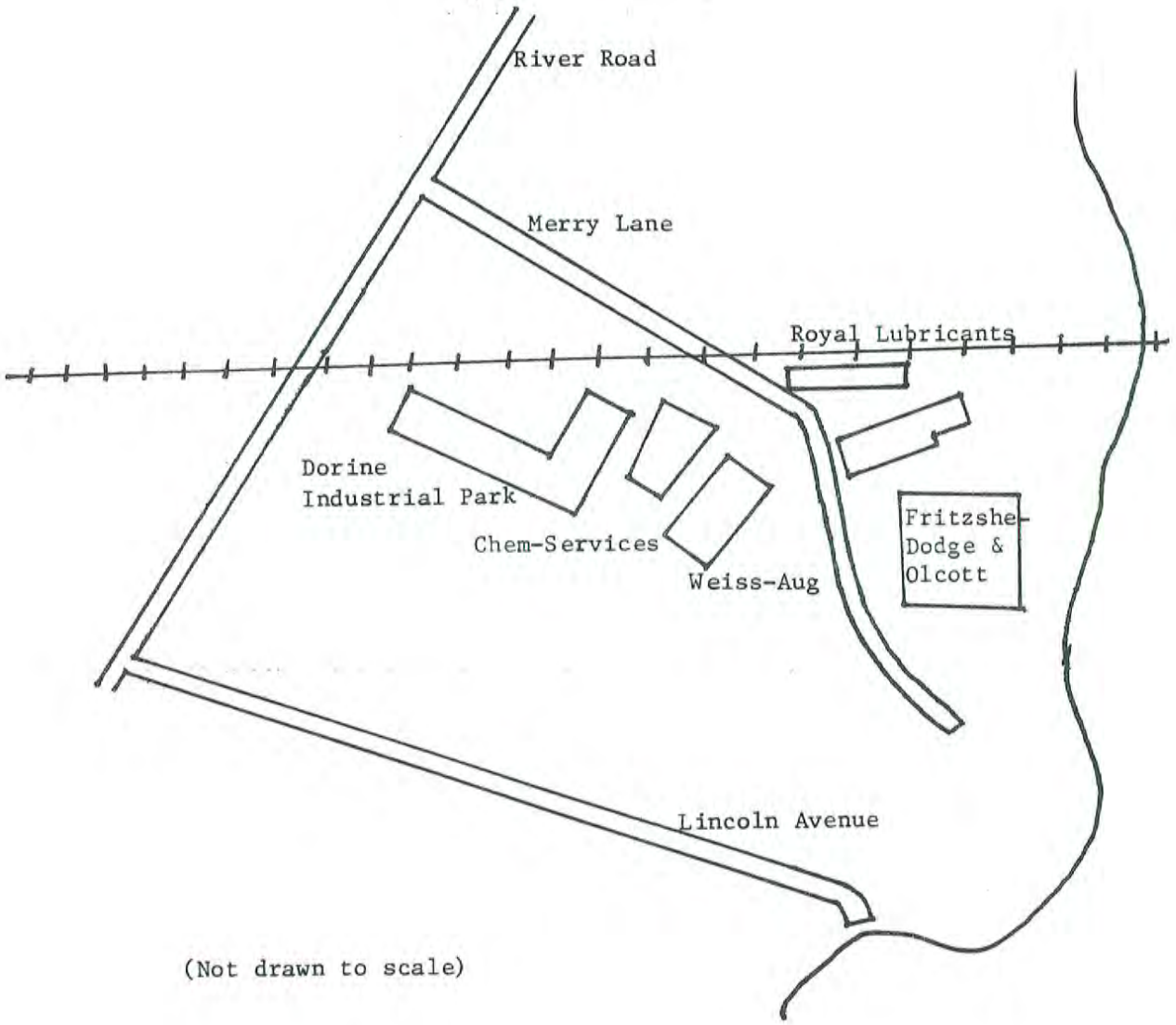


Figure VII-11. Merry Lane Contamination Area

Samples from the lagoon taken by the NJDEP revealed very high levels of dibromochloromethane and chloroform, the latter of which was also found in one monitor well (at a maximum of 330 ppb). However, monitor wells near and downgradient of the lagoon are not highly contaminated. Septic tanks contained oil constituents and significant levels of VOCs. Toluene, various benzene compounds, methylene chloride and naphthalene were among the contaminants. Four of the monitor wells also show high levels of 1,1,1 trichloroethane (maximum of 560 ppb). Most of the contamination appears to be derived from the septic system seepage pits, as the most contaminated monitor wells are located near or downgradient of the seepage pits and not the lagoon. At Royal Lubricants, monitor wells have been installed and tested. The septic systems were pumped out, cleaned and tested. Non-domestic waste sources were disconnected from the septic systems. The NJDEP determined in 1983 that actions to discontinue waste discharges through the septic system appeared successful.

The NJDEP concluded in 1983 that Weiss-Aug, Dorine Industrial Park and Royal Lubricants all contributed to ground water contamination in the area and required further sampling by each to determine relative contributions so that cleanup costs may be equitably distributed. Some mitigation work has been performed, specifically cleaning of the septic systems and replacement of private wells with public water supplies, but no decontamination actions have begun. Existing evidence suggests that Royal Lubricants may be a source of benzene within the plume, while Weiss-Aug and ChemServices in the Dorine Industrial Park may have contributed the 1,1,1 TCEA and other VOCs which were not found in Royal Lubricants lagoon or septic system.

Sites of Concern for Contamination Prevention

Existing sites of ground water contamination have been discussed in this chapter. Also of concern are the many sites which have not experienced contamination to date, but pose a greater or lesser potential for contamination due to the nature of the activity on the sites. Sites of concern include facilities which store, treat or dispose of hazardous wastes, discharge or may discharge effluent to ground water, contain underground storage tanks for fuels or hazardous substances, or contribute urban contaminants to ground water. Additionally, landfills pose potential threats to ground water whether they are closed or active. Excavation projects and dredging of rivers may open aquifers to contamination. Residential septic systems are both recharge sources

and potential contaminants. Recharge induced by pumping wells may draw contaminants to water supplies, and the potential for well contamination is increased when potentially hazardous land uses are allowed near wells. This section also discusses the agencies involved in pollution analysis and enforcement.

RCRA Facilities

RCRA is the Resource Conservation and Recovery Act, passed by Congress in 1976 and amended by the Solid and Hazardous Waste Act Amendments of 1984. RCRA is the federal law under which firms that produce, store, transport and dispose of hazardous wastes beyond certain small quantities are regulated by either the U.S. Environmental Protection Agency (USEPA) or a state agency which is given authority by delegation from the USEPA. RCRA was amended in 1984 to reduce the threshold for regulations (the volume of wastes that a firm must handle before regulations take effect) and to add an entirely new section on underground storage tanks which are used to store petroleum fuels and hazardous substances other than hazardous wastes.

The NJDEP has been delegated authority by the USEPA to implement the RCRA programs for hazardous wastes within the State of New Jersey. The NJDEP has also been delegated authority under the registration program for underground storage tanks but not for tank regulation (federal standards have not been promulgated except for the Interim Tank Standards for new tanks).

There are many industries within the Buried Valley Aquifer Systems that use some quantity of hazardous substances. For some, hazardous wastes are minimal and RCRA does not apply. Others store hazardous wastes on their properties for some length of time before the wastes are transported to other facilities for disposal or treatment. Table VII-12 lists the facilities within the region which are classified as TSD (treatment, storage or disposal) facilities under RCRA. Most store hazardous wastes prior to transport. Only those indicated to require ground water monitoring are considered land disposal facilities. Each facility which may affect ground water quality must receive a permit from the NJDEP-Division of Water Resources, Bureau of Ground Water Quality Management. The permit specifies the number, location, construction and monitoring frequency and parameters for monitoring wells.

TABLE VII-12

RCRA TSD FACILITIES

Facility & Location	TSD Activity	GW Monitoring*
Hewlett Packard Co. Rockaway Township	Storage in containers and tanks	None
Keuffel & Esser Co. Redon Plant Rockaway Township	Storage in containers	None
Pettit Paint Co. Rockaway Borough	Land disposal of waste water	Yes
McWilliams Forge Co. Rockaway Township	Storage and treatment in surface impoundments	Yes
Jersey Plating Co. Boonton	Storage in containers and tanks, disposal in a surface impoundment	Yes
Johanson Manufacturing Boonton Township	Treatment in tanks, disposal in a surface impoundment	Yes
U.S. Army-Armaments Development Command Rockaway Township	Storage in containers, tanks, surface impoundments, treatment in tanks, open burning, and disposal in a landfill	Yes
Metem Corp. Parsippany	Storage in tanks	None
Calvin Klein Cosmetics Parsippany	Storage in containers and tanks	None
Synfax Fairfield	Storage in tanks	None
Singer Co.-Kearfott Div Fairfield	Storage in containers	None
Curtiss Wright Flight Systems, Inc. Fairfield	Storage in tanks	None
Foster Wheeler Development Corp. Livingston	Storage in containers and tanks	None

TABLE VII-12 (Cont'd)

Facility & Location	TSD Activity	GW Monitoring**
Ciba Geigy Corp. Summit	Storage in containers and tanks	None
Allied-Signal Corp. Morris Township	Storage in containers	None
Diamond Shamrock Corp. Morris Township	Storage in containers	None
Mennen Company Morris Township	Storage in containers	None
Exxon Research & Engineering Center Florham Park	Storage in containers	None
Royal Lubricants East Hanover	Storage in containers	None
Sandoz, Inc. East Hanover	Storage in containers and tanks (Treatment of non-hazardous waste in a surface impoundment)	None
AT&T Bell Laboratories Hanover Township	Storage in containers and tanks	None

*Only ground water monitoring requirements through the RCRA program are indicated here. The same facilities may have monitoring programs in place in compliance with other regulatory programs.

Source: NJ Department of Environmental Protection, Division of Waste Management, 20 March 1986.

NJPDES-GW Facilities

The NJDEP-Bureau of Ground Water Quality Management also is responsible for permits under the New Jersey Pollutant Discharge Elimination System (NJPDES) program which involve facilities that do or may discharge pollutants of any type to the ground water regime. A wide variety of activities are included. Industrial septic systems require NJPDES-GW permits (residential septic systems do not), as do unlined lagoons, semi-permeable lagoons, sludge drying beds and sites that contaminate or may contaminate ground water due to past disposal practices. NJPDES-GW permits are used both to regulate and limit the discharge of pollutants to ground water and to determine what nature and level of pollutants have already been discharged to ground water in previously unregulated sites such as old landfills.

The NJPDES-GW program was first authorized under the NJ Water Pollution Control Act of 1981. Prior to that time, ground water discharges were only limited by regulatory programs addressing specific facilities such as landfills. The federal government, other than RCRA and the Solid Waste Disposal Act, has no program for ground water discharge regulation. The New Jersey program is still in its early years, and has a massive backlog of permit applications. Table VII-13 lists the facilities which have received NJPDES-GW permits within the Buried Valley Aquifer Systems region, while Table VII-14 lists applications which are being processed by the NJDEP as of August, 1986.

Major issues in the NJPDES-GW program include the level of pollutants which the NJDEP allows applicants to discharge to ground water and the difficulty of enforcing the effluent limits (measuring effluent quality in ground water is more expensive than sampling surface waters). In addition, new examples of industries which have not applied for permits are found constantly. Until these issues are resolved, the NJPDES-GW program will not fulfill its promise. Municipalities may assist in the enforcement of the program by ensuring that all existing and proposed ground discharge sources have received or at least applied for NJPDES-GW permits. The NJDEP gives highest priority to the processing of permits for proposed new discharges.

Underground Storage Tanks

The Passaic Valley Ground Water Protection Committee in 1981 introduced a major initiative to protect aquifers from leaking underground storage tanks. Beginning with a model ordinance for local implementation and

TABLE VII-13

NJPDES-GW PERMITS

Facility & Location	SIC#	Description of SIC Number
Madison-Chatham Joint Meeting Chatham Borough	4952	Sewerage Systems
Chatham Twp-Main Plant Chatham Township	4952	Sewerage Systems
Chemical Component Div. East Hanover	2821	Plastics Materials and Resins
Royal Lubricants Co. East Hanover	2992	Lubricating Oils and Greases
Orange Products Chatham Borough	3079	Misc. Plastics Products
Precision Rolled Products Florham Park	3399	Primary Metal Products
AT&T Bell Laboratories Hanover	7391	Research & Development Lab
Hanover Twp STP Hanover	4952	Sewerage Systems
NJDOT-I287 Rest Area Harding	4784	Fixed Facilities for Vehicles
Montville Twp MUA Montville	4952	Sewerage Systems
Rovi Atlantic Corp Montville	6514	Not provided
Thermal American Fused Quartz Montville	3823	Not provided
Parke-Davis-Warner Lambert Morris Plains	2834	Pharmaceutical Preparations
Morristown STP Morristown	4952	Sewerage Systems
Asco Electrical Products Co. Parsippany	3499	Fabricated Metal Products
Rockaway Valley Regional Sewerage Authority Boonton	4952	Sewerage Systems

TABLE VII-13 (Cont'd)

Facility & Location	SIC#	Description of SIC Number
Passaic Twp STP Millington	4952	Sewerage Systems
D&A Partnership Rockaway Borough	6512	Nonresidential Bldg Operation
McWilliams Forge Co. Inc. Rockaway Township	3462	Iron and Steel Forgings
Howmet Turbine Components Dover	3369	Not provided
NJ Department of Defense Rockaway	9999	Dover Armory
U.S. Army-Armaments Development Center, Picatinny Arsenal Rockaway Township	9711	National Security
County Concrete Corp Kenvil (Roxbury Twp)	1442	Concrete Products
Hercules Incorporated Kenvil (Roxbury Twp)	2892	Explosives
L.E. Carpenter & Co. Wharton	2851	Paints and Allied Products
Mt. Hope Rock Products, Inc. Wharton	1429	Crushed and Broken Stone
Bernards Twp Sewer Auth Basking Ridge	4952	Sewerage Systems
Veterans Administration Hospital Lyons (Bernards Twp)	9711	National Security
Warren Twp Sewer Auth Stage 5 STP Warren	4952	Sewerage Systems
Reheis Chemical Co. Berkeley Heights	2833	Medicinals and Botanicals

Source: NJ Department of Environmental Protection, Division of Waste Management, Bureau of Permits Administration, 19 May 1986.

TABLE VII-14

NJPDES-GW PERMITS - PENDING

Facility	County	NJPDES No.
County Concrete, Morris Twp	Morris	0063991
Paramount Aviation Corp	Morris	0063574
Regional Oil Company	Morris	0061255
Southeast Morris County MUA	Morris	0098540
Welsh Farms, Inc.	Morris	0001236

*The listed permit applications have been filed since 1 July 1985. In addition, the NJDEP has a backlog of permit applications for existing facilities (in operation as of the enactment of the Water Pollution Control Act of 1981). The listing of backlog applications was not available. NJDEP processes permit applications on a ranked priority basis, with higher priorities generally given to new facilities and to existing facilities which pose a higher risk of ground water contamination.

Source: NJ Department of Environmental Protection, Division of Water Resources, Water Quality Element-Bureau of Permits Administration, computer printout 17 September 1986.

eventually leading to statewide legislation, the PVGWPC advanced the idea that underground storage tanks pose one of the greatest threats to ground water in the region. Some facilities with underground storage tanks have implemented detailed pollution control techniques, including the use of fiberglass or protected steel tanks, secondary containment and monitoring systems. Other facilities, however, have unprotected steel tanks (which are highly prone to corrosion) and do not monitor the tanks for leakage.

Table VII-15 lists the twenty-eight industries in the Buried Valley Aquifer Systems which are known to have underground storage tanks that hold fuels or hazardous chemicals. The list is derived from the files of the Bureau of Air Pollution Control which regulates emissions from vents to these tanks. It is highly likely that additional industrial tanks exist in the region. Registration data for the federal underground storage tank program should identify most of these tanks, as registration was required by May 8, 1986. The NJDEP has received many thousands of registration forms, but has not compiled the data as of summer 1986.

Information provided by the NJ Department of the Treasury, Division of Taxation, indicates that there are approximately 640 gasoline stations in the region. Assuming that these stations have an average of perhaps three tanks, a total of 2,000 gasoline storage tanks are in place. The Passaic River Coalition and Dames & Moore, a consulting firm, collaborated to produce Figure VII-12, a map of the gasoline stations and public water supply wells in the region. The map also shows the location of the known industrial underground storage tanks. Many of the tanks are located in close proximity to major wells.

Major legislation was signed into law by Governor Thomas H. Kean in September 1986. The law (A-2055/S-1479) established a statewide program for the regulation of underground storage tanks. Included within the program are motor fuel tanks with a capacity of more than 1,100 gallons, hazardous substance tanks of any size, and heating oil tanks of greater than 2,000 gallons where the heating oil is consumed on the premises. Specifically excluded are most farm tanks, smaller heating oil and fuel oil tanks, hazardous waste tanks (regulated under RCRA) and tanks for which NJDPES-GW permits have been received.

The underground storage tank law provides for a schedule of tank integrity testing, new tank and tank closure standards, requirements for responses to any discharges to the environment, and mandatory retrofitting of existing tanks with secondary containment or continuous

TABLE VII-15

INDUSTRIES WITH UNDERGROUND STORAGE TANKS

Facility & Location	Tank Contents (Number)
Tri-County Asphalt Corporation Roseland	Fuel Oil #2 (2)
Gannett Outdoor Co. of New Jersey Fairfield	Gasoline (3) Fuel Oil #2 (2)
Fairfield Maintenance, Inc. Fairfield	Gasoline
Mennen Company Morris Plains	Fuel Oil #6 Alcohol, Anhydrous (4)
Norda, Inc. (ADRON) Boonton	Acetone (16 Closed Tanks)
GHA Lock Joint, Inc. Wharton	Gasoline Fuel Oil #2
Morris Hills Regional District Denville	Emylcamate
Aircraft Radio Corporation Boonton Township	Hydrocarbons, Unburned Fuel (10)
County Concrete Morris Township	Gasoline
Tetley Inv. Morris Plains	Fuel Oil #6
Pyro Chem, Inc. Boonton Township	Aromatic Sulfonates (2)
Amax Specialty Metals Corp. Forham Park	Fuel Oil #2
AT&T-Bell Laboratories Whippany (Hanover Twp)	Fuel Oil #4 (4) Fuel Oil #2 (6) Waste Oil Gasoline (3)
Agway Petroleum Corp Rockaway Borough	Fuel Oil #2
Litton Industries Morris Plains	Ephedra Equisetina

TABLE VII-15 (Cont'd)

Facility & Location	Tank Contents (Number)
Apollo Technologies, Inc. Whippany (Hanover Twp)	Petroleum
Harry Charlton Co. Boonton	Kerosine
Scerbo Brothers, Inc. Boonton	Fuel Oil #2 (3) Kerosine
Mt. Hope Rock Products, Inc. Wharton	Gasoline
Hedden Company Dover	Gasoline
Mitchell Supreme Fuel Oil East Hanover	Fuel Oil #2 (3)
White Meadow Petroleum Inc. Rockaway	Gasoline
Conkling Miller Company Bernardsville	Fuel Oil #2 (4)
T.F. Barry Oil Service, Inc. Berkeley Heights	Fuel Oil #2 (2) Gasoline (3)

Source: NJ Department of Environmental Protection, Division of Environmental Quality, Bureau of Air Pollution Control, 24 September 1984.

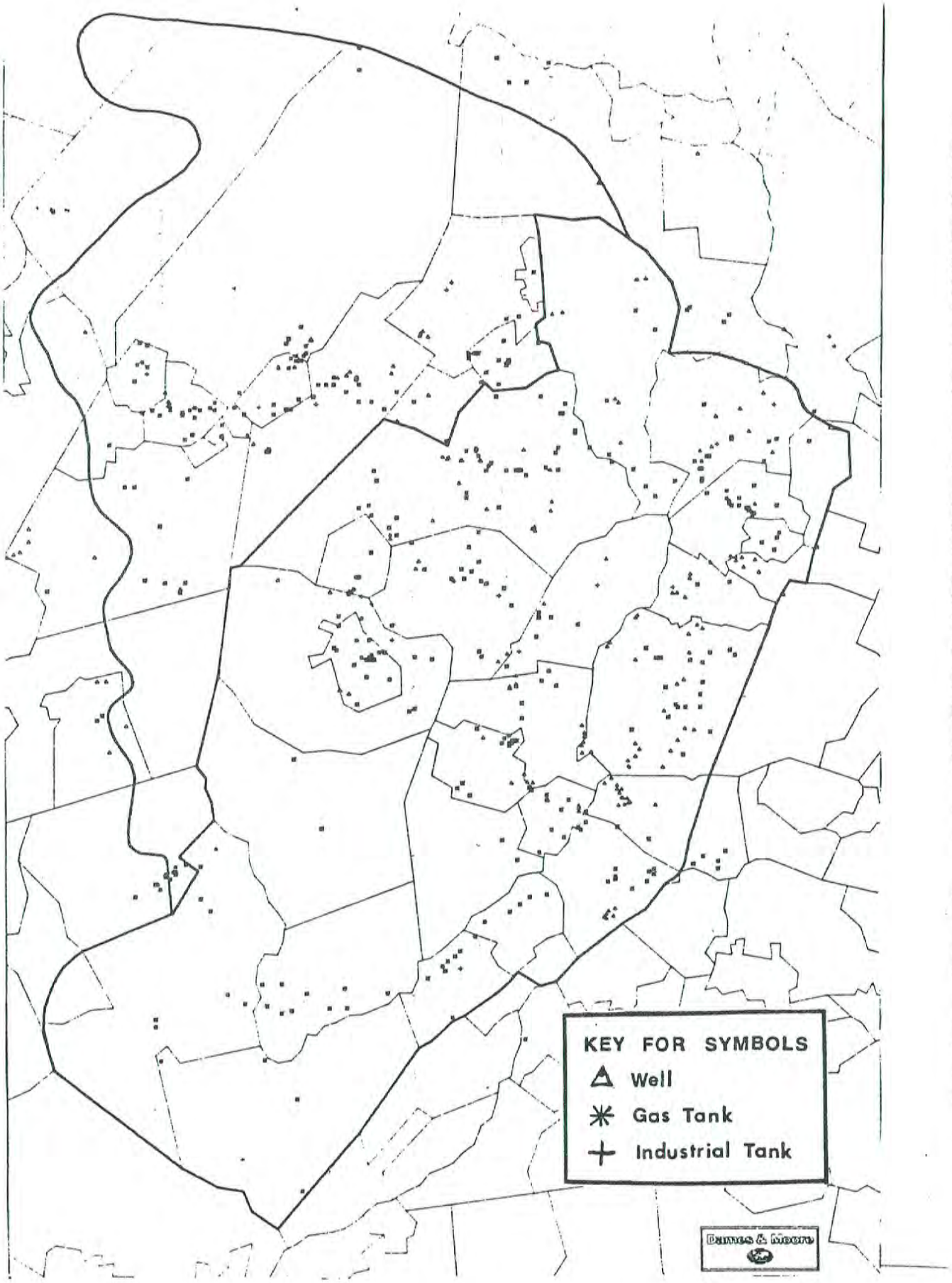


Figure VII-12. Public Water Supply Wells, and Industrial and Gasoline Underground Storage Tank Sites

Source: Dames and Moore and Passaic River Coalition, 1986

monitoring systems within five years. To aid small businesses, a low-interest loan program was established. The regulatory program will be implemented by the NJDEP-Division of Water Resources, Bureau of Underground Storage Tanks.

Urban Contaminants

No program regulates urban contaminants, those pollutants which reach ground or surface waters through storm runoff. Urban contaminants include oils and grease from parking lots, road salts, minor chemical and fuel spills, and many other small sources of contaminants which can add up to a "background" pollution load to aquifers and streams. These contaminants are generally called **nonpoint source pollution** because there is no obvious, single source which can be directly regulated. Little has been done to minimize nonpoint pollution, though some planning boards have started to require that runoff from parking lots be routed through oil and grease separators prior to discharge. The control of urban contaminants in ground water will require research and local involvement with support from technical agencies at the State and federal levels.

Closed or Existing Landfills

The NJDEP has enforcement responsibility for all active and closed landfills in the State of New Jersey. Closed landfills must provide for ground water monitoring, closure plans and post-closure activities to minimize the amount of surface and ground water pollution. Active landfills must meet construction and operating standards, prepare closure plans for each section of the landfill and the landfill itself, and set aside the necessary funds for closure and post-closure activities.

The NJDEP-Division of Solid Waste is responsible for the regulation of solid waste facilities and the enforcement of applicable laws and regulations. Table VII-16 lists the known active and closed solid waste facilities in the study area and provides some information on the nature of wastes disposed there. The facility numbers are also given. More information on each of these facilities is available from the Division.

TABLE VII-16

SOLID WASTE FACILITIES

File #	Facility	Contact	Function
0707A	Caldwell Trucking Co. Trans St. 222 Passaic Avenue Fairfield	George O'Connor	Transfer Station Wastes 73-74
0712A	Millburn Twp Compost Kennedy Parkway Millburn	John W. Pritchard Millburn Twp	Compost Waste-23
0715A	Essex Co. Sanitorium Courtier Lane North Caldwell	Robert O. Turlington E.C. Dept. Banks & Bridges	Compost Waste-23
0718A	Roseland Boro Compost Blk 21 Lot 12 Roseland Boro	James A. Burkhardt	Compost
0721A	West Caldwell Boro Leaf Dump Bloomfield Ave. West Caldwell	Benedict Martorana	Solid Wasted Landfill
0721B	Caldwell Boro Compost Pine Tree Place West Caldwell	John J. Mastrobuono Caldwell	Compost Waste-23
1405A	Vito Marchetto River Road Chatham Twp	Vito Marchetto 1 Loveland St. Chatham Twp	Solid Waste Landfill
1405B	Chatham Twp Compost Blk 18 Lot 92 Tanglewood Drive Chatham Twp	Alice B. Lundt 24 Southern Blvd Chatham Twp	Compost Fac. Waste-23
1409A	Dover Town SWDA Sussex St Dover Town	Dover Mun Bldg	Solid Waste Landfill
1410A	Metro Ltd, Inc Melanie Lane East Hanover Twp	George Deskovick 59 Pitt Rd Boonton	Solid Waste
1410B	Michael Deskovick End of Klinger Rd East Hanover	Michael Deskovick 72 DeForest Ave East Hanover	Solid Waste Landfill Waste 13, 23

TABLE VII-16 (Cont'd)

File #	Facility	Contact	Function
1410C	East Hanover Twp 8 Melanie Lane East Hanover	Township	Compost
1410B	Park Meadows SLF Disruption Meadow Road East Hanover	W.F.Horstman Park Meadows, Meadow Road East Hanover	Disruption
1410E	Larker Park Facility Blk 30-24, Lot 30-41 (near Eagle) East Hanover	Township of East Hanover	Compost Waste 23
1411A	Passaic Ave Landfill Passaic Ave Florham Park	Borough	Solid Waste Landfill
1411B	Green Valley Tree Serv North Passaic Ave Florham Park	Robert R. Jacobus Box 572 Chatham	Compost Waste 23
1412A	Whippany Paper Board Co Parsippany Rd Blk 8901-LO Hanover	Attanasio Carmine Whippany Paper Board Co 1 Ackerman Ave Clifton	Solid Waste Wastes 13,23,27
1412B	Henry Hansch SWDA Whippany Road Hanover Twp	Henry Hansch 185 Whippany Rd Whippany Rd	Solid Waste Landfill
1421A	Ecology Lake Club Inc Riverside Dr Montville Twp	Ron Davis Ecology Lake Club RD #2 Box 466B Boonton	Solid Waste Landfill Waste 23
1429A	Parsippany-Troy Hills Township SWDA Edwards Rd Parsippany	Township	Solid Waste Landfill
1429B	Disruption for Tertiery Treatment Facility Edwards Rd Parsippany	Township	Disruption- Redeposition under 1429C
1430A	Twp of Passaic 1223 Valley Rd Passaic Twp	Township	Solid Waste Landfill

TABLE VII-16 (Cont'd)

File #	Facility	Contact	Function
1435B	Lavin Bros Inc SWDA Lavin Rd Rockaway Twp	Lavin Bros Inc Box 40, Lavin Rd Wharton	Solid Waste Landfill
1436B	Hercules, Inc Howard Blvd Roxbury Twp	James E. DeLancey Hercules Inc Kenvil	Solid Waste Landfill
2018A	Summit Mun Transfer Sta New Providence Ave Summit City	City	Transfer Station Wastes 10,13,18,23
2018B	Summit Compost Area New Providence Ave Summit City	City	Compost Waste 23

Source: NJ Department of Environmental Protection, Division of Waste Management, 25 March 1986.

Excavation and Dredge Cuts

Vecchioli and Gill (1962) were among the first to recognize the harmful effects of stream channelization on the local aquifers, during their study of a proposed channel deepening of the Passaic River between Chatham Borough and Little Falls. They concluded that channelization would cut through confining clays along and under the river, allowing an increased flow of ground water from the confining aquifers and reducing the static water level of those aquifers. The Passaic Valley Ground Water Protection Committee has continued to raise the same question with regard to highway projects (where pilings or road cuts may penetrate through the clay layers), building excavations, river dredging, etc. No regulatory program exists which determines whether soil excavation or dredging will expose previously confined aquifers or will result in the dewatering of unconfined aquifers. (The NJDEP does regulate active dewatering of aquifers for the purpose of preparing building foundations or other construction projects.) For this reason, no listing of such sites is available.

Septic Systems

Much of the Central Passaic River Basin has public sewerage available. Few residential or industrial septic systems remain. The same is now true of the Rockaway River watershed, where most developed areas are tied to the Rockaway Valley Regional Sewerage Authority facility or will be in the near future. However, there are significant areas where public sewers are not and will not be available. Septic systems will remain the dominant method of wastewater treatment. Depending on the location, concentration and method of operation, septic systems can be either valuable and safe contributors to aquifer recharge or sources of significant contamination. According to Geonics (1979b), septic systems are undesirable in prime recharge areas in close proximity to major wells. In such locations, the effluent tends to be drawn too quickly to the well and treatment is insufficient. Septic systems are also not the proper treatment system where soils are too thin or too impermeable, the water table is too high, or the lots are too small for sufficient treatment and dilution of nitrates. However, septic systems are preferable for treatment and recharge of aquifers where the site and soil characteristics are favorable. Figure G-8 indicates the areas that are served by public sewers. Septic system concentrations may be estimated by comparing the public sewerage map with Figure G-6 which indicates the density of wells drilled in the area. Where private wells are common and public sewers are not, septic systems are in use.

Land Uses Within Well Zones

Well Protection Zones--New Jersey requires that public wells be surrounded by a buffer zone 50 feet in radius owned by the water purveyor. A buffer zone this small does not offer much protection to the well other than against the travel of substances down the drilling hole. Ideally, public water wells should be buffered by a larger protection zone in which land use is restricted to uses which generally do not include potentially hazardous and polluting uses.

The State of New Jersey does not mandate that public water supplies be safeguarded by well protection zones through local zoning codes, and most municipalities have not developed protection zones on their own. The protection of well zones beyond the initial 50 foot radius falls by default into the hands of the owners of those lands immediately surrounding the wells, owners who may or may not maintain clean, non-polluting premises. The result of improper land use around water wells can be contaminated water supplies.

The concept of well protection zones is further complicated in that northeastern New Jersey has been industrialized since the eighteenth century. The fact that surface activities can and do affect the quality of water pumped up from underground has only recently been recognized widely. In other words, the siting of factories and other businesses near water wells was not viewed as a cause for alarm, nor was the practice of environmentally unsound techniques of waste disposal, such as on-site disposal. The reverse has also been true: municipalities thought nothing of drilling wells in the middle of a commercial zone. This practice is recognized as unwise today, but the knowledge of groundwater systems today was not available to planners of the past.

In response to the need for protection zones around public supply wells, a municipality could change its zoning ordinances--a move that is practical in undeveloped areas but not so in areas where development has already taken place. A viable approach to the problem would be to amend the zoning ordinance to include well protection zones in undeveloped areas and to make sure that business and industry located near wells in developed areas are operating in an environmentally sound manner, so as not to pose a threat to groundwater quality.

Protection Zone Survey--The Passaic River Coalition has developed a handbook on well protection through **protection zone surveys.** The

methodology was applied to an area around three public water supply wells in Roseland. The procedure outlined in this survey provides a municipality with a method of listing potential sources of groundwater contamination located near public water wells. With this list, the municipality can recommend to each land owner how to maintain a potential contaminant source(s) in order to prevent that source from contaminating the nearby well.

At its lowest level of effectiveness, this land use survey will heighten a town's awareness of possible dangers that lie unnoticed around its public wells. At a higher level of effectiveness, this survey will provide a town with a data base of all potential contaminant sources located around its wells. This data base in turn is a starting point for an investigation of a contamination incident, in the unfortunate case that one should occur. At its highest level of effectiveness, this survey will actually prevent contamination incidents from occurring, when land owners agree to work with a municipality to maintain their potential sources properly. The survey is a non-regulatory approach to groundwater protection and should be conducted with a spirit of cooperation between the town and its land owners.

The Case Study--The Borough of Roseland, New Jersey, is a residential town in northern New Jersey. Private land use practices led to the contamination of two public supply wells with trichloroethylene, or TCE, an industrial solvent and degreaser. The wells sit in the middle of a business zone which is bounded on two sides by manufacturing zones. The boxed area of Figure VII-13, enlarged in Figure VII-14, shows the location of the two contaminated wells.

The survey involves six steps:

1) Definition of the cone of influence around each well, either using a known radius of influence or an estimate based on similar wells.

2) Catalog the land ownership and land uses around each well within the cone of influence.

3) Inventory potential contamination sources, either through direct or indirect knowledge of the chemicals used or stored on the properties within the cone of influence. Industrial surveys are useful.

4) Inventory any existing, known sources of contamination.

5) Develop recommendations for best management practices that each land owner may use to protect the aquifer from potential sources of contamination discovered at each property. Negotiate with the owner to correct any perceived problems.

6) Assess the level of cooperation and noncooperation, and determine whether local regulatory measures are required.

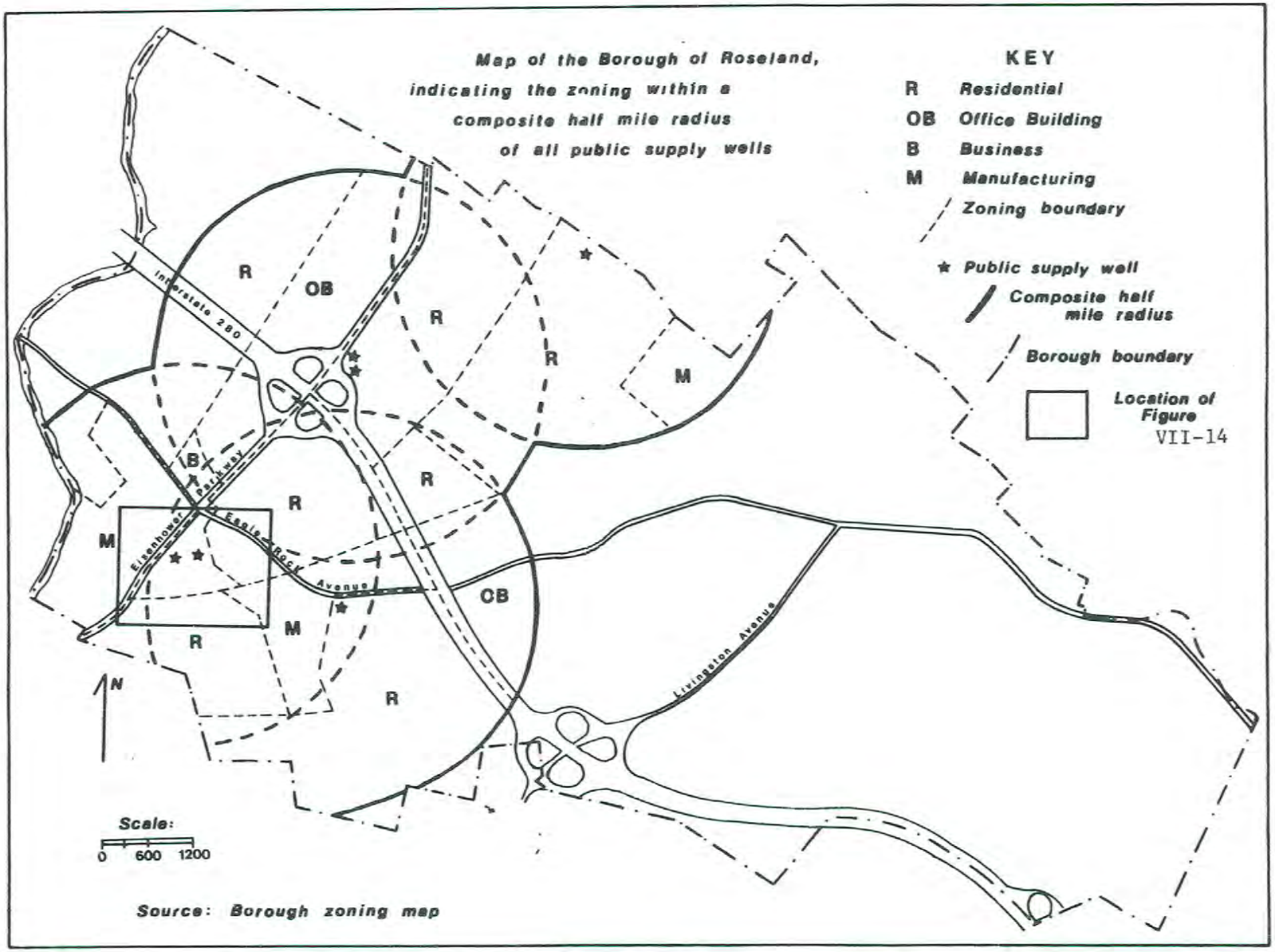


Figure VII-13. Well Zone Protection Survey - Case Study Area

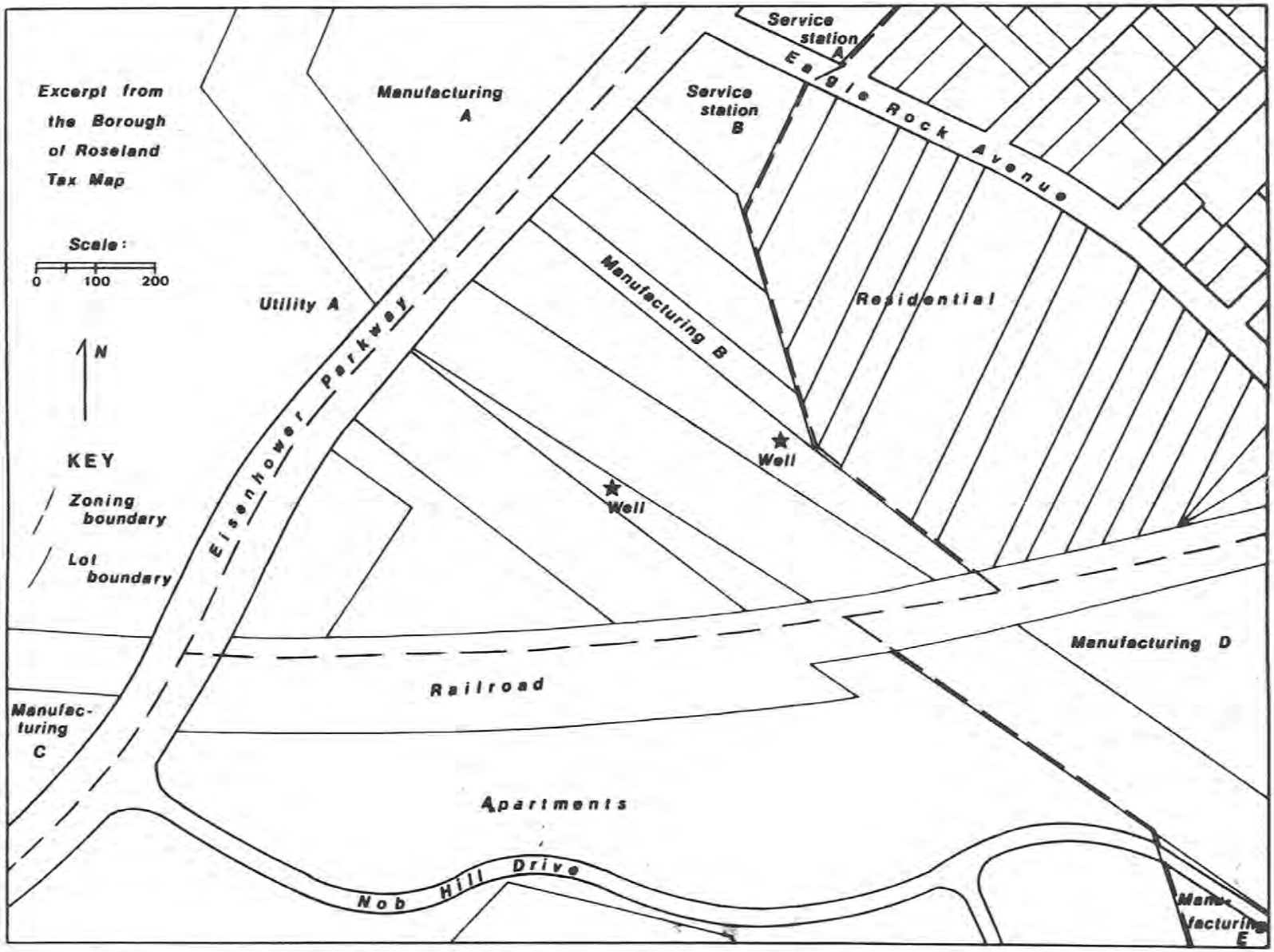


Figure VII-14. Enlarged View of Case Study Area, Well Zone Protection Survey

The land use survey was taken to step four in the Roseland case study. Several potential, existing sources of contamination were discovered by NJDEP investigations, and other potential sources exist within the study area.

Induced Recharge From Contaminated Surface Waters

Where surface waters are contaminated with biological or non-volatile contaminants, wells which induce recharge from surface waters may also draw in significant contamination. The most susceptible aquifer may be the Rockaway Buried Valley, where wells induce the recharge of from 20 to 50 per cent of their yield from the overlying Rockaway River. If the Rockaway River was to become contaminated (temporarily or permanently), then the public wells might cause the contamination of the aquifers.

Lyford, et al., (1984) brings out another concern related to the introduction of contaminated induced recharge. They cite research in Rhode Island which showed "that manganese in water from wells may be attributed to induced flow from streams through bottom sediments." It is worth noting that several public wells in the region, such as two of Florham Park's wells and Denville Well 6, have high manganese levels. The affected wells are also expected to derive some of their yield from induced recharge. The forthcoming USGS report on the glacial aquifers of the northeastern United States may provide a better understanding of this phenomenon.

Agencies Involved in Pollution Analysis and Enforcement

In New Jersey, the primary agencies involved with pollution analysis and enforcement are the USEPA-Superfund program, the NJDEP and local health agencies. The Superfund program has been explained in an earlier section. Local health agencies have significant authorities to test water supplies, condemn wells, force local industries to sample for contaminants, etc. Local health agencies can serve as valuable partners with the NJDEP in both pollution analysis and enforcement.

The NJDEP has by far the greatest responsibilities in pollution analysis and enforcement. Table VII-17 provides an overview of the NJDEP's administrative structure dealing with issues related to ground water. NJDEP's structure has changed a great deal recently due to the creation of three divisions to deal with waste management and site cleanups. Important to note is that each regulatory division of the NJDEP has an

TABLE VII-17

NJ DEPARTMENT OF ENVIRONMENTAL PROTECTION
GROUND WATER MANAGEMENT STRUCTURE

Commissioner
Deputy Commissioner

Office of Science and Research
Planning Group

Assistant Commissioners	Divisions	Bureaus
Environmental Management and Control	Water Resources	Enforcement-Northern Enforcement-Metro Ground Water Quality Management Water Allocation Safe Drinking Water Underground Storage Tanks NJGS-Ground Water Pollution Analysis NJGS-Ground Water Resources Evaluat'n
	Environmental Quality	Emergency Response
	Solid Waste	Facility Review Sanitary Landfill Closure Compliance and Enforcement
Hazardous Waste Mgt	Hazardous Site Management	Enforcement Hazardous Waste Planning ECRA Hazardous Waste Facility Permits
	Hazardous Site Mitigation	Sites Management Risk Assessment
Regulatory and Govt'l Affairs	Office of Regulatory Services	

enforcement arm. The enforcement bureaus are located in four common offices according to the region of the State. Two enforcement offices are active in the study area. The Metropolitan Region includes western Essex and Union Counties, while the Northern Region includes the remainder of the Buried Valley Aquifer Systems. Although the enforcement bureaus from the Divisions of Solid Waste and Hazardous Site Management are important to ground water protection, most cases of ground water contamination begin with the enforcement bureau of the Division of Water Resources.

The Division of Water Resources, Northern Enforcement Office has two sections. The first is Field Inspection and Compliance Monitoring. The second is Enforcement. A complaint goes first to the Field Inspection staff, which attempts to locate potential sources and sample them. If the problem is minor, then the responsible party is required to apply to the Bureau of Ground Water Quality Management for closure of the spill. If the problem is greater it is referred to the Enforcement staff. The Enforcement office attempts to get the responsible party to implement an interim remedial action and perform a hydrogeologic investigation to determine the extent of the problem. This information is used to verify the nature of any threat to ground water. A directive is then used to have the responsible party implement cleanup actions as required. If a responsible party refuses to cooperate, the NJDEP has implemented a new policy in 1986 which allows the department to act directly to assess and clean up the site using funds from the NJ Spill Fund while assessing triple the cost to the responsible party. Administrative Compliance Orders (ACO) are the legal mechanism used to direct site actions. Administrative orders are used where detailed cases against a recalcitrant responsible party are being developed. A site geologist is generally assigned to work with the enforcement staff. The NJ Geological Survey's Bureau of Ground Water Pollution Analysis is usually involved with site assessment, while geologists from the Bureau of Ground Water Quality Management become involved once an ACO is being followed. ACOs, reports from responsible parties (or NJDEP consultants) and the site permits are all information available to the public. (Plumb, personal communication, 1986).

Local Pollution Prevention Activities

Municipalities have taken direct action to protect their potable water supplies from harm. These actions generally respond to local concerns and local initiatives, as the NJDEP does not have a program to encourage

local aquifer protection. As a result, application of aquifer protection concepts is scattered and incomplete. No municipality uses even half of the protection mechanisms available, and many are not involved in aquifer protection at all. Municipal utilities authorities and private water companies are in a more difficult position. They lack the police power of municipalities and so cannot regulate land uses or industrial practices. The only protection techniques available to them are the purchase of water reserves or wellhead protection areas and involvement in local decision-making as "interested parties."

This section does not address the variety of local protection techniques that are in practice elsewhere, nor does it recommend specific actions. Such management recommendations will be developed under the third phase of the cooperative work undertaken by the Passaic River Coalition and the Passaic Valley Ground Water Protection Committee. This section does report on current local aquifer protection programs in the Buried Valley Aquifer Systems. Information on local actions is derived from discussions with consultants, water engineers and supervisors, and administrators of public water supply systems in the region.

Water Reserves

Only two water reserves exist in the region - the East Orange Water Reserve and the Alamatong Well Field. A common thread is seen here, as in both cases the water reserves are owned by public water supplies that divert ground water from aquifers in one municipality and deliver that water to other areas. Therefore, both systems lack the land use controls which might otherwise serve to protect the aquifers.

The East Orange Water Reserve is a local ground water protection program in its own right, consisting of some 2,300 acres in Millburn, Livingston and Florham Park. The Township of Millburn has zoned Water Reserve property for conservation and assessed the land accordingly. The Township of Livingston has not followed suit to date, zoning the land for some measure of development. There has been some consideration of developing some parcels in the past, to reduce the tax burden, but opposition from East Orange residents resulted in these plans being dropped. No plans exist or are likely to come forward for development of Water Reserve property, though concerns with taxes on the property exist. The Water Reserve also plays a role in protecting the quality and quantity of ground water in downgradient areas, such as the Canoe Brook well field of Commonwealth Water Company.

The existence of the Alamatong Well Field, owned by the Morris County Municipal Utilities Authority, is a significant protection mechanism. Most of the surrounding area is lightly developed and not sewered. Roxbury and Randolph Townships are considering expansion of a sewage treatment plant just upstream of the well field which would allow additional development in the area. The northernmost portion of the Lamington River watershed is relatively heavily developed near Kenvil and Succassuna in Roxbury Township.

Well Head Protection

The NJDEP requires that public supply wells be protected by 50 feet of land around the well head. A number of municipalities, either deliberately or as the result of land purchases, own more than the minimum well head protection zones. However, several of these areas are also used as public works compounds, introducing potential contamination hazards. The water reserves owned by the East Orange Water Commission and the MCMUA are, of course, well head protection zones as well.

The well field owned by Boonton consists of the land between the Rockaway River and the Morris Canal, approximately one-half mile in length. The northern (downstream) section of the well field is wetlands while the land opposite the Morris Canal in Boonton Township is farmland. Boonton Township has evidenced a concern about protecting the well field. Boonton and Boonton Township recently worked with local activists to deter development just upstream from the well field in Denville Township. The land is zoned for high density development using septic systems or sewers. The Boontons hope to protect the well field through county acquisition of that property as an addition to the Tourne Park of Morris County.

Among the Commonwealth Water Company well fields, the Canoe Brook well field is best protected, due to its location within the reservoir property of Commonwealth. The Passaic River wells are bounded by the river and a Hilton hotel. The Baltusrol well field is located near the alignment of Interstate 78. Commonwealth has not had problems with the municipalities over well protection.

Denville protects its wells in part through their location in large tracts of land. Wells 1 and 4 are located in the public works compound, which provides a buffer against surrounding land uses but is also a land use with potential hazards. Protection actions such as the use of sti-P3 underground storage tanks reduce the hazard. Well 5, in the Gardners

Field Complex, has a 1,000 foot open space buffer. Wells 3 and 6 are located in the center of a land parcel with 1,600 feet of road frontage.

Madison Borough wells are protected by small parcels of public property which have been fenced. The Station Road facility is also used as an office and the borough garage is just upgradient of the well field (as is much of Madison). Both well fields were originally surrounded by open fields which have since been developed.

Parsippany owns its well sites to a 50 foot diameter, as required by law, but only in the Troy Brook area is a greater land area owned (5 to 6 acres). The wells along Troy Meadows are protected by the undeveloped nature of the wetlands, which are not owned by Parsippany. Although Lee Meadows is mostly undeveloped now, anticipated development will occur near the new well. Clay strata commonly found above the buried valleys provides some natural protection to the wells.

Rockaway Township has instituted an aquifer protection zone upstream of its well field in an attempt to preserve 80 acres of land over the prime aquifer area from development. Land owners may transfer density to other sites from the aquifer zone.

Southeast Morris County MUA owns some land around many wells which provides some buffer.

Septic System Management

The most common response to septic system problems in the more developed areas of the region has been to replace the septic systems with public sewers. In municipalities which were developed decades ago with small residential lots, this action is reasonable. Some concerns are now being raised that sewerage should be limited to problem areas and not replace functional septic systems which recharge ground water.

Almost all of Fairfield Township has been sewered since 1980, replacing the septic systems used on all properties. Public water supplies have been provided to over half of the township and are available in most areas. The two programs result in less contamination from small-lot septic systems and less hazard from localized ground water contamination incidents. East Hanover, which has experienced major problems from industrial septic systems, also recently completed its sewer system, which discharges to the Parsippany-Troy Hills Sewage Treatment Plant. Parsippany, in turn, requires that all facilities must tie-in to the

public sewer system, so that the use of on-site septic systems is minimal. Wharton Borough is forcing hookups to sewers as allocations become available from the Rockaway Valley Regional Sewerage Authority, to eliminate failing septic systems.

Control of Potentially Hazardous Land Uses

Land use controls reside primarily in local governments and are delegated to the Planning Boards and Zoning Boards of Adjustment. In developed municipalities, limited controls are available other than when industrial facilities are altered significantly. Developing municipalities have broader options for aquifer protection, but have not taken advantage of their powers in most cases.

Chatham Borough was considering a local ordinance controlling underground storage tanks prior to state legislative action on the same subject. As a fully developed community, Chatham Borough has little control over the existing uses. In Denville the Planning Board requires potentially hazardous land uses (such as gasoline stations) to provide for monitor wells.

Montville is pursuing local protection actions. Site fill must be uncontaminated. An ordinance is being considered to place a fee on new development in the Towaco Aquifer's prime area for monitoring wells to ensure aquifer protection. There is a provision also for the clustering of industrial and residential development with the deeding of aquifer lands to the township. Most of the densest growth in Montville will be south of Route 202 which cuts just south of the Towaco Aquifer. The lack of sewerage in the aquifer area will limit growth.

Mountain Lakes adopted a local ordinance for the protection of its prime aquifer area and implements the ordinance as part of the planning board's site plan review process. The ordinance mandates maintenance of the natural rate of recharge, treatment of runoff before recharge, local approval of any new wells, and test wells for any new underground tanks for residences. Underground tanks for residences may only be used if no other fuels are available. Maintenance of all ground water protection systems is the responsibility of the land owner.

The Rockaway Borough contamination incident has resulted in some local ground water protection actions, including mandatory integrity tests for local gasoline stations, an industrial survey, and a closer analysis of new industries. The public responded by calling in information about

possible sources of the VOC contamination. However, Rockaway Borough is mostly developed, limiting land use management options.

Rockaway Township uses the site review process to impose strict standards on new gasoline storage tanks, requiring secondary containment and monitoring wells. Retention basins with some mechanism for separating out contaminants are required for new developments, as well.

Wharton formed an Environmental Commission in 1985, which among other activities will evaluate monitoring data from a landfill closed by the NJDEP which is near the Thatcher Glass property and Well 3.

Spill/Dumping Response

Although the NJDEP is the most visible agency that responds to spills and dumping incidents that threaten ground water, many municipalities watch for leaks and spills, initiating local action while informing the NJDEP. However, such programs are mostly informal, based on citizen calls and casual observation by municipal employees.

Chatham Borough, for instance, has an informal pollution watch which seems effective. Madison Borough employees attempt to locate any private, abandoned wells and force the owners to seal them for ground water protection. They also respond to pollution incidents identified by citizens or borough employees.

In 1986 Montville adopted an ordinance requiring connections to public water supplies where the NJDEP has determined that the private supplies are contaminated or have a high potential for contamination and public water is reasonably available. The ordinance is intended to address the Marotta pollution incident directly, but may be used in other situations. Additional municipalities will be adopting such ordinances, such as East Hanover, or have them already, such as Fairfield. Responses of this type react to the consequences of contamination and are not cleanup or enforcement programs.

Inspection of Facilities Handling Hazardous Substances

Concerns with industrial contamination of ground water led many municipalities to conduct industrial surveys. One municipality, Fairfield, has pursued the concept further and implemented a regular inspection program for all industries which use hazardous substances.

Dover prepared an industrial survey early in the 1980's, primarily concerned with an inventory of underground storage tanks. Among the noted concerns was the existence of large fuel oil tanks just north of the Princeton Avenue well field. Inspections have been conducted to safeguard the wells. Dover residents have become more observant and willing to report possible violations of pollutions laws in recent years, perhaps in response the Well 4 contamination incident.

The Fairfield program involves inspection and enforcement of business and industry involved in the transport, storage or manufacture of hazardous chemicals in 1980. Underground storage tanks are a specific focus of the Division of Fire Prevention which implements the program, including integrity tests every five years. Annual inspections of all non-residential buildings are made by Township personnel. The program was prompted by a chemical fire in the 1970's. Cooperation from local businesses is improving.

Planning boards, zoning boards of adjustment, environmental commissions, building inspectors and fire inspectors all can plan a role in the proper design of facilities (such as underground storage tanks) and their proper installation and maintenance. The inspectors of all municipalities have a mandate to ensure that all codes and plans are followed.

The Wellhead Protection and Sole Source Aquifer Demonstration Programs of the 1986 Amendments to the Safe Drinking Water Act of 1974

Amendments to the Safe Drinking Water Act were enacted on June 19, 1986 as P.L. 99-339, providing for a reauthorization of the act and new sections establishing important ground water management initiatives at the federal level. Two programs are especially relevant to the Buried Valley Aquifer Systems. The first is a Wellhead Protection Program which provides grants to States which elect to design and implement programs to protect the quality of drinking water from wells through wellhead protection. The second program is a demonstration program for the management of "Critical Aquifer Protection Areas" within federally-designated sole source aquifers. The two programs in combination are the first federal programs affecting the full range of land uses which may threaten the quality of drinking water aquifers.

Wellhead Protection Program

The new Section 1428 of the Safe Drinking Water Act defines wellhead protection areas as "the surface and subsurface area surrounding a water well or well field, supplying a public water supply system, through which contaminants are reasonably likely to move and reach such water well or well field." States have up to three years to submit programs for review by the USEPA for matching grants of 50 to 90 percent to reimburse costs incurred by the states in developing and implementing the plans. A plan must meet the following minimum standards, among others:

1) Specify duties of State and local agencies and public water systems with respect to the development and implementation of wellhead protection (WHP) programs.
2) Determine the extent of WHP areas for each wellhead based on all reasonably available hydrogeologic and other information.
3) Determine all potential anthropogenic sources of contaminants which may have any adverse effect on the health of persons within each wellhead protection area.
4) Describe a program to protect the water supply within WHP areas from such contaminants.
5) Require that all potential sources of contaminants within the expected WHP area of new wells in a public water supply be considered prior to construction.

The State must attempt to implement its program within two years of submittal to the USEPA. The USEPA will be issuance technical guidance on the delineation of WHP areas and the general requirements of state programs, but does not have any authority to implement programs if the states do not.

The Congressional Research Service has analyzed the Wellhead Protection Program to determine the likelihood of success in implementing its provisions and to point out potential difficulties (Feliciano, 1986). Perhaps the most salient difficulty is the antipathy of USEPA hierarchy and the current administration to a federal role in ground water protection, as the USEPA in 1984 had eschewed the need for any further federal authorities in its Ground Water Protection Strategy. Although some states and regions (such as Dade County in Florida) have already implemented or considered wellhead protection, there is also a concern among some state officials that the program may intrude upon local land use prerogatives. However, Feliciano points out that "a State is not

required to develop a regulatory program unless it chooses to do so." Federal agencies must comply with state WHP programs, also, which may encourage state involvement.

Other difficulties with the new program involve fitting wellhead protection to existing wells in urbanized areas, the lack of sufficient hydrogeological information to define WHP areas, and the difficulty in applying the technique to confined aquifers (Feliciano, 1986). On the other hand, states may set priorities for defining WHP areas, and may wish to upgrade land uses near existing wells to protect the water supplies. Local governments and water supply systems must certainly play a major role in such programs, which should increase local understanding of ground water resources. It is uncertain how much money will actually be appropriated for the WHP program, as EPA grants for local and state assistance have been stable (approximately $270 million) since 1980. There is some fear that the program will simply increase competition for existing, limited resources.

Sole Source Aquifer Demonstration Program

Congress decided to initiate an innovative demonstration program which would result in the implementation of comprehensive aquifer protection programs in a few sole source aquifers. Up to $4 million may be provided to any one sole source aquifer, in a matching grant of up to 50 percent of the costs of developing and implementing the plans, from a total authorization which begins at $10 million and increases to $17.5 million from year three to five (FY 1989 to FY FY 1991). Eligible areas include those designated as a sole source aquifer which have existing aquifer protection plans approved under Section 208 of the Clean Water Act (a provision clearly aimed toward the Nassau/Suffolk County 208 Plan on Long Island), and those designated as sole source aquifers up to two years after the date of enactment which develop plans meeting EPA criteria (to be developed).

The new section 1427 of the Safe Drinking Water Act establishes the purpose of the program as the development and implementation of a comprehensive management plan which will ensure maintenance of ground water quality for protection of human health, environment and ground water. Applicants may include any State, municipal or local government or entity with sufficient jurisdiction, but all applicants other than the State must apply jointly with the governor of that state. Each application must delineate Critical Aquifer Protection Areas (CAPA) according to USEPA criteria, designate a planning entity which must have

the authority to develop and plan carry out the plan, complete a hydrogeological assessment of surface and ground water resources within the CAPA, provide a management plan, and a submit schedule and implementation method for the plan.

The comprehensive management plan must include:

1) A map detailing the boundary of the CAPA.
2) Existing and potential point and non-point sources of ground water degradation.
3) Assessment of the impacts of land use on ground water quality.
4) Specific actions and management practices to prevent adverse impacts on ground water quality.
5) Identification of authority adequate to implement the plan, estimates of costs and sources of State matching funds.

A variety of optional components are also cited, including:

1) Quality of existing ground water recharged through the area and the natural recharge capabilities of the CAPA watershed.
2) Comprehensive statement of land use management for the maintenance or improvement of the quality of underground sources of drinking water.
3) Actions designed to prevent adverse impacts on recharge and/or water quality.
4) Program for State and local implementation of the plan.

The demonstration program has clear and vital application to the protection of the Buried Valley Aquifer Systems. Congress envisions the program as a limited demonstration of what can be done, and very few of the 39 proposed and designated sole source aquifers will actually attempt to implement a plan, nor could all be funded. Congress must still decide how much funding to actually appropriate, and USEPA must develop the necessary guidelines. Sole source aquifers such as the Nassau/Suffolk County effort will have a sizable lead for funds.

However, research efforts by the State, the US Geological Survey and the Passaic River Coalition, including this report, move the Buried Valley Aquifer Systems well into contention for federal funds, especially with the involvement of municipalities through the Passaic Valley Ground Water Protection Committee. If the various agencies and governments involved in the region are serious about aquifer management, a joint effort of the NJDEP and the Passaic Valley Ground Water Protection Committee could implement a comprehensive management plan for the Buried

Valley Aquifer Systems with the close involvement of local governments. Chapter VIII describes research efforts of the NJ Geological Survey and US Geological Survey which will help define the aquifer systems. Also described is research jointly sponsored by the Passaic River Coalition and the Passaic Valley Ground Water Protection Committee to develop a management program for local implementation, the third phase of work which follows the PRC's 1983 and current research reports and which is scheduled to commence in the fall of 1986.

CHAPTER VIII

CURRENT RESEARCH ON THE BURIED VALLEY AQUIFER SYSTEMS

Chapter IV described the major research efforts leading to the current state of knowledge with regard to the Buried Valley Aquifer Systems. As sound management of the aquifers depends upon a thorough understanding of their characteristics, research is essential. The current level of information is not sufficient, despite several recent studies, but current research efforts by the New Jersey Geological Survey (NJGS) and the United States Geological Survey (USGS) should significantly increase the knowledge of the aquifer systems. In addition, the Passaic River Coalition (PRC) and the Passaic Valley Ground Water Protection Committee (PVGWPC) have committed to an extensive effort to develop management recommendations for municipal, county, state, federal governments and private interests, so that the Buried Valley Aquifer Systems are not past effective management by the time current and planned research efforts are concluded. This chapter provides a brief summary of four research efforts that occurred or concluded during 1986 (publication of reports expected in 1987), two major research efforts planned by the NJGS and USGS to start in late 1986 or early 1987, and the joint planning efforts of the PRC and PVGWPC.

New Jersey Geological Survey

The New Jersey Geological Survey (NJGS) is a branch of the N.J. Department of Environmental Protection, Division of Water Resources. It is comprised of three bureaus, each of which is heavily focused on ground water or has a major ground water component. The Bureau of Ground Water Pollution Analysis (BGWPA) serves as an internal consultant to all NJDEP programs which deal with ground water pollution, including the Divisions of Hazardous Site Mitigation, Water Resources, Solid Waste and Environmental Quality, assisting in detailed ground water contamination investigations leading to the identification of responsible parties and remediation of site contamination.

The Bureau of Geology and Topography (BG&T) performs research and analysis work on the geology of New Jersey, including the identification and mapping of bedrock formations, surficial deposits and the form of the land's surface. As an understanding of aquifers requires an understanding of the aquifer's geology, BG&T is a critical partner in efforts by NJGS to research the Buried Valley Aquifer Systems.

The Bureau of Ground Water Resources Evaluation (BGWRA) is the third part of the NJGS and is most directly involved in aquifer research. BGWRA performs the bulk of research work by the NJGS involving broad scale definition of the aquifers, their characteristics and dependable yields. A considerable amount of this work has, in the past, and will in the future be conducted in cooperation with the USGS-Water Resources Division.

Lower and Central Rockaway River Basin Study

The NJGS-BGWRA and the USGS cooperated in a study of the lower and central portions of the Rockaway River Basin, including all or portions of the municipalities of Parsippany-Troy Hills, Montville, Boonton Town, Boonton Township, Mountain Lakes, Denville, Rockaway Borough, Rockaway Township, Dover, Mine Hill, Wharton and Randolph. Essentially all of the Rockaway River was included downstream of Jefferson and Roxbury Townships. The upper Rockaway River watershed had been the subject of an earlier study, described in Chapter IV.

The study purpose was "to generate a more complete understanding of the hydrogeology of the Pleistocene valley fill aquifer in the Rockaway River and its tributaries." The research involved surface geophysics, water level observation wells, river seepage measurements and water level measurements in existing domestic, industrial and municipal water supply wells. Goals of the study were a better understanding of the geographic extent of the valley fill aquifer, the quantities and movement of ground water in the system, the relationship between ground and surface water, and water quality. (Kasabach, personal communication, 1984).

Draft results of the NJGS research have been used in Chapter IV of this report. Among other project outputs, the NJGS developed a map of bedrock contours along the length of the project area. The map clearly shows that the Rockaway Buried Valley extends through Denville and then exits the Rockaway River watershed through a bedrock gap in Mountain

Lakes (the Mountain Lakes Gap), enters the Whippany River watershed in Parsippany-Troy Hills under Troy Brook (the Troy Brook Buried Valley) and extends southeast into Troy Meadows. The location of the Mountain Lakes Gap and the continuous buried valley through it radically alters prior maps of the Rockaway Buried Valley which was earlier assumed to follow the current course of the Rockaway River north from Denville into Boonton Township. The buried valley that does underlie the Rockaway River in Boonton Township is now believed to be a spur valley, connecting with the Rockaway Buried Valley in central Denville.

The "Lower and Central Rockaway River Basin Study" is tremendously important for its discovery of the true course of the Rockaway Buried Valley. Old notions that the Rockaway Quaternary Aquifers were distinct from the Buried Valley Aquifer Systems are no longer valid. The Buried Valley Aquifer Systems may be considered a single system, from the Chatham Buried Valley to the upper Rockaway Buried Valley. This single finding emphasizes the unity of the aquifer systems and the concept that management of the aquifers as a regional system is necessary.

Additional results from the NJGS study will be forthcoming in a report tentatively scheduled for release in early 1987. Funding for the study was provided by the U.S. Environmental Protection Agency through its Underground Injection Control (UIC) program. The research will benefit decision-making for permits to reinject waste waters (primarily heated water from industries) into the aquifers through wells. The NJGS is also cooperatinv with the USGS on a three dimensional flow model of the Rockaway Buried Valley aquifer system, through a research effort planned to last two or more years which will include extensive ground water level monitoring.

COGEOMAP

The New Jersey Legislature appropriated $200,000 in 1984 for the purpose of developing a new geologic map for the State of New Jersey, replacing the 1912 map (revised in 1950) which was the last complete map. NJGS is working with the USGS through a program called COGEOMAP to prepare the new map. Under COGEOMAP, the USGS provides matching funds for the work. The new map will be at 2.5 times the old scale, and at the new scale of 1:100,000 will cover three sheets. The NJGS, however, eventually plans to reach a scale of 1:24,000 (1 inch=2,000 feet) in the most geologically complex areas so that site specific decisions may be made based on the maps. The five year project is in progress. The final maps will aid in ground water analysis.

Analysis of the Buried Valley Aquifer Systems in the Central Passaic River Basin

The NJGS will lead a research program in cooperation with the USGS to fully delineate the buried valleys of the Central Passaic River Basin, determine the dependable yields of both the buried valleys and the bedrock aquifers, describe and quantify the relationship between the buried valley and the bedrock aquifers, and develop a computer model simulating the flow relationships so that estimates of yields and the effects of current and new diversions may be made for the aquifer systems. The project is expected to take five years, starting late in 1986 or early in 1987. Details of the research program are not available as of this writing, but an outline of the research program is shown in Table VIII-1. The project will also encompass the Upper Passaic River watershed during the initial periods.

The study should resolve the existing questions about the delineation of buried valleys in the region. The study area will include the Chatham, Southern Millburn, Northern Millburn, Canoe Brook, Slough Brook, East Hanover, Troy Brook and Great Piece Buried Valleys, and should also cover the areas of deep glacial sediments with no known connection to the other buried valleys, such as Lee Meadows in Parsippany-Troy Hills and Hanover and the deposits under North Branch Foulerton Creek in Essex Fells. In addition, the new computer model should considerably improve on the existing model by Meisler (1976) which does not cover the entire area and does not include the bedrock aquifers.

Glacial Deposits Mapping

The NJGS-BG&T is involved in a major mapping effort within the central Rockaway River watershed, mapping glacial deposits in the area based on USGS 7.5 minute quadrangle maps. The mapping includes both plan view and cross-sectional analyses. The Boonton quadrangle is ready for printing and additional maps (such as the Dover quadrangle) are expected by late 1986 and early 1987. This mapping project provides considerable value to aquifer research, defining as it does the stratigraphy of glacial deposits for a broad area. Previous studies had, for the most part, identified the main channels of the buried valleys but did not develop extensive information on the nature of the deposits in them.

TABLE VIII - 1

NEW JERSEY GEOLOGICAL SURVEY RESEARCH OUTLINE FOR THE ANALYSIS OF THE BURIED VALLEY AQUIFER SYSTEMS IN THE CENTRAL PASSAIC RIVER BASIN

Year One

A. Plan of Study
B. Well Compilation
C. Water Use Inventory
D. Water Levels
E. Streamflow
F. Geology
G. Test Drilling
H. Geophysics
I. Report on Well Compilation
J. Administration (each of five years)

Year Two

A. Water Use Inventory
B. Water Levels
C. Water Quality
D. Geology
E. Test Drilling
F. Geophysics
G. Synoptic Water Level Program
H. Water Budget
I. Report on Geology of Surficial Deposits
J. Report on Bedrock Contours

Year Three

A. Ground Water Model Design
B. Water Levels
C. Report on Existing Hydrogeological Conditions
D. Report on Water Budget

Year Four

A. Ground Water Model Utilization
B. Water Levels

Year Five

A. Water Levels
B. Report on Ground Water Levels

Source: New Jersey Geological Survey, unpublished, 1986.

Additional Research Ideas

NJGS-BGWRA is also pursuing additional research concepts. A contract was signed in 1985 with the American Geological Institute for a complete bibliography of geological information for New Jersey, from the 1700's to current times. The contract will run for several years. The NJGS is also working with other elements of the NJDEP to develop a Geographical Information System (GIS), a computer based data and mapping effort that will include a wide variety of data on natural resources, ground water contamination, geology, historic sites, developed areas and other information useful in environmental decision-making.

NJGS is also considering a research effort to connect its prior aquifer studies in the Ramapo River valley with current research in the Rockaway and Central Passaic River watersheds. The study would determine whether the Ramapo Valley glacial aquifers are connected with the Towaco Buried Valley and the Great Piece Buried Valley along the line of the Pompton River through the valley between Hook Mountain and the Mountain View section of Wayne. Timing for this research is not known.

Periodically, NJGS-BGWRA becomes involved in assisting the BGWPA in determining the broader characteristics of major ground water contamination sites. During 1986, BGWRA conducted an analysis of ground water conditions in the East Hanover Buried Valley north of Route 10 to determine the configuration of the aquifer. The information will be used to identify probable sources for contamination of the East Hanover Well 2 and the Ridgedale/DeForest Avenues regional contamination incident.

United States Geological Survey

The United States Geological Survey (USGS) has two major branches that work in New Jersey. The Water Resources Division, located in Ewing Township near Trenton, is more involved with aquifer research. It is the Water Resources Division which conducts most of the cooperative research with the NJGS. The other USGS program active in New Jersey is the Geologic Division, based in Reston, Virginia, which works with the NJGS on COGEOMAP, previously described.

Glacial Aquifer Systems in the Northeastern United States

The USGS began a nationwide program in 1978 called the Regional Aquifer System Analysis (RASA) program, covering 29 regional aquifers. The RASA program is concerned with providing knowledge for evaluating and managing major aquifer systems. One study involved the glacial aquifer systems in the northeastern United States, with a research effort that began in 1984 and ended in 1986. The study focused on specific aquifers in the Northeast which are glacially-derived, so that general principles of aquifer form, hydraulic properties, recharge and discharge, physical and chemical properties of water and interactions between water and rock could be described for the regional system.

One of the local study areas was the Rockaway Buried Valley in the Dover area. Work was completed in early 1986 and a report prepared. The results of the report are not available pending the completion of internal review by the USGS. Release of the report is expected in early to middle 1987. As with each of the localized studies, the Dover RASA research attempted to define the following (Lyford, et al., 1984):

(1) Aquifer geometry (stratigraphy of deposits, nature of bedrock valley walls, basin size);
(2) Streamflow and ground water flow relations;
(3) Recharge estimates from water budgets;
(4) Streamflow-recession curve analysis (to estimate ground water evapotranspiration, leakage and recharge from an analysis of streamflow hydrographs);
(5) Analysis of ground water quality;
(6) Analysis of surface water quality;
(7) Vulnerability of glacial aquifers to high iron and manganese;
(8) Recharge to buried valleys from uplands;
(9) Vertical hydraulic conductivity near streams (measuring how streams gain or lose water to aquifers with respect to natural and anthropogenic effects);
(10) Chemistry of water in glacial aquifers;
(11) Relationship between surface and ground water quality;
(12) Generalized flow modeling.

The Dover RASA study specifically involved estimation of induced recharge of the glacial aquifers from streams, tritium testing of ground water to determine its longevity in the aquifer, ground water temperature profiles, and estimates of gaining and losing stretches of local streams around the Princeton Avenue well field in Dover. Many observation wells were drilled for the study. The study should result

in precise aquifer transmissivities and storage coefficients. Cones of depression were determined, showing a good connection between the river and the aquifers (Harte, personal communication, 1986). NJGS-BGWPA files indicate that wells next to the Rockaway River induce flow from the river, to levels of 20 to 50 per cent of their total yield.

Upper Rockaway River Watershed Synoptic Analysis

A second major study by the USGS is also completed and the study is progressing through internal review prior to publication in late 1986 or early 1987. The USGS-Water Resources Division performed a synoptic analysis of the ground water and surface water for the Rockaway River watershed upstream of a streamflow gauging station just above the Jersey City Reservoir (Harte, personal communication, 1986). The purpose of the synoptic analysis is to generate a comprehensive data base on the surface and ground water characteristics in specific watersheds to serve as a baseline for future research to understand how water systems change over time due to development and other affects. The synoptic analyses also point out significant hydrologic features for further study. The first synoptic study was performed in the Ramapo River watershed. The second covered the Rockaway River watershed. One synoptic assessment is performed every two years, and the USGS intends to return to each watershed after fifteen years for reassessment.

The Rockaway River synoptic analysis relied on past and current research by the NJGS for information on the bedrock depths along the buried valleys, bedrock structure and surficial geology. The USGS performed research on surface and ground water quality and quantity using two streamflow gauging stations (one near the Jersey City Reservoir and one in the southern Berkshire Valley), eight continuous water level recorders, 35 additional wells, 15 stream water quality and 7 bottom material sampling sites, 26 ground water quality sampling wells, and monthly sampling at two streamflow gaging stations for one year. Water quality analyses in the streams occurred both at low flow and rain-flush events. Ground water sampling included inorganics, organics, nutrients, metals and VOCs. The NJDEP-Division of Water Resources assisted with sampling and analysis of stream biota. Long term water budgets for the watershed have been developed, assuming no change in ground water storage over time.

A general analysis of gaining and losing streams was performed based on four seepage runs (analyses) using 38 measurement stations. The four runs used two low base flow events, one medium base flow event and one

high base flow event, all four of which were base flow events rather than runoff events due to precipitation. A preliminary ground water flow analysis was also completed. The final report, when released, should considerably improve understanding of the water budget and hydrologic system of the Rockaway River watershed, improving the possibility of aquifer management in the region.

Upper Lamington Aquifer Analysis

The USGS-Water Resources Division will serve as lead agency in a cooperative study with the NJGS-BGWRA of the aquifers under the upper Lamington River watershed in Roxbury, Randolph and Chester Townships. The study will have the same goals and methodology as the aquifer analysis led by the NJGS for the Buried Valley Aquifer Systems in the Central Passaic River Basin. However, the research will begin at least one year after commencement of the NJGS research to facilitate the common use of personnel and equipment.

Additional Research Ideas

The USGS-Water Resources Division is pursuing with NJGS a follow-up study to the Upper Rockaway River Synoptic Analysis. The three year study would result in a sophisticate, three-dimensional computer model of the watershed so that the effect of ground water pumpage changes on surface water low flow may be better understood. The model would also estimate ground water level changes due to new wells or increased diversions from old wells. The research would involve a continuation of water level measurements at all points of the synoptic analysis plus additional points. Due to the existence of several surface water supplies downstream of the upper Rockaway River watershed (Jersey City Reservoir, Wanaque South Project intake, Passaic Valley Water Commission intake), a model to estimate the loss of surface water flows during droughts due to increased ground water diversions will be very valuable, as the safe yield of surface water supplies is heavily dependent upon ground water flow during periods of low precipitation.

Passaic River Coalition and Passaic Valley Ground Water Protection Committee

The Passaic River Coalition (PRC) and the Passaic Valley Ground Water Protection Committee (PVGWPC) have a seven year history of cooperative efforts for the protection of ground water quality and yields in the Buried Valley Aquifer Systems. The liaison has resulted in numerous important gains for aquifer protection, including the federal designation of the Buried Valley Aquifer Systems in 1980, development of the PVGWPC as a voice for local government concerns about ground water management, enactment of state legislation for the regulation of underground storage tanks, provision for research funds through the NJ Statewide Water Supply Master Plan for hydrogeologic research by the NJGS and USGS in the Buried Valley Aquifer Systems, publication of the Hydrogeology of the Buried Valley Aquifer Systems in 1983 and publication of this report.

The two PRC reports on the Buried Valley Aquifer Systems complete a multi-year effort to compile and assess all currently available information on the aquifers and their contamination. The PRC and the PVGWPC have developed a third cooperative project, scheduled to begin in late 1986, for the development of an interim management plan for the Buried Valley Aquifer Systems.

The management plan will be developed in three major phases. First, the PRC will itemize the management issues for the aquifer in a white paper which will serve as the basis for the development of management concepts. Second, the PRC will present management techniques which may prove valuable in protecting the regional aquifers. Third, the PRC will prepare recommendations for a comprehensive aquifer management program.

Each step will occur with input from the Passaic Valley Ground Water Protection Committee (an intermunicipal association), other municipal officials, hydrogeologists and water resource managers. Public input will be solicited through information meetings on each of the three documents prepared.

The National Ground Water Forum recently released its proposed conclusions and recommendations, entitled "Groundwater: Saving the Unseen Resource." The National Ground Water Forum reached several important conclusions. The Forum declared that **"A new environmental partnership is essential to groundwater protection, and the full participation of local governments is critical to partnership success."**

The Passaic Valley Ground Water Protection Committee has recognized the critical importance of local aquifer management as a basic tenet of its existence.

Management of the Buried Valley Aquifer Systems

The primary management concern in the buried valleys region is pollution of public and private wells. The concern is justified. This report has identified a wide variety of contamination sources. Five public well systems are designated as "National Priority List" sites under the federal Superfund program. Several other municipal wells have been contaminated with TCE, gasoline and other toxic substances. There are approximately 100 major and minor ground water contamination incidents in the region. Over 350 gasoline stations exist, along with 27 industrial facilities, with underground storage tanks. In addition, the thousands of individual septic tanks may cause untold contamination in the region. Documentation of potential threats is occurring through the PRC's research efforts and State regulatory programs. The control of these threats is critical.

A second concern is the potential for excessive withdrawals. PRC analysis of the State's methods for ground water allocations indicate that too little is known of the dependable yield and recharge of the aquifers to determine allocation limits. In several cases, the size and configurations of the aquifers are not yet known, making estimates of dependable yields difficult. There are at least two aquifers which exhibit excessive withdrawals. The region is growing rapidly. Some balance between demand and supply must be struck before the capacity of aquifers is exceeded.

A third concern is the loss of recharge to aquifers. Aquifers may recharge through percolation of rainfall or from neighboring rivers. In the former case, some lands are better for recharge than others. Development of the region has been indiscriminate without concern for aquifer recharge. As recharge is reduced and stormwater runoff is increased, aquifer yields decline. This process could hasten the day when aquifers become excessively utilized.

A fourth concern is the lack of data. Municipalities face charges of arbitrary decision-making unless sufficient information exists to justify zoning and health ordinances protecting the aquifers. The PRC has been providing valuable information through its research but lacks the resources for field studies and aquifer analyses. The increase in

ground water research funds at the state level will result in vital information, but only after years of research. Therefore, a major planning constraint is the lack of relevant data. The interim management program resulting from this proposal must overcome this factor.

A fifth concern is State policy with regard to aquifer management. The N.J Division of Water Resources has consistently eschewed any direct involvement with the control of land uses to protect aquifers. Even in critical areas where severe drawdown of aquifers has occurred, the State has relied on its powers to control water allocations as a substitute for direct controls. Additional efforts may be necessary, if allocation controls are not sufficient. The State may, however, try alternatives if the current method fails.

A final concern is that many municipalities lack the regional perspective necessary for management of a regional aquifer. Actions in one area clearly affect surrounding areas. Some measure of guidance and interaction is necessary to achieve regional cooperation. The Passaic Valley Ground Water Protection Committee has promoted regional cooperation and becomes more successful as its membership increases. A regional management system, as proposed here, can provide a solid basis for additional interaction. As an intermunicipal committee, the PVGWPC cannot enforce its plan but rather must rely on the force of persuasive argument and information. As there is no agency or government that can manage the regional aquifer as a whole, a cooperative, intermunicipal approach is the only valid technique. A management plan will serve as the foundation for all further action.

Developing the Management Plan

Several points are clear from the Chapters IV through VII of this report. First, the region is extremely and permanently dependent upon ground water for potable and industrial uses. Second, development in the region is increasing ground water use while simultaneously posing threats to the aquifers through pollution and the loss of aquifer recharge. Third, detailed hydrogeologic information will not be available for years. Initial results for the first projects may be released four or five years hence. Fourth, no one government has comprehensive responsibility or authority for regional aquifer management. Fifth, no regional aquifer management plan exists. Sixth, the rate of contamination, the cost of cleanups and the rate of development are clear evidence that protection of the aquifers, especially through a preventive approach, is needed now and has been

needed for years. Seventh, the complex problems of an urbanizing aquifer region constitute a new management situation in ground water protection.

The Passaic River Coalition will work cooperatively with the Passaic Valley Ground Water Protection Committee to develop a regional aquifer management plan which will result in policies for the long-term protection of the buried valley aquifers. This plan will have several key characteristics:

1) The plan must be oriented primarily toward implementation by local governments. Local governments control land uses and their impacts on ground water. They will have the greatest say in the development of a management program. In addition, municipalities rely on the aquifers for public supply. There is a tremendous incentive to protect those supplies, so long as a clear, rational case is made. This incentive is the reason why local cooperation can provide the bulk of a management scheme.

2) The plan must consider the role of county governments. Counties have significant roles to play in highway development, storm water management, and technical assistance to municipalities. The counties also are responsible for solid waste management. They must be included in any regional management plan.

3) State government is responsible for approving and funding for transportation, sewerage and flood control projects. It also regulates many types of development, the allocation of water to major users, and well drilling. State policies have an important effect on the direction and rate of growth in rural and suburban areas. The State also conducts ground water research, investigates and cleans up contamination sites, and regulates waste management. While the State cannot be controlled by a regional plan, a well-designed plan may have a significant impact upon State policies and decisions.

4) The federal government has devised a ground water program using existing authorities. Most are not amenable to control by a regional plan. However, no regulations exist for federal review of projects in a designated, sole source aquifer. A regional plan could provide valuable guidance to the U.S. Environmental Protection Agency and serve as a basis for discussion of review parameters.

5) The plan will be based upon research that has been completed, such as the PRC's studies. The characteristics of the aquifers and the

various threats to aquifer yield and quality are being defined. By using previous studies, the plan will focus on management techniques rather than technical information.

6) The plan will be conservative in nature. Not enough is known about the aquifer system to define exact yields, development constraints, pollution threats or dispersal rates, etc. Therefore, the plan must be conservative in its approach so that the resource is not lost prior to the existence of sufficient technical information. New research can be used at any time to redefine the controls needed to protect the aquifers, but the plan must assume that the aquifer is very prone to disturbance and loss.

Planning Methodology

Development of the regional aquifer management plan will be conducted by staff of the Passaic River Coalition, working with the Passaic Valley Ground Water Protection Committee and other advisors such as municipal and county officials, scientists and water resource managers. The methodology consists of seven steps:

1) Define the management needs of the regional aquifer system. The PRC will use its two studies and advice from the Committee, area municipalities and technical experts to list the ground water management requirements that must be met by the plan. The needs identified will serve as a foundation for all additional work and a guide against which the plan may be measured.

2) Examine management methods used in other regions and aquifers. Therefore, contacts will be made with state and regional ground water managers to identify useful management ideas. A literature review will be prepared. Municipalities in the buried valleys region will react better to new management concepts if other regions have tested them successfully.

3) Develop additional management ideas. New ideas will result from the identification of research needs, as extensions of techniques used elsewhere, and as spinoffs from the management of other critical resources. Each viable idea will be developed so that a comparison of management tools is possible.

4) Identify research needs in detail. Over the long term, successful management of the regional aquifer will depend on new

research. The PRC will detail the research needs for the region and identify priority projects for immediate implementation.

5) Critique the utility of each management technique. The goal of the project is a comprehensive management plan. A prerequisite step involves weeding out those techniques which are not applicable to the region. The process for selecting functional techniques will involve the Committee and other advisors. The final stage of the process will involve decisions as to which management concepts hold the greatest promise for the region.

6) Using the best techniques, devise a management plan. The goal of any regional plan is successful management of the resource at minimum social and financial cost. The plan will maximize use of existing laws, authorities, programs and funds. It will embody a regional perspective to management that simultaneously shows the local benefits of cooperation and implementation. However, actions at other levels will be recommended where local initiatives are unlikely to achieve the necessary level of protection.

Regulations, through local ordinances, will be a necessary component of the regional plan. However, the plan will attempt to make maximum use of non-regulatory methods. The first priority of the plan will be protection of major wells and well fields from contamination. The second priority will be ensuring a continued balance between demand and dependable yield. The third priority will be prevention of ground water contamination throughout the region. The plan will conclude with a detailed list of recommended governmental actions to implement the goals of the management program.

7) Document the process and results so that affected parties may fully understand the steps and implications of the report, and that managers and planners in other regions may adapt the process to circumstances specific to their region.

CHAPTER IX

RESEARCH NEEDS FOR GROUND WATER MANAGEMENT IN THE BURIED VALLEY AQUIFER SYSTEMS

The nations of the European Economic Community have implemented an extensive system of hydrogeologic research, mapping and management based on a common policy that points out the necessity of abundant, clean supplies of ground water as a foundation for economic health (Filippone, 1986). Most states of this nation have not placed a similar priority on ground water management, though many rely very heavily on aquifers for potable water, irrigation, and industrial uses. New Jersey has performed some aquifer research in past decades, but only in the past few years have the larger resources required for detailed research been available. The first large research project by the State in decades (within the Buried Valley Aquifer Systems) will begin in late 1986 or early 1987, with an expected expenditure of $1 million. This research begins twenty years after the drought-emergency studies performed in 1966 and 1967.

If ground water is to continue playing a dominant role in water supply for the Buried Valley Aquifer Systems region - and it must, considering that most surface water supplies are allocated to the cities of northern New Jersey - then ground water contamination must be curtailed and ground water diversions must be balanced with aquifer recharge.

This report has pointed out many questions that remain without answers - questions of aquifer delineations, characteristics, yields, flow and contamination. This chapter brings those research questions together with ideas for research gleaned from conversations with consultants, water engineers and supervisors, and administrators of public water supply systems within the Buried Valley Aquifer Systems region. The PRC recommends that efforts be made to find the answers to these research questions so that a sound understanding of the aquifers may lead to firm and balanced management decisions by municipal, county, State and federal governments, citizens and business interests.

Buried Valley Aquifer Delineations

Despite the considerable expenditure of funds for buried valley aquifer delineations, there are many open questions. The following aquifer delineation issues are the most important facing the region. Some of these questions are being analyzed by the NJGS and USGS in their upcoming research projects (see Chapter VIII).

1) East Hanover Buried Valley--The connection of the northern and southern portions of the East Hanover Buried Valley near Route 10 should be fully delineated and a hydraulic analysis made to determine exactly what connection exists between the two aquifer segments.

2) Lee Meadows--The large diversions by the Southeast Morris Water Authority and the increasing diversions by Parsippany-Troy Hills lead to questions about the full extent of stratified deposits under Lee Meadows and the surrounding area. Connections with other buried valleys, if any, should be identified.

3) Chatham Buried Valley--The western extent of the Chatham Buried Valley into Morris Township remains undefined. Research should explore this question. On the eastern edge of the Chatham Buried Valley, the possible penetration of stratified deposits through Hobart Gap (which would create a hydraulic link with buried valley aquifers in the Rahway River Basin) should be fully explored. Markewicz has noted evidence from the Echo Lake Country Club well indicating that the Chatham Buried Valley may be hydrologically continuous with the Springfield buried valley aquifer on the east side of Hobart Gap.

4) Northern Millburn Buried Valley--This buried valley is poorly defined in Livingston, Roseland and East Hanover. Among other questions is whether the northern extremities of the buried valley connect with the northern reaches of the East Hanover Buried Valley.

5) Great Piece Buried Valley--Despite a cross-section from Hook Mountain to Hanover Neck showing deep stratified deposits and the knowledge of the buried valley in eastern Fairfield, the Great Piece Buried Valley remains poorly understood. Part of the difficulty lies in difficult access through Great Piece Meadows. An effort should be made to fully define the buried valley.

6) North Branch Foulerton Buried Valley--Deep stratified deposits

in Essex Fells lead to an assumption that a buried valley exists, but no verification has been made. Research should be performed in Essex Fells, West Caldwell and western Fairfield to delineate the stratified deposits and verify the buried valley, including any connections with the Great Piece Buried Valley.

7) Southern Montville Area--Several buried valleys seemed to aim for the southern Montville area, just south of Hook Mountain. The Northern Millburn and East Hanover Buried Valleys trend north toward the area, while the Troy Brook Buried Valley and the spur valley along the lower Rockaway River trend southeast toward the same point. The Great Piece Buried Valley trends southwest toward southern Montville as well. Evidence from the Sharkey Landfill Superfund investigation shows the existence of a confined sand aquifer with minimal gradients, possibly indicating a ground water divide, and hinted at a channel trending southwest to northeast in the bedrock. Considerable research will be necessary in the area of Troy Meadows, Hatfield Swamp and southern Montville to fully delineate the buried valleys and their connections. Montville suggests that research define the aquifer in southern Montville and the impacts of the Sharkey's Landfill and Bloomfield Avenue contamination sites on the potential for major wells in the area (there currently are no public wells in southern Montville).

8) Towaco Buried Valley--The NJGS should determine the eastern extent of the Towaco Buried Valley into Lincoln Park, verify the existence of a confined, stratified aquifer below the Pompton River between Hook Mountain and the Mountain View section of Wayne, and determine the connection, if any, of the Towaco Buried Valley with the Great Piece Buried Valley. Montville Township is particularly interested in research on this topic.

9) Lake Intervale--Information from contamination incidents in the Lake Intervale area indicate deep stratified deposits with ground water flowing generally south, toward the Troy Brook Buried Valley. Given the contamination, research to determine the nature of sediments and flow between Lake Intervale and the Troy Brook Buried Valley is in order.

10) Upper Lamington and Rockaway Buried Valleys--The unusual connection between the Upper Lamington Buried Valley and the Rockaway Buried Valley should be further explored. Frank Markewicz notes that the Lamington River now drains to the southwest. The bedrock, however, rises to the surface toward the southwest where it forms a narrow gap near Milltown, just west of Chester. Paleozoic bedrock slopes or becomes deeper to the northeast and was instrumental in forming the bed

of the Ancestral Rockaway. Though the NJGS 1983 report began the research, the geology and delineation of the buried valley aquifer systems should continue so that ground water flows and budgets may be possible for the area.

11) Buried Valleys and the Terminal Moraine--The variability of relations between the buried valleys (particularly the Rockaway and the Chatham) and the terminal moraine should be further explored. The USGS has conducted some research along the interface between the Chatham Buried Valley and the terminal moraine, while the NJGS has similarly performed some mapping work in the Rockaway Buried Valley. Additional study is needed.

12) Stratigraphic Analyses--It is not enough to delineate the buried valleys. The aquifers of the buried valleys are more important to public policy and management. Only through a detailed analysis of the stratigraphy of the buried valleys will the flow, yields and connections of buried valleys be fully understood. NJGS has begun mapping work of this nature in the central Rockaway Buried Valley. More research of the same type should commence elsewhere.

Bedrock Aquifer Research

Four major questions exist with regard to bedrock in the Buried Valley Aquifer Systems. They deal with the dolomitic limestone formations of western Morris County, the relationship between buried valley aquifers and the surrounding bedrock, the Triassic Shale aquifer of the Morristown area and the flow of ground water along the Watchung slope. The upcoming NJGS and USGS research on the Upper Lamington, Rockaway and Central Passaic River watershed areas will result in answers to several key concerns raised here.

1) Dolomite Aquifers--Markewicz suggests that a great deal of further work is needed on the underlying deep dolomite formation. The depth, thickness, faulting, strike trend and subsurface extent should be determined. Also needed is an hydraulic flow analysis within the dolomite formation to determine flow gradients and ground water divides. Markewicz believes the center of the flow divide and formation may be near the Rockaway River and then into the Rockaway Buried Valley to the east. The dolomite may connect from the Lamington valley into the Flanders valley, and from there into Hunterdon County.

2) Bedrock and the Buried Valleys--Markewicz and others have recommended that the rock bordering the buried valley aquifers should be definitively mapped, as outlined in the NJGS report of 1983. The hydraulic connection of the bedrock to the stratified deposits should then be determined and used in computer models. The proposed research in the Central Passaic River Basin and the Upper Lamington River watershed, by the NJGS and USGS, should provide many answers. To the extent that recently completed USGS research does not answer the same questions for the Rockaway Buried Valley, additional research planned by the USGS should be valuable.

3) Morristown Triassic Shale--As noted in Chapter IV, the Triassic Shale aquifers near Morristown are considered to be stressed by continuing diversions. Almost no research on the shale aquifer has been conducted, however. An analysis of the aquifer should be undertaken.

4) Watchung Slope--Much of the ground water in aquifers of western Essex County travels along the western slope of the Second Watchung Ridge. Research to determine the nature of the bedrock aquifer in this region would assist in the estimation of yields, flow patterns, etc.

Aquifer Flow Nets

Relatively little is known about the regional and local flow patterns of ground water in the Buried Valley Aquifer Systems. Research by the USGS near Dover should add some light to flow patterns in that area, but most of the flow information in the remainder of the region is derived from contamination site analyses and localized research. Therefore, one valuable research effort would be to define the regional pattern of ground water flow in the Buried Valley Aquifer Systems. This information will supplement the delineation efforts suggested above to produce a comprehensive understanding of how the buried valleys are connected both physically and hydraulically. Part of this research effort should include the determination of flow patterns between bedrock and stratified deposit aquifers, and between the stratified deposit aquifers and overlying surface waters. The USGS research to develop a aquifer flow model for the Rockaway Buried Valley will answer many critical questions.

The delineation of ground water divides would aid efforts to estimate dependable yields for subregions of the aquifer systems and to define potentially responsible parties for ground water contamination cases. In addition, ground water flow patterns and divides will be necessary

data for the development of land use ordinances to protect ground water. The intensive use of the Buried Valley Aquifer Systems results in an artificial alteration of the aquifer flow patterns. The nature, extent and severity of cones of influence from major pumping centers should be examined. Finally, an analysis of flow nets in the Great Piece Buried Valley would be desirable to determine the impact of the Fairfield regional contamination incident on the availability of uncontaminated ground water.

Dependable Yields

The determination of dependable yields is of utmost importance to the management of the Buried Valley Aquifer Systems. Not only will such information help stabilize diversions prior to excessive allocation of the aquifers, but it provides a rationale for aquifer management, including land use management. Several levels of research are needed.

1) Regional models--Computer models which simulate the aquifer systems should be developed for the major areas of the region. The NJGS and USGS have already indicated their intention of pursuing this line of research in the Central Passaic River Basin, the Rockaway River watershed and the Upper Lamington River watershed. Results of the models, however, will not be finallized until 1990 to 1992. Every effort should be made to decrease the lag time before results are available.

2) Localized models--Based on current knowledge of stressed or potentially stressed areas of the aquifer systems, computer models of local aquifers should be developed rapidly for decision-making with regard to ground water allocations, water conservation efforts and land use management. Areas of concern include: (1) the Chatham, Millburn, Slough Brook and Canoe Brook Buried Valleys; (2) Lee Meadows, which has increased diversions and also faces increased development; (3) Troy Brook Buried Valley; (4) central Rockaway Buried Valley; (5) Morristown Triassic Shale aquifer.

3) Regional observation well network--Funds should be made available and local cooperation sought to implement a fully regional network of observation wells with continuous water level monitoring. The observation well network will provide invaluable data for confirming or altering computer aquifer models and providing continuous assessments of drought effects on the aquifer systems. The NJGS and USGS plan to use some wells from their research for this purpose, and will tie in new

wells to the drought network. However, past lapses in funding could happen again. Sufficient funding should be provided permanently.

4) Diversion of ground water to surface water--Most of the new development in the region will derive its potable water from aquifers and will treat effluent in wastewater treatment plants which discharge to surface waters, usually far downstream of the aquifer. The net effect of such water transfers on the dependable yields of aquifers should be determined. Rockaway Township, for instance, has expressed an interest in the effects from new ground withdrawals to supply development which discharges to the RVRSA treatment facility.

Recharge Area Identification

The identification of recharge areas is a continuing priority of the Passaic Valley Ground Water Protection Committee. Many municipal officials recommended research on this topic. Unfortunately, no funds had been allocated by the NJDEP or the Legislature for this purpose, although 1986 legislation by Assemblywoman Maureen Ogden (Essex) would provide $1 million and may receive legislative approval. The NJDEP plans to use this funding for the development of a methodology for recharge area identification which could be applied by any interest.

The development of a methodology is clearly the proper first step. The methodology should be applied according to a priority system. The highest priority should go to undeveloped lands in the vicinity of aquifers which are at or near their dependable yield. Other undeveloped lands should be analyzed next, followed by industrial zones that present potential or confirmed threats to important aquifers. The estimation of recharge from bedrock aquifers and from uplands is important, as the narrow widths of the buried valleys mean that much of the recharge must come to the aquifers indirectly. An analysis of induced recharge effects should be performed wherever public wells are near major streams. Finally, the relative importance of recharge areas should be determined, both on the basis of recharge volume per square mile and the percentage of total recharge. This information will be critical in the development of land management policies to protect sufficient recharge so that dependable yields do not fall below diversions due to the development of recharge areas.

Aquifer Contamination

Research into confirmed and suspected contamination should be a continued high priority. Both the NJDEP and the USEPA have high profile programs to identify responsible parties, assess the contamination, and develop site management plans. Every effort should be taken to continue this work and speed results, especially in the seven largest contamination cases identified in Chapter VII. A system should be implemented by the NJDEP to compile hydrogeologic results from site investigations into a regional data base, so that a more complete picture of the Buried Valley Aquifer Systems will result as a positive outcome from the unfortunate contamination of the aquifers.

In addition, a proactive response to the contamination incidents of the region should be undertaken by municipalities and the NJDEP. A scan of wells near public supply wells, along with industrial surveys and any necessary geophysical analyses, should occur as soon as possible. Such research may detect contamination plumes prior to the contamination of the public supply well. Research to determine the mechanics of contaminant flow in aquifers and apply the results within the region are also warranted.

Summary

The research suggestions provided in this chapter will cost money. The future viability of the Buried Valley Aquifer Systems relies on the expenditure of millions of dollars by all levels of government and private interests. The timeline for the research, if it is to be effective in anticipating management needs, must be short - mostly on the order of five years or less, depending upon the research topic. Longer timelines are possible in less developed and intensively pumped parts of the aquifer systems, but few subregions of the Buried Valley Aquifer Systems lack either current management problems or future development expectations that will stress the capacity of aquifers to supply ample quantities of clean ground water. The combined stresses of pumping, recharge area development and contamination face every corner of the region. Research that supplies information which can be applied through intelligent management is critical.

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APPENDIX A

EXHIBIT 1

GOALS AND STRATEGIES

Passaic River Coalition, 246 Madisonville Rd., Basking Ridge, NJ 07920
(201) 766-7550 WINTER, 1979

PRC, East Orange Petition for Aquifer Protection

East Orange Mayor Thomas H. Cooke, Jr. and Ella F. Filippone, PRC Executive Administrator sign "Sole Source" petition in East Orange City Hall.

BEFORE THE UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY

Douglas M. Costle, Administrator

IN THE MATTER of the Petition of the CITY OF EAST ORANGE, NEW JERSEY and THE PASSAIC RIVER COALITION Under Section 1424 (e) of the Safe Drinking Water Act of 1974 With Respect to the Buried Valley Aquifer System of Western Essex and Eastern Morris Counties, New Jersey.

PETITION

1. The City of East Orange New Jersey was incorporated in 1909 and is in Essex County (Northern) New Jersey. The city has a population of 88,000 and is totally dependent on the Buried Valley Aquifer System, that is the subject of this petition, as a sole source of drinking water for its residents.

(continued page 2)

The Passaic River Coalition and the City of East Orange have jointly sponsored a petition requesting the U.S. Environmental Protection Agency (EPA) to designate the Buried Valley Aquifer System of the Central Passaic River Basin as a "sole source" aquifer. East Orange Mayor, Thomas H. Cooke, Jr., (PAC Chairman) and Passaic River Coalition Executive Administrator, Ella F. Filippone, (PAC Vice-Chairman) signed the petition January 16, 1979 at East Orange City Hall. The petition was filed in compliance with Section 1424 (e) of the Safe Drinking Water Act of 1974.

An aquifer is a geological formation which stores and yields water in economically usable quantities. The Buried Valley Aquifer is an approximately eighty square mile area located in eastern Morris and western Essex Counties. It is the sole source of potable water for an estimated 587,000 people in northern New Jersey, and produces approximately twenty-four million gallons of water daily with an estimated potential of producing forty million gallons daily.

The aquifer is the result of the Wisconsin Glacier, which moved into the area approximately ten to fifteen thousand years ago. The glacier deposited sand and gravels in the existing valleys as it advanced south. When the glacier melted, Glacial Lake Passaic was formed and the fine sediments in the water settled to form an impermeable clay layer that has protected the aquifer from pollution

The aquifer system consists of Pleistocene glacial deposits and the surrounding shales and sandstones of the Triassic-Jurassic Brunswick Formation.

In order to qualify for "sole source" designation, the aquifer must be the sole or principal drinking water source for an area, supplying at least fifty-one percent of the area's residents. The Buried Valley Aquifer supplies nearly ninety percent of the water to the residents of thirty-one municipalities.

(continued from page 1)

PRC, EAST ORANGE PETITION FOR AQUIFER PROTECTION

Designation of the aquifer would officially recognize that this drinking water is the only source for over 580,000+ people in northeastern New Jersey. In addition any Federally-funded project in the area would receive careful scrutiny when reviewed by the EPA to determine the environmental impact on the Buried Valley Aquifer. Safeguards to protect the aquifer would have to be included in any construction design. Federal projects which did not meet the environmental standards would not qualify for funding. The designation will not effect private development.

The EPA will hold a public hearing at the Environmental Education Center in Roseland on the petition in May at which time elected officials, municipalities, organizations and private citizens will have the opportunity to express their views on the project. Support is being sought for the petition from all segments of society: elected officials, municipalities, private corporations, civic organizations, and private citizens.

The petition was initially conceived through the efforts of the Northeast Policy Advisory Committee (PAC) for Water Quality Management (208), initiated by Herb Cannon, Chatham Borough Engineer, and Alice Hoffman, and others of the Chatham Borough Environmental Commission.

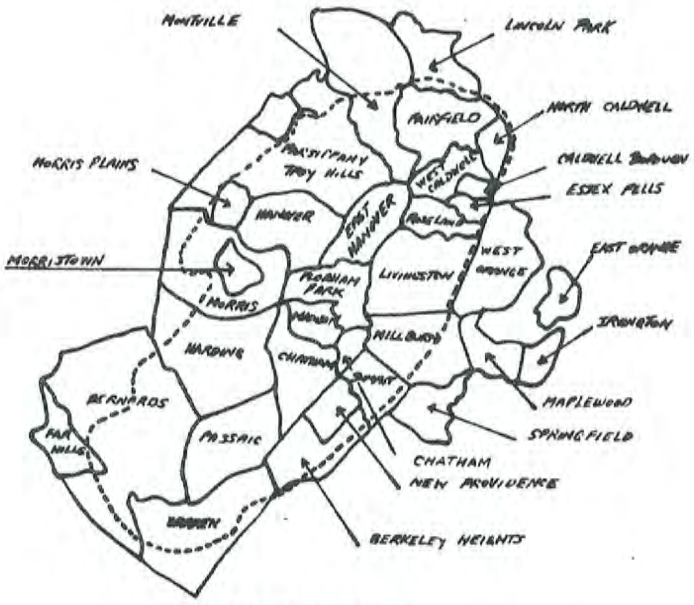
"The aquifer yields clean, unpolluted water at this time but how long it will last without protection is a gamble that is too big to take," Mayor Cooke said.

Mrs. Filippone said, "Now is the time to protect this valuable natural resource. We are lucky it is still clean and as yet unpolluted since there has been considerable development in that area.

"I can forsee no great problems getting the petition through the EPA process in a few months and have the designation granted. There are no underlying motives to this project. Our concern, as always, is to protect and preserve the waters of the Passaic River Basin.

"In the event that the aquifer were to become polluted, an alternative water supply would be both physically and economically impractical. Water would have to be diverted from the Hudson River or piped in from the Great Lakes."

The full text of the petition is printed in the newsletter so that the public will have a better idea as to the specific issues which it addresses. Figures 1-4 have been omitted for publication and are available on request from the PRC office. Figure A did not appear in the original petition but is included here to give you a better idea as to the aquifer's location.



SERVICE AREA MAP

Area Proposed for Designation .....

(continued from page 1) PETITION

City Hall is located at 44 City Hall Plaza, East Orange, New Jersey - 07017, (201-675-8049).

The Passaic River Coalition is a non-profit, urban watershed association concerned with water quality, water supply, land-use and the overall quality of the environment in the Passaic River Basin in northern New Jersey. Its headquarters is located at 246 Madisonville Road, Basking Ridge, New Jersey - 07920 (201-766-7550).

2. A petition to the Administrator of the United States Environmental Protection Agency, requesting that the Pleistocene Buried Valley and Associated Bedrock Aquifer Systems in the Central Basin of the Passaic River Watershed, New Jersey, be designated as a sole source aquifer as provided under Section 1424 (e) of the Safe Drinking Water Act. (P.L. 93-523), which provides as follows:

> (e) If the Administrator determines, on his own initiative or upon petition, that an area has an aquifer which is the sole or principal drinking water source for the area and which, if contaminated, would create a significant hazard to public health, he shall publish notice of that determination in the Federal Register. After the publication of any such notice, no commitment for federal financial assistance (through a grant, contract, loan guarantee, or otherwise) may be entered into for any project which the Administrator determines may contaminate such aquifer through a recharge zone so as to create a significant hazard to public health, but a commitment for Federal fi-

(continued page 3)

(Continued from page 2)

> nancial assistance may, if authorized under another provision of law, be entered into a plan or design the project to assure that it will not so contaminate the aquifer.

3. President Jimmy Carter's Urban Policy consists of an integrated set of commitments to urban America including Policy Statement number nine:

> "Improve the urban physical environment and the cultural and aesthetic aspects of urban life."

Protection of the Buried Valley Aquifer System under Section 1424 (e) of the Safe Drinking Water Act would help protect the environment of the urban centers in northern New Jersey that are dependent on this aquifer as a source of drinking water, thereby fulfilling some of the objectives of the President's Urban Policy.

4. The area proposed for Sole Source Aquifer designation is a portion of the Central Basin of the Passaic River Watershed in southeast Morris, eastern Essex, and portions of Union and Somerset Counties, New Jersey. Geologically, the area lies within the Piedmont Physiographic Province and is underlain by Triassic-Jurassic (about 190 million years old) shales and sandstones of the Brunswick Formation, along with interspaced basaltic lava flows (the Watchung Mountains). The Brunswick Formation is overlain by a thick covering of Pleistocene (14,000 to 80,000 years ago) glacial deposits, consisting of unconsolidated sands, gravels, silts and clays. The proposed designation would apply to buried valley and channel deposits of glacial origin and the associated bedrock (Brunswick Formation and Watchung Basalt).

5. The area being proposed is generally the Central Basin of the Passaic River Watershed as defined by the U.S. Army Corps of Engineers with some modifications. The area is bordered on the north by Hook Mountain (a basaltic lava flow) and by a line which roughly bisects the town of Montville. The western boundary is defined by the trace of the Ramapo Fault and the beginning of the Highlands Physiographic Province. The boundary to the south and the east is formed by the Second Watchung Mountain range, including portions of Union, Essex and Somerset Counties, New Jersey.

6. The public water supply systems, as well as a large private water company and many industrial and private well owners depend on this aquifer system as a source of drinking water. Groundwater withdrawn from within the boundary of the designated area is also exported to municipalities outside of that proposed designation area. The two purveyors exporting groundwater outside of the proposed aquifer boundary are the City of East Orange and the Commonwealth Water Company. The total population of the proposed designation area and the service area is approximately 587,188 residents. A total of 31 municipalities are included in the service and designation areas, and of this number nearly 90 percent of the municipalities are dependent on the aquifer as a source of drinking water. Table 2 gives a breakdown of drinking water sources by municipality along with population figures.

7. A listing of public water supply systems utilizing the aquifer appears on Table 2.

8. Figure A shows an outline of the Buried Valley Aquifer System.

9. Continued development in the area makes protection of recharge areas imperative. Development in northern New Jersey has already degraded surface water quality, placing greater reliance and demands on groundwater. The Borough of Chatham, which is totally dependent on the aquifer for drinking water, notes in its Natural Resource Inventory:

> The static water level in our No. 1 well has dropped 31 feet from 1931 to 1969. This is of course due to increased local usage, but it is also indicative of increased urbanization in the surrounding region. With this have come increased demands on the aquifer and, at the same time, a reduced recharge capability due to the construction of homes, buildings, and paved areas in the region. This is supported by the experience of the well fields in Millburn Township and southwestern Livingston where two water companies - Commonwealth, and the City of East Orange - operate pumping stations. Their wells have experienced a drop in the static water level of 54 feet from 1925 through 1965.

10. The U.S. Army Corps of Engineers is currently undertaking a Phase I advanced engineering and design study of the Passaic River Basin to develop a basin-wide plan for meeting the flood control and other associated

(continued page 4)

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water resource and related land resources needs of the basin. The Buried Valley Aquifer is located within their study area. The Army Corps of Engineers, in its Preliminary Draft Plan of Study (August 1978) of the Passaic River Basin, stated that:

> The major surface water supply developments are located primarily in the upstream tributaries and serve the urban concentrations in the Lower Valley. As a result, groundwater is the major water supply source in the Central Basin and Highland Area. Groundwater provides 75% of the water used above Little Falls and represents 16% of that area's total developed water supply including that exported below Little Falls.

11. The Policy Advisory Committee of the Northeast Water Quality Planning Program (established under Section 208 of Public Law 92-500) recognized the necessity of protecting sole source aquifers and their recharge areas and recommends the following policy:

> The required information for 'sole source determination' of the Buried Valley Aquifer in East Morris and West Essex Counties, New Jersey, should be developed and submitted to the U.S. EPA for Sole Source Designation pursuant to the Safe Drinking Water Act (42 U.S.C. 300F. 300h - 3(e); 88 Sat. 1660 et seq. Public Law 93-523)

12. The City of East Orange, New Jersey (population: 88,000) depends entirely on groundwater from wells overlying the Buried Valley Aquifer System. A 1976 study by Geraghty and Miller, consulting groundwater geologists, Port Washington, New York, of the groundwater conditions at the East Orange Water Reserve determined that increased pumpage and loss of recharge areas to urbanization in the region has had a significant effect on the groundwater resources of the water reserve. The Geraghty and Miller study made the following observation:

> The quality of groundwater within the reserve is more than adequate to meet the needs of a potable water supply but has been degraded over the past twenty years by the effect of changing land-use patterns in the areas surrounding the reserve and from the incursion of highways and sewer lines within the Reserve.

13. A 1978 study by Geraghty and Miller, Inc. identified a section of the Buried Valley Aquifer near Pine Brook, New Jersey which could provide an additional .5 to 1.0 mgd of groundwater. Until further studies are completed, Geraghty and Miller suggested that the designated area should temporarily be set aside and any land development there should be halted until each site can be thoroughly tested as to its potential for groundwater development.

14. The Morris County Master Plan Water Supply Element (1971) recognized the importance of groundwater in the County:

> Despite the extensive development of surface supplies within the County, the major source of supply for consumption within the county is from well water supplies. Over the past three years, surface supplies in the County have accounted for only 10% of the consumption from public water supplies within the county.

15. The Township of Livingston, New Jersey (population 32,500) is totally dependent on groundwater from the Buried Valley Aquifer System. The 1976 Geraghty and Miller study for the East Orange Water Reserve made the following reference to Livingston:

> In Livingston, most of the areas overlying promising sites for groundwater development have been urbanized. In addition, recharge has been reduced due to the covering of prime aquifer recharge areas with impervious surfaces, resulting in a reduction of overall

(continued page 5)

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> groundwater availability. A third problem is the preponderance of potential sources of groundwater pollution. For example, several wells have shown that groundwater quality has been impaired as a result of leakage from nearby gasoline and/or oil storage tanks.

16. Thompson (1932) showed the importance of the groundwater resource in supplying drinking water to the area, in the publication, *Ground Water Supplies of the Passaic River Valley Near Chatham, N.J.*:

> The principal supply of ground water is obtained from beds of sand and gravel, of Pleistocene age, which lie at a depth of approximately 100 to 135 feet and which are confined to pre-glacial channels cut in the bedrock. Elsewhere in the region the bedrock, which consists of red sandstone and shale and trap rock of Triassic age, is struck at depths as shallow as 60 to 75 feet, and the overlying material consists largely of clay which yields little or no water. In the well fields that have been studied the water-bearing formation is overlain by relatively impervious clay and there is little if any recharge directly from rain in the immediate vicinity. An unresolved problem is as to whether there is sufficient recharge to meet the present and future draft.

17. In the *Computer Simulation Model of the Pleistocene Valley-Fill Aquifer in Southwestern Essex and Southeastern Morris Counties, New Jersey* by Harold Meisler, U.S. Geological Survey, Water - Resources Investigations 76-25, the importance ot the Buried Valley Aquifer as a water supply source is noted in the following introductory statement:

> Sand and gravel deposits of Pleistocene age have been an important source of water for communities and industries in southwestern Essex and southeastern Morris Counties for several decades. Withdrawal from these deposits had increased from an estimated 5 Mgal/d during the period 1900-29 to approximately 28.5 Mgal/d during the period 1972-1973. Yet virtually all this water was withdrawn from a buried valley-fill aquifer occupying an area of approximately 20 mi^2.

18. Current land-use and water quality laws do not adequately protect the Buried Valley Aquifer System or its recharge areas.

19. The highly developed and industrialized environment of northern New Jersey provides for many sources of groundwater contamination including septic systems, accidental spills, landfill leachates, waste lagoons, etc.

20. We, therefore, conclude: The Buried Valley Aquifer System is a sole source of drinking water for municipalities and private well owners in the region, and contamination of this aquifer would create significant hazard to public health.

Therefore, we respectfully request that the Administrator of the U.S. Environmental Protection Agency determine that the Buried Valley Aquifer System in Eastern Morris and Western Essex Counties, New Jersey, be designated as the sole or principal drinking water source for the area and that this determination be printed in the Federal Register, as required by Section 1424 (e) of the Safe Drinking Water Act of 1974.

Respectfully submitted,

Thomas H. Cooke, Mayor
City of East Orange

Ella F. Filippone, Executive Administrator
Passaic River Coalition

(continued page 6)

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The following studies describe the Buried Valley Aquifer System and its importance as a source of water supply to the area.

Borough of Chatham Environmental Commission, 1976, *Natural Resources - A Study and Inventory for the Borough of Chatham*.

Geraghty & Miller, Inc., 1976, *Ground-Water Conditions, City of East Orange Water Reserve*, Port Washington, New York.

Geraghty & Miller, Inc., 1978, *An Evaluation of Ground-Water Resources of the Rockaway River Valley Within the Communities of Denville, Boonton Township, Town of Boonton, Montville and Mountain Lakes, New Jersey*, Port Washington, New York.

Gill, H.E., and Vecchioli, J., 1965, *Availability of Groundwater in Morris County, New Jersey*, New Jersey Dept. of Conservation and Economic Development, Special Report #25.

Meisler, Harold, 1976, *Computer Simulation Model of the Pleistocene Valley-Fill Aquifer in Southwestern Essex and Southeastern Morris Counties, New Jersey*, USGS Water Resources Investigation 76-25.

Morris County Planning Dept., 1971, *Morris County Master Plan - Water Supply Element*, (prepared by Elson T. Killam Associates, Inc.).

Nichols, William D., 1968, *Groundwater Resources of Essex County, New Jersey*, New Jersey Dept. of Conservation and Economic Development, Special Report # 28.

Nichols, William D., 1968, *Bedrock Topography of Eastern Morris and Western Essex Counties, New Jersey*, USGS Misc. Geol. Inv. Map I-594.

Thompson, David G., 1932, *Groundwater Supplies of the Passaic River Valley Near Chatham, New Jersey*, New Jersey Dept. of Conservation and Economic Development.

Vecchioli, John and Nichols, W.D., 1966, *Results of the Drought Disaster Test-Drilling Program Near Morristown, New Jersey*, New Jersey Dept. of Conservation and Economic Development, Water Resources Circular # 16.

Vecchioli, John, Nichols, W.D., and Nemickas, B., 1967, *Results of the Second Phase of the Drought Disaster Test Drilling Program Near Morristown, New Jersey*, New Jersey Dept. of Conservation and Economic Development, Water Resources Circular # 17.

TABLE 1

POPULATION FIGURES

MUNICIPALITY	POPULATION	COUNTY	% GROUNDWATER	% SURFACE WATER	COMMONWEALTH WATER CO.
Chatham	9,566	Morris	100		
Chatham Township	8,500	Morris			X
East Hanover	7,734	Morris	100		
Florham Park	8,000	Morris	100		
Hanover	10,700	Morris	100		
Harding Township	3,249	Morris	100		
Madison	16,710	Morris	100		
Montville	11,846	Morris	100		
Morris Plains	5,540	Morris	100		
Morristown	17,780	Morris	50		
Morris Township	20,000	Morris	65		
Parsippany-Troy Hills	57,910	Morris	100		
Passaic Township	8,000	Morris			X
Caldwell	8,719	Essex	100		
East Orange	88,000	Essex	100		
Essex Fells	2,541	Essex	100		
Fairfield	7,230	Essex	100		
Irvington	59,742	Essex			X
Livingston Township	32,500	Essex	100		
Maplewood	24,485	Essex			X
Millburn	21,000	Essex			X
North Caldwell	6,790	Essex	100		
Roseland	4,605	Essex	100		
West Caldwell	11,887	Essex		100	
West Orange	43,715	Essex			X
Berkeley Heights	13,023	Union			X
New Providence	13,796	Union			X
Springfield	16,000	Union			X
Summit	23,620	Union			X
Bernards Township	14,000	Somerset	wells and Commonwealth Water Co.		
Warren Township	10,000	Somerset	wells and Elizabeth Water Co.		

TABLE 2

PUBLIC WATER SUPPLY SYSTEMS UTILIZING THE AQUIFER

		Population Served	Treatment
1.	Livingston Township Water Department	32,500	Chlorination
2.	Southeast Morris County Municipal Utilities Authority	57,013	Chlorination (Manganese Removal at Black Brook Well Field)
3.	East Orange Water Department	88,000	Chlorination
4.	Florham Park Water Department	8,000	Chlorination (excessive Manganese in one well)
5.	Madison Water Department	16,710	Chlorination
6.	Chatham Borough Water Department	9,566	Chlorination
7.	Commonwealth Water Company	223,881	Chlorination
8.	East Hanover Water Department	7,734	Chlorination and Manganese Removal
9.	Parsippany-Troy Hills Water Department	57,910	Chlorination
10.	Montville Water Department	11,846	Chlorination
11.	Essex Fells Water Department	22,655	Chlorination
12.	Fairfield Water Department	7,230	Chlorination

EXHIBIT 2

PRC

GOALS AND STRATEGIES

Passaic River Coalition, 246 Madisonville Rd., Basking Ridge, N.J. 07920 —— (201) 766-7550
SPRING, 1979

EPA Hearing Held: on Aquifer Designation

A hearing was held by the U. S. Environmental Protection Agency (EPA) on May 23, 1979 at the Center for Environmental Studies, Eagle Rock Avenue, Roseland, New Jersey to solicit comments from the public on the proposed "sole source" designation of the Buried Valley Aquifer of the Central Passaic River Basin.

The hearing was held in response to a petition submitted by the City of East Orange, New Jersey and the Passaic River Coalition, which seeks to protect the aquifer systems in the Central Valley of the Passaic River Basin. This vast aquifer supplies over 587,000 people, in an approximately 85 square mile area, with their daily water supply.

John Malleck of the water supply branch of EPA was the presiding officer at the hearing. He was assisted by hydrologist, Grant Kimmel; water supply planner John Mateo; water supply branch chief, Harry Smith; and water supply planner, Sheryl Foster. All are with the Region II office of EPA.

Malleck explained sole source designation saying, "The purpose of this sole source program is to prevent grants of federal financial assistance to projects which may contaminate the sole source aquifer, so as to create a significant hazard to public health.

"I think that it is fair to say that the real objective of the program at hand is to ensure that groundwater considerations are built into the design, construction and operation of projects, which are cited for the sole source area.

"If designation is given, it would mean that federally-funded projects would have to be reviewed by EPA to determine what the environmental

(continued on next page)

John Wilford, N. J. DEP Assistant Director of the Division of Water Resources

Cameron Boehme, Representative of the N. J. League of Women Voters

East Hanover Committeeman Vincent Leo

(continued from Page 1)

impact would be on the aquifer. Projects by private developers are not covered by the petition."

East Orange Mayor Thomas H. Cooke, Jr. (N.E. N. J. PAC Chairman), the first of several speakers of the evening, briefly explained how the petition was initiated through the efforts of the Northeast 208 Water Quality Policy Advisory Committee (PAC). The PAC is an advisory group of municipal officials, environmentalists, and private citizens who advise the State Department of Environmental Protection (DEP) on water quality in the northeastern section of the state.

Herb Cannon, Chatham Borough engineer, first suggested that the PAC should initiate an evaluation of ways to protect the groundwater supplies of the Buried Valley Aquifer.

Mayor Cooke and Ella F. Filippone, PRC Executive Administrator (PAC Vice Chairman), then jointly submitted the petition through their respective organizations.

Mayor Cooke then elaborated on the importance of receiving sole source designation. In addition, he read into the record the list of elected officials, municipal governments, corporations, and civic organizations which have sent support letters to EPA Administrator Douglas Costle and Eckardt C. Beck, EPA Administrator for Region II.

Mrs. Filippone told the audience that the State Assembly had passed a resolution in support of the aquifer petition. The resolution was passed April 26, 1979 after being introduced February 13, 1979, by Morris County Assemblyman Dean Gallo. State Senator James Wallwork (Essex County) has introduced a companion resolution in the State Senate in support of the petition also.

A citizen petition, containing 540 signatures, which was circulated by the PRC was submitted, evidence that people in northern New Jersey are concerned about protecting their water supply, Mrs. Filippone said.

John Wilford, N. J. DEP Assistant Director of the Division of Water Resources, presented a statement on behalf of the State of New Jersey saying that the State of New Jersey "strongly supports" the petition to designate the Buried Valley Aquifer a "sole source" aquifer.

He said, "Those communities in the region, which depend on the Buried Valley Aquifer for their water supply, currently have little, if any, flexibility regarding availability of alternative sources of supply, in the event such sources would be required. It is especially significant, therefore, to note that the affected communities in the area initiated the petition.

Wilford said, "The department recognizes the importance of the aquifer to the sustaining well-being of those communities, and the region as as whole, and the need for an effective and comprehensive program, for its protection.

EPA PANEL (ℓ to r)
Grant Kimmel, John Malleck, Sheryl Foster, and Harry Smith

"The DEP is planning activities that will be relevant to the Buried Valley Aquifer such as delineating the aquifer area, and associated recharge zones.

"Due to the proliferated use of toxic substances in New Jersey, we feel there is a need to develop better tools to manage toxics, especially in critical water supply areas", he said.

East Hanover Committeeman Vincent Leo spoke on behalf of the petition saying, "...East Hanover depends solely and entirely on the aquifer for their source of drinking water. Therefore, we are for anything that will protect our water and the purity thereof.

"East Hanover is for the protection of the water. We've seen it happen in the northern counties of New Jersey and the New York area, where their water system has become polluted, it is further deteriorating, and we hope that this won't happen here in New Jersey, but there will have to be more stringent regulations reaching more than just the federally-funded projects."

David Miller of Geraghty and Miller, consulting engineers, said, "We support the sole source aquifer because it finally brings attention to the vulnerability of these particular aquifers concerned."

Cameron Boehme, the Natural Resource Director for the 7000-member New Jersey League of Women Voters, presented a support statement.

Mrs. Boehme said, "Damage to the quality of water in any part of this aquifer removes that water from the total supply. Since it is not possible to import water, and the water is already intensively used, the total supply of the basin will be effectively diminished by contamination. Should the contamination continue, or should the contamination spread within the aquifer, the potable supply could be seriously threatened.

EXHIBIT 3

PRC

GOALS AND STRATEGIES

Passaic River Coalition, 246 Madisonville Rd., Basking Ridge, N.J. 07920 —— (201) 766-7550
SPRING, 1980

SOLE SOURCE DESIGNATION FOR BURIED VALLEY AQUIFER

The Buried Valley Aquifer of the Central Passaic River Basin has been designated as a "sole source" aquifer by Douglas M. Costle, Administrator of the U.S. Environmental Protection Agency. The designation comes in response to a petition seeking "sole source" aquifer designation under Section 1424 (e) of the Safe Drinking Water Act of 1974, which was submitted by the Passaic River Coalition and the City of East Orange, N.J. in January 1979.

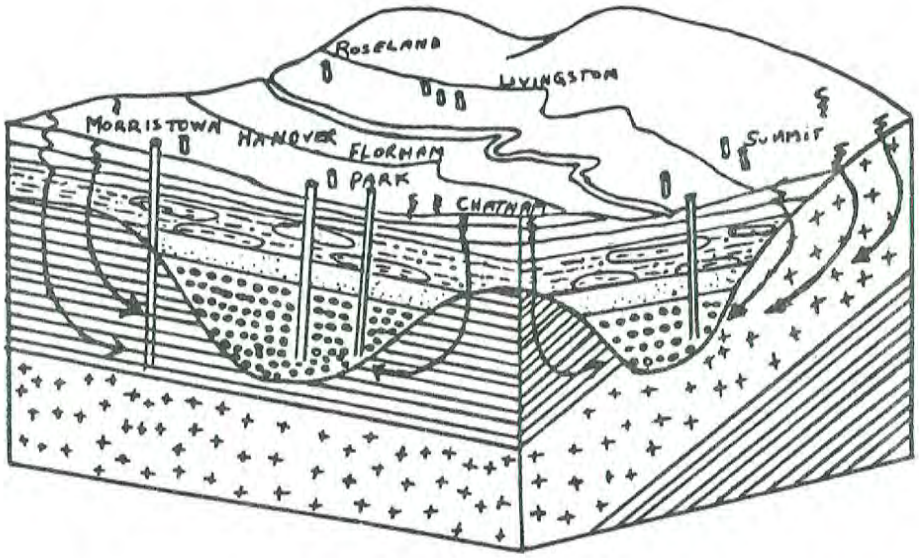
The Buried Valley is the first such designation in the state and the seventh in the entire country. "Sole source" designation means that over 50 per cent of the population in the service area depends on this supply as their only source of drinking water. In the case of the Central Valley of the Passaic River, 90 per cent of the population depends on the aquifer.

The initial impact of this designation means that any Federally funded project in the area would have to be closely reviewed by the U.S. EPA to determine the environmental impact it would have on the Buried Valley Aquifer. Safeguards to protect the aquifer would have to be included in any construction design. Federal projects which did not meet the environmental standards could not qualify for funding. While private development would not be affected by the designation, the State of New Jersey has already begun to develop standards for the ground water supplies to be evaluated by the public in the near future.

PRC Executive Administrator, Ella Filippone, stated that "this is a major step forward in the long-term effort to protect our present water supply and prevent it from becoming polluted. (Continued on p. 2)

BURIED VALLEY

AQUIFER SYSTEM



AQUIFER

Wells

Recharge

SAND and GRAVEL — Both are sediments deposited by the Wisconsin glacier in valleys that existed before the glacier advanced in New Jersey. These valleys, called Buried Valleys, are where the aquifer water supply is contained.

CLAY LENSE — These clay layers were formed by the settling of sediment in Glacial Lake Passaic after the glaciation.

SILT — Fine particles of soil or rock that can be carried by air or water and deposited as sediment.

BRUNSWICK FORMATION — Composed primarily of soft red shale with large amounts of sandstone and conglomerate. Is a quite porous material; it contains jointing patterns. *These patterns are cracks in the formation which allow water to infiltrate into the ground to replenish the aquifer.*

WATCHUNG BASALT FLOW — The basalt cannot form an aquifer, due to the face that it is not naturally porous. When the liquid basalt flowed from the earth it developed a bubbly froth at the surface. This froth caused a network of small openings in the basalt when it cooled.

AQUIFER PETITION RECEIVES SUPPORTERS

The following elected officials, municipal governments, corporations and civic organizations have sent letters supporting the Buried Valley Aquifer petition to Douglas M. Costle, Administrator of the U. S. Environmental Protection Agency and Eckardt C. Beck, EPA Administrator for Region II: New Jersey Department of Environmental Protection - Daniel J. O'Hern (For Gov. Byrne); Congressman Peter Rodino, Congressman Andrew Maguire, Congressman Joseph Minish, Congressman Matthew J. Rinaldo, Congresswoman Millicent Fenwick; N. J. Assembly by Resolution; Assemblyman Walter J. Kavanaugh, Assemblywoman Rosmarie Totaro; Somerset County Planning Board; West Orange, Berkeley Heights Twp., Bernards Twp, Boonton Twp., Chatham Twp., East Hanover, Hanover Twp., Harding Twp, Town of Irvington, Livingston Twp., Millburn Twp., Montville Twp., Morris Twp. - Mayor, Township Clerk and Planning Board, City of Newark, Morris Twp. Department of Health, Chatham Borough, Caldwell Borough, Borough of Essex Fells, Fairfield, Environmental Advisory Committee (Florham Park), Florham Park Board of Health, Roseland Borough - Board of Health, American Association of University Women, Commonwealth Water Company, Environmental Policy Center, Friends of the Earth, Greystone Hospital, League of Women Voters, Mid-Atlantic Council of Watershed Associations, Millburn - Short Hills Citizen League for Environmental Action Now, Morristown Memorial Hospital, Northeast 208 Policy Advisory Committee, omerset-Union Soil Conservation District, Southeast Morris County Municipal Utilities Authority, Sierra Club.

(Continued from p. 1)

SOLE SOURCE DESIGNATION

The designation is one of the most significant accomplishments in the New Jersey environmental field in recent years by the combined efforts of a citizen organization and a major city. The people in northern New Jersey will now be assured that their water supply will begin to be protected from irresponsible environmental practices.

"The aquifer is unpolluted and protection of this valuable natural resource could not have come at a better time. We have been lucky that it is still, as yet, unpolluted since there has been considerable development in the area. I cannot stress enough the importance of this water supply. If it were to become polluted and unusable an alternative water supply would be both physically and economically impractical. Water would have to be diverted from the Hudson River or piped in from the Great Lakes."

The petition was initially conceived through the efforts of the Northeast Policy Advisory Committee (PAC) for Water Quality Management (208). Chatham Borough Engineer Herbert Cannon was one of the driving forces in the initial process, according to Mrs. Filippone. Support for the petition was received at all levels of government, from civic organizations, the business community, and private citizens.

In anticipation of the designation, the Passaic Valley Ground Water Protection Committee was formed in December 1979 to act as a regional planning group in areas of water supply. The committee, chaired by East Orange Water Engineer Anthony Scillia is comprised of approximately 15 municipal, environmental, and corporate representatives.

An aquifer is a geological formation which stores and yields water in economically usable quantities. The Buried Valley Aquifer is an approximately 80 square mile area located in parts of eastern Morris, western Essex, and northern Union and Somerset Counties. It is the sole source of drinking water for an estimated 587,000 people in northern New Jersey. It produces approximately 24 million gallons of water daily with an estimated potential of producing 40 million gallons per day. The aquifer is the result of the Wisconsin Glacier, which moved into the area approximately 10 to 15 thousand years ago. The glacier deposited sand and gravels in the existing valleys as it advanced south. When the glacier melted, Glacial Lake Passaic was formed and the fine sediments in the water settled to form an impermeable clay layer that has protected the aquifer from pollution. The aquifer system consists of Pleistocene glacial deposits and the surrounding shales and sandstones of the Triassic-Jurassic Brunswick Formation.

The sole source designation was strongly supported by municipal officials.

Mayor Thomas H. Cooke, Jr., City of East Orange: "What we have done by filing this petition and obtaining designation will have far reaching impacts on all of north Jersey. I am very pleased to have been a part of this process; it will continue to have my complete and sincere support".

Richard J. Riordan, Chairman of Borough of Chatham Planning Board: "... the designated status of Sole Source Aquifer is a major step in protecting our valuable water supply not only for ourselves but future generations".

Mayor Maureen B. Ogden: "The Township of Millburn is pleased to join in applauding the government decision to designate the Buried Valley Aquifer as a 'sole source'".

Mayor Dominick A. Crincoli, Township of Livingston: "This designation will hopefully strengthen our hand to continue the efforts already under way to protect this vital resource".

EXHIBIT 4

GOALS AND STRATEGIES

Passaic River Coalition, 246 Madisonville Rd., Basking Ridge, N.J. 07920 —— (201) 766-7550

Winter 1980

AQUIFER PROTECTION COMMITTEE FORMED

The Passaic Valley Ground Water Protection Committee was established in December, 1979 to help formulate education and public service programs in anticipation of the "sole source" designation for the Buried Valley Aquifer of the Central Valley of the Passaic River in northern New Jersey.

The committee is comprised of approximately 15 municipal, corporate, and environmental representatives. They represent the interests of the Central River Valley under which the aquifer lies.

The Buried Valley Aquifer is expected to be designated "sole source" by the U.S. Environmental Protection Agency (EPA) in early Spring of 1980. In January 1979, the Passaic River Coalition and the City of East Orange, N.J. filed a petition seeking "sole source" designation under Section 1424 (e) of the Safe Drinking Water Act of 1974. The designation which is awaiting the signature of the EPA Administrator, means that any federally-funded projects in the designated area must be closely reviewed by EPA to determine what type of impact they will have on the aquifer's water supply. The designation will insure that all federally-funded projects such as highways, sewers, hospitals, etc. are built to insure the most proper environmental management available.

The principal role that the committee will have after the designation is to educate the general public as well as elected and appointed officials of the decision and how it will effect their municipality. In addition, the committee will work with the municipal officials to develop guidelines for development which is outside the federally-funded category. The committee wants to insure that all development within the designated area is accomplished with sound environmental planning and management.

The committee has outlined five goals which they hope to achieve. These are: 1) Development of an education program to be presented to the Planning and Zoning Boards of the region so that they consider ground water in their site plan reviews. 2) A study be undertaken to identify the recharge area for the aquifer. 3) A service be provided to the Planning and Zoning Boards which would aid them in site plan review as it affects ground water, and provide assistance for Master Plan revision. 4) A funding mechanism be established for setting aside critical lands. 5) The committee be able to respond collectively to issues of common interest.

The committee in order to proceed with its goals has elected the following officers to formulate and implement policies. They are: Chairman, Anthony Scillia, Chief Engineer, City of East Orange Water Department; Vice-Chairman, Herbert J. Cannon, Engineer, Borough of Chatham; Treasurer, Robert Weiner, Executive Director, Montville Municipal Utilities Authority; Secretary Ella F. Filippone, Executive Administrator, Passaic River Coalition.

The committee meets on a monthly basis in the Mayor's Conference Room, East Orange City Hall. Anyone interested in learning more about the committee is urged to call the Passaic River Coalition, 766-7550.

EXHIBIT 5

GOALS & STRATEGIES

Passaic River Coalition, 246 Madisonville Road, Basking Ridge, N.J. 07920 • (201) 766-7550 Spring 1981

PVGWPC 1980 Activities

AFTER the Buried Valley Aquifer was designated on May 8,1980,a committee was formed entitled the *Passaic Valley Ground Water Protection Committee*. Following is a list of its activities during the year of 1980.

The PVGWPC devoted much of its efforts to informing the public about the importance of preserving ground water.In addition,it began to influence State government on the importance of ground water.

In April,a request was sent to Water Resource Division Director Arnold Schiffman requesting Sole Source designation be included in Section 7C of the N.J.Water Supply Master Plan.This was accomplished.

The PVGWPC reviewed a site plan for a Surgical Center Development in Roseland, and urged the Roseland Planning Board to recognize the potential for ground water contamination during their deliberations on projects of this type.

A letter was sent to Charles Warren,EPA Regional Administrator,requesting that the recharge areas of the Upper Passaic be delineated under the 201 facilities plan. Such a study was done for the Upper Rockaway in their 201 facilities plan,which is a neighboring area,and surplus funds exist within the construction grants program so that this might be done.This report should be completed by EPA consultants by Spring, 1981.

A letter was sent to Doug Clark,NJDEP Deputy Director,Water Resources,requesting that the Buried Valley Aquifer Sole Source designation be highlighted in Water Quality Standards revision under the Ground Water Protection Standards Section.

The Committee,at the request of the Township of Montville,submitted its opinion about a project called *Ecology Lake*. This proposed lake would be located within the wetlands of the Rockaway River.Soils would be removed from this area to a depth of about 50 feet.It would then be filled with water and deeded to the Township for recreational purposes.The PVGWPC requested the Montville Township Planning Board to carefully consider the impact of the project on the ground water in the area.In addition,a letter was sent to the N.J.Department of Environmental Protection asking why a soil removal permit was granted without consideration to the area's ground water.

The Committee notified the mayors of Chatham Borough, Chatham Township, Florham Park, and Madison of its support for the completion of Route 24 to Route 287 as long as all proper environmental precautions are taken to insure the protection of the Buried Valley Aquifer water supply.

The Committee commented on a plan to place solid waste sites in Fairfield-in the aquifer area-in a letter to George Tyler,N.J.DEP,pointing out to the State the importance of not placing any dump sites within the boundaries of the Buried Valley Aquifer.

The PVGWPC supported East Hanover's application for monies to construct collector lines for sewage.

The PVGWPC supported the petition for Sole Source Aquifer designation of the Upper Rockaway Aquifer,which would complement the Buried Valley.

Preparations were started to develop a brochure describing the need for ground water protection and to inform the public regarding the importance of ground water.

An Environmental Defense Fund grant-in-aid was received by Herbert Cannon to pay his expenses while representing the PVGWPC at a hearing on EPA's Ground Water Protection Strategy. This hearing took place in Washington, D.C.

Special Meetings:

Livingston - To recognize the EPA designation of the Buried Valley Aquifer as a Sole Source,and to obtain comments from the Federal and State government officials as to their commitment to protect this ground water resource.Statements were presented by municipalities which serve as founders of the PVGWPC.

East Orange - In August; for EPA to present the scope of the Sole Source designation to regional representatives,over 100 officials,and other interested citizens.

Meeting with Industry:

In November at Sandoz in East Hanover to which PVGWPC invited the major corporations in the Valley.Twenty-six corporate representatives attended.Presentations were made by members of the PVGWPC,N.J.DEP, and the U.S.EPA.

APPENDIX B

EXHIBIT 1

BEFORE THE UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY

Douglas M. Costle, Administrator

IN THE MATTER of the Petition of
THE CITY OF EAST ORANGE, NEW JERSEY
and THE PASSAIC RIVER COALITION Under
Section 1424 (e) of the Safe Drinking
Water Act of 1974 With Respect to the
Buried Valley Aquifer System of Western
Essex and Eastern Morris Counties, New
Jersey.

PETITION

1. The City of East Orange New Jersey was incorporated in 1909 and is located in Essex County (Northeastern) New Jersey. The city has a population of 88,000 and is totally dependent on the Buried Valley Aquifer System, that is the subject of this petition, as a sole source of drinking water for its residents. City Hall is located at 44 City Hall Plaza, East Orange, New Jersey - 07017, (201-675-8049).

The Passaic River Coalition is a non-profit, urban watershed association concerned with water quality, water supply, land-use and the overall quality of the environment in the Passaic River Basin in Northern New Jersey. Its headquarters is located at 246 Madisonville Road, Basking Ridge, N. J. - 07920, (201-766-7550)

2. A petition to the Administrator of the United States Environmental Protection Agency, requesting that the Pleistocene Buried Valley and Associated Bedrock Aquifer System in the Central Basin of the Passaic River Watershed, New Jersey, be designated as a sole source aquifer as provided under Section 1424 (e) of the Safe Drinking Water Act. (P.L. 93-523), which provides as follows:

> (e) If the Administrator determines, on his own initiative or upon petition, that an area has an aquifer which is the sole or principal drinking water source for the area and which, if contaminated, would create a significant hazard to public health,

> he shall publish notice of that determination in the Federal Register. After the publication of any such notice, no commitment for Federal financial assistance (through a grant, contract, loan guarantee, or otherwise) may be entered into for any project which the Administrator determines may contaminate such aquifer through a recharge zone so as to create a significant hazard to public health, but a commitment for Federal financial assistance may, if authorized under another provision of law, be entered into to plan or design the project to assure that it will not so contaminate the aquifer.

3. President Jimmy Carter's Urban Policy consists of an integrated set of commitments to urban America including Policy Statement number nine:

> "Improve the urban physical environment and the cultural and aesthetic aspects of urban life.

Protection of the Buried Valley Aquifer System under Section 1424 (e) of the Safe Drinking Water Act would help protect the environment of the urban centers in northern New Jersey that are dependent on this aquifer as a source of drinking water, thereby fulfilling some of the objectives of the President's Urban Policy.

4. The area proposed for Sole Source Aquifer designation is a portion of the Central Basin of the Passaic River Watershed in southeast Morris, eastern Essex, and portions of Union and Somerset Counties, New Jersey. Geologically, the area lies within the Piedmont Physiographic Province and is underlain by Triassic-Jurassic (about 190 million yrs. old) shales and sandstones of the Brunswick Formation, along with interspaced baseltic lava flows (the Watchung Mountains). The Brunswick Formation is overlain by a thick covering of Pleistocene (14,000 to 80,000 years ago) glacial deposits, consisting of unconsolidated sands, gravels, silts and clays. The proposed designation would apply to buried valley and channel deposits of glacial origin and the associated bedrock (Brunswick Formation and

Watchung Basalt).

5. The boundary of the proposed designation is shown in Figure I. The area being proposed is generally the Central Basin of the Passaic River Watershed as defined by the U. S. Army Corps of Engineers with some modifications. The area is bordered on the north by Hook Mountain (a baseltic lava flow) and by a line which roughly bisects the town of Montville. The western boundary is defined by the trace of the Ramapo Fault and the beginning of the Highlands Physiographic Province. The boundary to the south and the east is formed by the Second Watchung Mountain range, including portions of Union, Essex and Somerset Counties, New Jersey.

6. The public water supply systems, as well as a large private water company and many industrial and private well owners depend on this aquifer system as a source of drinking water. Groundwater withdrawn from within the boundary of the designated area is also exported to municipalities outside of that proposed designation area. Therefore, a second map termed the service area (Figure 3,) shows distribution outside of the proposed designation area for the aquifer. The two purveyors exporting groundwater outside of the proposed equifer boundary are the City of East Orange and the Commonwealth Water Company. The total population of the proposed designation area and the service area is approximately 587,188 residents. A total of 31 municipalities are included in the service and designation areas, and of this number nearly 90 percent of the municipalities are dependent on the aquifer as a source of drinking water. Table 2 gives a breakdown of drinking water sources by municipality along with population figures.

7. A listing of public water supply systems utilizing the aquifer

appears on Table 2.

8. Figure 2 shows an outline of the Buried Valley Aquifer System and shows the location of major public supply and private well fields. Figure 4 shows a cross section of the aquifer and demonstrates the hydraulic connection between the Buried Valley and the surrounding Brunswick Formation and the Watchung Basalt.

9. Continued development in the area makes protection of recharge areas imperative. Development in northern New Jersey has already degraded surface water quality, placing greater reliance and demands on groundwater. The Borough of Chatham, which is totally dependent on the aquifer for drinking water, notes in its Natural Resource Inventory:

> The static water level in our No. 1 well has dropped 31 feet from 1931 to 1969. This is of course due to increased local usage, but it is also indicative of increased urbanization in the surrounding region. With this have come increased demands on the aquifer and, at the same time, a reduced recharge capability due to the construction of homes, buildings, and paved areas in the region. This is supported by the experience of the well fields in Millburn Township and southwestern Livingston where two water companies - Commonwealth, and the City of East Orange - operate pumping stations. Their wells have experienced a drop in the static water level of 54 feet from 1925 through 1965.

10. The U. S. Army Corps of Engineers is currently undertaking a Phase I advanced engineering and design study of the Passaic River Basin to develop a basin-wide plan for meeting the flood control and other associated water resource and related land resources needs of the basin. The Buried Valley Aquifer is located within their study area. The Army Corps of Engineers, in its Preliminary Draft Plan of Study (August, 1978) of the Passaic River Basin, stated that:

> The major surface water supply developments are located primarily in the upstream tributaries and serve the urban concentrations in the Lower Valley. As a result, groundwater is the major water supply source in the Central Basin and Highland Area. Groundwater provides 75% of the water used above Little Falls and represents 16% of that area's total developed water supply including that exported below Little Falls.

11. The Policy Advisory Committee of the Northeast Water Quality Planning Program (established under Section 208 of Public Law 92-500) recognized the necessity of protecting sole source aquifers and their recharge areas and recommends the following policy:

> "The required information for 'sole source determination' of the Buried Valley Aquifer in East Morris and West Essex Counties, New Jersey, should be developed and submitted to the U. S. EPA for Sole Source Designation pursuant to the Safe Drinking Water Act (42 U.S.C. 300F. 300h - 3(e); 88 Sat. 1660 et seq. Public Law 93-523)"

12. The City of East Orange, New Jersey (population: 88,000) depends entirely on groundwater from wells overlying the Buried Valley Aquifer System. A 1976 study by Gerahty and Miller, consulting groundwater geologists, Port Washington, New York, of the groundwater conditions at the East Orange Water Reserve determined that increased pumpage and loss of recharge area to urbanization in the region has had a significant effect on the groundwater resources of the water reserve. The Gerahty and Miller study made the following observation:

> The quality of groundwater within the reserve is more than adequate to meet the needs of a potable water supply but has been degraded over the past 20 years by the effect of changing land-use patterns in the areas surrounding the reserve and from the incursion of highways and sewer lines within the Reserve.

13. A 1978 study by Geraghty and Miller, Inc. identified a section of the Buried Valley Aquifer near Pine Brook, New Jersey

(see Figure 2) which could provide an additional .5 to 1.0 mgd of groundwater. Until further studies are completed, Geraghty and Miller suggested that the designated area should temporarily be set aside and any land development there should be halted until each site can be thoroughly tested as to its potential for groundwater development.

14. The Morris County Master Plan Water Supply Element (1971) recognized the importance of groundwater in the County:

> Despite the extensive development of surface supplies within the County, the major source of supply for consumption within the county is from well water supplies. Over the past three years, surface supplies in the County have accounted for only 10% of the consumption from public water supplies within the county.

15. The Township of Livingston, New Jersey (population 32,500) is totally dependent on groundwater from the Buried Valley Aquifer System. The 1976 Geraghty and Miller study for the East Orange Water Reserve made the following reference to Livingston:

> "In Livingston, most of the areas overlying promising sites for groundwater development have been urbanized. In addition, recharge has been reduced due to the covering of prime aquifer recharge areas with impervious surfaces, resulting in a reduction of overall groundwater availability. A third problem is the preponderance of potential sources of groundwater pollution. For example, several well sites have shown that groundwater quality has been impaired as a result of leakage from nearby gasoline and/or oil storage tanks.

16. Thompson (1932) showed the importance of the groundwater resource in supplying drinking water to the area, in the publication. GROUND WATER SUPPLIES OF THE PASSAIC RIVER VALLEY NEAR CHATHAM, N. J.:

> "The principal supply of ground water is obtained from beds of sand and gravel, of Pleistocene age, which lie at at depth of approximately 100 to 135 feet and which are confined to pre-glacial channels cut in the bed rock. Elsewhere in the region the bed rock, which consists of red sandstone and shale and trap rock of Triassic age, is struck at depths as shallow as

> 60 to 75 feet, and the overlying material consists largely of clay which yields little or no water. In the well fields that have been studied the water-bearing formation is overlain by relatively impervious clay and there is little if any recharge directly from rain in the immediate vicinity. An unresolved problem is as to whether there is sufficient recharge to meet the present and future draft."

17. In the Computer Simulation Model of the Pleistocene Valley-Fill Aquifer in Southwestern Essex and Southeastern Morris Counties, New Jersey by Harold Meisler, U. S. Geological Survey, Water - Resources Investigations 76-25, the importance of the Buried Valley Aquifer as a water supply source is noted in the following introductory statement:

> Sand and gravel deposits of Pleistocene age have been an important source of water for communities and industries in southwestern Essex and southeastern Morris Counties for several decades. Withdrawal from these deposits had increased from an estimated 5 Mgal/d during the period 1900-29 to approximately 28.5 Mgal/d during the period 1972-73. Yet virtually all this water was withdrawn from a buried valley-fill aquifer occupying an area of approximately 20 mi^2.

18. Current land-use and water quality laws do not adequately protect the Buried Valley Aquifer System or its recharge areas.

19. The highly developed and industrialized environment of northern New Jersey provides for many sources of groundwater contamination including septic systems, accidental spills, landfill leachate, waste lagoons, etc.

20. We, therefore, conclude. The Buried Valley Aquifer System is a sole source of drinking water for municipalities and private well owners in the region, and contamination of this aquifer would create significant hazard to public health.

Therefore, we respectfully request that the Administrator of

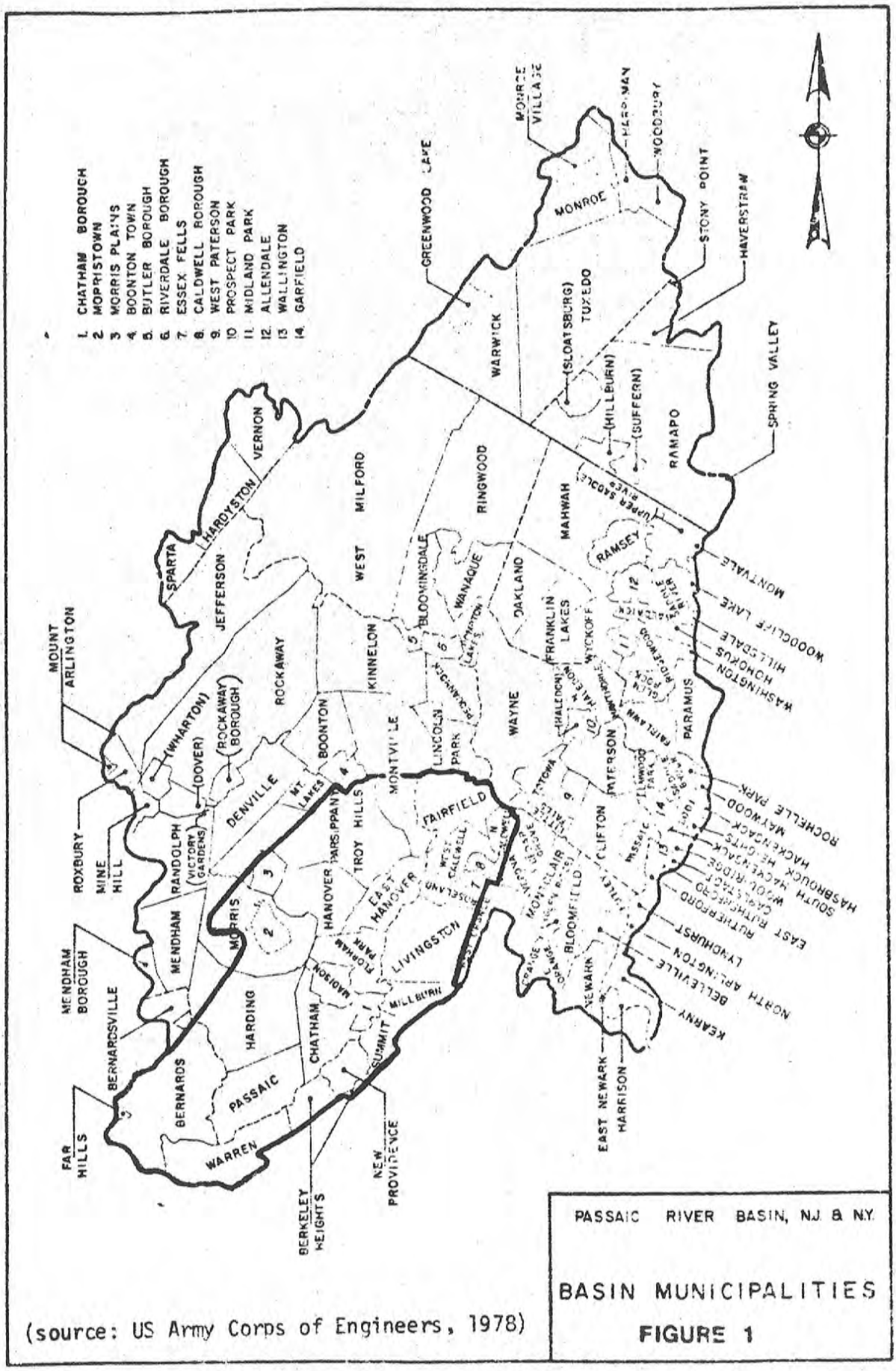
the U. S. Environmental Protection Agency determine that the Buried Valley Aquifer System in Eastern Morris and Western Essex Counties, New Jersey, be designated as the sole or principal drinking water source for the area and that this determination be printed in the Federal Register, as required by Section 1424(e) of the Safe Drinking Water Act of 1974.

Respectfully submitted,

Thomas H. Cooke, Mayor
City of East Orange

Ella F. Filippone, Executive Administrator, Passaic River Coalition

12-19-78



PASSAIC RIVER BASIN, NJ & NY.

BASIN MUNICIPALITIES

FIGURE 1

(source: US Army Corps of Engineers, 1978)

AREA PROPOSED FOR SOLE SOURCE AQUIFER DESIGNATION

(South Central Basin)

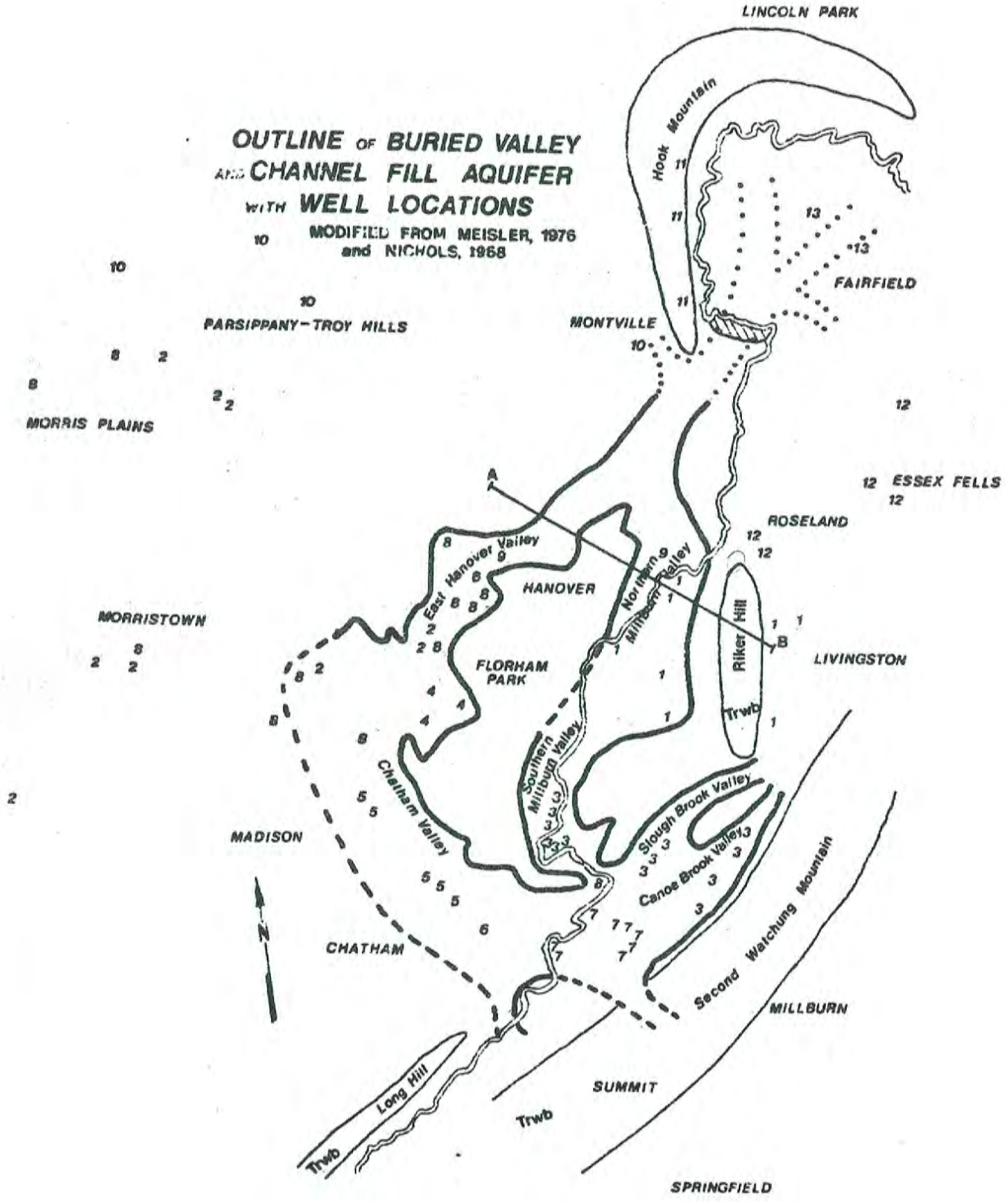

OUTLINE OF BURIED VALLEY
AND CHANNEL FILL AQUIFER
WITH WELL LOCATIONS
MODIFIED FROM MEISLER, 1976
and NICHOLS, 1968
LINCOLN PARK
Hook Mountain
FAIRFIELD
PARSIPPANY-TROY HILLS
MONTVILLE
MORRIS PLAINS
ESSEX FELLS
ROSELAND
East Hanover Valley
HANOVER
Northern Millburn Valley
MORRISTOWN
Riker Hill
LIVINGSTON
FLORHAM PARK
Trwb
Southern Millburn Valley
Slough Brook Valley
Canoe Brook Valley
Chatham Valley
MADISON
CHATHAM
Second Watchung Mountain
MILLBURN
Long Hill
SUMMIT
SPRINGFIELD
A
B
N
1 1/2 0 1 2 Miles

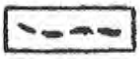
Figure 2

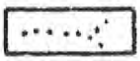
KEY TO FIGURE 2

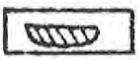
(Numbers on map correspond to locations and owners of public and private well fields. Note that there may be more than one well at each numbered site. In addition, other well owners may exist but are not listed here.)

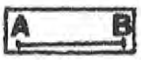
1. Livingston Twp. Water Dept.
2. Southeast Morris County Municipal Utilities Authority
3. East Orange Water Dept.
4. Florham Park Water Dept.
5. Madison Water Dept.
6. Chatham Borough Water Dept.
7. Commonwealth Water Company
*8. Large Private Well Fields
9. East Hanover Water Dept.
10. Parsippany-Troy Hills Water Dept.
11. Montville Water Dept.
12. Essex Fells Water Dept.
13. Fairfield Water Dept.

Boundary of Valley Fill Deposits

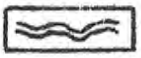

Inferred Boundary of Valley Fill Deposits

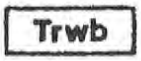

Nichols, 1968 - continuation of the buried valley deposits inferred from bedrock topography


Geraghty & Miller, Inc., 1978 - potential recovery of .5 to 1.0 mgd from stratified drift deposits. (should be protected from development until further studies are completed.)



Cross-Section Area (see Figure 4)

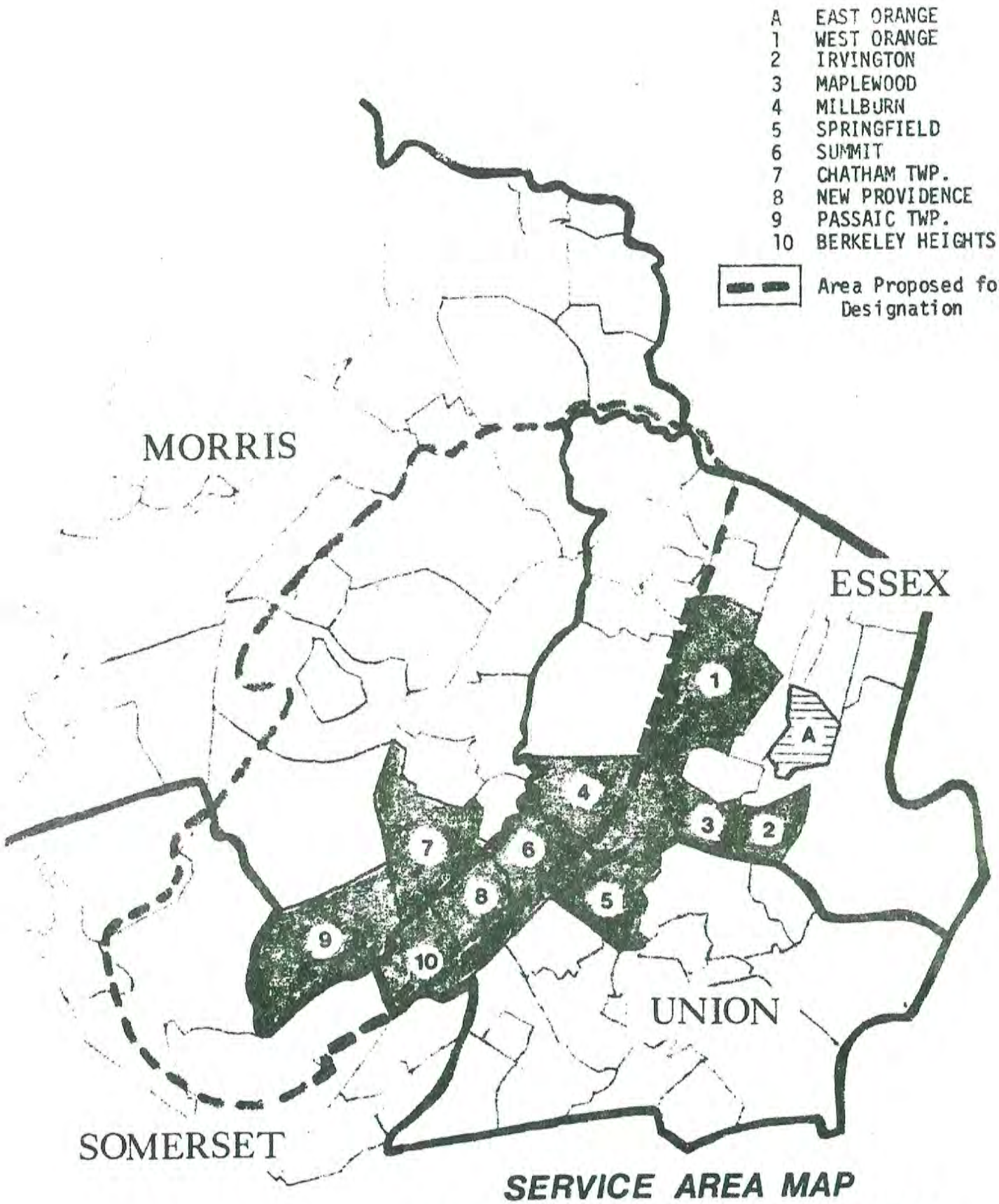

Passaic River



Triassic Watchung Basalt

* Large private well owners are as follows:

Warner Lambert, Co., New Jersey State Hospital-Greystone Park, Morristown Memorial Hospital, Suburban Propane Gas Corp., Sandoz Inc., Wilbur B. Driver Inc., Allied Chemical Corp., Orange Products Inc., Exxon Research and Engineering, Morris County Golf Club



SERVICE AREA MAP

Municipalities Served By Commonwealth Water Co.
(Shaded, numbered areas)

FIGURE 3

All other service areas fall within the designated boundary (dashed line) except for the City of East Orange

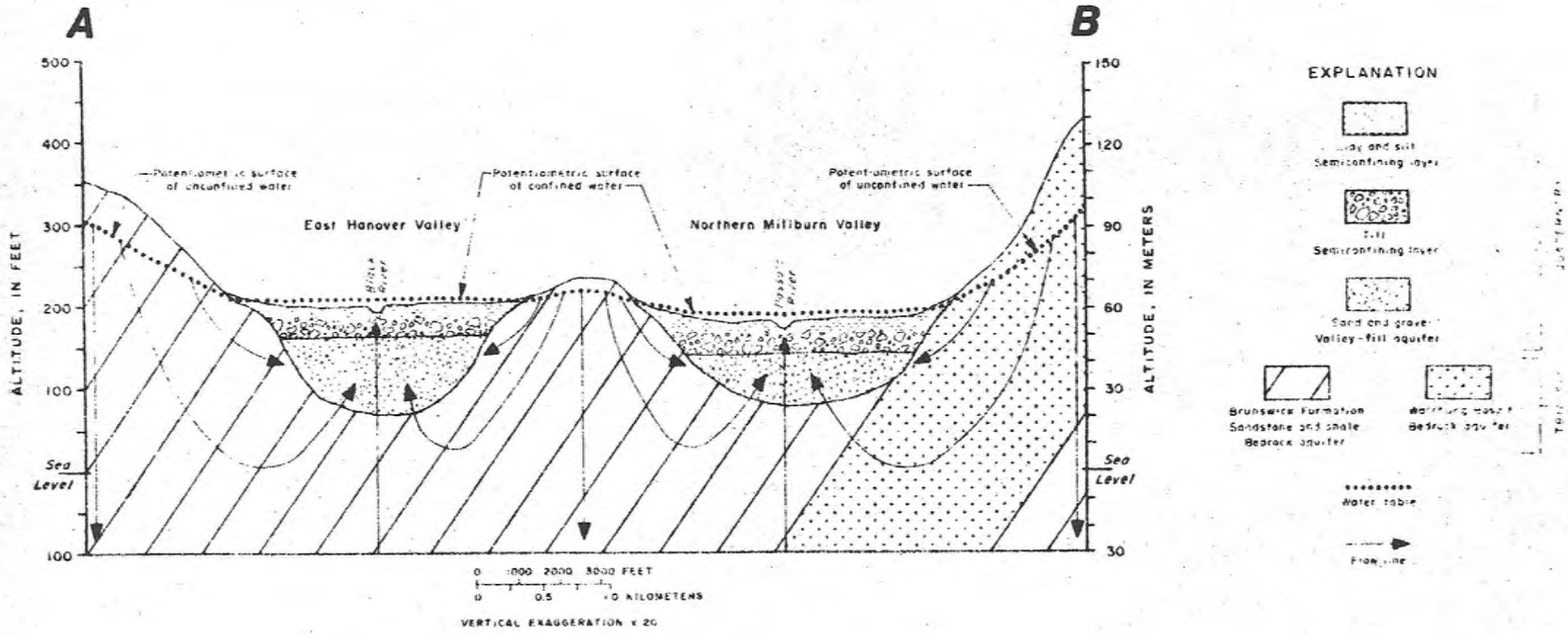


FIGURE 4

CROSS SECTION OF THE BURIED VALLEY AQUIFER SYSTEM

(refer to figure 2)

source: Meisler, 1976

TABLE 2

PUBLIC WATER SUPPLY SYSTEMS
UTILIZING THE AQUIFER

		Population Served	Treatment
1.	Livingston Twp. Water Dept.	32,500	Chlorination
2.	Southeast Morris County Municipal Utilities Authority	57,013	Chlorination (Manganese removal at Black Brook Field)
3.	East Orange Water Dept.	88,000	Chlorination
4.	Florham Park Water Dept.	8,000	Chlorination (excessive Manganese in one well)
5.	Madison Water Dept.	16,710	Chlorination
6.	Chatham Borough Water Dept.	9,566	Chlorination
7.	Commonwealth Water Company	223,881	Chlorination
8.	East Hanover Water Dept.	7,734	Chlorination and Manganese removal
9.	Parsippany-Troy Hills Water Dept.	57,910	Chlorination
10.	Montville Water Dept.	11,846	Chlorination
11.	Essex Fells Water Dept.	22,655	Chlorination
12.	Fairfield Water Dept.	7,230	Chlorination

The following studies describe the Buried Valley Aquifer System and its importance as a source of water supply to the area.

Boro of Chatham Environmental Commission, 1976, Natural Resources- A Study and Inventory for the Borough of Chatham

Geraghty & Miller, Inc., 1976, Ground-Water Conditions, City of East Orange Water Reserve, Port Washington, NY 11050

Geraghty & Miller Inc., 1978, An Evaluation of Ground-Water Resources of the Rockaway River Valley within the Communities of Denville, Boonton Twp., Town of Boonton, Montville, and Mountain Lakes, New Jersey. Port Washington, NY

Gill, H.E., and Vecchioli, J., 1965 Availability of Groundwater in Morris County, New Jersey , New Jersey Dept. of Conservation and Economic Development , Special Report # 25

Meisler, Harold, 1976 Computer Simulation Model of the Pleistocene Valley-Fill Aquifer in Southwestern Essex and Southeastern Morris Counties, New Jersey, USGS Water Resources Investigation 76-25

Morris County Planning Dept., 1971, Morris County Master Plan - Water Supply Element, (prepared by Elson T. Killam Associates, Inc.)

Nichols, William D., 1968 Groundwater Resources of Essex County, New Jersey, New Jersey Dept. of Conservation and Economic Development Special Report # 28

Nichols, William D., 1968 Bedrock Topography of Eastern Morris and Western Essex Counties, New Jersey USGS Misc. Geol. Inv. Map I-594

Thompson, David G., 1932 Groundwater Supplies of the Passaic River Valley Near Chatham, New Jersey New Jersey Dept. of Conservation and Economic Development

Vecchioli, John and Nichols, W.D., 1966 Results of the Drought Disaster Test-Drilling Program Near Morristown, New Jersey New Jersey Dept. of Conservation and Economic Development Water Resources Circular # 16

Vecchioli, John, Nichols, W.D., and Nemickas, B., 1967 Results of the Second Phase of the Drought Disaster Test Drilling Program Near Morristown, New Jersey New Jersey Dept. of Conservation and Economic Development, Water Resources Circular # 17

ENVIRONMENTAL PROTECTION AGENCY

[FR 1417-6]

Aquifers Underlying Western Essex and Southeastern Morris Counties, N.J.; Determination

Notice is hereby given that pursuant to Section 1424(e) of the Safe Drinking Water Act (42 U.S.C. 300f, 300h-3(e); 88 Stat. 1660 et seq., P.L. 93-523) the Administrator of the Environmental Protection Agency has determined that the buried valley and bedrock aquifer system underlying the Central Basin of the Passaic River in western Essex and southeastern Morris Counties, New Jersey, is the principal source of drinking water for these counties and that, if the aquifer system were contaminated, it would create a significant hazard to public health.

Background

The Safe Drinking Water Act was enacted on December 16, 1974. Section 1424(e) of the Act states:

> If the Administrator determines, on his own initiative or upon petition, that an area has an aquifer which is the sole or principal drinking water source for the area and which, if contaminated, would create a significant hazard to public health, he shall publish notice of the determination in the Federal Register. After the publication of any notice, no commitment for Federal financial assistance (through a grant, contract, loan guarantee, or otherwise) may be entered into for any project which the Administrator determines may contaminate such aquifer through a recharge zone so as to create a significant hazard to public health but a commitment for Federal financial assistance may, if authorized under another provision of law, be entered into to plan or design the project to assure that it will not so contaminate the aquifer.

On January 15, 1979 the City of East Orange, N.J. and Passaic River Coalition, Basking Ridge, N.J. petitioned and Administrator to designate the aquifer system underlying western Essex and southeastern Morris Counties, New Jersey, as a sole source aquifer under the provisions of the Act. A notice of receipt of this petition, together with a request for comments was published in the Federal Register March 29, 1979, 44 FR 18732. In response to the Notice and request for comments, written comments were received from both the public and private sectors. On May 23, 1979, the Environmental Protection Agency (EPA) held a public hearing in Roseland, N.J. to hear the views of persons interested in the Buried Valley System issue.

On the basis of the information which is available to this Agency the Administrator has made the following findings, which are the basis for the determination noted above:

(1) The Buried Valley Aquifer System is the sole or principal source of drinking water for approximately 600,000 people in western Essex and southeastern Morris Counties, New Jersey. In 1978, the system supplied approximately 42 million Gallons per Day (MGD) water. Current water supply treatment practice for public supplies is generally limited to disinfection for drinking purposes; with some plants capable of manganese removal. There is no alternative source of drinking water supply which could economically replace this aquifer system if it were contaminated.

(2) The Buried Valley Aquifer System is vulnerable to contamination through its recharge zone, particularly from septic tanks and, to a lesser extent, from leaching of discharges to streams and rivers in the recharge and streamflow source zones. Since ground water contamination can be difficult or impossible to reverse, and because this aquifer is relied upon for drinking purposes by many people, contamination of the aquifer would pose a siginficant hazard to public health.

Section 1424(e) of the Act requires that a Federal agency may not commit funds to a project which may contaminate the aquifer system through a recharge or streamflow source zone so as to create a signficant hazard to public health. The recharge zone is that area through which water enters into the aquifer system.

The area in which projects may be reviewed is the area encompassed by: (1) The boundary of the Buried Valley Aquifer Systems, and (2) its streamflow source zones.

The Buried Valley Aquifer System is the principal source of drinking water in southeastern Morris and western Essex Counties, New Jersey. The surface boundary of the aquifer's recharge zone is identical with the boundary of the aquifer.

The recharge zone is defined by the outside boundary of the following municipalities: On the south—Bernards Township and Warren Township, on the east—Berkeley Heights, New Providence, Summit Millburn, Livingston Township, Roseland, Essex Falls, Caldwell, West Caldwell and North Caldwell, on the north—Fairfield, and Montville, on the west—Parsippany-Troy Hills, Morris Township and Harding Township. Included within these perimeter communities are also the following: Passaic Township, Chatham, Chatham Township, Madison, Florham Park, Morristown, Hanover, East Hanover and Morris Plains.

The stream flow source zone of the aquifer system lies within the boundaries of the Rockaway River Sub-Basin, which, in turn, is part of the Passaic River Basin. This zone includes those portions of the sub-basin which ultimately drain to the recharge zone. This area encompasses all or part of the following municipalities: Bernardsville, Boonton Town, Boonton Township, Denveille, Dover, Jefferson, Kinnelon, Lincoln Park, Mendham Borough, Mendham Township, Mine Hill, Mountain Lakes, Mount Arlington, Randolph, Rockaway Borough, Rockaway Township, Roxbury Sparta, Victory Gardens and Wharton.

The information utilized in this determination includes: The petition, written and verbal-comments submitted by the public, a detailed map of the area and independent analyses by EPA. All this information is available to the public and may be inspected during normal business hours at the office of the Environmental Protection Agency, Region II, Water Supply Branch, 26 Federal Plaza, Room 24-130, New York, N.Y. 10007.

A copy of the above documentation is also available at the U.S. Environmental Protection Agency, Waterside Mall, Public Information and Reference Unit, Room 2922, 401 M Street SW., Washington, D.C. 20460.

EPA proposed national regulations for implementing Section 1424(e) of the Safe Drinking Water Act on September 29, 1977, 42 FR 51574. The proposed regulations contain procedures for review of Federal financially assisted projects which may contaminate aquifer systems designated as "sole or principal source" aquifers through the recharge zone so as to create a significant hazard to public health. Until their final promulgation, these regulations will be used as interim guidance for implementing a sole source program under Section 1424(e). Questions and comments concerning the possible effect of the regulations on federally assisted projects in the Buried Valley Aquifer System area should be directed to Region II, Environmental Protection Agency, Attn: Harry F. Smith, Jr., P.E., Chief, Water Supply Branch, U.S. Environmental Protection Agency, 26 Federal Plaza, New York, N.Y. 10007.

EPA, Region II, is working with the Federal agencies which intend, or may intend to fund projects in the area of concern to develop procedures for notifying EPA projects in the area which might contaminate the aquifer. EPA will evaluate such projects and, where necessary, will conduct an in-depth review, including soliciting public comments where appropriate. More stringent review criteria will be applied to those projects that have a greater potential for contaminating the aquifer, such as those located in the recharge zone.

Although the project review process cannot be delegated, the Regional Administration in Region II will rely to the maximum extent possible upon and existing or future State and local control mechanisms in protecting the southeastern Morris and western Essex Counties, New Jersey. Included in the review of any Federal financially assisted project will be coordination with the State and local agencies. Their determinations will be given full consideration and the Federal review process will function so as to complement and support State and local protection programs.

Dated: May 2, 1980.

Douglas M. Costle,

Administrator.

[FR Doc. 80-14343 Filed 5-7-80; 8:45 am]

BILLING CODE 6560-01-M

UPPER LAMINGTON SUBREGION
MINOR CONTAMINATION CASES

I260 HERCULES, INC., ROXBURY 1981

1) Overview--An initial hydrogeologic investigation was conducted at Hercules Kenvil explosives manufacturing plant. Fifteen ground water monitoring wells in addition to soil borings were inventoried to determine ground water flow direction and quality. The investigation is in progress to determine the nature and extent of inorganic and organic pollution, as well as further define aquifer flow conditions. There are two landfill sites on the property, one of which has been closed since 1975. Four monitor wells were installed for ground water sampling. Contamination has not been indicated by sample results.

Hercules Inc. manufactures black powder and nitroglycerine on a 1200 acre site in the Kenvil section of Roxbury Township. Because of violations of an NJPDES permit, the USEPA issued a Findings of Violation and Order to Show Cause to Hercules on October 1, 1981. The NJDEP has been in the lead in following up on compliance with this document, and in addition, directed Hercules to conduct a hydrogeologic study to determine whether ground water contamination exists at the site, leading to the investigations described above.

To correct the NJPDES violations, Hercules has constructed a number of dikes and a comprehensive system to consolidate, eliminate and/or collect all of their process waste streams. The NJDEP and Hercules entered into an Administrative Consent Order on May 8, 1984 which formalizes a time schedule leading to the design, construction and operation of an advanced wastewater treatment facility.
2) Location of the contaminated site--Roxbury approximately one mile south of Route 46.

A-280 ROXBURY WATER COMPANY 1985

1) Overview--Finished water samples showed PCE levels of 20 ppb, with Well 3 having 39 ppb PCE in 1985. Monthly monitoring was required in 1985. Roxbury Water Company has identified the route of flow for the contamination to the well and repaired the well. Retesting of the well revealed PCE at 3.7 ppb. However, the original source of the PCE has not been determined. Level 2 contamination--lowest action level. Investigation continues.
2) Location of the contaminated site--Kenvil area of Roxbury Township.

TOWACO VALLEY SUBREGION
MAJOR CONTAMINATION CASES

A BELLOWS LANE, MONTVILLE 1985

1) Overview--Private residential wells in the vicinity of the former Fairclough Oil facility on Route 202 in Towaco (Montville Township) have fuel oil-like odors. This is a reopening of a case dating back to 1977. NJDEP has concluded that 1,300 gallons of fuel oil were discharged by Fairclough. Provision of public water to Bellows Lane and Route 202 is under consideration. Investigation continuing.
2) Location of the contaminated site--Bellows Lane and Route 202 in the Towaco section of Montville Township.
3) Severity of contamination--Fuel-like odors have been found in 15 residential wells, one with very strong odors and black sediment. One well sampled in 1986 showed petroleum hydrocarbon levels of 56.9 ppm.
4) Extent of contamination/Ground water flow--Based on odors, the contaminated area is 500 feet wide and 1000 feet long, at least to Benefly Road. The Towaco Aquifer is located to the north of this site. The site lies over bedrock from the Towaco Mountain, which slopes downward to the north below the 200 foot deep aquifer of glacial deposits.
5) Suspected and confirmed sources--NJDEP has concluded that Fairclough Oil discharged 1,300 gallons of fuel oil and required them to sample the residential wells, perform soil contamination remediation and a ground water investigation and remedial plan. 1977 findings by NJDEP indicated that successive spills could have led to contamination. There also are five underground oil tanks for the private residences. NJDEP has ordered the installation of monitor wells at the now defunct Fairclough oil facility. No wells have been installed.
6) Mitigation actions--Public water was recommended in 1977, but was not provided. Penalties of $3,000 were assessed against Fairclough in 1978 when Montville Township indicated continued problems. Public water is again being considered in 1986.
7) Decontamination actions--None to date.
8) Continuing investigations--A cleanup directive was issued to Fairclough in December 1985. Fairclough refuses to present a remedial action plan and denies responsibility. Further enforcement action is being directed against Fairclough, including an Administrative Order to be issued to Fairclough to pay for water main installation and hookups which are being designed by the Division of Water Resources. A cost of $700,000 is anticipated.

I158 MAROTTA SCIENTIFIC CONTROLS, MONTVILLE TWP April 1982

1) Overview--Detection of organic chemicals in the Town of Boonton water tunnel led the NJDEP to investigate Marotta as one of several suspected sources. Deep production wells are heavily contaminated with organic chemicals. Deep and shallow monitor wells revealed extensive ground

water contamination. Seven domestic wells are contaminated and have had carbon filters installed. An extensive domestic well sampling project resulted in an agreement with the Township of Montville to provide public water to the affected area of over 50 homes. Additional monitor wells are being installed and the investigation of the Boonton water tunnel is continuing, and that matter is in litigation between Boonton and Marotta. The NJDEP investigation is continuing.

2) Location of the contaminated site--Marotta is located in a valley in the northwestern section of Montville near the Boonton Township border at the intersection of Rockaway Valley Road and Boonton Avenue.

3) Severity of contamination--extensive contamination of the Marotta site has occurred, with monitor wells exhibiting VOC levels of 150 ppb frequently and up to 324 ppb in one well. On-site soil samples showed contamination by TCE, PCE, 1,1,1 trichloroethane and benzene. The NJDEP had discovered VOCs in private wells and septic systems in the area.

4) Extent of contamination/Ground water flow--The contamination has migrated off-site and has apparently affected the Boonton Aqueduct. At least 55 private wells have been threatened by contamination. The site is located in a valley with swampy areas to both the north and south which are poorly drained glacial sediments. The ground water flow is assumed to be <u>both</u> northeast and southwest, as the VOCs have migrated in both directions. Bedrock is generally 9 feet below grade, increasing to 40 feet to the southwest in a valley-fill aquifer area. A major fault probably underlies the site but may be fairly impermeable ("tight").

5) Suspected and confirmed sources--Marotta Scientific has been confirmed as the source of contamination.

6) Mitigation actions--Marotta began pumping its well to treatment with the discharge going to septic systems, so as to purge the aquifer and slow the flow of contamination off-site. Marotta has also agreed to assume $1.8 million of the cost to connect the nearby residences to public water. Marotta also will correct the Boonton aqueduct problem while reserving the right to pursue action to recover costs from Boonton, under an Administrative Consent Order signed on 29 April 1986 with a $500,000 letter of credit from Marotta.

7) Decontamination actions--The consultant to Marotta has recommended that 30 wells of 6 inch diameter be used to recovery contaminated water, with aquifer tests to determine the required level of flow.

8) Continuing investigations--The NJDEP continues to work with Marotta toward a remediation program.

TOWACO VALLEY SUBREGION
MINOR CONTAMINATION CASES

I161 PENICK CORPORATION, MONTVILLE TWP 1979

1) Overview--On-site disposal of botanical and chemical wastes in a lagoon and landfill resulted in ground water contamination. Penick ceased operations at the site in 1978 and a ground water study was conducted by a consultant in 1979. Some waste material was removed at that time. Additional overburden and bedrock monitor wells were installed in May, 1982. Case inactive.
2) Location of the contaminated site--The Penick site is located on Crooked Brook in Montville Township, north of Interstate 287 and south of Lake Valhalla, on Taylortown Road.
3) Severity of contamination--Monitor wells samples from downgradient of the facility had high levels of phenols, total organic compounds and conductivity. The phenols constituted the primary concern.
4) Extent of contamination/Ground water flow--There were two waste disposal sites, a lagoon and a drum burial area. Most but not all of the drums were removed in 1974. The phenols emanated from drums and plastic bags which had broken. The lagoon had been pumped out but the sludges remained as of 1979. The site is 10 to 21 feet of glacial outwash over bedrock in the vicinity of the Ramapo Fault. The ground water flow is toward Crooked Brook. Samples from the brook showed no water quality effects. Monitor wells showed significant levels of phenols (37.5 mg/L, compared to water quality standards of 2.0 mg/L maximum) but no volatile organic chemicals. Tests from a monitor well in a development across Crooked Brook showed low levels of PCE and TCE, which NJDEP believes are not from migration under the brook.
5) Suspected and confirmed sources--The lagoon and drum burial areas were the two confirmed sources. No additional sources are suspected.
6) Mitigation actions--111 drums were repacked and 200 tons of soil were shipped off-site.
7) Decontamination actions--As phenols will biodegrade, the NJDEP agreed to a self-monitoring program.
8) Continuing investigations--The NJDEP visited the site in late 1982 and found some drums and wastes still on the site, and suggested that the NJDEP-Division of Waste Management require deed restrictions prior to a sale of the property by Penick. ECRA action is anticipated. A NJPDES-GW permit may required in the old lagoon area for further ground water monitoring.

NORTHWEST ESSEX SUBREGION
MAJOR CONTAMINATION CASES

I37 FAIRFIELD TOWNSHIP REGIONAL CONTAMINATION April 1976

1) Overview--Two public wells and many private wells closed due to high levels of volatile organic chemicals. Two local firms, Caldwell Trucking and General Hose, have been required to install monitor wells. Several other firms are under investigation. The contamination is regional, covering an extensive area of eastern Fairfield Township, and is a National Priority List site under Superfund with an ongoing Superfund investigation in addition to a NJDEP investigation.
2) Location of the contaminated site--The contaminated areas are between the North Caldwell boundary with Fairfield and Route 46, from near the western end of the Caldwell Wright Airport northeast to the Passaic River.
3) Severity of contamination--Total VOC levels of 9 ppm or greater are common in private wells within the contaminated area. VOC levels at Caldwell Trucking have been as high as 580 ppm, highest in the area. Fairfield Well 7 has had a maximum VOC level of 670 ppb, while Well 2 is less severely affected, with a maximum of 200 ppb (TCE and 1,1,1 TCEA). Other contaminants within the plume include carbon tetrachloride, PCE, 1,2 dichloroethane and methylene chloride. Well 7 and the major plume contain carbon tetrachloride while Well 2 does not.
4) Extent of contamination/Ground water flow--The total contaminated area exceeds one square mile. The contamination of Fairfield Wells 2 and 7 are apparently unrelated to each other, at least to the extent of the carbon tetrachloride contamination. Over 20 private wells were found to be contaminated with levels up to 21 ppm of VOCs. Neither Well 7 nor 2 are located within the most extensively contaminated area, but rather are upgradient of the site. The major plume (over 10 ppm) is approximately 1250 feet wide and 4000 feet long. Wells north of Route 46 and west of Well 7 show VOC levels less than 21 ppb.

Ground water flow in the entire area is toward the Passaic River along a northeast gradient. The geology of the area consists of bedrock sloping down toward the northwest from the Caldwells, overlying shale. Glacial sediments up to 150 feet deep consist of a thick layer of low permeability deposits over a layer of stratified drift. Percolation of contaminants from the surface to the deep glacial and shale aquifers is expected to be slow except under pumping conditions.

Samples from Deepavaal Brook in the northern area of the site have revealed VOC levels 10 to 100 times above background, primarily TCE with chloroform, 1,1,1 trichloroethane, carbon tetrachloride and PCE. The TCE levels are normally 40 to 60 ppb with peaks of 130 to 165 ppb.
5) Suspected and confirmed sources--Caldwell Trucking and General Hose are known contaminant sources, and have been considered major sources since 1976 and 1981, respectively. General Hose also was a customer of Caldwell Trucking for several years. Well 7 is located upgradient of the Caldwell Trucking site, but during pumping conditions Caldwell Trucking is considered to contribute to the pollution. Caldwell Trucking may not be the only source. Well 2 has evidently been polluted

by separate sources. However, National Electric Coil has been identified as a major discharge source to ground water upgradient of both Well 7 and Well 2, with contaminants similar to both wells except for the carbon tetrachloride in Well 7. Investigations under development may determine whether National Electric Coil should be considered a contributor to the Well 7 or Well 2 contamination.

Fairfield installed sewers to much of the township in the late 1970's but has not sewered all areas. Prior to sewering, all industries and residences used septic systems or cesspools. Many of the industries use contaminants found in the ground water and may have discharged them to septic systems prior to installation of the sewers.

6) Mitigation actions--Fairfield Wells 7 and 2 were shut down in 1981 and 1982, respectively. Fairfield attempted to use Well 7 for golf course irrigation under a NJDEP permit in 1981, hoping that the level of contamination would reduce. Continued high levels led to discontinuation of the pumping. The contaminated private wells have been replaced with public water. Unimatic Corporation was directed to cease pumping contaminated water for cooling water, as this water was later discharged to a stream. The NJDEP will require a broad study from Fairfield Township if any new wells are proposed, to ensure that the contamination is not diverted to them.

7) Decontamination actions--None.

8) Continuing investigations--Fairfield Township hired a consultant in 1982 to assess the contamination and its effects on Fairfield's water supplies. The NJDEP is investigating potential contamination sources for both Fairfield wells. The NJDEP first investigated pollution in the area in 1976 and cited knowledge of contamination as early as 1974 when a water analysis cited foul odors "that would be considered foreign to potable waters" in certain private wells. The NJDEP investigation began in earnest in 1980. The Caldwell Trucking site is the subject of a Superfund investigation. Differences exist between the EPA (lead agency) and the NJDEP on the extent of the investigation, especially with regard to the contamination of Well 7 and its treatment. The RI/FS was released in draft form in June, 1986, for public review. Only the Caldwell Trucking plume was investigated. No conclusions were presented on the contamination of either Well 7 or Well 2. The National Electric Coil investigation is handled by the NJDEP, while the General Hose site is part of the Superfund enforcement case through USEPA.

I218 CALDWELL TRUCKING, FAIRFIELD TWP June 1982

1) Overview--Caldwell Trucking hauled septage waste to an unlined lagoon on their property. Monitor wells on-site show severe ground water contamination by organic chemicals. Caldwell Trucking has been ordered to clean up the site and initiate ground water remediation, but requested a hearing. The site is on the National Priority List for Superfund cleanup in connection with the contamination, and a Superfund investigation is in progress. Investigation continuing.

2) Location of the contaminated site--Passaic Avenue at O'Conner Drive. The site is 15 acres.

3) Severity of contamination--Sludge samples from the property contained high concentrations of TCE, 1,1,1 TCEA, PCBs, lead and chromium, up to ten times the levels in ground water. Ground water from the plume area

contains TCE to 36 ppm, methylene chloride to 13 ppm, trans-1,2 dichloroethylene to 12 ppm, 1,1,1 TCEA to 9.6 ppm, vinyl chloride to 4.9 ppm, chloroform to 4.4 ppm, PCE to 3 ppm, 1,1 dichloroethane to 1.1 ppm, and other chemicals. Acetone exists at levels up to 110 ppm. The plume is mobile. The chlorinated ethenes may degrade to vinyl chloride, a more toxic chemical which also exists in the plume.

Known or suspected carcinogens in the plume include benzene, 1,1,1 TCEA, chloroform, 1,1 dichloroethylene, methylene chloride, PCE, TCE, PCBs, arsenic, cadmium and nickel. The greatest health risks were from ingestion or domestic use of the water, including inhalation of volatilized compounds. However, this risk has been negated, as public water has been installed in the plume area.

In addition, Fairfield Well 7 was contaminated by similar VOCs up to 1632 ppb, considerably less than in the plume but well above potable levels. However, Well 7 also shows carbon tetrachloride, which is not found at Caldwell Trucking and in the plume. Surface water contamination has taken place also, with VOC levels in Deepavaal Brook ranging from 1000 to 2000 ppb.

4) Extent of contamination/Ground water flow--The site geology consists of basalt bedrock near the surface on the southeast corner of the site and sloping below the surface to the northwest to a depth of 50 to 75 feet. The overburden consists of sandy gravels and silty sands over sands and silty sands. To the west and northwest of the site, a clay aquitard lies over a sand and gravel aquifer. In addition to the glacial aquifer, a bedrock aquifer exists at between 150 and 230 feet below the surface (sloping at 10 degrees to the west) at a contact metamorphic zone between the basalt and a shale layer. The contact zone is highly fractured. Ground water flow in the bedrock is to the north-northeast under static conditions. The glacial aquifer flow is in the same direction under static conditions.

When Fairfield Well 7 (to the southwest) is pumped, the gradient in both aquifers shifts. The potential exists for flow to Well 7 from Caldwell Trucking in the glacial aquifer and possibly in the bedrock aquifer as well. Well 7 draws from the bedrock below the glacial aquifer. The bedrock and the glacial aquifer are hydraulically connected, possibly through vertical columnar jointing in the basalt which intersects both the bedrock aquifer and the glacial deposits but more likely through near vertical tectonic fractures. In static conditions the gradient is from the bedrock aquifer to the glacial aquifer, perhaps limiting contamination of the bedrock. However, the gradient reverses during the pumping of Well 7.

The contamination plume is 2500 feet wide and 4250 feet long, extending northeast from the site to the Passaic River. Well 7 is located to the southwest, upgradient of the site. Although all of the Well 7 contaminants but carbon tetrachloride are found in the plume from Caldwell Trucking, monitoring wells located in a straight line between the site and Well 7 remained clean during a pumping test of Well 7, except for one monitor well just upgradient of the site which became heavily contaminated during the pumping test. The results could be due to complex hydrogeology, or a different contamination source for Well 7.

5) Suspected and confirmed sources--Caldwell Trucking cleaned out septic systems, including industrial, and dumped the septage in unlined lagoons on their property from the 1940's until 1973. General Hose was one of the industries which Caldwell Trucking serviced. Sludge was periodically removed and disposed off site. Clarified lagoon water was

moved to a disposal lagoon for percolation. Caldwell Trucking has been pinpointed as a major source of pollution in the major plume. A 1982 industrial survey revealed that many industries used substances in the plume, but only Caldwell Trucking and General Hose were current sources. Other industries may have contributed prior to connection with the public sewer system. General Hose is considered a contributor to the major plume, but not at the same level as Caldwell Trucking.

The relationship between Caldwell Trucking and Fairfield Well 7 is less clear. Consultants to EPA contend that the contamination of Well 7 is likely the result of sources other than Caldwell Trucking. The NJDEP and EPA contend that the flow reversal from pumping Well 7 makes Caldwell Trucking a potential contributor, past or future, and that treatment of Well 7 is necessary. With the Well 7 major contaminants identical to those found in the soil and ground water of Caldwell Trucking (except for carbon tetrachloride), the possibility exists that both Caldwell Trucking and other sources contributed to the Well 7 contamination. The Superfund investigation has not pinpointed the sources of contamination for Well 7 nor the relative extent of General Hose' contribution to the main plume.

6) Mitigation actions--Fairfield has discontinued use of Well 7. Private wells have been replaced with public water though some private wells are used for nonpotable purposes and must be sealed.

7) Decontamination actions--Fairfield attempted to purge Well 7 through pumping to irrigation. Current knowledge that flow is induced from Caldwell Trucking by Well 7 makes purging impossible. Caldwell Trucking received an administrative order from the NJDEP in 1982, requiring that all discharges to the soil and ground water be ceased and that a plan for delineation of the plume and decontamination of the ground water be prepared.

8) Continuing investigations--A Superfund investigation with EPA as lead agency is underway. A draft remedial investigation is complete, which did not form any conclusions on the causative link between Fairfield Well 7 and the Caldwell Trucking site. EPA is considering whether to exclude the Well 7 contamination from the Caldwell Trucking study. Epidemiological studies of residents exposure to high levels of VOCs and other contaminants through private well use over significant periods are being considered.

I219 GENERAL HOSE, FAIRFIELD TWP June 1982

1) Overview--General Hose has leaked solvents into the ground and contaminated the soil. They have installed monitor wells at the request of NJDEP which confirmed severe ground water contamination. The site is adjacent to Caldwell Trucking, which is on the National Priority List for Superfund cleanup in connection with the contamination of Fairfield Township's Well 7. Investigation continuing.

2) Location of the contaminated site--Sherwood Lane off Passaic Avenue, northeast of and adjacent to the Caldwell Trucking site.

3) Severity of contamination--Monitor wells onsite show VOC contamination levels up to 43 ppm, including TCE, 1,1,1 TCEA, 1,2-dichloroethylene, chloroform, PCE and other chemicals (descending order).

4) Extent of contamination/Ground water flow--The site geology consists of glacial deposits to approximately 27 feet in depth and then weathered

basalt bedrock. Ground water flow is to the northwest on the site, apparently due to a ground water mound. The regional flow is northeast.
5) Suspected and confirmed sources--A highly contaminated well at a nearby industry led to NJDEP investigations. General Hose had leaking waste storage tanks on the east side of its building (with extremely high soil concentrations (581 ppm) of TCE, benzene, PCE, 1,1,1 TCEA, cymene and dichlorobenzene) and reportedly used a series of connected septic tanks for industrial wastewater disposal until 1980. General Hose used TCE and 1,1,1 TCEA. Spillage was found in the storage areas. The septic tanks revealed moderate (460 ppm total) levels of chloroform, TCE and 1,1,1 TCEA, which also were found in the water supply well. Consultants to EPA consider General Hose a possible contributor to the main plume.
6) Mitigation actions--NJDEP required the installation of monitor wells in 1981, and later served a penalty against General Hose along with an Administrative Consent Order. No mitigation actions have occurred.
7) Decontamination actions--None.
8) Continuing investigations--General Hose is part of the Superfund investigation on Caldwell Trucking.

I313 ESSEX FELLS WATER DEPARTMENT, ROSELAND 1984

1) Overview--Three wells of the Essex Fells Water Department have been closed due to contamination with TCE. Wells 10 and 12 are located in the western section of Roseland, while Well 8 is located in southwest Essex Fells. Industrial surveys around both sites have identified potential sources of contamination. Monitor wells have been installed by all potential contributors to the contamination. Several sources of ground water contamination have been confirmed. Investigation continuing.
2) Location of the contaminated site--Wells 10 and 12 are located south of Eagle Rock Avenue and east of Eisenhower Parkway in Roseland. Well 8 is located in southwest Essex Fells near Woodland Road.
3) Severity of contamination--The Essex Fells water system was delivering finished water with 30 to 50 ppb of VOCs, mostly TCE, in 1983 and part of 1984. When Wells 10 and 12 were taken off line, the levels dropped to less than 10 ppb. When Well 8 was taken off line, the levels dropped to 2.5 ppb. Of the 15 Essex Fells wells, 10 have no detectable levels of VOCs. Well 7 has had levels as high as 15 ppb, but dropped to less than 5 ppb in 1985. Well 8 ranged from undetectable levels to 38 ppb from 1983 to 1985 over several cycles, and was at 59 ppb when shut down in early 1986. Well 10 had over 110 ppb when shut down late in 1983, but 5 to 15 ppb later. Well 12 had 300 to 350 ppb when shut down in October of 1983, dropping to approximately 150 ppb in 1984 and 90 ppb in 1985.
4) Extent of contamination/Ground water flow--There are two distinct contamination areas. One is in the area of Well 8 while the other includes Wells 10 and 12. The site geology consists of glacial deposits of up to 50 feet in depth over shale bedrock. Each of the three wells draws from the shale. Ground water flow is approximately northwest in the Well 10 and 12 area.
5) Suspected and confirmed sources--A pumping test of Well 12 was conducted in late 1985 to test the effectiveness of a water treatment

unit. Simultaneously, monitor well records were taken to determine the radius of influence for each potential source of contamination. The potential sources include Ketcham & McDougall, Tri-County Asphalt, PSE&G, Allied (Amphenol Products Co.), Merrick Corporation and Intedge. PSE&G has been eliminated as a contributing source, as may others as further data are developed. (See site descriptions for each firm.)

To date, the only industry identified as a potential contributor to the Well 8 contamination is Resistoflex Corporation, which has severe soil contamination near its abandoned septic system. The investigation has not proceeded sufficiently to confirm Resistoflex as a source or as the only source.

6) Mitigation actions--All three wells were shut down and none are pumping to waste or treatment. Each of the industries identified as potential sources have conducted site investigations and short-term cleanup operations to minimize ground water contamination. More extensive cleanups will be required at some sites. Essex Fells Water Department intends to install a water treatment unit for Wells 10 and 12. Funding is expected to come from the NJ Spill Fund or corporations which accept responsibility for contributing to the contamination.

7) Decontamination actions--None.

8) Continuing investigations--Investigations and cleanup plans are in process at several sites.

I344 MCGRAW-EDISON/NATIONAL ELECTRIC COIL, WEST CALDWELL

1) Overview--National Electric Coil refurbishes used electric motors, using solvent sprays for equipment cleaning. Waste solvents were at one time discharged to septic systems creating high levels of soil and ground water contamination. The site is upgradient of Fairfield Wells 2 and 7 and may be a contributor to the contamination of those wells. Investigation continuing.

2) Location of the contaminated site--7 Fairfield Crescent Road, near the Caldwell Wright Airport.

3) Severity of contamination--Monitor wells indicate ground water contamination with TCE to 6300 ppb, PCE to 3300 ppb, chloroform and trans-1,2 dichloroethylene to 1100 ppb each, 1,1,1 TCEA to 1000 ppb, and other VOCS from 100 to 200 ppb. 1986 results reportedly indicate even higher contamination levels.

4) Extent of contamination/Ground water flow--The site geology consists of 80 feet of stratified glacial deposits over the shale bedrock. The regional ground water flow is northeast toward the Passaic River. Fairfield Well 7 is less than 3000 feet northeast of the site, while Fairfield Well 2 is less than 1 mile north of the site. Both wells exhibit contamination with similar substances as found on the National Electric Coil (NEC) site. The consultant to NEC contended that the site may be on a ground water divide and that the site has a low permeability, both of which would limit the contribution of the site to regional contamination, but recent investigations indicate a definite northeast ground water flow.

5) Suspected and confirmed sources--NEC disassembles old electrical motors, cleans them, rewinds the coils and reassembles. The cleaning involves high pressure soap cleaning and then use of solvent if soap is insufficient. The solvents used are 30 per cent TCE and 68 per cent PCE

mixed with mineral spirits. Until recently, NEC used a septic system. Up to 10,000 gallons of waste solvent were disposed of in the system. The septic system contained TCE, PCE, mineral spirits, 1,1 dichloroethane, 1,1,1 TCEA, toluene and ethyl benzene. Pit sampling revealed vinyl chloride to 136 ppm, methylene chloride to 4.9 ppm, TCE to 18.4 ppm, PCE to 52 ppm, trans-1,2 dichloroethylene to 58.9 ppm, 1,1,1 TCEA to 43.4 ppm, toluene to 2.3 ppm and petroleum hydrocarbons to 3000 ppm. The downgradient monitor wells have an almost total correlation with the contaminants in Fairfield Wells 2 and 7. Soil contamination is confined to the site but vertical contamination has not been defined.

6) Mitigation actions--NEC attempted to remove contaminated soil from near the septic systems but failed due to high ground water in the pit. The two septic disposal basin were removed and waste discharges halted.

7) Decontamination actions--None to date, but action planned.

8) Continuing investigations--NEC instituted a sampling plan in 1985 based on NJDEP approval. The plan defined the soil contamination but not the ground water regime or aquifer contamination. The possibility exists that pumping from Fairfield Wells 2 and 7 could induce the migration of pollutants from the NEC site to the wells. Further data will be developed by NEC along with immediate development of a recovery well as a short-term remedial action. Eight additional overburden monitor wells were installed in April 1986, for a total of twelve monitor wells on the site.

I348 KETCHAM & MCDOUGALL, ROSELAND

1) Overview--Elevated levels of TCE in the Essex Fells Water Department Wells 10 and 12 led the NJDEP to conduct an industrial survey in the surrounding area. Ketcham & McDougall was found to have discharged industrial effluent from its marine products manufacturing facility to unlined open pits. High levels of TCE were found in the area. The pits were closed and pumped. Investigations are attempting to determine the relative contribution of each suspect industry to the contamination. Monitor wells have been installed on this and other sites. Investigation continuing.

2) Location of the contaminated site--Ketcham & McDougall (K&M) is sited at 465 Eagle Rock Avenue in Roseland, southeast of Wells 10 and 12.

3) Severity of contamination--Essex Fells Wells 10 and 12 have TCE contamination of up to 190 ppb. The regional extent of the pollution is not known.

4) Extent of contamination/Ground water flow--The site geology consists of bedrock up to 80 feet below the surface, under unstratified glacial deposits, clays and stratified sand and gravel deposits. The aquifer in the shale bedrock follows bedding planes (which dip to the northwest) and fractures. The Essex Fells bedrock wells (Wells 10 and 12) were artesian when drilled but are now significantly lower. The overlying glacial deposits are a principal recharge source through leakage in the fractures. Well 10 has only 30 feet of glacial overburden, while the depth to bedrock at the K&M site is 80 feet. The glacial deposits at Essex Fells Well 11 and K&M (very close together) are relatively permeable, while the deposits at Wells 10 and 12 have more clay and silt. Regional ground water flow under static conditions is north-

northwest toward Foulertons Brook and Hatfield Swamp. The flow from the K&M site is therefor perpendicular to the direction to Wells 10 and 12. However, it is believed that during pumping conditions Wells 10 and 12 draw water along the bedding planes and divert the normal plume. Well 10 and 12 both exhibit contamination trends which support the theory of a diverted plume. Contamination levels are lower after extended rest periods, but climb rapidly in Well 12 after prolonged pumping and less rapidly in Well 10.

The full extent of ground water contamination in the area is not known. However, K&M is cooperating with hydrogeologic studies at the site to determine the ground water regime and plume contours. A recent pumping test of Well 12 resulted in measurable drawdown at K&M.

5) Suspected and confirmed sources--K&M is located approximately 400 feet from the Wells 10 and 12 and is considered a likely source. K&M is considered a confirmed source of pollution generally, but may not be the only contributor. Other potential sources are discussed under I-313.

K&M maintained two large seepage pits, one inside the building and one outside, which were connected and used for cooling water and waste TCE. TCE discharges had essentially ceased by 1984, but the NJDEP water sample indicated TCE levels of 400 ppm, 1,2-dichloroethylene of 70 ppm, and 1,1,1 TCEA of 1.5 ppm. Sludge samples showed TCE at 6.7 per cent, 0.5 per cent 1,2-dichloroethylene and 11,000 ppb of PCE. The discharge was halted in 1984. Later water samples from the pits showed markedly lower TCE levels with a high of 490 ppb.

6) Mitigation actions--K&M removed the sludges from the pits and ceased use of the discharge pits entirely.

7) Decontamination actions--None. Under an Administrative Consent Order of 1984, K&M would have agreed to pay for the remediation of ground water contamination for which it is proven responsible. The ACO was never signed.

8) Continuing investigations--Additional monitor wells were installed in early 1986 to further define the contamination plume.

I349 TRI-COUNTY ASPHALT, ROSELAND

1) Overview--Elevated levels of TCE in the Essex Fells Water Department Wells 10 and 12 led the NJDEP to conduct an industrial survey in the surrounding area. Investigations are attempting to determine the relative contribution of each suspect industry to the contamination. Monitor wells have been installed on this and other sites. Investigation continuing.

2) Location of the contaminated site--Eisenhower Parkway south of Eagle Rock Avenue and Essex Fells Wells 10 and 12.

3) Severity of contamination--High levels of petroleum hydrocarbons (up to 5.8 per cent of the soil samples) with attendant ethylbenzene, toluene and methylene chloride contamination (up to 1500 ppb total VOC), were found on site. No VOCs were found in the 212 foot deep well onsite.

4) Extent of contamination/Ground water flow--The petroleum hydrocarbon contamination affected several areas of the site, including gravel packing around a Livingston sewer line. The possibility of ground water contamination which has not reached the deep well has not been explored. The site geology consists of bedrock very near the surface to 28 feet

below grade. Ground water flow patterns are not known.
5) Suspected and confirmed sources--An oil rack area, eight underground storage tanks, and the gravel packing around the trunk sewer line were suspected contaminated areas. All were either operated by or affected by Tri-County Asphalt. The benzene and toluene derive from the oil, while the methylene chloride may be a breakdown product from the VOC used to test asphalt.
6) Mitigation actions--Tri-County removed two underground storage tanks and the contaminated soil from the oil rack area.
7) Decontamination actions--Contamination soil removal.
8) Continuing investigations--Ground water investigations have not begun for this site but Tri-County has agreed to install two bedrock wells.

I352 INTEDGE, ROSELAND

1) Overview--Elevated levels of TCE in the Essex Fells Water Department Wells 10 and 12 led the NJDEP to conduct an industrial survey in the surrounding area. Investigations are attempting to determine the relative contribution of each suspect industry to the contamination. Monitor wells have been installed on this and other sites. Investigation continuing.
2) Location of the contaminated site--565 Eagle Rock Avenue near Eisenhower Parkway.
3) Severity of contamination--Liquid samples from a seepage pit on the east side of the facility showed a wide variety of benzenes and VOCs, with a total VOC level of 83 ppm. Included were carbon tetrachloride at 14 ppm, chlorobenzene at 9 ppm, TCE at 8 ppm, etc.
4) Extent of contamination/Ground water flow--The contribution of Intedge, if any, to the regional ground water contamination is not known. Site geology information has not been developed, but may be inferred as similar to the surrounding area with glacial deposits lying over a shale bedrock.
5) Suspected and confirmed sources--Intedge had a floor drain near its oil and solvent (1,1,1 TCEA) storage to the seepage pit.
6) Mitigation actions--Intedge removed the liquid and sludge contents of the seepage pit in 1985 under NJDEP order.
7) Decontamination actions--None.
8) Continuing investigations--There is no record of monitor wells being required or installed. Investigation continues.

I365 RESISTOFLEX, ROSELAND

1) Overview--The TCE contamination of Essex Fells Well 8 led to a NJDEP industrial survey of the area. Resistoflex Company, Division of Unidynamics Corporation, was found to have soil contamination due to spillage and an abandoned septic system. Hydrogeologic studies have been required and are in progress. Investigation continues.
2) Location of the contaminated site--Woodland Road and Steel Court in Roseland.
3) Severity of contamination--Essex Fells Well 8 exhibited up to 105 ppb of TCE prior to being shut down. The Resistoflex well (305 feet deep)

showed 8 ppb each of TCE and PCE. Soil samples revealed total VOC levels of up to 120 ppm, with high levels of benzene, toluene, TCE, 1,1,1 TCEA, and 1,2 dichloroethylene. Water from the septic system revealed total VOC levels of up to 17.5 ppm, most of which was 1,2 dichloroethylene. Sludge from the septic system had total VOCs up to 750 ppm with 480 ppm of TCE.

4) Extent of contamination/Ground water flow--There are six Essex Fells wells within 1500 feet of the site. The site geology and ground water flow patterns have not been defined, nor have the horizontal or vertical extent of any contamination.

5) Suspected and confirmed sources--The septic system was in use from 1956 to 1960, at which point a connection with the public sewer system was made for sanitary wastes and the process wastewater was treated and released to surface waters. Site inspections revealed that Resistoflex uses large quantities of TCE. A 2000 gallon aboveground storage tank and 55 gallon drums had overfilling spills and no secondary containment. Cutting oils were directed to an underground tank with frequent overflows. NJDEP concluded that Resistoflex may have contributed to the Well 8 contamination. In the meantime, Unidynamics was merged with Crane Company, triggering ECRA site investigation and cleanup criteria.

6) Mitigation actions--Resistoflex sealed drains, cleaned up spill areas and sludges, removed the waste oil underground storage tank and improved its containers for non-waste chemicals.

7) Decontamination actions--Crane Company and Resistoflex cosigned a $1 million bond to guarantee cleanup of the site.

8) Continuing investigations--A sampling plan was approved by the ECRA program in early 1986, with the condition that cleanup occur if the investigation shows that ground water contamination is linked to Resistoflex. A hydrogeologic investigation commenced at Resistoflex in July, 1986.

NORTHWEST ESSEX SUBREGION
MINOR CONTAMINATION CASES

I350 PUBLIC SERVICE ELECTRIC & GAS, ROSELAND

1) Overview--Elevated levels of TCE in the Essex Fells Water Department Wells 10 and 12 led the NJDEP to conduct an industrial survey in the surrounding area. Investigations are attempting to determine the relative contribution of each suspect industry to the contamination. Monitor wells have been installed on this and other sites. The PSE&G site apparently has not contributed to ground water contamination. Investigation to be closed.
2) Location of the contaminated site--Eisenhower Parkway, south of Eagle Rock Avenue and near the Passaic River.
3) Severity of contamination--Soil contamination resulted due to an oil spill from a 120,000 gallon tank without secondary containment.
4) Extent of contamination/Ground water flow--The site geology consists of glacial till and clays with some glacial outwash near the surface, all of a relatively low permeability. Bedrock is 30 to 35 feet below the surface. The ground water flow is northwest toward the Passaic River and away from Essex Fells Well 12 (1500 feet east). Chlorinated ethanes or ethenes, benzene or toluene were found in surficial soils. All monitor well results were "none detected."
5) Suspected and confirmed sources--The oil spill was confirmed as coming from the PSE&G tank. There is no reason to believe that PSE&G is connected with the regional contamination problem.
6) Mitigation actions--PSE&G installed secondary containment around the tank to prevent future soil contamination in the event of spillage.
7) Decontamination actions--The contaminated soils were removed.
8) Continuing investigations--Case closed February, 1986.

I351 ALLIED-AMPHENOL, ROSELAND

1) Overview--Elevated levels of TCE in the Essex Fells Water Department Wells 10 and 12 led the NJDEP to conduct an industrial survey in the surrounding area. Contaminated soils and ground water contamination were found on this site. Investigations are attempting to determine the relative contribution of each suspect industry to the contamination. Monitor wells have been installed on this and other sites. Investigation continuing.
2) Location of the contaminated site--Southwest quadrant of the Eagle Rock Avenue and Eisenhower Parkway intersection.
3) Severity of contamination--Ground water contamination in the monitor wells exists at low levels. Soil samples were highly contaminated with PCE, ethylbenzene, methylene chloride and toluene, up to 23 ppm.
4) Extent of contamination/Ground water flow--The site geology consists of glacial till from the surface to 13 to 28 feet in depth, stratified glacial deposits of 5 to 16 feet thick, and then weathered and competent bedrock. A shallow water table aquifer and a deep aquifer (flowing

artesian) exist. Ground water flow is to the northwest (away from Essex Fells Wells 10 and 12) with a very slow velocity.

The extent of Amphenol's contribution to the regional ground water contamination is under investigation. Consultants to Amphenol indicate that no TCE (the pollutant in the Essex Fells wells) has been used or found at Amphenol. Natural ground water flow is apparently northwest toward the Passaic River, but pumping from the Essex Fells Wells 10 and 12 are suspected to influence local flow patterns. Amphenol's consultant estimated that the site would not be affected but awaited further data from pumping tests. In addition, the hydraulic upwelling at the site is suspected to have limited downward migration of the soil contaminants.

5) Suspected and confirmed sources--Amphenol manufactures precision plastic products. Amphenol maintained a mineral spirits underground storage tank on site. Overfilling and spillage of the tank led to some contamination. In addition, the tank has been used for storing liquid hazardous wastes without a RCRA permit.

6) Mitigation actions--NJDEP required that Amphenol end use of the underground tank for storing liquid hazardous wastes, in compliance with federal and state law, and prepare a closure plan. The tank was removed by Amphenol in May, 1986. In addition, Amphenol will take part in a pump test to determine whether ground water may flow to the Essex Fells wells.

7) Decontamination actions--NJDEP files did not indicate that soil removal, ground water containment or treatment has occurred as of early 1986.

8) Continuing investigations--The Amphenol site is being investigated on its own merits and as a possible contributor to the regional contamination. Allied-Signal Corporation has posted a letter of credit for $1 million toward ensuring the cleanup of the site, as part of a $19 million agreement through ECRA for Allied properties in New Jersey.

I364 MERRICK CORP, ROSELAND

1) Overview--Elevated levels of TCE in the Essex Fells Water Department Wells 10 and 12 led the NJDEP to conduct an industrial survey in the surrounding area. Investigations are attempting to determine the relative contribution of each suspect industry to the contamination. Monitor wells have been installed on this and other sites. Investigation continuing.

2) Location of the contaminated site--Merrick Drive in Roseland, near the Ketcham & McDougall facility, 1000 feet upgradient of Essex Fells Well 11.

3) Severity of contamination--Well 11 is contaminated with TCE to a lesser extent than Wells 10 and 12.

4) Extent of contamination/Ground water flow--The site geology is not fully known. Consultants to Merrick indicate that the site is mapped as glacial moraine but that the Ketcham & McDougall site has permeable sand and gravel and a former gravel pit exists near the Merrick site. The bedrock is basalt over shale. Ground water flow is assumed to be toward the north. The extent of contamination is not known.

5) Suspected and confirmed sources--Merrick Corporation occupied the site since 1980. Prior to that time, Babcock & Wilcox owned the site

from 1970 to 1980, and Walter J. Kidde Corporation prior to 1970. Under a proposed ECRA sampling plan, the existence of an abandoned underground storage tank was noted. In addition, a former septic field existed on or near the site, but may have been demolished for a townhouse project. Due to the regional TCE contamination, the NJDEP has asked for ground water investigations.
6) Mitigation actions--None required unless contamination confirmed.
7) Decontamination actions--None required.
8) Continuing investigations--The ECRA analysis began in 1986. Four overburden monitor wells were installed in April, 1986.

ECRA #85-603 PANELGRAPHIC CORPORATION, WEST CALDWELL 1985

1) Overview--An ECRA evaluation was triggered by the purchase of the corporation. Some evidence of pesticides (the area had been a golf course), thallium and VOCs were identified. The VOCs may derive from a drum storage area. The investigation is continuing to verify the nature and extent of any contamination.
2) Location of the contaminated site--10 Henderson Drive in the West Essex Industrial Park.
3) Severity of contamination--Ground water at the site included chloroform at 40 ppb, methylene chloride at 23 ppb, 1,2-trans dichloroethylene at 12 ppb, with the total VOC level less than 100 ppb.
4) Extent of contamination/Ground water flow--Not determined.
5) Suspected and confirmed sources--Panelgraphic produces plastic optical filters and lenses. The site includes a drum storage area with spillage noted, a former storage area with some spillage, and a floor drain which experienced miscellaneous discharges. None of the compounds found in the ground water are known to have been used at the site. However, low levels of VOCs were found in the soils and may have percolated. The site was once a golf course, which could explain the existence of pesticides. The geology of the site consists of glacial overburden.
6) Mitigation actions--None.
7) Decontamination actions--None.
8) Continuing investigations--Mitigation and decontamination await the results of further testing and an analysis of need.

WHIPPANY-LOWER ROCKAWAY RIVERS SUBREGION
MAJOR CONTAMINATION CASES

L47 SHARKEY FARMS LANDFILL, PARSIPPANY 1984

1) Overview--The Sharkey Farms Landfills began operation as a landfill in 1945 and closed in 1972. In 1977 part of the landfill was relocated to make room for the Parsippany-Troy Hills Sewage Treatment Plant. The landfill is allegedly the disposal site for hazardous waste from Ciba-Geigy from 1962-1968, and also for midnight dumping. A Superfund investigation is underway at the site to determine the location, extent and remediation options for the site. Investigation continues.
2) Location of the contaminated site--Edwards Road and Interstate 280 on the Whippany and Rockaway Rivers in Parsippany-Troy Hills.
3) Severity of contamination--Samples taken in 1977 showed 10 to 15 ppm organic chemicals in the leachate, considered consistent with non-chemical landfills. 1985 surface water samples indicated no significant VOCs, low level of phenols (a possible concern if chlorinated at the Passaic Valley Water Commission treatment facility), cadmium and mercury as being contributed by the landfill site. No priority pollutants were found in the surface or leachate water in significant quantities. As part of a Superfund RI/FS, 26 monitoring wells were installed and sampled.
4) Extent of contamination/Ground water flow--Monitor wells were not required for the closure of Sharkey Landfill in 1973, though they were considered. Nor were wells required when the landfill's South Fill was moved to the North Fill area in 1977, because the toxicity of landfills was known and therefor contamination was assumed. Analysis of the excavated wastes did take place continuously.

The site geology includes two aquifers of sand with a clay aquitard of 20 to 40 feet thick between them. The lower aquifer is artesian. The clay aquitard is fairly impermeable to the flow of water. The bedrock slopes from a depth of 30 feet below grade north of the site to 140 feet below grade at the southern end of the landfill area. The bedrock slopes from northeast down toward the southwest. The RI/FS investigation revealed a possible buried valley channel under the site. The RI/FS investigations identified at least one possible ground water contamination plume, extending east of the southern side of North Fill at least 100 feet beyond the pool near the fill. Contamination was not confirmed by analysis. The direction of ground water flow in the upper aquifer is in all directions from mounded ground water beneath the landfills. The gradient of the confined aquifer is essentially flat. The RI/FS concluded that benzene and TCE were present in the water table aquifer in levels exceeding the recommended drinking water levels. Benzene was also found to exceed potable levels in one well placed into the confined aquifer but had not migrated off-site.
5) Suspected and confirmed sources--Ciba-Geigy solid wastes are reported to include toluene (560,000 pounds), benzene (130,000 pounds), chloroform (40,000 pounds), methylene chloride (20,000 pounds) and dichloroethylene (3,000 pounds). It has also been reported but not verified that three million gallons of unknown quality wastewater was

taken to "Sharkeys Disposal-Pinebrook" from Koppers Chemical Company in Kearny, nor is the location definitely the same.
6) Mitigation and decontamination actions--Mitigation and decontamination await completion of the Superfund studies and funding.
8) Continuing investigations--The Superfund Remedial Investigation/ Feasibility Study was released in 1986. The study was delayed at least one year by the lack of a certified laboratory for sample analysis and conflicts over the ground water monitoring program. The RI/FS recommended capping of the landfills and continued ground water monitoring. Further sampling by the NJDEP is occurring.

D-15 CHAMPION INTERNATIONAL, MORRIS TOWNSHIP 1978, 1985

1) Overview--In 1978, 10,000 gallons of ink and solvents were dumped or spilled on the property between the buildings and a creek in the back (west of the buildings). 330 cubic yards of soil were removed and an impermeable cap installed which must be maintained. In 1985, Champion International notified the NJDEP that a drywell accepting floor drain discharges from the hazardous materials storage area was found to contain pooled solvents and other hazardous materials. A nearby monitor well showed high VOC levels. Soils were also contaminated. The facility, Dairypak, produced milk cartons and used solvents and inks for printing.
2) Location of the contaminated site-East Hanover Avenue in Morris Township near Hanover Township.
3) Severity of contamination--Monitor well contamination near the dry well exceeds 18,000 ppb VOCs. Soil samples show toluene over 100 ppm, ethyl acetate over 500 ppm, ethanol over 40 ppm, and methanol over 75 ppm.
4) Extent of contamination/Ground water flow--The site is underlain by glacial overburden. Depth to bedrock is probably more than 150 feet. The drywell, which was used for more than 20 years, appears to be in a glacial clay layer which extends to 9 feet below grade under most of the site. Below the clay, the glacial material grades to a coarse sand and gravel. to 15 feet with the clay lense. Shallow ground water flow is southwest toward the stream, which is significantly lower in elevation than the facility. The ground water is unconfined with a water table at 38 to 40 feet below grade. Champion's consultant considers the permeability low. Soil contamination extends from 5 to 35 feet below grade near the drywell. There are several major wells within 1/2 mile, but none were affected by the contamination, which has a limited plume.
5) Suspected and confirmed sources--The Dairypak facility is the confirmed source.
6) Mitigation actions--The drywell was removed.
7) Decontamination actions--Remedial actions await completion of the investigation. Results of sampling in December, 1985, and June, 1986, indicated non-detectable levels of contaminants.
8) Continuing investigations--The investigation continues.

ECRA 85-17 VAN DYK RESEARCH, HANOVER 1985

1) Overview--This site contained two underground tanks, three underground settling tanks, a leaching pit for the septic system, a former septic leaching field, a former cadmium sulfate waste pile and former U.S. Radium effluent lagoons. A radioactive hotspot has been identified along with some VOC contamination and a plume from the larger underground storage tank. The adjacent site is Apollo Technologies, formerly the site of Allied Chemical-Plastics Division, which has contamination from two successive tank farms and from contamination emanating from the Van Dyk site. The Apollo site included a drum storage area, septic tank and seepage pit in addition to the tank farm.
2) Location of the contaminated site--Jefferson Road, 1/2 mile south of Route 10.
3) Severity of contamination--Sludge samples from the lagoons show the presence of methylene chloride, benzene, and other VOCs. Ground water samples at Van Dyk show no VOCs but some isophorone. Soil samples from Van Dyk have Radium in excess of EPA cleanup standards. The 10,000 gallon underground tank has caused contamination. The waste pile contains heavy metals including cadmium, lead and zinc. The Apollo site indicates a migration of the Van Dyk (U.S. Radium) radiation to the Apollo site. In addition, Apollo monitor well samples reveal up to 163 ppb of VOCs (100 ppb 1,1 dichloroethane), while the tank farm catch basin has VOCs in excess of 6,300 ppb and soil near the tank farm contains 2 ppm of naphthalene.
4) Extent of contamination/Ground water flow--The site geology consists of ground morainal material to bedrock at 70 feet. Ground water flow is south toward the Whippany River. The closest public well is 1 mile northwest, upgradient of the site. There are abandoned wells on the Apollo site which could route contaminants to ground water (8 to 10 feet below grade) and to the bedrock aquifer.

The extent of the contamination on both sites is not known. Van Dyk is responsible for identifying and correcting contamination from its site through the ECRA process. Although Apollo Technologies closed prior to ECRA (in 1983), sale of the site will be contingent upon approval through the ECRA process.
5) Suspected and confirmed sources--The current and former owners are collectively the causes of contamination on the site.
6) Mitigation and decontamination actions--Van Dyk Laboratories is responsible for actions on its site. No actions have occurred to date. The tank farm on the Apollo site has been removed. A 6,000 gallon leaking fuel oil tank was also removed from the ground at the Apollo site, under the ECRA program.
8) Continuing investigations--Additional information will be provided by Van Dyk Laboratories through the required site analysis. Investigation continues.

ECRA #84-294 NORDA, INC., EAST HANOVER 1984

1) Overview--Norda, Inc. apparently reorganized into ADRON, Inc., triggering the ECRA site analysis and cleanup criteria. Nearby wells are contaminated with 1,1,1 TCEA. A large number of storage tanks exist on the site, along with several large drum burial sites. Removal of the drums is in process. Monitor wells indicate a contamination plume onsite. ECRA process continues.

2) Location of the contaminated site--140 Route 10.

3) Severity of contamination--Thermo-cision Molded Products, Inc. found levels of 1,1,1 TCEA rising through 1984 and 1985 from 60 to 200 ppb. The ground water contamination at Norda includes VOCs (tentatively identified compounds) totaling up to 5 ppm in one well, 1.8 ppm in another, and lower levels in the remainder. Chloroform, carbon tetrachloride and 1,2 dichloroethane were identified as being above the standards for potability.

4) Extent of contamination/Ground water flow--The site geology consists of a surface layer of 14 to 20 feet of clays and sandy clays, with sand and gravel deposits below that are coarser with depth. Bedrock is estimated to be 120 to 140 feet below the surface. A deep well for cooling water exists on site. The monitor wells are drilled to a less permeable strata located 40 to 70 feet below grade. The contamination plume extends south-southwest along the driveway toward Route 10. The full horizontal extent of contamination has not been established.

The drums are stacked three high on their sides in pits dug into the clay layer. Water from the test pits had 1.2 ppm of total VOCs and 1.3 ppm of phenols. The site had failed percolation tests in the past, and water in the test pits did not percolate, leading Norda's consultant to suggest that the clay layer served as a sufficient barrier to ground water contamination from the barrels. The water table is greater than 40 feet below the bottom of the drum cells.

5) Suspected and confirmed sources--The barrels are both intact and degraded, emanating a sweet odor. More than 3600 barrels were buried onsite. Six priority pollutants in the drum cell water (all at 115 ppb or less) are also detected by the monitor wells (TCE, xylene, methylene chloride, diethylphthalate, bis(2-ethylhexyl)phthalate, toluene). 11 others are in the soil and water but not in the ground water.

Integrity tests of the storage tanks indicated that all were tight.

6) Mitigation actions--The barrel removal program is in progress, with contaminated water and soil from the pits also being removed.

7) Decontamination actions--ADRON claims that the ground water pollution detected in the monitor wells is not from the site due to the clay layer serving as a barrier to contaminant movement. The contaminant plume on the property has not been addressed.

8) Continuing investigations--The ECRA process continues. A NJPDES-GW interim permit will be issued to Norda for on-going ground water monitoring.

ECRA #84-063 LYDO PRECISION PRODUCTS, MOUNTAIN LAKES 1984

1) Overview--The merger of Lydo Precision with another company led to an ECRA evaluation. Several areas of potential concern were identified, involving soil and ground water contamination. The site is upgradient of the Norda and Synthatron sites. Investigation continuing.
2) Location of the contaminated site--8 Morris Avenue, north of the Conrail line which forms the northern border of Norda and Synthatron.
3) Severity of contamination--Petroleum hydrocarbons and VOC contamination was found in all four monitor wells, up to 6 mg/l of petroleum hydrocarbons and 639 ppb of VOCs. The VOCs include 1,1,1 TCEA to 820 ppb, TCE to 215 ppb, PCE to 60 ppb, toluene to 271 ppb and trans-1,2 dichloroethylene to 109 ppb. Total chromium exceeds NJDEP standards. The septic system contained benzene at 910 ppb, methylene chloride at 1300 ppb, toluene at 1900 ppb and 1,1,1 TCEA at 6200 ppb. High copper levels were found in contaminated soils near the railroad line.
4) Extent of contamination/Ground water flow--The site geology consists of over 65 feet of glacial materials, approximately the top 50 feet of which is till, over bedrock. The water table ranges from 2 to 10 feet below the surface. Ground water flow is generally south.
5) Suspected and confirmed sources--A septic field on the site received industrial wastes. A drum storage area was periodically washed and the runoff went to a storm sewer which became contaminated with waste oils from the area, TCE (63 ppb) and 1,1,1, TCEA (502 ppb). An underground storage tank existed on site. Water based cutting oil wastes with metal chips were dumped by hand near the railroad bed. Lydo Precision uses cutting oils and 1,1,1 TCEA in its facility which manufactures precision medical parts. Other VOCs may derive from cleaning solvents.
6) Mitigation actions--The underground storage tank was removed.
7) Decontamination actions--None.
8) Continuing investigations--Additional ground water monitor wells will be installed to define the upgradient background levels and the extent of the contamination. Investigation continuing.

I28 ALLIED-SIGNAL CORPORATION December 1976

1) Overview--Two organic compounds, carbon tetrachloride and chloroform, were discovered in Allied's Well 2 in 1976. Consultants to Allied performed a site investigation, assessed off-site effects and developed a remedial program. NJDEP approved a program of pumpage to waste from one and, later, two supply wells on the site. Recovery pumping has occurred since 1977. The water is discharged to surface water under a NJDPES permit, reaching levels of less than 1 ppb at the point of discharge. Contamination levels, initially at 80 to 130 ppb, have declined slowly. Decontamination is continuing.
2) Location of the contaminated site--Allied Chemical Corporation (now Allied-Signal), is located on Columbia Turnpike in Morris Township near the Florham Park border. The contamination is hydraulically controlled on-site.
3) Severity of contamination--Initial levels of organic contamination were typically 80 to 130 ppb in Well 2. Carbon tetrachloride and chloroform are the primary substances of concern.

4) Extent of contamination/Ground water flow--The exact location of the contamination has not been determined, but it is believed to be near Well 2 and 10, the former installed in 1982 for the purpose of enhancing the pumping-to-waste program. Little or no contamination appears to have migrated off-site. Testing of wells nearby yielded results from several wells (Exxon, Fairleigh Dickinson University, Morris County Country Club) of greater than 1 ppb carbon tetrachloride. However, the Country Club well is not affected by Allied's well. The Allied facility is located on the northern side of the terminal moraine, which has discontinuous layers of till and stratified drift, the latter of which connects with the Chatham Valley Aquifer. Ground water flow on the site is west-northwest to east-southeast, toward Black Brook and the conjunction of the Chatham and East Hanover Valley Aquifers. The Borough of Madison discovered low level carbon tetrachloride contamination in its well field in 1986, but a connection with the Allied contamination has not been shown.
5) Suspected and confirmed sources--Allied has shipped its wastes off-site since 1962. A suspected cause of the contamination are very old spills. No drums were found. No cause was ever pinpointed.
6) Mitigation actions--Well 2 was pumped to waste both to create a hydraulic gradient keeping the contaminants on-site and to treat the ground water. Pumping started in 1977. In 1982 it was determined that a 1000 gpm diversion rate from Well 2 was needed to maintain an adequate hydraulic gradient, more than Well 2 could provide. Well 10 was drilled; it is located closer to the inferred source and is pumped simultaneous with Well 2 for a total discharge of 400 gpm. Well 10 effluent contains higher concentrations than Well 2, indicating that Well 10 is effectively intercepting the plume.
7) Decontamination actions--The pumping of Wells 2 and 10 serve to decontaminate the aquifer. Levels of contamination have slowly declined over the eight years of pumping. Levels reached 50 ppb total organics in late 1985. Pumping will continue, though NJDEP is concerned about the large withdrawal for nonpotable purposes, and Allied is evaluating alternate uses for the discharge. Allied-Signal is concerned, in turn, that additional withdrawals nearby will disturb the hydraulic gradient and perhaps allow off-site migration of the contaminants.
8) Continuing investigations--No further investigations are underway on site. A nearby proposed diversion is being assessed to ensure that no mobilization of on-site contaminants occurs if the diversion is approved.

I81 AIRTRON, MORRIS PLAINS 1977

1) Overview--Company discharged plating wastes to unlined lagoons. The sludge was found to contain high levels of TCE. The sludge was removed and the lagoons backfilled. Contamination of the underlying aquifer is believed to be more than local. Wells at Mennen Company, nearby, were contaminated by TCE. Airtron is investigating decontamination options. Investigation continuing.
2) Location of the contaminated site--Airtron, Division of Litton Industries, is on Hanover Avenue due north of the Mennen Company site.
3) Severity of contamination--Monitor wells at Airtron have TCE levels of 4.6 to 7.0 ppm. Mennen's wells have contamination levels of 1.3 ppm.

4) Extent of contamination/Ground water flow--The contamination extends from the Airtron site to the Mennen site and may be captured at that point by the Mennen wells. The area geology consists of 100 feet of poorly sorted glacial deposits over shale bedrock with water at 40 to 70 feet below the surface under leaky artesian conditions and a transmissivity of 5,610 gpd/ft. The upper (glacial) aquifer unit varies from 20 to 44 feet thick (the latter at Mennen). The ground water flow at the Airtron site is to the west-southwest, toward Mennen's wells which have a 8,500 foot radius of influence, but the regional flow is to the east-southeast.
5) Suspected and confirmed sources--Airtron is considered the source of the contamination. Airtron disposed of sludge in unlined lagoons on-site, but removed the sludge and installed monitor wells on NJDEP's order. Consultants to Airtron consider the contamination the result of a single incident, but the continued high levels of contamination and the lack of an identified incident make the theory unverified.
6) Mitigation actions--The sludge was removed from the unlined lagoons at Airtron.
7) Decontamination actions--At least some decontamination is provided by continued pumping of the Mennen wells, which Airtron claims has captured the contaminant plume. The claim must be proven by a hydrogeologic investigation.
8) Continuing investigations--Airtron must determine whether the full plume is captured by Mennen's pumping.

I152 ADRON (Formerly NORDA), BOONTON June 1981

1) Overview--This site is an old flavor and fragrance plant with underground storage, septic tanks and underground waste tanks. Chemical seepage at a sewer line construction site near Lake Intervale was noted in 1979, causing a NJDEP investigation. The NJDEP has monitored the company's compliance with its NJPDES-SW permit also. A consultants report was submitted in April, 1981. Based on subsequent work in the area, Norda agreed to install four monitor wells in spring, 1984. The four monitor wells have been sampled three times since June 1984. Investigation continuing.
2) Location of the contaminated site--Norda is 1000 feet north of Lake Intervale (Parsippany) by the railroad line along Morris Avenue at its junction with Fanny Road.
3) Severity of contamination--Contamination of a dewatering well used in construction of a sewer line was discovered in 1979. Contaminants included benzene (2000 ppb) and toluene (1390 ppb). Monitor well 3 at Norda had 52 ppb of 1,4 dichlorobenzene and trace contamination with other compounds in 1981. In 1984 monitor well 2 had 66 ppb of acetone and less than 10 ppb of 1,1,1 trichloroethane and chloroform. Monitor wells at Synthatron, adjacent and downgradient of Norda, indicate extensive organic compounds, with wells sampled at 41,000 ppb benzene, 137,000 isoproponol, 300,000 toluene and 325,000 acetone in 1983.
4) Extent of contamination/Ground water flow--Norda is located over thick glacial deposits, approximately 135 feet thick, consisting of fine sediments with lenses of coarse outwash and sand in the upper 70 feet which are permeable. The ground-water flow is southwest toward Lake Intervale. The contamination has affected the Norda and Synthatron

sites and the downgradient area to Lake Intervale. Although no private potable wells are nearby and the nearest public well is 1.5 miles, the connection of the glacial sediments with the aquifer tapped by the public wells has caused concern. The bedrock is Triassic sandstone. Norda's septic systems showed low-level contamination. Two monitor wells at Norda had no contamination, while Well 2 was contaminated. The highest levels of contamination in the area are apparently not on the Norda site as of the last sampling.
5) Suspected and confirmed sources--An electromagnetic conductivity survey by the NJDEP indicated lower conductivity values north (upgradient) of Norda and higher values to the south, indicating that the contamination at Synthatron has come from an upgradient site. Many of the compounds in the Synthatron Well 2 were stored in underground tanks at Norda (over 20 tanks were used for hexane, acetone, toluene, isopropol, methanol, fuel oil, etc.) or were found in septic systems at Norda. The NJDEP concluded in 1983 that all of the investigations indicate that Norda was likely to be the source of the majority of the ground-water contamination in the Lake Intervale area. Norda has suggested that spills at the railroad line, which is upgradient of Norda, could also be a source. Norda had three production wells, all of which showed some level of contamination, but the depth of the wells (minimum of 300 feet) minimized their value for assessing shallow contamination.
6) Mitigation actions--NJDEP recommended that the underground tanks at Norda be tested for leakage, that all non-domestic wastewater discharges to the septic systems be eliminated, and that a system of monitor wells be installed. Status of these actions is not known.
7) Decontamination actions--None as of 1985.
8) Continuing investigations--NJDEP has indicated that intensive investigations are necessary to precisely determine the sources and relative contributions to ground water contamination.

I162 ROYAL LUBRICANTS, EAST HANOVER October 1981

1) Overview--An unlined lagoon was found to contain organic chemicals which may be contaminating ground water. Septic tanks contained oil products during an investigation. Monitor wells have been installed and the investigation is continuing. The Royal Lubricants case is part of a larger investigation involving the industries of the Merry Lane area.
2) Location of the contaminated site--Royal Lubricants is located on Merry Lane, off of River Road near the Passaic River in East Hanover.
3) Severity of contamination--Septic tank samples indicated high levels of VOCs in 1982, including toluene (up to 1965 ppb), various benzene compounds (1780 ppb), methylene chloride (230 ppb) and naphthalene. Royal Lubricants tests of the septic systems indicated lower levels (e.g. toluene at 490 ppb). Samples from the lagoon taken by the NJDEP revealed very high levels of dibromochloromethane (38,000 ppb) and chloroform (1100 ppb), the latter of which was also found in monitor well 5 (at a maximum of 330 ppb). Four of the monitor wells also show high levels of 1,1,1 trichloroethane (maximum of 560 ppb).
4) Extent of contamination/Ground water flow--The lagoon has five feet of sand over approximately 25 feet of clay which limits percolation. The lagoon receives floor drain and stormwater effluent. Monitor wells

near and downgradient of the lagoon are not highly contaminated. Downgradient of the septic system seepage pits, high VOC levels are found. The flow of ground water is south-southeast, toward the Passaic River.
5) Suspected and confirmed sources--Most of the contamination appears to be derived from the septic system seepage pits, as the most contaminated monitor wells (5, 6, 7 and 8) are located near or downgradient of the seepage pits and not the lagoon. There may be contamination also from nearby industries, from their septic systems. The NJDEP also noted sloppy housekeeping practices on site which resulted in small spills.
6) Mitigation actions--Royal Lubricants installed 8 monitor wells under order from the NJDEP. The septic systems were pumped out, cleaned and tested. Non-domestic waste sources were disconnected from the septic systems. The NJDEP determined in 1983 that actions to discontinue waste discharges through the septic system appeared successful.
7) Decontamination actions--No decontamination activities existed as of early 1986.
8) Continuing investigations--The NJDEP has suggested a thorough hydrogeological investigation of the Merry Lane industries (Dorine Industrial Park, Weiss-Aug, Royal Lubricants) and recommended a joint undertaking by the affected industries.

I163 DORINE INDUSTRIAL PARK, EAST HANOVER July 1981

1) Overview--A household well in which water had turned green and had chemical taste from fluorescein dye, benzene, and 1,1 dichloroethane led the NJDEP to investigate Dorine Industrial Park. Several septic systems were sampled and found to contain volatile organic chemicals. NJDEP ordered that the septic systems be cleaned out. Monitor wells have been installed. The homeowner has been tied into the public water system.
2) Location of the contaminated site--Dorine Industrial Park is located on River Road and Merry Lane in East Hanover near the Passaic River.
3) Severity of contamination--Flourescein dye (nontoxic) was found in several private, residential wells. VOC analyses revealed contamination of the same wells with 1,1,1 TCEA, benzene, 1,2 dichloroethylene and 1,1 dichloroethane to a maximum of 163 ppb.
4) Extent of contamination/Ground water flow--The ground water flow is toward the Passaic River at the southeast. The line of flow extends through ChemServices to Weiss-Aug (both located in the industrial park) and beyond. The contamination is apparently distinct from the regional contamination near the Whippany River.
5) Suspected and confirmed sources--ChemServices' septic system contained VOCs of the same nature as the contamination. Other septic systems also existed at the industrial park. Contamination levels were as high as 1110 ppb of chloroform and total VOCs of 1500 ppb.
6) Mitigation actions--All septic systems were required to be pumped out and cleaned. ChemServices also sealed a discharge point, floor drains and a collection pit.
7) Decontamination actions--The NJDEP approved a remedial program for the flourescein dye from ChemServices in 1984.
8) Continuing investigations--This case is part of the overall East Hanover regional investigation.

I171 BOONTON ELECTRONICS, PARSIPPANY June 1982

1) Overview--Boonton Electronics dumped small quantities (approximately 2 gallons per day) of 1,1,1 trichloroethane on the ground and into a dry well behind their facility for over a decade until September 1978. NJDEP was alerted of this practice when Boonton Electronics reported it on an industrial survey. Three monitor wells were installed and sampled. Severe ground water contamination was confirmed. Additional monitor wells were installed to assess the contamination, but additional monitor wells are necessary to delineate the full vertical and horizontal extent of contamination. Investigation continuing.
2) Location of the contaminated site--499 Pomeroy Road off of Smith Road and Interstate 287.
3) Severity of contamination--Contamination in monitor wells at the site includes 1,1,1 TCEA from 1200 to 9800 ppb, 1,1 dichloroethylene to 1200 ppb, and 1,1 dichloroethane to 860 ppb. The worst areas have total VOC levels of 10,500 to 11,480 ppb.

In addition, Well 7 of the Parsippany-Troy Hills Water Department has been contaminated with low levels of VOCs such as TCE at 5.5 ppb, 4.0 ppb of trichlorofluoromethane and a bad odor. To date, this contamination of the lower aquifer has not been shown to have a connection with the Boonton Electronics contamination.
4) Extent of contamination/Ground water flow--The site geology consists of 100 to 150 feet of stratified glacial deposits with alternating layers of gravel, sand, silt and clay. The flow is in a southerly direction, with a slower flow with in 30 feet of the surface than at 30 to 80 feet below the surface, the upper aquifer. An aquifer exists at the 110 to 165 foot level. Public and industrial wells, including the Parsippany Well 7 at 0.5 miles south, draw from the deeper aquifer. The full extent of the contamination vertically and horizontally is not known.
5) Suspected and confirmed sources--Boonton Electronics Corporation dumped approximately 12,000 pounds of 1,1,1 TCEA at approximately 2 gallons per day. The waste derived from the cleaning of electronic parts in 1,1,1 TCEA solution. Used solvent was dumped in a fill area and a dry well. The remaining components are degradation products from the original wastes. The dumping occurred from the 1960's to the 1970's. Later housekeeping practices ended the dumping and Boonton Electronics manifested its waste to disposal firms. Operations ceased in 1983.
6) Mitigation actions--Dumping practices ceased.
7) Decontamination actions--The NJDEP has recommended that all contaminated soils be remediated, the dry well removed, and that decontamination of the aquifer take place. Consultants to Boonton Electronics recommended and instituted a recovery well, pumping to the sewage treatment facility in Parsippany. The site was intended for redevelopment. A water allocation permit hearing scheduled for early 1986 was postponed and finally pumping at 200 gpm was approved. Approval of the discharge to the sewer has also occurred. Remedial work has been at the risk of Boonton Electronics. Soils with more than 1 ppm VOCs must be dealt with.
8) Continuing investigations--NJDEP is requiring that the full horizontal and vertical extent of the contamination be identified and a

remedial plan developed to respond to the results, toward a goal of complete aquifer restoration.

I229 SYNTHATRON CORP., PARSIPPANY November 1981

1) Overview--In the past Synthatron produced arsine gas and was engaged in gas purification. Analysis of their basement sumps and septic tank showed VOCs. Synthatron had a ground water study prepared in 1982 in which 3 monitor wells were drilled and sampled. The ground water was found to be contaminated with VOCs and arsenic. NJDEP has requested Synthatron to install additional monitor wells to determine the extent of arsenic contamination. In addition, NJDEP is investigating upgradient industries (primarily Norda) as possible sources for the VOC pollution. Investigation continuing.
2) Location of the contaminated site--Synthatron and Norda are located south of Morris Avenue and west of Fanny Road in Parsippany-Troy Hills Township near the border with the Town of Boonton. Norda's property is north and east of Synthatron.
3) Severity of contamination--The NJDEP determined that elevated levels of arsenic, chlorides, sulfates, pH and total dissolved solids existed on the Synthatron property. VOC contamination is extremely high, with 22 VOCs above 100 ppb, 10 above 1000 ppb, and four above 40,000 ppb (benzene at 41,000 ppb, isopropanol at 137,000 ppb, toluene at 300,000 ppb and acetone at 325,000 ppb).
4) Extent of contamination/Ground water flow--The ground water flow is apparently from the northwest to the southeast, toward Lake Intervale. Some of Parsippany's public supply wells are 1.5 miles away, though no private supply wells exist in the area. The contamination in the area affects both the Synthatron and Norda properties at very high levels. The contaminant plume appears to be moving off site to the southeast. Total VOC contamination of Synthatron Well 2 in 1982 was 661,000 ppb.
5) Suspected and confirmed sources--There are several suspected sources. Synthatron handled chemicals which could cause the arsenic, chloride, sulfate, total dissolved solids and pH contamination. Synthatron had basement sumps tied to the septic system, receiving wastes from sinks, ground water seepage, etc. All of the VOCs registering the highest levels at Synthatron were found in the Norda septic system or were known to be stored in underground tanks at Norda, which is upgradient of Synthatron. In addition, a railroad siding is located upgradient of both sites and has been suggested as a possible source by consultants to both industries. In 1983, the NJDEP concluded that studies to that time "all indicate that Norda is almost certainly the source of the majority of ground water contamination in the Lake Intervale area."
6) Mitigation actions--None. Synthatron is closed, as the result of a court suit by Parsippany against the industry. Synthatron, which began operations in 1978, won a stay of shutdown but in 1982 was put on a timetable to close with the court holding the power to stop the sale of the property. Synthatron requested that Judge Stanton certify the property for sale in 1985.
7) Decontamination actions--None.
8) Continuing investigations--Consultants to Synthatron suggest that Norda and the railroad handled all of the materials which have been found on the Synthatron property, not just the VOCs, suggesting that

Synthatron is the victim of pollution passing through its property from upgradient. The NJDEP had decided in 1983 that Synthatron was unlikely a major source of the VOCs in its wells but that additional sampling and monitor wells are necessary to determine the extent of the for arsenic and the other non-VOC contaminants. The investigation continues.

I239 CHEMICAL COMPONENTS, EAST HANOVER May 1983

1) Overview--Contamination of private potable supply wells with volatile organic chemicals led to an investigation of disposal practices of area industries. Analysis of seepage pit contents indicated the presence of volatile organic chemicals. Buried hazardous chemical drums were removed from the site. Investigation continuing.
2) Location of the contaminated site--Chemical Components, Inc., is located on DeForest Avenue next to Triangle Industrial Park, just north of the Morristown and Erie Railroad.
3) Severity of contamination--Samples of the seepage pits showed methylene chloride (90 ppm), TCE, 1,2,3 trichlorobenzene, and benzene. 25 drums were found buried on the site with high levels of xylene. A filled lagoon used for wastewater prior to 1976 was found to have positive values for total organic chemicals and chemical oxygen demand. NJDEP characterizes the site as an immediate threat to ground water. A private well on DeForest Avenue was contaminated but with different chemicals than found at Chemical Components.
4) Extent of contamination/Ground water flow--The ground water has been contaminated with high levels of TCE, 1,1 dichloroethane and methylene chloride. The extent of Chemical Component's contribution to the regional pollution in East Hanover near Ridgedale and DeForest Avenues has not been determined.
5) Suspected and confirmed sources--Chemical Components manufactures and blends specialty chemicals. Aside from the drums and the lagoon, three seepage pits received non-domestic wastes from lab sinks and drains in the facility. The drains collect cooling water, which contained TCE.
6) Mitigation actions--The septic system contents were removed and sources of contamination to the septic systems eliminated. 25 buried drums were excavated and removed.
7) Decontamination actions--None.
8) Continuing investigations--The NJDEP has recommended that 7 shallow wells and 3 deep wells be installed and sampled along with 19 boreholes to determine the extent of contamination below the site.

I262 WEISS-AUG, EAST HANOVER March 1982

1) Overview--Analysis of septic effluent indicated the presence of VOCs. The source was traced to wash water directed to a sink. The source has been eliminated. Monitor wells have been installed. Investigation continuing.
2) Location of the contaminated site--Merry Lane, near the Passaic River, in an industrial zone.
3) Severity of contamination--Monitor wells have disclosed contamination with 1,2 dichloroethylene ranging from 120 ppb to 480 ppb, and 1,1,1

trichloroethane from 57 ppb to 210 ppb. Monitor Well 3 is least affected and apparently upgradient (north) of the contamination source.
4) Extent of contamination/Ground water flow--The flow of ground water is toward the Passaic River, to the south and southeast. The Weiss-Aug contamination is linked with other septic system contamination in the Merry Lane area at the Dorine Industrial Park.
5) Suspected and confirmed sources--Wash water discarded to a sink was identified as the cause of the septic system contamination. Over the broader area, several industrial septic systems have contaminated ground water to some extent.
6) Mitigation actions--The septic system contents were removed in 1982. Testing of septic wastes must verify the effectiveness.
7) Decontamination actions--None have been taken, pending a further investigation.
8) Continuing investigations--The NJDEP concluded in 1983 that Weiss-Aug, Dorine Industrial Park and Royal Lubricants all contributed to ground water contamination in the area and required further sampling by each to determine equitable, relative contributions to cleanup costs.

I298 BRONNER MANUFACTURING AND TOOL CO., EAST HANOVER February 1984

1) Overview--Citizen complaints of liquid discharges to the ground led to an investigation by the East Hanover Health Department. Samples of the discharge showed high levels of VOCs as well as petroleum hydrocarbons. Investigation continuing.
2) Location of the contaminated site--Ridgedale Avenue northwest of its intersection with the Morristown and Erie Railroad, and west of DeForest Avenue.
3) Severity of contamination--The East Hanover Health Department investigation termed the site an imminent health hazard, with existing contamination of several private wells. Many of East Hanover's 800 plus private wells are located between Bronner and the Whippany River. Well water samples indicated VOCs in excess of 1000 ppb, including 1727 ppb TCE in one well sample. An illegal discharge through a garden hose had methylene chloride, TCE, PCE, toluene, 1,1,1 trichloroethane, and 1,1,2 trichloroethane for a total VOC of over 28,000 ppb, plus petroleum hydrocarbons of 2600 ppb. The septic tank contained similar VOCs at over 6,400 ppb.
4) Extent of contamination/Ground water flow--Nearby private wells showed elevated levels of the same contaminants as found in the hose discharge and septic tank. Two wells were closed. The total extent of the contamination is not known. The surficial deposits at the site include fine to coarse sand with numerous clay lenses which may form small perched water tables. Glacial till exists in some areas. The water table is 50 to 70 feet below grade, with an inferred flow northwest toward the Whippany River.
5) Suspected and confirmed sources--The garden hose discharge and the septic tank are confirmed sources. A fuel oil tank was abandoned in 1976 after it leaked, condition unknown. In addition, other industries in the immediate area may be implicated in a broader contamination pattern.
6) Mitigation actions--The illegal discharge to the ground from the hose was stopped. Bronner was required to hire a ground water consultant in

1985. Removal of the septic system contents is required.
7) Decontamination actions--None as of early 1986, due to the need for hydrogeologic analysis prior to cleanup actions.
8) Continuing investigations--Bronner has contracted with a consultant and a workplan was being developed as of early 1986. In addition, a NJDEP analysis of the entire region has been proposed to determine bedrock levels, aquifer systems and ground water flow as an aid in determining contaminant plume flow.

I308 PINE BROOK WELL CONTAMINATION, MONTVILLE 1983

1) Overview--Six private wells were contaminated by PCE, apparently from a dry cleaning business in a small shopping center. During the course of investigations, the business changed hands in the rental storefront. Public water is being supplied by Montville to replace the contaminated wells. Investigation continuing.
2) Location of the contaminated site--Northwest corner of Route 46 and Hook Mountain Road.
3) Severity of contamination--PCE levels have been detected in wells at up to 4400 ppb. Soil contamination behind the dry cleaner includes PCE at 21,000 ppb, 1420 ppb benzene and 865 ppb TCE.
4) Extent of contamination/Ground water flow--The site geology consists of basalt bedrock (the southern end of Hook (or Towaco) Mountain) for 90 feet and then shale. Wells are drilled into the shale. Ground water moves through joints in the basalt and may transmit spills to deeper zones. The shale wells are contaminated, indicating that the two formations are connected. The contamination is moving northwest both horizontally and vertically, but the full extent is not known. By 1984 the wells had between 50 and 350 ppb of PCE.
5) Suspected and confirmed sources--NJDEP found that the dry cleaner was improperly storing spent dry cleaner filters on the ground in the rear, with spillages. Well contamination was first noticed by Montville in 1978, in the shopping center well which was closed.
6) Mitigation actions--Carbon filters were installed in three locations. Discharges from the dry cleaner were discontinued.
7) Decontamination actions--None. The current owner of the dry cleaner is contesting responsibility.
8) Continuing investigations--NJDEP is requiring monitor wells to assess the contamination.

I315 SIDMAK, EAST HANOVER 1984

1) Overview--Regional contamination of ground water near Ridgedale Avenue and DeForest Avenue in East Hanover led the NJDEP to investigate the industries in the area. Prior to 1984 when public sewers became available, the industries relied on septic systems. The septic system at Sidmak Laboratories was found to contain VOCs at high levels. Investigation continuing.
2) Location of the contaminated site--Sidmak Laboratories is on West Street near DeForest Avenue, south of DeForest Investment and Gasparine Garage.

3) Severity of contamination--Samples of the septic system at Sidmak exhibited very high VOc contamination, with 12 VOCs above 50 ppb, 7 above 100 ppb, and four above 1,000 ppb. The latter are 1,1 dichloroethane (18,400 ppb), 1,1 dichloroethylene (5,100 ppb), methylene chloride (172,000 ppb) and 1,1,1 trichloroethane (21,000 ppb). The leaching pit samples showed benzene, methylene chloride and 10,640 ppb of chloroform.
4) Extent of contamination/Ground water flow--The extent of Sidmak's contribution to the regional contamination and the extent of off-site contamination generally from Sidmak is not known. Glacial outwash deposits of sand and gravel are approximately 100 feet thick below Sidmak. Samples from a private well west of Sidmak on DeForest Avenue was not contaminated.
5) Suspected and confirmed sources--Floor drains received daily wash water from the laboratory which went to the septic system. Sidmak used all of the chemicals found in its septic system.
6) Mitigation actions--Use of the septic system has been discontinued. Monitor wells have been required by the NJDEP.
7) Decontamination actions--None as of early 1986.
8) Continuing investigations--The NJDEP considers this site to be a significant threat to ground water and has suggested an extensive hydrogeological investigation.

I317 TRIANGLE INDUSTRIAL PARK, EAST HANOVER 1984

1) Overview--Regional contamination of ground water near Ridgedale Avenue and DeForest Avenue in East Hanover led the NJDEP to investigate the industries in the area. Prior to 1984 when public sewers became available, the industries relied on septic systems. The septic system at Triangle was found to contain VOCs at high levels. Investigation continuing.
2) Location of the contaminated site--On DeForest Avenue just east of Chemical Components, along the Morristown and Erie Railroad.
3) Severity of contamination--The septic system contained 4,646 ppb of 1,1,1 trichloroethane in 1984 samples, with significant differences between the septic tank and the seepage pit which could indicate that the discharge had ceased or could be due to a former tenant. Other VOCs in the septic system included trans-1,2 dichloroethylene (101 ppb), vinyl chloride (187 ppb), toluene (63 ppb), 1,2 dichloroethane (65 ppb), and 1,1 dichloroethane. Late 1984 samples taken by consultants to Triangle found much lower levels of VOCs before and after the septic system was pumped. Monitor wells on site show levels of trans-1,2 dichloroethylene of 20 to 30 ppb and of TCE from 340 to 620 ppb. A nearby parochial school well was contaminated with 1700 ppb of TCE, 204 ppb of trans-1,2 dichloroethane, and 90 ppb of 1,1,1 TCEA.
4) Extent of contamination/Ground water flow--The regional contamination involves private wells along Ridgedale and DeForest Avenues with elevated levels of TCE, 1,1,1 trichloroethane, 1,1 dichloroethane and trans-1,2 dichloroethylene. Chemical Components and Bronner Tool & Manufacturing both had hazardous waste spills, etc. The extent to which Triangle Industrial Park has contributed to the regional contamination, as opposed to the local contamination, is not known. The site area has an upper layer of fine till with cobbles and boulders, while the lower

layer is a gravelly glacial outwash, totaling 100 to 120 feet thick. The water table is 30 to 40 feet below grade. The direction of flow is not known, but is predicted to be northwest toward the Whippany River. The aquifer has a high transmissivity.
5) Suspected and confirmed sources--A survey of tenants found none which currently used the substances found in the septic system.
6) Mitigation actions--The septic system has been pumped out and the industrial park is connected to public sewers. Two monitor wells were installed.
7) Decontamination actions--None as of early 1986.
8) Continuing investigations--Triangle decided to hire its own consultant rather than work with nearby suspect firms to determine the source(s) of contamination. NJDEP investigation continuing.

I362 EAST HANOVER WELL #2, EAST HANOVER

1) Overview--TCE, methylene chloride and trans-1,2 dichloroethylene have been found in the well. Possible sources of contamination include the Metro Landfill on Melanie Lane, seepage pits at G&F Industrial Park on Littel Road, and an abandoned lot next to well and suspected to be a former landfill. Monitor wells were placed around the well. Investigation continuing.
2) Location of the contaminated site--Melanie Lane, East Hanover.
3) Severity of contamination--The TCE levels in Well 2 have ranged from 30 to 60 ppm in 1984 and 11 to 30 ppb in 1985, with 5 ppb of trans-1,2-dichloroethylene.
4) Extent of contamination/Ground water flow--An extensive survey and hydrogeologic analysis of the Well 2 area is being conducted by the NJDEP to map the ground water flow system and contamination plume.
5) Suspected and confirmed sources--Metro Landfill was approved by the NJ Department of Conservation and Economic Development to accept chemical wastes for disposal, limited to the extent that the existing construction wastes were capable of absorbing the chemicals without ponding or seepage. The wastes apparently were excess activated sludge from Whippany Paper Board, consisting of paper fibers and pigments. A 1974 review of the landfill noted that the site was stratified glacial deposits with clay layers, in a swamp with a high water table. The NJDEP at that time recommended monitor wells and stream sampling, due to the high ground water pollution hazard and the proximity of East Hanover's Wells 1 and 2. The landfill received demolition materials and had not received a stream encroachment permit. The property was leased at the time from JCP&L.

1985 test results of the abandoned septic pit at G&F Industrial Park revealed chloroform at 28 ppb, PCE at 17 ppb and TCE at 76 ppb.

An auto body shop also exists on Melanie Lane across from Well 2 which has a septic tank and is suspected of using degreasers and solvents. No investigation had begun as of early 1986.
6) Mitigation actions--Use of Well 2 was discontinued until a treatment system was installed by East Hanover. A treatment system was installed.
7) Decontamination actions--None.
8) Continuing investigations--A major investigation for the source(s) of the Well 2 contamination is being conducted by the NJDEP.

I MENNEN COMPANY, MORRIS PLAINS 1984

1) Overview--Mennen operated a washwater disposal system on the northwest corner of its main building from 1964-1966 at 18,000 gpd, after which the effluent was routed to an injection well. Soil and ground water samples revealed no migration of contaminants, though the septic system sludges showed low levels of PCE, TCE, and other VOCs. The tanks have been removed. Mennen's production wells have been contaminated by TCE from the Airtron facility to the north. The Airtron investigation is continuing.
2) Location of the contaminated site--Hanover Avenue, one mile west of Interstate 287.
3) Severity of contamination--The septic system contained low levels of VOCs. The ground water in general is significantly contaminated with TCE, to the extent that the Mennen wells cannot be used for potable water supply.
4) Extent of contamination/Ground water flow--The Airtron facility is 0.25 miles north of Mennen. TCE contamination of ground water exists at that site and at Mennen. The regional ground water flow is generally from west to east, but locally the pumping of Mennen's wells results in a flow from the Airtron property south to Mennen.
5) Suspected and confirmed sources--Soil contamination on site due to the septic system is not considered major. The Airtron facility has reported TCE contamination from the disposal of sludge on its site and is a confirmed source of TCE contamination affecting Mennen.
6) Mitigation actions--The septic tanks were removed in 1985 with soils tests around each one. Results were negative.
7) Decontamination actions--Mennen's wells are resulting in a regional drawdown of the aquifer and local dewatering of the aquifer. The result is induced flow from Airtron. Mennen uses the water for irrigation and non-contact cooling, resulting in some decontamination of the aquifer.
8) Continuing investigations--The Airtron investigation continues.

I G&F INDUSTRIAL PARK, EAST HANOVER 1984

1) Overview--The contamination of East Hanover Well 2 led to a survey of potential sources. Seepage pits contained moderate levels of VOCs and PCBs. Investigation continues.
2) Location of the contaminated site--Littel Road, near Ridgedale Avenue and Route 10, adjacent to the Melanie Lane well field.
3) Severity of contamination--The highest VOC levels in the seepage pits reached 169 ppb of PCE, 106 ppb of trans-1,2 dichloroethylene, 64 ppb of methylene chloride, and 35 ppb of TCE. 6 tanks had low PCB levels in sludge.
4) Extent of contamination/Ground water flow--The hydrogeology of the site, the ground-water flow direction and the extent of contamination have not been determined.
5) Suspected and confirmed sources--The industrial park has 31 tenants in 5 buildings. Former tenants may also have contributed to septic system contamination.
6) Mitigation actions--None cited.

7) Decontamination actions--None.
8) Continuing investigations--As part of East Hanover Well 2 study.

WHIPPANY-LOWER ROCKAWAY RIVERS SUBREGION
MINOR CONTAMINATION CASES

A22 AMOCO, MORRISTOWN August 1978

Overview--Located on Morris Street. Approximately 3000 gallons of gasoline leaked and 225 gallons were recovered from ground by sump method. Recovery was terminated in the fall, 1978, and NJDEP closed the case in 1978. The tanks were expected to be removed. The presence of a NJDEP inspector was recommended. Contaminated soils must be taken to an approved landfill (Edgewater).

A153 SHELL GASOLINE STATION, LAKE HIAWATHA, PARSIPPANY October 1980

Overview--Located on North Beverwyck Road in Lake Hiawatha. A gasoline spill of 3000 gallons occurred. Monitoring and recovery wells were installed and 300 to 400 gallons of product were recovered. By fall, 1981, the wells were clean and the gasoline assumed to have been absorbed by the soil. A 1982 site visit indicated a sheen of product but no recoverable quantities. Monitoring well samples during the investigation showed very high levels of benzene, toluene (16900 ppb), p-xylene and oxylene. The ground water flow is apparently toward Barry's Creek. All wells but one were closed and the case closed in 1982.

A186 MOBIL GASOLINE STATION (RAY PETROLEUM), HANOVER February 1982

1) Overview--A NJ Bell manhole on Route 10 was contaminated with gasoline. Strong fumes and floating product were observed. The manhole is adjacent to Ray Petroleum. The station installed monitor wells and recovery wells to remove the gasoline from the ground. The station also relined its storage tanks, at which point the gasoline contamination began abating quickly. Decontamination is continuing. A lawsuit was filed by Ray Petroleum in 1986 to recover costs for the decontamination program from the tank manufacturers and installers and Exxon, the prior lessee.
2) Location of the contaminated site--Route 10, Hanover Township.

A242 VAN WINKLE GULF, MONTVILLE ?

1) Overview--A private well (Bennco Corporation) located adjacent to the Gulf station was contaminated with 12 ppm of petroleum ether. However, the Gulf station well tested clean. A nearby contaminated well (O'Dowd industrial establishment) was not contaminated with the same substances, having chloroform, bromoform, and other VOCs totaling 65 ppb.

Additional sampling by the Montville Health Department revealed no other contaminated wells in the area. The Bennco well may have been self-contaminated through an old septic system.
2) Location of the contaminated site--On Van Winkle Avenue between Route 46 and Bloomfield Avenue in southern Montville.

ECRA 85-300 C.G. WINANS COMPANY, HANOVER 1985

1) Overview--A 2,000 gallon tank for oil was removed, as was a 10,000 gallon tank. The geology of the site shows a complex interbedding of glacial till and sand lenses to approximately 140 feet below grade where shale bedrock is encountered. The highest hydrocarbon level was 350 ppm, in excavated and removed soils. At present, soil contamination levels are less than 100 ppm petroleum hydrocarbons, the action level for ECRA. No migration of contamination from the tank excavation pits was detected by the three monitor wells installed on site. Case prepared for closing 4/86.
2) Location of the contaminated site--Ridgedale Avenue in the Cedar Knolls section of Hanover Township.

ECRA 84-310 WHIPPANY SOAP PRODUCTS, HANOVER 1985

1) Overview--Whippany Soap produced tallow for soap and crackling for animal feed and fertilizer. Two gasoline underground tanks and two aboveground tanks for fuel oil exist on site. No hazardous chemicals were used on site. Contamination of soils and a swale with petroleum hydrocarbons up to 818 ppm from a truck parking area, and of soils near one underground tank of up to 4,400 ppm (after tank removal), were identified. The aboveground tanks were also removed, and petroleum hydrocarbon contamination of up to 24,000 ppm directly below one tank identified. A sampling and soil removal plan has been devised, toward a remedial plan to bring contamination levels below the 100 ppm action level for petroleum hydrocarbons. Monitor wells have been installed.
2) Location of the contaminated site--Eden Lane, Hanover Township.

ECRA 85-319 ROWE INTERNATIONAL, HANOVER 1985

1) Overview--Areas of concern include an old settling tank and septic system under a building (used to collect plating rinse water), two septic tanks used for industrial discharges, two fuel tanks from which over 4,000 gallons were lost through spills (most of which was removed along with soils), five additional underground tanks, and a drum and storage area. Four tanks and the surrounding soil were removed. Petroleum hydrocarbon contamination under the access road and beyond is likely to exceed the 100 ppm action level. A sampling plan including monitor wells is under development to fully assess contamination of the site and allow development of a remedial program. Investigation continues.
2) Location of the contaminated site--Troy Hills Road, Hanover Township.

I69 COLLOID CHEMICAL, HANOVER TOWNSHIP November 1979

1) Overview--Phenol from a cooling water discharge was found seeping into the Whippany River as a result of poor housekeeping and surface spillage. Shallow monitor wells were installed and sampled in 1981, with no ground water contamination detected. The same was true of samples from an abandoned deep well on-site. The deep well was sealed in 1982, and an administrative order issued to deal with the surface water problems. Case closed by NJDEP in January, 1983.
2) Location of the contaminated site

I123 BELL LABORATORIES, AT&T, HANOVER TWP February 1981

1) Overview--Bell Labs utilized sand filter and sludge drying beds which received high concentrations of organics and metals. Monitor wells were installed to determine the impact of the beds on ground water. Wells indicate several sources of contamination. A leaking gasoline tank and an unlined salt pile have been removed. No evidence of contamination from the beds has been found. The source of contamination of a previously clean well is unknown. However, a leaking onsite sewer was reported and repaired. Ground water is being monitored under the terms of a NJPDES-GW permit.
2) Location of the contaminated site--One-half mile south of Route 10 on Jefferson Road.

I172 BOONTON ELECTRONICS, HANOVER TWP September 1981

1) Overview--Boonton Electronics dumped small quantities of 1,1,1 trichloroethane on the ground behind their facility for several years until the practice was stopped in 1979. NJDEP was alerted of the dumping when Boonton Electronics reported it on an industrial survey. Contaminated soil was removed from the site. Soil samples and water samples from potable wells in the area were analyzed. The impact on the ground water is considered unlikely. Case closed.
2) Location of the contaminated site--Eastman Road.

I220 BALLANTINE LABORATORIES, INC., PARSIPPANY October 1980

1) Overview--Ballantine manufactures electrical equipment. In October 1980 an analysis of their septic tank showed elevated levels of VOCs. The septic system has been pumped and Ballantine connected with the Parsippany sewer line. The source of ground water contamination appears to be upgradient of Ballantine. Therefore, NJDEP is concentrating its investigation on adjacent industries (Norda and Synthatron). Investigation continuing.
2) Location of the contaminated site--Fanny Road in the Lake Intervale area of Parsippany near Boonton.

I280 WHIPPANY PAPERBOARD COMPANY, HANOVER TWP July 1983

1) Overview--Six settling lagoons were located on the site. During the operation of the plant, odors were a problem from these lagoons. In an effort to blanket the smell, fuel oil was sprayed on the sludge. Abandonment of four of the lagoons consisted of backfilling, which buried the oil. Soil borings done in the filled lagoons indicated the presence of benzene, toluene and other VOCs. Monitor wells were to be installed in 1984, and subsequently sampled in May 1984. The results indicated lead and manganese in excess of NJDEP ground water standards and VOCs in excess of 500 ppb. Investigation continuing. Excess activated sludge from this facility was apparently disposed of in the Metro Landfill near Melanie Lane in East Hanover.
2) Location of the contaminated site--Eden Lane, Whippany.

I314 ELL-BEE CHEMICAL, EAST HANOVER 1984

1) Overview--Regional contamination of ground water near Ridgedale Avenue and DeForest Avenue in East Hanover led the NJDEP to investigate the industries in the area. Prior to 1984 when public sewers became available, the industries relied on septic systems. The septic system at Ell-Bee Chemical was found to contain VOCs at elevated levels. Investigation continuing.
2) Location of the contaminated site--The far eastern end of West Street off DeForest Avenue, next to Foster-Wheeler.
3) Severity of contamination--Samples from the septic systems revealed toluene contamination of approximately 200 ppb, acetone at 500 ppb, and variable levels of TCE in the septic tanks, with considerably lower levels in the seepage pit areas.
4) Extent of contamination/Ground water flow--High toluene contamination was found in soil samples taken by consultants to Ell-Bee near the tank farm, in a clay layer above the water table. The consultant concluded that Ell-Bee did not contribute to the regional contamination problem, though a local source did exist. The TCE levels were low. However, one septic system had carbon tetrachloride at 70 ppb.
5) Suspected and confirmed sources--The septic systems were confirmed as containing contaminants. A storage tank released toluene.
6) Mitigation actions--None noted in files.
7) Decontamination actions--None noted in files.
8) Continuing investigations--Ell-Bee Chemical has initiated an ECRA evaluation prior to sale of the property.

I316 FOSTER-WHEELER, EAST HANOVER 1984

1) Overview--Regional contamination of ground water near Ridgedale Avenue and DeForest Avenue in East Hanover led the NJDEP to investigate the industries in the area. Prior to 1984 when public sewers became available, the industries relied on septic systems. The septic system at Foster Wheeler was found to contain VOCs at significant levels. Investigation continuing.

2) Location of the contaminated site--At the eastern end of West Street near E11-Bee Chemicals. The building is owned by DeForest Investment Company and leased by Foster Wheeler.
3) Severity of contamination--Analysis of the seepage pit in 1983 found methylene chloride (66 ppb), 1,1,1 trichloroethane (111 ppb), and low levels of 1,1 dichloroethane, TCE, PCE and benzene.
4) Extent of contamination/Ground water flow--The extent to which the local contamination contributes to regional contaminant levels is not known, nor is the pattern of ground water flow.
5) Suspected and confirmed sources--A dye test by the East Hanover Health Department confirmed that Foster Wheeler was the sole company connected to the contaminated septic system. Foster Wheeler maintains that there is no knowledge of any discharges to the septic system of the chemicals found.
6) Mitigation actions--The septic system has been pumped out. Foster Wheeler has hired a consultant to conduct further investigations.
7) Decontamination actions--None as of early 1986.
8) Continuing investigations--The consultant to Foster Wheeler will continue the investigation, as will the NJDEP.

I338 DEFOREST INVESTMENT, EAST HANOVER June 1983

1) Overview--DeForest Investment Company operates a small industrial complex. An unlined stormwater retention pond was found to contain VOC contamination. Several contaminated septic systems were also discovered on the site. The NJDEP has required that DeForest apply for a NJPDES ground water discharge permit for the lagoon, and that the septic systems be decontaminated. Investigation continuing.
2) Location of the contaminated site--DeForest Avenue and West Street, on the northeastern quadrant, in East Hanover. The site is just north of Sidmak Laboratories, west of E11 Bee Chemicals and south of Triangle Industrial Park.
3) Severity of contamination--The stormwater retention pond was sampled in 1983 as containing 1,1,1 trichloroethane (220 ppb) and 1,1 dichloroethane (11 ppb). Later tests found significant levels of benzene (290 ppb) in the pond, without the other contaminants. Contaminated septic systems were also found on the site.
4) Extent of contamination/Ground water flow--The ground water flow has not been determined. Investigations in the area indicate that the site may be on a ground water divide between flow to the Whippany River (northwest) and flow to the Passaic River (southeast). Regional contamination with 1,1,1 trichloroethane and TCE exists in the vicinity. The relative contribution from any one facility is not known. The stormwater basin may not contribute significant percolation to ground water.
5) Suspected and confirmed sources--Industrial septic systems used for non-domestic wastes are considered a combined source of significant contamination. The contaminated runoff apparently derives from a floor drain in the Gasparine Garage, just south of the pond, which drains to the pond. Gasoline spills may introduce the benzene.
6) Mitigation actions--NJDEP has required that DeForest and Gasparine Garage apply for a NJPDES-GW permit due to the floor drain from the garage, the contaminants in the pond, and septic systems on site.

7) Decontamination actions--None.
8) Continuing investigations--NJDEP considers additional information necessary to establish the relative contribution to regional pollution of contamination by each facility in the area.

I360 CHEMCOAT, EAST HANOVER 1984

1) Overview--As part of the East Hanover ground water contamination investigation, Chemcoat Labs, Inc., was found to have a septic system receiving non-sanitary wastes without a NJPDES permit. The septic tank was cleaned and its use discontinued. Toluene was found in the septic system to 76 ppb along with chloroform to 12 ppm, but neither has been used at the site. A toluol underground storage tank passed an integrity test in 1984. Investigation continuing.
2) Location of the contaminated site--14 West Street.

I EAST HANOVER REGIONAL CONTAMINATION 1984

1) Overview--Regional contamination led to a NJDEP industrial survey to determine potential sources. The following sites have been identified and will be or have been investigated:

a) Craftsman Photo Litho Offset Corporation, 34 DeForest Avenue. Septic tank contained chloroform, 1,1 dichloroethane, methylene chloride, 1,1,1 TCEA and toluene totaling 35 ppb. Probably source of photo developing wastes. Required to pump out and eliminate the source.

b) DEH Realty, Owner, 6 DeForest Avenue. Septic tank with chloroform, methylene chloride, 1,1,1 TCEA and TCE totaling 45 ppb. Required to pump out and eliminate the source.

c) Tech Turf, 40 DeForest Avenue. Septic system with no VOCs or pesticides.

d) C&S Tool Co., 304 Ridgedale Avenue. Septic system confirmed cleaned and permanently sealed in 1985.

e) Prime Fabricators, 40 DeForest Avenue. Well water tested in 1983 and contained 155 ppb of 1,1 dichloroethane, 640 ppb of 1,1,1 TCEA and 15 ppb of 1,1 dichloroethylene. This firm was one of several offered the possibility of a joint hydrogeological study to determine the sources of regional contamination.

CHATHAM/MILLBURN VALLEYS SUBREGION
MAJOR CONTAMINATION CASES

A MADISON CARE CARE EXXON, MADISON 1985

1) Overview--Exxon discovered a product loss estimated at 1,152 gallons in late 1981, installed monitor wells and discovered free floating product of up to 3 feet on the water table. Exxon tested the product and suggests that the product originated at a Sunoco station across the street. There are four sets of underground storage tanks at the intersection, complicating analysis. They are the Exxon station, a Sunoco station with four steel tanks lined in 1984 with fiberglass, a Shell station with three fiberglass tanks, and an auto dealership with abandoned underground tanks. The site geology consists of six feet of fill over a clay strata at 28 feet below grade. This case was not assigned as of May 1986. The Madison Borough wells are within one-half mile of the site.
2) Location of the contaminated site--Main and Greenwood Streets, east corner, Madison Borough.
3) Severity of contamination--Free product was observed in more than one well. Dissolved constituents are likely to exist in the ground water.
4) Extent of contamination/Ground water flow--The full extent of the contamination is not known. Ground water flow is most likely toward the north, following the surface slope toward the Chatham Valley Aquifer.
5) Suspected and confirmed sources--Exxon identified an inventory loss, leading to its investigations. Exxon collected samples from its pumps, the Sunoco pumps, and the monitor wells in 1985 to identify the source. No results are reported in the files.
6) Mitigation actions--The NJDEP files indicate no actions other than monitor wells (six).
7) Decontamination actions--Exxon has recovered some amount of product from above the water table.
8) Continuing investigations--Pending.

A-280 LIVINGSTON TOWNSHIP WATER DEPARTMENT 1985

1) Overview--TCE was detected in the distribution system at 11 ppb, along with lower levels of PCE and 1,1,1 trichloroethane. Livingston identified Well 4 as a source of the contaminated water and curtailed use of the well in 1985 while it is being redeveloped. The well will be resampled once brought back on line. A second well (Well 6) has also been discovered to have low TCE levels at the Level 2 contamination, the lowest action level. Investigation continues.
2) Location of the contaminated site--Well 2 is near Livingston Avenue in the Slough Brook Buried Valley. Well 6 is located at Squiretown School, southwest of the Route 10/Eisenhower Parkway intersection.

A-280 MADISON BOROUGH WELLS

1) Overview--Madison's wells had shown no contamination through 1985. In January, 1986, tests of two wells and the water system revealed low level (Level II) contamination of wells B and D with PCE. Tests during the late spring of 1986 of all wells showed PCE in wells A, B and D, with 1,1,1 TCEA and carbon tetrachloride in well D. Wells A and B were discontinued from use as was well D. However, subsequent tests showed that well C, very close to well D, developed 1,1,1 TCEA contamination once pumping of well D ceased. At no time has the level of any one contaminant exceeded 2.7 ppb in any well. As of July 1986, Madison was pumping wells D and E to supply the majority of system needs, with some use of well C as a secondary source. Methods of reducing peak hour rates of use were developed to retain system pressure and tank storage. The configuration of the Madison distribution system is that water from some wells is mixed for some users (through storage tanks) but not for others. For this reason, Madison is more sensitive to contamination of individual public wells than some neighboring systems. The source(s) of the contamination is unknown, as are whether the contamination consists of one or more slugs or plumes and whether the source(s) is active or not.

Madison has also discovered leakage from a transformer near three of its wells which contaminated the soil with PCBs but did not penetrate to the wells themselves. Removal of the contaminated soil began during the summer of 1986.

CHATHAM/MILLBURN VALLEYS SUBREGION
MINOR CONTAMINATION CASES

ECRA 84-595 WARREN COMMUNICATIONS, LIVINGSTON 1985

1) Overview--A spill of PCE had occurred at this manufacturer of military and commercial measuring devices. The greatest contamination exceeded 7,500 ppm of PCE. Warren Communications excavated the area to levels of 0.19 to 14.3 ppm of PCE, over an area of approximately 400 square feet and to a depth of 2 to 12 feet. Installation and sampling of monitor wells is expected. Investigation continues.
2) Location of the contaminated site--Okner Parkway along the Passaic River in Livingston.

ECRA #85-263 PAPER MART, INC., LIVINGSTON 1985

1) Overview--The ECRA evaluation was triggered by sale of the property to Apple Recycling, Inc., subsidiary of Coca Cola Bottling Company of New York. Paper Mart distributed writing and printing papers. Four underground diesel oil storage tanks existed on site, three of which tested tight. The fourth, used for gasoline, was drained and sealed in 1983 when the fuel was contaminated with water. Soils from near the tank evidenced obvious hydrocarbon odors. The tank and surrounding soils were excavated. The soils contained up to ten times the ECRA cleanup standard for petroleum hydrocarbons. Floating product was observed in the pit. Ground water monitoring may be required to test for gasoline dissolved products such as benzene and toluene. Because of amendments to the ECRA regulations, this site is no longer subject to the ECRA process. Therefore, the NJDEP has informed ECRA that this case should be followed up by NJDEP enforcement.
2) Location of the contaminated site--120 Dorsa Avenue.

UPPER PASSAIC SUBREGION
MAJOR CONTAMINATION CASES

A17 MOHAWK OIL (SUNOCO), HARDING TOWNSHIP September 1977

1) Overview--Located on Route 202 north of Bernardsville near the Depot. Between 2000 and 6000 gallons of gasoline were lost from underground tanks, contaminating four domestic wells and ground water to 78 feet below grade. Carbon filters were placed on the domestic wells which were redrilled and cased to approximately 100 feet. Recovery wells captured several hundred gallons of gasoline before becoming ineffective. All monitoring wells clean as of May, 1981. The case was inactive but not closed in case other private wells were contaminated. No further complaints had been received by 1984.

A228 WASHINGTON VALLEY AUTO, WARREN TOWNSHIP December 1983

1) Overview--The local health department began a sampling program after residents complained of gasoline odors in water from domestic supply wells. A service station was found to have had a leak. Residents were connected to the municipal water supply. A hydrogeological study to determine the extent of contamination is underway using the NJ Spill Fund as the funding source. Investigation continuing.
2) Location of the contaminated site

ECRA MILLMASTER ONYX, BERKELEY HEIGHTS 1982

1) Overview--Berkeley Chemical Company, later Millmaster Onyx, was engaged in specialty chemicals manufacture on the site. The facility was closed in 1982 and all structures removed, at which point Gulf Oil Products (the owner, later purchased by Chevron Corporation) began site investigations and cleanup actions. Extensive PCB contamination from a 1967 fire and organic pollutants from lagoon sludges were discovered. Contamination of a surficial aquifer has occurred. Contamination of a lower aquifer also exists, but the connection to the surface pollution is not established. The investigation by Chevron continues under the ECRA program.
2) Location of the contaminated site--Directly adjacent to the Passaic River in Berkeley Heights, at the foot of the Watchung Mountain.
3) Severity of contamination--PCB concentrations of 50 to 100 ppm exist in some soil areas both on-site and off-site. Polynuclear aromatic hydrocarbons (PAH) and chlorinated benzenes near one filled lagoon reach 10 to 15 ppm, with PAH levels of 2 to 3 ppm in two former lagoons. Shallow ground water contaminants include ethylbenzene, toluene, xylene, chlorobenzene and mixed phenolics. Deep ground water contaminants include PCE, TCE, and dichloroethane.
4) Extent of contamination/Ground water flow--The PCB contamination is

in the soils rather than the ground water. Surface soils, especially in the southeast corner of the site, two lagoons and to the south of the site, are contaminated. Some PCB contamination has reached the Passaic River with sediments in runoff to the river prior to a new stormwater management system. The shallow ground water contamination emanates from former lagoons used for wastewater treatment. The deep ground water is separated from the shallow system by a clay layer of 9 to 40 feet thick, increasing in thickness toward the river and thinning toward the Watchung ridge. The shallow aquifer flows directly toward the Passaic River to the north, except where intercepted by bedding material in a sewer line that crosses the property from west to east. The deep aquifer is assumed to flow toward the Passaic River as well. Both aquifers are minor and do not provide significant yields. The river was sampled and no contamination found. The PCB sediments in the river are limited to an area immediately adjacent to the site.

5) Suspected and confirmed sources--The PCBs were introduced to the site in 1967 from a fire in a hot oil heat exchanger system. The organic chemicals in the shallow aquifer derive from sludges in several filled lagoons which had been used for wastewater treatment when the plant operated from 1940 to 1980. The deep aquifer contamination may be from off-site, perhaps from a nearby closed dump.

6) Mitigation actions--Soils with PCBs located off site have been brought on-site in 1983 and 1985. A new stormwater management system was installed in 1982 to contain surface pollutants on the property, including PCB soils.

7) Decontamination actions--The facility must meet the requirements of ECRA prior to being sold.

8) Continuing investigations--Consultants to Chevron have investigated the site and will develop, in concert with the NJDEP, a cleanup program. Additional sampling to determine the source of the deep aquifer contamination is likely.

UPPER PASSAIC SUBREGION
MINOR CONTAMINATION CASES

A123 EXXON GASOLINE STATION, BERNARDSVILLE April 1980

1) Overview--Inventory loss of 72 gallons. Four monitoring wells installed. All wells were free of product. Case closed by NJDEP May, 1980.
2) Location of the contaminated site--Route 202 in the center of Bernardsville.

A GREEN VILLAGE SUNOCO, CHATHAM TOWNSHIP 1985

1) Overview--During the excavation and replacement of an underground storage tank, a heavy sheen was noticed along with contaminated soil (70 ppm organic chemicals). A substandard monitor well indicated no free product but a heavy gasoline odor. The owner was prevented from using the excavated soil as clean fill. A monitor well was required by NJDEP but has not been implemented as of early 1986. Investigation continuing.

I297 MILLINGTON ASBESTOS DUMPS, PASSAIC TWP April 1984

1) Overview--An asbestos dump was discovered on the banks of the Passaic River in Millington and at sites located northeast of Meyersville and in the Great Swamp National Wildlife Refuge. Quantities of methyl mercury were dumped into the asbestos site along the Passaic River. A remedial investigation/ feasibility study is underway, funded by the responsible party under the Superfund program. Investigation continuing.

State and Federal monitoring of conditions at the site date back to 1971 when the National Gypsum Company, which had purchased the property in the early 1950's, applied for a permit to discharge process wastewater to the Passaic River. Water conservation and pollution control equipment was installed and in April, 1974, the final permit was issued requiring construction of additional treatment facilities and upgrading of the existing settling lagoons. Inspection in January, 1975 revealed two process water discharges, one from the asbestos processing operation and the second from a paint wash line discharging into an unlined lagoon. The company initially proposed installation of total recycling system to eliminate discharge, but subsequently decided to closed the Millington plant permanently, citing economic considerations and environmental constraints. In 1976, the property was sold to TIFA, Ltd., a pesticide equipment manufacturing company,.

Complaints about exposed asbestos waste as a result of erosion and concern about potential pollution of the Passaic River led to the issuance of an Administrative Order to the National Gypsum Company by the New Jersey Department of Environmental Protection (NJDEP) in February, 1978. The Company was required to cover the exposed material

and to submit a long-term plan for site remediation. The mound was subsequently covered with soil and seeded, the river bank was stabilized with riprap, and lagoons used in waste water treatment were covered and regraded into the landscape.

A scope of work detailing the activities to be undertaken in the Remedial Investigation/Feasibility Study (RI/FS) has been completed. The U.S. Environmental Protection Agency (USEPA) negotiated with the responsible parties to perform this study. U.S. Gypsum has funded the RI/FS work at the Millington site and two asbestos dump sites in the Great Swamp. Work on the RI/FS began in the summer of 1986.

2) Location of the contaminated site--Passaic Township, several sites.

APPENDIX C

[OW-FRL-2460-4]

Unconsolidated Quaternary Aquifer, In the Rockaway River Area, New Jersey; Final Determination

AGENCY: U.S. Environmental Protection Agency.

ACTION: Notice.

SUMMARY: Notice is hereby given that, pursuant to Section 1424(e) of the Safe Drinking Water Act, the Administrator of the U.S. Environmental Protection Agency (EPA) has determined that the Unconsolidated Quaternary Aquifer in the Rockaway River Basin is the sole or principal source of drinking water for the Rockaway River Basin Area, and that the Unconsolidated Quaternary Aquifer, if contaminated, would create a significant hazard to public health. As a result of this action, all Federal financially assisted projects constructed in the Rockaway River Basin Area will be subject to EPA review to insure that these projects are designed and constructed without a significant hazard to public health.

ADDRESSES: The data on which these findings are based is available to the public and may be inspected during normal business hours at the U.S. Environmental Protection Agency, Region II, Water Supply Branch, Room 824, 26 Federal Plaza, New York, New York 10278.

FOR FURTHER INFORMATION CONTACT: Damian J. Duda, Water Supply Branch, Environmental Protection Agency, Region II at 212-264-1800.

SUPPLEMENTARY INFORMATION: Notice is hereby given that pursuant to Section 1424(e) of the Safe Drinking Water Act (42 U.S.C. 300f, 300h-3(e), Pub. L. 93-523), the Administrator of the U.S. Environmental Protection Agency (EPA) has determined that the Unconsolidated Quaternary Aquifer of the Rockaway River Basin Area is the sole or principal source of drinking water for the Town of Boonton, Boonton Township, Denville, Dover, Jefferson Township, Mine Hill, Mountin Lakes, Randolph Township, Rockaway Borough, Rockaway Township, Roxbury, Victory Gardens and Wharton. Pursuant to Section 1424(e), Federal financially assisted projects constructed in the Rockaway River Basin Area, which is delineated by the watershed boundaries of the Rockaway River, the Black (Upper Lamington) River Basin in Roxbury Township and Lake Arrowhead in Denville and Mountain Lakes, will be subject to review.

I. Background

Section 1424(e) of the Safe Drinking Water Act states:

> If the Administrator determines, on his own initiative or upon petition, that an area has an aquifer which is the sole or principal drinking water source for the area and which, if contaminated, would create a significant hazard to public health, he shall publish notice of that determination in the **Federal Register**. After the publication of any such notice, no commitment for Federal financial assistance (through a grant, contract, loan guarantee, or otherwise) may be entered into for any project which the Administrator determines may contaminate such aquifer through a recharge zone so as to create a significant hazard to public health, but a commitment for Federal financial assistance may, if authorized under another provision of law, be entered into to plan or design the project to assure that it will not so contaminate the aquifer.

On November 30, 1979, EPA received a petition from the Upper Rockaway River Watershed Association requesting that EPA designate the Quaternary Wisconsin stratified drift deposits as a sole source aquifer. In response to this petition, EPA published a notice in the **Federal Register** on September 11, 1980 (45 FR 60010) announcing a public comment period and setting a public hearing date. A public hearing was conducted on October 15, 1980, and the public was requested to submit comments on the petition until November 14, 1980.

II. Basis for Determination

Among the factors to be considered by the Administrator in connection with the designation of an area under Section 1424(e) are: (1) whether the Unconsolidated Quaternary Aquifer is the Area's sole or principal source of drinking water, and (2) whether contamination of the aquifer would create a significant hazard to public health.

On the basis of information available to this Agency, the Administrator has made the following findings, which are the basis for the determination noted above:

1. The Quaternary deposits represent an aquifer which currently serves as the "sole source" of drinking water for approximately 90,000 residents.

2. There are no existing alternative drinking water sources or combination of sources, which would provide fifty percent or more of the drinking water to the designated area, nor is there any reasonably available alternative future source capable of supplying the drinking water demands of the Rockaway River Basin Area.

3. The Unconsolidated Quaternary Aquifer is glacial in origin and is composed of unconsolidated sand and gravel deposits.

As a result of its highly permeable soil characteristics, the Unconsolidated Quaternary Aquifer is susceptible to contamination through its recharge zone from a number of sources, including, but not limited to, chemical spills, highway runoff, septic tanks, leaking storage tanks, and leaching from open dumps. There is current evidence of localized contamination of the aquifer from gasoline spills, individual disposal systems, leaking fuel tanks, and wastewater treatment systems. Since ground water contamination can be difficult or impossible to reverse, and since this aquifer is relied on for drinking water purposes by the general population, contamination of the aquifer would pose a significant hazard to public health.

III. Description of the Unconsolidated Quaternary Aquifer and its Recharge Zone

The Unconsolidated Quaternary Aquifer underlies thirteen municipalities in Morris County, in the Rockaway River Basin Area. The municipalities are the Town of Boonton, Boonton Township, Denville, Dover, Jefferson Township, Mine Hill, Mountain Lakes, Randolph Township, Rockaway Borough, Rockaway Township, Roxbury, Victory Gardens and Wharton. The area in which Federal financially assisted projects will be subject to review is the area which includes the unconsolidated Quaternary Aquifer's (1) recharge zone—delineated by the floodplain areas of the Rockaway River Basin and a portion of the Black (Upper Lamington) River Basin and (2) streamflow source zone—the watershed boundaries of the Rockaway River Basin, a portion of the Black (Upper Lamington) River Basin and Lake Arrowhead.

IV. Information Utilized in Determination

The information utilized in this determination includes the petition, written and verbal comments submitted by the public and the New Jersey Department of Environmental Protection and a study on the available water supply in the Rockaway Area (Tetra-Tech, 1979).

The above data is available to the public and may be inspected during normal business hours at the Environmental Protection Agency Region II, Water Supply Branch, Room 824, 26 Federal Plaza, New York, New York.

V. Project Review

EPA Region II is working with the Federal agencies that may in the future provide financial assistance to projects in the area of concern. Interagency procedures have been developed in which EPA will be notified of proposed commitments by Federal agencies for projects which could contaminate the Unconsolidated Quaternary Aquifer. EPA will evaluate such projects and, where necessary, conduct an in-depth review, including soliciting public comment where appropriate. Should the Administrator determine that a project may contaminate the aquifer through its recharge zone so as to create a significant hazard to public health, no commitment for Federal financial assistance may be entered into. However, a commitment for Federal financial assistance may, if authorized under another provision of law, be entered into to plan or design the project to assure that it will not so contaminate the aquifer.

Although the project review process cannot be delegated, the U.S. Environmental Protection Agency will rely to the maximum extent possible on any existing or future State and local control mechanisms in protecting the ground water quality of the Unconsolidated Quaternary Aquifer.

Included in the review of any Federal financially assisted project will be coordination with the State and local agencies. Their comments will be given full consideration and the Federal review process will attempt to complement and support State and local ground water protection mechanisms.

VI. Summary and Discussion of Public Comments

Most of the comments received from Federal, State and local government agencies and from the public were strongly in favor of designation. Only two commenters expressed any reservations regarding the designation.

Two commenters felt that EPA currently has sufficient ground water protection mechanisms, which, together with State and local mechanisms, render a sole source designation unnecessary. Each felt that a municipality should have the responsibility of protecting its own water resource. Although a number of ground water protection measures are available at the Federal, State and local level, none of these , either individually or collectively, permit EPA to act as directly and comprehensively as would a sole source designation in the review and approval of Federal financially assisted projects. In addition, EPA feels that the sole source project review process will foster integration rather than duplication of environmental review efforts.

One other commenter, although generally in favor of the designation had some recommendations to the existing petition. Specifically the two recommendations are (1) to extend the recharge area and (2) to expand any project review to include both federally assisted and non-federally assisted projects mainly public and semi-public. EPA has evaluated the recharge suggestion and determined the extent of the recharge area for project review. At present, only Federal financially assisted projects can come under sole source review. EPA does not have the legal means to review any non-federally funded project without amendment to the Safe Drinking Water Act. Federal financial assistance will only be withheld in those instances where it is determined that a proposed project may contaminate the aquifer so as to create a significant hazard to public health and no acceptable remedial measures are available to prevent the potential hazard.

VII. Economic and Regulatory Impact

Pursuant to the provisions of the Regulatory Flexibility Act (RFA), 5 U.S.C. 605(b), I hereby certify that the attached rule will not have a significant impact on a substantial number of small entities. For purposes of this Certification the "small entity" shall have the same meaning as given in Section 601 of the RFA. This action is only applicable to the Rockaway Rover Basin Area. The only affected entities will be those Area-based businesses, organizations or governmental jurisdictions that request Federal financial assistance for projects which have the potential for contaminating the aquifer so as to create a significant hazard to public health. EPA does not expect to be reviewing small isolated commitments of financial assistance on an individual basis, unless a cumulative impact on the aquifer is anticipated; accordingly, the number of affected small entities will be minimal.

For those small entities which are subject to review, the impact of today's action will not be significant. Most projects subject to this review will be preceded by a ground water impact assessment required pursuant to other Federal laws, such as the National Environmental Policy Act, as amended (NEPA), 42 U.S.C. 4321, et seq. Integration of those related review procedures with sole source aquifer review will allow EPA and other Federal agencies to avoid delay or duplication of effort in approving financial assistance, this minimizing any adverse effect on those small entities which are affected. Finally today's action does not prevent grants of Federal financial assistance which may be available to any affected small entity in order to pay for the redesign of the project to assure protection of the aquifer.

Under Executive Order 12291, EPA must judge whether a regulation is "major" and, therefore, subject to the requirement of a Regulatory Impact Analysis. This regulation is not major because it will not have an annual effect of $100 million or more on the economy, will not cause any major increase in costs or prices, and will not have significant adverse effects on competition, employment, investment, productivity, innovation, or the ability of United States enterprises to compete in domestic or export markets. Today's action only affects the Rockaway River Basin Area. It provides an additional review of ground water protection measures, incorporating State and local measures wherever possible, for only those projects which request Federal financial assistance. This regulation was submitted to office of Management and Budget for review under EP 12291.

Dated: January 12, 1983.

William D. Ruckelshaus,

Administrator.

[FR Doc. 84-1888 Filed 1-23-84; 8:45 am]

BILLING CODE 6560-50-M

APPENDIX D

BEFORE THE UNITED STATES

ENVIRONMENTAL PROTECTION AGENCY

Lee Thomas, Administrator

IN THE MATTER of the Petition of
THE TOWNSHIP OF WEST MILFORD, NEW JERSEY
and the PASSAIC RIVER COALITION Under
Section 1424 (e) of the Safe Drinking
Water Act of 1974 with Respect to the
Highlands Aquifer Systems of Northern
Passaic, Northwestern Morris, Northeastern
Sussex Counties, New Jersey and Southwestern
Orange County, New York.

PETITION

1.) The Township of West Milford, incorporated in 1834, is located in northern Passaic County, New Jersey. The Township has a population of 25,000 in an area of 80 square miles that is totally dependent on ground-water. Private wells are the only means of obtaining water for the residents. Ground water is obtained from a complex of Quaternary sand and gravel aquifers overlying Precambrian aquifers, comprising in total, the Highlands Aquifer Systems.

Town Hall is located at 1480 Union Valley Road, West Milford, Passaic County, New Jersey 07480. (201) 728-7000.

The Passaic River Coalition is a non-profit, urban watershed association concerned with water quality, water supply, land use, and the overall quality of the environment in the Passaic River Basin within New Jersey. Its headquarters is located at 246 Madisonville Road, Basking Ridge, New Jersey 07920. (201) 766-7550.

2.) A petition to the administrator of the Environmental Protection Agency requesting that the Highlands Aquifer Systems, New Jersey (as defined) be designated as a sole source aquifer under Section 1424 (e) of the Safe Drinking Water Act P.L. 93-523, which provides as follows:

> "(e) If the Administrator determines, on his own initiative or upon petition, that an area has an aquifer which is the sole or principal drinking water source for the area and which, if contaminated, would create a significant hazard to public health, he shall publish notice of that determination in the Federal Register. After publication of any such notice, no commitment for Federal financial assistance (through a grant, contract, loan guarantee, or otherwise) may be entered into for any project which the Administrator determines may contaminate such aquifer through a recharge zone so as to create a significant hazard to public health, but a commitment for Federal financial assistance may, if authorized under another provision of law be entered into to plan or design the project to assure that it will not so contaminate the aquifer."

3.) The area proposed for sole source designation is the Highlands Aquifer Systems, consisting of the complex of aquifers within the Pequannock, Pochuck, and Wanaque River watersheds of northern Passaic County, northwestern Morris County, northeastern Sussex County, New Jersey, southwestern Orange County, New York (see Figure 1) and in all of the following municipalities or portions thereof:

a. Township of West Milford
b. Borough of Bloomingdale
c. Township of Hardyston
d. Township of Jefferson
e. Borough of Kinnelon
f. Borough of Ringwood
g. Township of Rockaway
h. Township of Vernon
i. Township of Warwick, N. Y.
k. Village of Greenwood Lake, N. Y.
l. Village of Florida, N.Y.
m. Township of Tuxedo, N.Y.

The proposed sole source aquifer is located within the Highlands Province. Primary sources of ground water include Quaternary sand and gravel deposits from the Wisconsonian glacial period and a series of bedrock aquifers.

4.) The Highlands Aquifer Systems include water-bearing formations from the Quaternary Period, the Precambrian age, and the Paleozoic age (Lucey-1972, Banino, Markewicz and Miller-1970). In the Highlands area, aquifers are generally coincident with surface water divides. According to the USGS, "Ground-water flow systems in the (region) are generally small, the largest underlying probably only a few square miles. No regional groundwater flow systems underlies the entire area (USGS-1976). This is due to the major northeast-trending faults which create distinct river valleys in the Highlands. The complex of localized aquifers is connected through the surface water system which flows through the region. Thus, the Highlands Aquifer Systems can be considered a ground water resource independent of other regions.

Precambrian rocks "are a major source of ground water for domestic use in the northwestern two-thirds of Passaic County", (USGS-1976) as well as for northwestern Morris County (USGS-1965). Yields range from 1 to 200 gallons/minute, with the highest yields in the larger valleys near surface water bodies (USGS-1976). The Precambrian rocks are generally gneissic, granitoid, foliated, and structurally complex.

Paleozoic rocks are used primarily for domestic water supply. The Kanouse Sandstone, Green Pond Conglomerate, and Hardyston Quartzite may yield significant supplies on a localized basis, due to their friable nature. Well yields are characteristically 1 to 35 gal/min.

Quaternary deposits are important sources of water in some locations, though the deposits "have not, for the most part, been extensively explored (USGS-1976)." (Figure 2) (USGS-1976) indicates the thickness of Quaternary deposits in the Highlands Aquifer Systems. They may be confined or unconfined (Gill and Vecchioli-1965). Reported well yields range from 4 to 920 gal/min. Most public supply wells are in these deposits.

The New Jersey Geological Survey, in a recent study of the Upper Rockaway Quaternary Deposits, located extensions of the buried valley aquifer from the Upper Rockaway (along the line of the Ancestral Rockaway River) into the Highlands Aquifer Systems area (NJGS-1983). The NJGS judges that the buried valleys may be good, untapped sources of potable water.

5.) The Highlands Aquifer Systems are located in three major watersheds: the Pequannock, the Wanaque and the Pochuck. Two public water systems have developed surface water reservoirs within these watersheds. The City of Newark operates five reservoirs within the Pequannock Watershed, while the North Jersey District Water Supply Commission operates one reservoir and will be constructing a second in the Wanaque and Pochuck Watershed. In both cases, the purveyors have allocation permits from the State of New Jersey for the surface waters of the watersheds, and have contracted for the sale of their supplies outside of the proposed sole source aquifer area. No surface water supplies from these systems are available to the municipalities of the Highlands Aquifer Systems.

6.) The entire proposed sole source aquifer area is very heavily dependent on ground water for potable water supplies, primarily from private wells (see Table 1). The region is predominantly rural or undeveloped in nature. Due to the diffuse nature of existing development and the lack of infrastructure for water supply, replacement of contaminated private water supplies through new wells or public water supplies is cost prohibitive. A total of 123,000 people are dependent on ground water in the affected municipalities.

7.) The New Jersey Department of Environmental Protection (NJGS-1983) found that "The chemical quality of ground water in the test areas is good to excellent. All test wells conform to potable water standards for all parameters except in some cases, total iron and manganese. Ground water in valley-fill aquifers under unconfined or semi-confined conditions. The presence of permeable sediments overlying the aquifers, therefore, makes them highly suseptible to contamination from the surface. The present low density of development in watershed areas probably accounts for the good chemical quality of the ground water."

Surface water quality of all streams in the region is also high, a further indication of ground water quality.

8.) The rate of population growth in the 12 municipalities increased dramatically after 1960, with several experiencing a doubling or tripling of population from 1960-1980 (See Figure 3 and Table 2). Further growth can be expected. The New Jersey State Development Guide Plan notes that "Due to its proximity to heavily populated areas, pressures to develop the area can be expected to intensify despite its considerable resource and recreational importance."

The City of Newark owns approximately 35,000 square acres of watershed lands in the region, for the protection of its water supplies. The existence of this watershed land has limited the potential for growth to date. However, the City of Newark is not constrained from selling or developing its property in compliance with local zoning ordinances.

Landfills for the disposal of municipal wastes have been proposed within the region, posing a potential threat to ground water quality. Also, there is some potential for exurban industrialization in some areas. Nearby municipalities have experienced ground water contamination from industry and underground storage tanks.

9.) Certain actions have been taken to preserve ground water resources within the area. The State Development Guide Plan designates most of the region as a Conservation Area of Limited Growth Area (Figure 4 (a), 4 (b), 4 (c).

Limited Growth Areas were designated based on: relatively poor accessibility to commuter rail and highway facilities, low density development with limited public water and sewer service, absence of large concentrations of prime agricultural lands, absence of concentrations of open space and environmentally sensitive lands of State-wide significance.

Conservation Areas were designated based on: low density development, large public holdings, major environmentally sensitive land within or adjacent to public lands, limited accessibility. The Plan identified the Highlands area specifically, indicating:

> "the Skylands Region along the State's northern border ... should also be considered as a significant resource to be appropriately managed and conserved by the State ... Accordingly, it is recommended that the State, in conjunction with other levels of government, initiate and implement a management plan for the Skylands region ... to allow suitable development in appropriate locations while protecting the vital nature and recreational resources of the area."

In addition to the State Development Guide Plan, some local municipalities have incorporated provisions in their Zoning Ordinances which protect ground water. For instance, the West Milford Land Use Ordinances seek to achieve the preservation of these sensitive areas through a Natural Features Protection Ordinance for critical environmental resources, which are identified and zoned appropriately for protection (Figure 5).

The State of New Jersey has recently authorized a major ground water research effort in northern New Jersey to be guided by the U.S. Geological Survey. However, this research will occur over the next fifteen to twenty years.

10). Protection efforts are not sufficient for the long term protection of the Highlands Aquifer Systems from contamination, especially given the lack of viable replacement supplies for contaminated private wells. No effective controls for ground water protection exist over activities funded by the federal government. Therefore, a federal role exists.

11.) We conclude that the ground water of the Highlands Aquifer Systems is the only source of potable water for 95% of the region's residents. We thereby conclude that contamination of the ground water within the boundaries of the Highlands Aquifer Systems would create a significant hazard to public health with far-reaching effects. We also conclude that there is a valid and important role for the federal government in preventing the contamination of ground water in the Highlands Aquifer Systems from federally-funded projects.

Therefore, we respectfully request that the Administrator of the United States Environmental Protection Agency determine that the ground water resources of the Highlands Aquifer Systems be designated as the sole or principal drinking source for the area, that this determination be published in the Federal Register as required by Section 1424 (e) of the Safe Drinking Water Act of 1974, and that the federal government take any and all actions necessary to prevent ground water contamination within the sole source aquifer as a result of federally funded projects.

Respectfully submitted,

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APPENDIX E

Table 1.—Substances Known to Occur in Groundwater, Ranges of Detected Concentrations, Exceeded Standards, Examples of Uses, and Quantitative Estimates of Carcinogenic Potency and Noncarcinogenic Toxicity[a]

Contaminant	Concentration[b]	Standard[c]	Examples of uses[d]	Carcinogenic potency[e,f]	Noncarcinogenic toxicity[e,g]
Aromatic hydrocarbons	(parts per billion)				
Acetanilide	—		Intermediate manufacturing, pharmaceuticals, dyestuffs		
Alkyl benzene sulfonates	—	•	Detergents		
Aniline	—		Dyestuffs, intermediate, photographic chemicals, pharmaceuticals, herbicides, fungicides, petroleum refining, explosives		
Anthracene	18[h]		Dyestuffs, intermediate, semiconductor research		
Benzene	0.6–20,230	•	Detergents, intermediate, solvents, antiknock gasoline	Low	
Benzidine	—		Dyestuffs, reagent, stiffening agent in rubber compounding	High	
Benzyl alcohol	—		Solvent, perfumes and flavors, photographic developer inks, dyestuffs, intermediate		
Butoxymethylbenzene	—		NA[i]		
Chrysene	10		Organic synthesis		
Creosote mixture	—		Wood preservatives, disinfectants		
Dibenz[a,h]anthracene	—		NA[i]		
Di-butyl-p-benzoquinone	—		NA[i]		
Dihydrotrimethylquinoline	—		Rubber antioxidant		
4,4-Dinitrosodiphenylamine	—		NA[i]		
Ethylbenzene	0.9–4,000	•	Intermediate, solvent		Low
Fluoranthene	31	•	NA[i]		
Fluorene	—		Resinous products, dyestuffs, insecticides		
Fluorescein	—		Dyestuffs		
Isopropyl benzene	290		Solvent, chemical manufacturing		
4,4'-Methylene-bis-2-chloroaniline (MOCA)	—		Curing agent for polyurethanes and epoxy resins	Low	
Methylthiobenzothiazole	—		—		
Naphthalene	6.7–82	•	Solvent, lubricant, explosives, preservatives, intermediate, fungicide, moth repellant		Low
o-Nitroaniline	—		Dyestuffs, intermediate, interior paint pigments, chemical manufacturing		
Nitrobenzene	—		Solvent, polishes, chemical manufacturing		Moderate
4-Nitrophenol	—		Chemical manufacturing		
n-Nitrosodiphenylamine	—		Pesticides, retarder of vulcanization of rubber		
Phenanthrene	18–471[h]		Dyestuffs, explosives, synthesis of drugs, biochemical research		
n-Propylbenzene	—		Dyestuffs, solvent		
Pyrene	48		Biochemical research		Low
Styrene (vinyl benzene)	—	•	Plastics, resins, protective coatings, intermediate		Low
Toluene	0.1–6,400	•	Adhesive solvent in plastics, solvent, aviation and high octane blending stock, dilutent and thinner, chemicals, explosives, detergents		
1,2,4-Trimethylbenzene	—		Manufacture of dyestuffs, pharmaceuticals, chemical manufacturing		
Xylenes (m,o,p)	0.07–300	•	Aviation gasoline, protective coatings, solvent, synthesis of organic chemicals		Low
Oxygenated hydrocarbons					
Acetic acid	—		Food additives, plastics, dyestuffs, pharamaceuticals photographic chemicals, insecticides		Low

Table 1.—Substances Known to Occur in Groundwater, Ranges of Detected Concentrations, Exceeded Standards, Examples of Uses, and Quantitative Estimates of Carcinogenic Potency and Noncarcinogenic Toxicity[a]—continued

Contaminant	Concentration[b]	Standard[c]	Examples of uses[d]	Carcinogenic potency[e,f]	Noncarcinogenic toxicity[e,g]
Oxygenated hydrocarbons (cont'd)	(parts per billion)				
Acetone	10–3,000		Dyestuffs, solvent, chemical manufacturing, cleaning and drying of precision equipment		Low
Benzophenone	—		Organic synthesis, odor fixative, flavoring, pharmaceuticals		Low
Butyl acetate	—		Solvent		
n-Butyl-benzylphthalate	10–38		Plastics, intermediate		
Di-n-butyl phthalate	470	•	Plasticizer, solvent, adhesives, insecticides, safety glass, inks, paper coatings		Low
Diethyl ether	—		Chemical manufacturing, solvent, analytical chemistry, anesthetic, perfumes		
Diethyl phthalate	—	•	Plastics, explosives, solvent, insecticides, perfumes		
Diisopropyl ether	20–34		Solvent, rubber cements, paint and varnish removers		
2,4-Dimethyl-3-hexanol	—		Intermediate, solvent, lubricant		
2,4-Dimethyl phenol	—		Pharmaceuticals, plastics, disinfectants, solvent, dyestuffs, insecticides, fungicides, additives to lubricants and gasolines		
Di-n-octyl phthalate	23		Plasticizer for polyvinyl chloride and other vinyls		
1,4-Dioxane	2,100	•	Solvent, lacquers, paints, varnishes, cleaning and detergent preparations, fumigants, paint and varnish removers, wetting agent, cosmetics		
Ethyl acrylate	—		Polymers, acrylic paints, intermediate		
Formic acid	—		Dyeing and finishing, chemicals, manufacture of fumigants, insecticides, solvents, plastics, refrigerants		
Methanol (methyl alcohol)	—		Chemical manufacturing, solvents, automotive antifreeze, fuels		High
Methylcyclohexanone	—		Solvent, lacquers		
Methyl ethyl ketone	—		Solvent, paint removers, cements and adhesives, cleaning fluids, printing, acrylic coatings		
Methylphenyl acetamide	—		Na[i]		
Phenols (e.g., p-Tert-butylphenol)	10–234,000	•	Resins, solvent, pharmaceuticals, reagent, dyestuffs and indicators, germicidal paints		
Phthalic acid	—		Dyestuffs, medicine, perfumes, reagent		
2-Propanol	—		Chemical manufacturing, solvent, deicing agent, pharmaceuticals, perfumes, lacquers, dehydrating agent, preservatives		
2-Propyl-1-heptanol	—		Solvent		
Tetrahydrofuran	—		Solvent		
Varsol	—		Paint and varnish thinner		
Hydrocarbons with specific elements (e.g., with N,P,S,Cl,Br,I,F)					
Acetyl chloride	—		Dyestuffs, pharmaceuticals, organic preparations		
Alachlor (Lasso)	190–1,700	•	Herbicides		Moderate
Aldicarb (sulfoxide and sulfone; Temik)	36–405	•	Insecticide, nematocide		High
Aldrin	—	•	Insecticides	High	
Atrazine	—	•	Herbicides, plant growth regulator, weed control agent		Moderate
Benzoyl chloride	—		Medicine, intermediate		
Bromacil	72–110	•	Herbicides		Moderate
Bromobenzene	1.9–5.8		Solvent, motor oils, organic synthesis		Moderate

Table 1.—Substances Known to Occur in Groundwater, Ranges of Detected Concentrations, Exceeded Standards, Examples of Uses, and Quantitative Estimates of Carcinogenic Potency and Noncarcinogenic Toxicity[a]—continued

Contaminant	Concentration[b]	Standard[c]	Examples of uses[d]	Carcinogenic potency[e,f]	Noncarcinogenic toxicity[e,g]
Hydrocarbons with specific elements (e.g., with N,P,S,Cl,Br,I,F) (cont'd)	(parts per billion)				
Bromochloromethane	—		Fire extinguishers, organic synthesis		Low
Bromodichloromethane	1.4–110	* -	Solvent, fire extinguisher fluid, mineral and salt separations		
Bromoform	2.4–110		Solvent, intermediate		Moderate
Carbofuran	4–160	*	Insecticide, nematocide		Moderate
Carbon tetrachloride	0.3–18,700	*	Degreasers, refrigerants and propellants, fumigants, chemical manufacturing	Moderate	
Chlordane	—	•	Insecticides, oil emulsions		
Chlorobenzene	2.7–41	•	Solvent, pesticides, chemical manufacturing		Moderate
Chloroform	1.4–1,890	*	Plastics, fumigants, insecticides, refrigerants and propellants		
Chlorohexane	—		NA[i]		
Chloromethane (methyl chloride)	44		Refrigerants, medicine, propellants, herbicide, organic synthesis		Low
Chloromethyl sulfide	—		NA[i]		
2-Chloronaphthalene	83		Oil: plasticizer, solvent for dyestuffs, varnish gums and resins, waxes wax: moisture-, flame-, acid-, and insect-proofing of fibrous materials; moisture- and flame-proofing of electrical cable; solvent (see oil)		
Chlorpyrifos	—		NA[i]		
Chlorthal-methyl (DCPA, or Dacthal)	—		Herbicide		
o-Chlorotoluene	2.4		Solvent, intermediate		
p-Chlorotoluene	—		Solvent, intermediate		
Dibromochloromethane	2.1–55		Organic synthesis		
Dibromochloropropane (DBCP)	1–137	*	Fumigant, nematocide		
Dibromodichloroethylene	—		NA[i]		
Dibromoethane (ethylene dibromide, EDB)	35–300	*	Fumigant, nematocide, solvent, waterproofing preparations, organic synthesis		
Dibromomethane	44.9		Organic synthesis, solvent		
Dichlofenthion (DCFT)	—		Pesticides		
o-Dichlorobenzene	2.7	•	Solvent, fumigants, dyestuffs, insecticides, degreasers, polishes, industrial odor control		Moderate
p-Dichlorobenzene	0.6–0.7	*	Insecticides, moth repellant, germicide, space odorant, intermediate, fumigants		Moderate
Dichlorobenzidine	—		Intermediate, curing agent for resins	Moderate	
Dichlorocyclooctadiene	—		Pesticides		
Dichlorodiphenyldichloroethane (DDD, TDE)	—		Insecticides		Low
Dichlorodiphenyldichloroethylene (DDE)	0.01–0.8		Degradation product of DDT, found as an impurity in DDT residues		
Dichlorodiphenyltrichloroethane (DDT)	0.05–0.22	•	Pesticides	High	
1,1-Dichloroethane	0.5–11,330		Solvent, fumigants, medicine		Low

Table 1.—Substances Known to Occur in Groundwater, Ranges of Detected Concentrations, Exceeded Standards, Examples of Uses, and Quantitative Estimates of Carcinogenic Potency and Noncarcinogenic Toxicity[a]—continued

Contaminant	Concentration[b]	Standard[c]	Examples of uses[d]	Carcinogenic potency[e,f]	Noncarcinogenic toxicity[e,g]
Hydrocarbons with specific elements (e.g., with N,P,S,Cl,Br,I,F) (cont'd)	(parts per billion)				
1,2-Dichloroethane	250–847	*	Solvent, degreasers, soaps and scouring compounds, organic synthesis, additive in antiknock gasoline, paint and finish removers	Low	
1,1-Dichloroethylene (vinylidiene chloride)	1.2–4,000	*	Saran (used in screens, upholstery, fabrics, carpets, etc.), adhesives, synthetic fibers	Moderate	
1,2-Dichloroethylene (cis and trans)	0.2–323	*	Solvent, perfumes, lacquers, thermoplastics, dye extraction, organic synthesis, medicine		
Dichloroethyl ether	1,100		Solvent, organic synthesis, paints, varnishes, lacquers, finish removers, drycleaning, fumigants		
Dichloroiodomethane	2.8–4.1		NA[i]		
Dichloroisopropylether (= bis-2-chloroisopropylether)	—		Solvent, paint and varnish removers, cleaning solutions		
Dichloromethane (methylene chloride)	4–8,400	*	Solvent, plastics, paint removers, propellants, blowing agent in foams		
Dichloropentadiene	0.36		NA[i]		
2,4-Dichlorophenol	—	•	Organic synthesis		
2,4-Dichlorophenoxyacetic acid (2,4-D)	1–85,000	*	Herbicides		Moderate
1,2-Dichloropropane	46–60	*	Solvent, intermediate, scouring compounds, fumigant, nematocide, additive for antiknock fluids		
Dieldrin	—	•	Insecticides	High	
Diiodomethane	2.0		Organic synthesis		
Diisopropylmethyl phosphonate (DIMP)	—	•	NA[i]		
Dimethyl disulfide	—		NA[i]		
Dimethylformamide	—		Solvent, organic synthesis		
2,4-Dinotrophenol (Dinoseb, DNBP)	124–400		Herbicides		Moderate
Dioxins (e.g., TCDD)	—	*	Impurity in the herbicide 2,4,5-T	High	
Dodecyl mercaptan (lauryl mercaptan)	—		Manufacture of synthetic rubber and plastics, pharmaceuticals, insecticides, fungicides		
Endosulfan	0.8	*	Insecticides		High
Endrin	—	•	Insecticides		High
Ethyl chloride	—		Chemical manufacturing, anesthetic, solvent, refrigerants, insecticides		
Bis-2-ethylhexylphthalate	12–170		Plastics	Low	
Di-2-ethylhexylphthalate	—	•	Plasticizers		
Fluorobenzene	67		Insecticide and larvicide intermediate		
Fluoroform	3.5		Refrigerants, intermediate, blowing agent for foams		
Heptachlor	—	•	Insecticides	Moderate	
Heptachlorepoxide	—	•	Degradation product of heptachlor, also acts as an insecticide		
Hexachlorobicycloheptadiene	2.2		NA[i]		
Hexachlorobutadiene	2.53		Solvent, transformer and hydraulic fluid, heat-transfer liquid		

Table 1.—Substances Known to Occur in Groundwater, Ranges of Detected Concentrations, Exceeded Standards, Examples of Uses, and Quantitative Estimates of Carcinogenic Potency and Noncarcinogenic Toxicity[a]—continued

Contaminant	Concentration[b]	Standard[c]	Examples of uses[d]	Carcinogenic potency[e,i]	Noncarcinogenic toxicity[e,g]
Hydrocarbons with specific elements (e.g., with N,P,S,Cl,Br,I,F) (cont'd)	(parts per billion)				
α-Hexachlorocyclohexane (= Benzenehexachloride, or α-BHC)	6	*	Insecticides		
β-Hexachlorocyclohexane (β-BHC)	3.8	*	Insecticides		
γ-Hexachlorocyclohexane (γ-BHC, or Lindane)	0.5–43	*	Insecticides		Moderate
Hexachlorocyclopentadiene	—		Intermediate for resins, dyestuffs, pesticides, fungicides, pharmaceuticals		
Hexachloroethane	4.6		Solvent, pyrotechnics and smoke devices, explosives, organic synthesis	Low	
Hexachloronorbornadiene	—		NA[i]		
Kepone	—	•	Pesticides		High
Malathion	—	•	Insecticides		
Methoxychlor	—	•	Insecticides		Moderate
Methyl bromide	7.4		Fumigants, pesticides, organic synthesis		
Methyl parathion	4.6	*	Insecticides		
Parathion	—	•	Insecticides		High
Pentachlorophenol (PCP)	—	•	Insecticides, fungicides, bactericides, algicides, herbicides, wood preservative		Moderate
Phorate (Disulfoton)	—	•	Insecticides		
Polybrominated biphenyls (PBBs)	—		Flame retardant for plastics, paper, and textiles		Low
Polychlorinated biphenyls (PCBs)	8–40	*	Heat-exchange and insulating fluids in closed systems	Moderate	
Prometon	—		Herbicides		
RDX (Cyclonite)	3,400	*	Explosives		
Simazine	—	•	Herbicides	Moderate	
Tetrachlorobenzene	5,000	*	NA[i]		
Tetrachloroethanes (1,1,1,2 & 1,1,2,2)	4	*	Degreasers, paint removers, varnishes, lacquers, photographic film, organic synthesis, solvent, insecticides, fumigants, weed killer	Moderate	
Tetrachloroethylene (or perchloroethylene, PCE)	717–2,405	*	Degreasers, drycleaning, solvent, drying agent, chemical manufacturing, heat-transfer medium, vermifuge	Low	
Toxaphene	1–570	*	Insecticides	Moderate	
Triazine	2		Herbicides		
1,2,4-Trichlorobenzene	37		Solvent, dyestuffs, insecticides, lubricants, heat-transfer medium (e.g., coolant)		
Trichloroethanes (1,1,1 and 1,1,2)	0.2–26,000	*	Pesticides, degreasers, solvent	Low	
1,1,2-Trichloroethylene (TCE)	210–37,000	*	Degreasers, paints, drycleaning, dyestuffs, textiles, solvent, refrigerant and heat exchange liquid, fumigant, intermediate, aerospace operations	Low	
Trichlorofluoromethane (Freon 11)	26		Solvent, refrigerants, fire extinguishers, intermediate		Moderate
2,4,6-Trichlorophenol	—		Fungicides, herbicides, defoliant		Low
2,4,5-Trichlorophenoxyacetic acid (2,4,5-T)	—	•	Herbicides, defoliant		Moderate

Table 1.—Substances Known to Occur in Groundwater, Ranges of Detected Concentrations, Exceeded Standards, Examples of Uses, and Quantitative Estimates of Carcinogenic Potency and Noncarcinogenic Toxicity[a]—continued

Contaminant	Concentration[b]	Standard[c]	Examples of uses[d]	Carcinogenic potency[e,f]	Noncarcinogenic toxicity[e,g]
Hydrocarbons with specific elements (e.g., with N,P,S,Cl,Br,I,F) (cont'd)	(parts per billion)				
2,4,5-Trichlorophenoxypropionic acid (2,4,5-TP or Silvex)	—	•	Herbicides and plant growth regulator		High
Trichlorotrifluoroethane	35–135		Drycleaning, fire extinguishers, refrigerants, intermediate, drying agent		
Trinitrotoluene (TNT	620–12,600	*	Explosives, intermediate in dyestuffs and photographic chemicals		
Tris-(2,3-dibromopropyl) phosphate	—		Flame retardant		
Vinyl chloride	50–740	*	Organic synthesis, polyvinyl chloride and copolymers, adhesives	Low	
Other hydrocarbons					
Alkyl sulfonates	—		Detergents		
Cyclohexane	540		Organic synthesis, solvent, oil extraction		
1,3,5,7-Cyclooctatetraene	—		Organic research		
Dicyclopentadiene (DCPD)	—		Intermediate for insecticides, paints and varnishes, flame retardants		
2,3-Dimethylhexane	—		NA[i]		
Fuel oil	—		Fuel, heating		
Gasoline	2,000–9,000	*	Fuel		
Jet fuels	—		Fuel		
Kerosene	243,000		Fuel, heating, solvent, insecticides		
Lignin	7,500[i]		Newsprint, ceramic binder, dyestuffs, drilling fuel additive, plastics		
Methylene blue activated substances (MBAs)	11	•	Dyestuffs, analytical chemistry		
Propane	—		Fuel, solvent, refrigerants, propellants, organic synthesis		
Tannin	7,500[i]		Chemical manufacturing, tanning, textiles, electroplating, inks, pharmaceuticals, photography, paper		
4,6,8-Trimethyl-1-nonene	—		NA[i]		
Undecane	—		Petroleum research, organic synthesis		
Metals and cations	(parts per million)				
Aluminum	0.1–1,200	*	Alloys, foundry, paints, protective coatings, electrical industry, packaging, building and construction, machinery and equipment		High
Antimony	—		Hardening alloys, solders, sheet and pipe, pyrotechnics		Moderate
Arsenic	0.01–2,100	*	Alloys, dyestuffs, medicine, solders, electronic devices, insecticides, rodenticides, herbicide, preservative	High	
Barium	2.8–3.8	*	Alloys, lubricant		High
Beryllium	less than 0.01	*	Structural material in space technology, inertial guidance systems, additive to rocket fuels, moderator and reflector of neutrons in nuclear reactors	Moderate	
Cadmium	0.01–180	*	Alloys, coatings, batteries, electrical equipment, fire protection systems, paints, fungicides, photography	High	
Calcium	0.5–225		Alloys, fertilizers, reducing agent		

Table 1.—Substances Known to Occur in Groundwater, Ranges of Detected Concentrations, Exceeded Standards, Examples of Uses, and Quantitative Estimates of Carcinogenic Potency and Noncarcinogenic Toxicity[a]—continued

Contaminant	Concentration[b]	Standard[c]	Examples of uses[d]	Carcinogenic potency[e,f]	Noncarcinogenic toxicity[e,g]
Metals and cations (cont'd)	(parts per million)				
Chromium	0.06–2,740	*	Alloys, protective coatings, paints, nuclear and high-temperature research	High	
Cobalt	0.01–0.18	*	Alloys, ceramics, drugs, paints, glass, printing, catalyst, electroplating, lamp filaments		High
Copper	0.01–2.8	*	Alloys, paints, electrical wiring, machinery, construction materials, electroplating, piping, insecticides		Moderate
Iron	0.04–6,200	*	Alloys, machinery, magnets		
Lead	0.01–5.6	*	Alloys, batteries, gasoline additive, sheet and pipe, paints, radiation shielding		High
Lithium	—	*	Alloys, pharmaceuticals, coolant, batteries, solders, propellants		Low
Magnesium	0.2–70		Alloys, batteries, pyrotechnics, precision instruments, optical mirrors		
Manganese	0.1–110	*	Alloys, purifying agent		High
Mercury	0.003–0.01	*	Alloys, electrical apparatus, instruments, fungicides, bactericides, mildew-proofing, paper, pharmaceuticals		High
Molybdenum	0.4–40	*	Alloys, pigments, lubricant		
Nickel	0.05–0.5	*	Alloys, ceramics, batteries, electroplating, catalyst	Moderate	High
Palladium	—		Alloys, catalyst, jewelry, protective coatings, electrical equipment		Low
Potassium	0.5–2.4		Alloys, catalyst		
Selenium	0.6–20	*	Alloys, electronics, ceramics, catalyst		High
Silver	9–330	*	Alloys, photography, chemical manufacturing, mirrors, electronic equipment, jewelry, equipment, catalyst, pharmaceuticals		High
Sodium	3.1–211	*	Chemical manufacturing, catalyst, coolant, non-glare lighting for highways, laboratory reagent		
Thallium	—		Alloys, glass, pesticides, photoelectric applications		High
Titanium	—		Alloys, structural materials, abrasives, coatings		Low
Vanadium	243	*	Alloys, catalysts, target material for x-rays		High, moderate
Zinc	0.1–240	*	Alloys, electroplating, electronics, automotive parts, fungicides, roofing, cable wrappings, nutrition		Moderate
Nonmetals and anions					
Ammonia	1–900	*	Fertilizers, chemical manufacturing, refrigerants, synthetic fibers, fuels, dyestuffs		
Boron	—	*	Alloys, fibers and filaments, semi-conductors, propellants		
Chlorides	1.0–49,500	*	Chemical manufacturing, water purification, shrink-proofing, flame-retardants, food processing		
Cyanides	1.05–14	*	Polymer production (heavy duty tires), coatings, metallurgy, pesticides		High
Fluorides	0.1–250	*	Toothpastes and other dentrifices, additive to drinking water		Moderate
Nitrates	1.4–433	*	Fertilizers, food preservatives		
Nitrites	—	*	Fertilizers, food preservatives		
Phosphates	0.4–33		Detergents, fertilizers, food additives		
Sulfates	0.2–32,318	*	Fertilizers, pesticides		
Sulfites	—		Pulp production and processing, food preservatives		

Table 1.—Substances Known to Occur in Groundwater, Ranges of Detected Concentrations, Exceeded Standards, Examples of Uses, and Quantitative Estimates of Carcinogenic Potency and Noncarcinogenic Toxicity[a]—continued

Contaminant	Concentration[b]	Standard[c]	Examples of uses[d]	Carcinogenic potency[e,f]	Noncarcinogenic toxicity[e,g]
Micro-organisms	(parts per million)				
Bacteria (coliform)	—	•			
Viruses	—				
Radionuclides	(picocuries per milliliter)				
Cesium 137	—		Gamma radiation source for certain foods		
Chromium 51	—		Diagnosis of blood volume, blood cell life, cardiac output, etc.		
Cobalt 60	6.4		Radiation therapy, irradiation, radiographic testing, research		
Iodine 131	—		Medical diagnosis, therapy, leak detection, tracers (e.g., to study efficiency of mixing pulp fibers, chemical reactions, and thermal stability of additives to food products), measuring film thicknesses		
Iron 59	—		Medicine, tracer		
Lead 210	—		NA[i]		
Phosphorus 32	—		Tracer, medical treatment, industrial measurements (e.g., tire tread wear and thickness of films and ink)		
Plutonium 238, 243	—		Energy source, weaponry		
Radium 226	0.8–25	*	Medical treatment, radiography		
Radium 228	12.5		NA[i]		
Radon 222	—	•	Medicine, leak detection, radiography, flow rate measurement		
Ruthenium 106	—		Catalyst		
Scandium 46	—		Tracer studies, leak detection, semi-conductors		
Strontium 90	0.817	•	Medicine, industrial applications (e.g., measuring thicknesses, density control)		
Thorium 270	—		NA[i]		
Tritium	150–353	•	Tracer, luminous instrument dials		
Uranium 238	10–500	*	Nuclear reactors		
Zinc 65	—		Industrial tracer (e.g., to study wear in alloys, galvanizing, body metabolism, function of oil additives in lubricating oils)		
Zirconium 95	—		NA[i]		

[a]Based on Abrams, et al., 1975; Bryant, et al., 1983; Harris, et al., n.d.; O'Brien and Fisher, 1983; Tucker, 1981; University of Oklahoma, 1983; Hawley, 1977; Considine and Considine, 1983; Lewis and Tatken, 1980; and Windholz, et al., 1982.

[b]Concentrations represent single reported concentrations or ranges of reported groundwater or domestic well concentrations from references surveyed; they generally do not include concentrations at hazardous waste sites. Dash (—) indicates contaminant detected but concentration not reported. Note that units differ among categories; units are defined at the beginning of each contaminant category.

[c]Solid bullet means that at least one type of standard exists for the substance. Asterisk means that at least one standard is known to have been exceeded. Note that these refer to standards for individual substances; standards for groups of substances or other measurements such as BOD are listed in app. C.

[d]Listed uses are primarily industrial applications. Some substances occur naturally in groundwater and may not be a result of human activities.

[e]Absence of an entry does not necessarily mean that no adverse health effects are associated with that substance; rather, entries reflect data available to OTA. In addition, if a value was found for carcinogenic potency of a substance, no search for non-carcinogenic toxicity of that substance was made.

[f]Carcinogenic potency is measured either according to unit risks developed by EPA Carcinogen Assessment Group or according to estimated unit risk based on assessment by EPA Office of Pesticides and Toxic Substances (as reported in Environ Corp., 1983); carcinogens are listed only if peer-reviewed unit risk data are available. Unit risk = risk per unit of exposure, where unit of exposure is defined as lifetime average daily intake. Estimates of lifetime risk are obtained by multiplying unit risk by actual exposure. Potency categories are defined as (Environ. Corp., 1983):
High potency = unit risk greater than 5 $(mg/kg/day)^{-1}$
Medium potency = unit risk equal to 0.1–5 $(mg/kg/day)^{-1}$
Low potency = unit risk less than 0.1 $(mg/kg/day)^{-1}$

[g]Noncarcinogenic toxicity is measured by Minimum Effective Dose (MED, the minimum dose known to cause adverse impact; Environ Corp., 1983):
High = MED less than 10 mg/kg body weight/day
Moderate = MED 10–100 mg/kg body weight/day
Low = MED greater than 100 mg/kg body weight/day.

[h]Value for combined anthracene and phenanthrene.

[i]NA — Information on use not available in standard references that were consulted.

[j]Value for combined lignin and tannin.

Source: Office of Technology Assessment, 1984

A.2 SUMMARY OF TOXIC EFFECTS OF ORGANIC AND INORGANIC CHEMICALS KNOWN TO OCCUR IN GROUNDWATER[a b]

CONTAMINANT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
A.1. AROMATIC HYDROCARBONS																								
1. Acetanilide																								
2. Alkyl benzene sulfonates	X	X	X											X										
3. Aniline									X							X								X
4. Anthracene			X																				X	X
*5. Benzene	X	X	X						X	X	X	X		X										X
6. Benzidine																								X
7. Benzyl alcohol		X																						
8. Butoxymethylbenzene																								
9. Chrysene																								X
10. Creosote Mixture																								
11. Dibenz (a.h.) anthracene																								X
12. Di-t-butyl-p-benzoquinone																								
13. Dihydrotrimethylquinoline																								
14. 4,4-Dinitrosodiphenylamine																								X
*15. Ethylbenzene	X	X		X		X	X	X																
16. Fluoranthene																								
17. Fluorene																								
18. Fluorescein dye																								
19. Isopropyl benzene																								

CONTAMINANT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
A.1. AROMATIC HYDROCARBONS (Continued)																								
20. Methylthiobenzothiazole																								
21. 4,4-Methylene-bis-2-chloroaniline (MOCA)	X			X		X	X									X							X	X
22. Naphthalene	X	X		X							X							X						
23. o-Nitroaniline																X							X	
24. Nitrobenzene						X	X		X		X					X			X	X	X			
25. 4-Nitrophenol					X											X								
26. n-Nitrosodiphenylamine						X																		X
27. Phenanthrene			X																				X	X
28. n-Propylbenzene										X														
29. Pyrene		X			X	X					X			X								X	X	
30. Styrene (vinyl benzene)	X	X		X		X	X		X					X							X		X	
*31. Toluene	X	X		X		X	X		X				X											
32. 1,2,4-Trimethylbenzene		X			X				X															
33. Xylenes (m,o,p)	X			X		X	X		X				X											

CONTAMINANT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
A.2. OXYGENATED HYDROCARBONS																								
1. Acetic acid	X	X		X	X																			
2. Acetone	X			X					X															
3. Benzophenone			X																					
4. Butyl acetate																								
5. N-butyl-benzylphthalate																								
6. Di-n-butyl phthalate	X			X					X															
7. Diethyl ether	X	X		X					X															
8. Diethyl phthalate		X		X																				
9. Diisopropyl ether																								
10. 2,4- Dimethyl-3-hexanol																								
11. 2,4-Dimethyl phenol																								
12. Di-n-octyl phthalate																								
*13. 1,4-Dioxane	X			X		X	X																	X
14. Ethyl acrylate																								
15. Formic acid	X	X		X					X															
16. Methanol	X					X			X									X						
17. Methyl alcohol																								
18. Methylcyclohexanone																								
19. Methyl ethyl ketone																								
20. Methylphenyl acetamide																								

CONTAMINANT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
A.2. OXYGENATED HYDROCARBONS (Continued)																								
*21. Phenols (e.g., p-tert-Butyl phenol)		X																						
22. Phthalic acid																								
23. 2-Propanol																								
24. 2-Propyl-1-heptanol																								
25. Tetrahydrofuran		X		X		X	X		X															
26. Varsol																								
A.3. HYDROCARBONS WITH SPECIFIC ELEMENTS																								
1. Acetyl chloride																								
*2. Alachlor (Lasso)																								
*3. Aldicarb (sulfoxide and sulfone; Temik)															X									
4. Aldrin		X				X	X		X											X				X
5. Atrazine		X			X				X		X										X		X	
6. Benzoyl chloride		X		X																				
7. Bromobenzene	X	X			X	X		X															X	
*8. Bromacil						X			X															
9. Bromochloromethane					X	X	X		X															
*10. Bromodichloromethane																								
11. Bromoform	X			X		X			X															
*12. Carbofuran						X									X									

CONTAMINANT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
A.3. HYDROCARBONS WITH SPECIFIC ELEMENTS (Continued)																								
*13. Carbon tetrachloride						X	X		X											X				X
14. Chlordane				X		X			X				X											X
15. Chlorobenzene	X			X	X	X	X		X											X			X	
*16. Chloroform	X	X				X	X		X					X							X			X
17. Chlorohexane																								
18. Chloromethane					X	X	X		X															
19. Chloromethyl sulfide																								
20. 2-Chloronaphthalene		X				X																		
21. Chlorpyrifos						X									X									
22. Chlorthal-methyl (DCPA, or Dacthal)																								
23. o-Chlorotoluene	X	X							X															
24. p-Chlorotoluene																								
25. Dibromochloromethane																							X	
*26. Dibromochloropropane (DBCP)	X	X			X	X	X													X			X	X
27. Dibromodichloroethylene																								
28. Dibromoethane																								
29. Dibromomethane																								
30. Dichlofenthion (DCFT)															X									

CONTAMINANT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
A.3. HYDROCARBONS WITH SPECIFIC ELEMENTS (Continued)																								
31. o-Dichlorobenzene	X	X		X	X	X	X		X		X													
*32. p-Dichlorobenzene	X			X	X	X	X		X		X													
33. Dichlorobenzidine	X			X	X									X										X
34. Dichlorocyclooctadiene																								
35. Dichlorodiphenyldichloroethane (DDD,TDE)																			X					X
36. Dichlorodiphenyldichloroethylene (DDE)																								
*37. Dichlorodiphenyltrichloroethane (DDT)					X	X			X		X									X			X	X
38. 1,1-Dichloroethane						X	X		X												X			
*39. 1,2-Dichloroethane	X	X			X	X	X		X				X	X					X	X			X	X
*40. 1,1-Dichloroethylene (vinylidiene chloride)	X	X		X	X	X	X		X				X						X		X		X	X
*41. 1,2-Dichloroethylene (cis and trans)																								
42. Dichloroethyl ether																								
43. Dichloroiodomethane																								
44. Dichloroisopropylether (= bis-2-chloroisopropylether)																								
*45. Dichloromethane (methylene chloride)	X	X				X	X		X												X			
46. Dichloropentadiene																								

CONTAMINANT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
A.3. HYDROCARBONS WITH SPECIFIC ELEMENTS (Continued)																								
47. 2,4-Dichlorophenol																								
*48. 2,4-Dichlorophenoxyacetic acid (2,4-D)									X	X												X	X	
49. 1,2-Dichloropropane						X	X																X	
50. Dieldrin						X			X											X				X
51. Diiodomethane																								
52. Diisopropylmethyl phosphonate (DIMP)																								
53. Dimethyl disulfide																						X		
54. Dimethylformamide																								
55. 2,4-Dinotrophenol (Dinoseb, DNBP)	X	X					X		X											X				
*56. Dioxins (e.g., TCDD)						X			X	X							X			X		X	X	X
57. Dodecyl mercaptan (lauryl mercaptan)	X	X	X						X														X	
*58. Endosulfan						X	X		X												X		X	
59. Endrin						X			X															
60. Ethyl chloride																								
61. Bis-2-ethylhexylphthalate	X	X				X														X	X	X		X
62. Di-2-ethylhexylphthalate																								

CONTAMINANT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
A.3. HYDROCARBONS WITH SPECIFIC ELEMENTS (Continued)																								
63. Fluorobenzene																								
64. Fluoroform																							X	
65. Heptachlor																								
66. Heptachlorepoxide																								
67. Hexachlorobicycloheptadiene																								
68. Hexachlorobutadiene																								
69. α - Hexachlorocyclohexane (=Benzenehexachloride, or α - BHC)																								
70. β - Hexachlorocyclohexane (β - BHC)																								
71. γ - Hexachlorocyclohexane (γ -BHC, Lindane)																								
72. Hexachlorocyclopentadiene	X			X	X	X	X						X						X					
73. Hexachloroethane						X	X		X												X			X
74. Hexachloronorbornadiene																								
75. Kepone						X	X													X	X			X
76. Malathion																								

CONTAMINANT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
A.3. HYDROCARBONS WITH SPECIFIC ELEMENTS (Continued)																								
77. Methoxychlor							X													X				
78. Methyl bromide																								
*79. Methyl parathion															X					X	X			
80. Parathion																					X			
81. Pentachlorophenol (PCP)	X	X		X		X			X						X									
82. Phorate (Disulfoton)																					X	X		
83. Polybrominated biphenyls (PBBs)						X						X												
*84. Polychlorinated biphenyls (PCBs)					X	X						X	X	X						X	X	X	X	X
85. Prometon																								
*86. RDX (Cyclonite)																							X	
87. Simazine									X															
*88. Tetrachlorobenzene																								
*89. Tetrachloroethane (1,1,1,2)						X															X		X	
*90. Tetrachloroethane (1,1,2,2,)				X		X	X		X					X							X	X	X	X
*91. Tetrachloroethylene (1,1,2,2) (perchloroethylene, PCE)	X			X	X		X		X												X			X
*92. Toxaphene						X	X		X												X		X	X
93. Triazine																								
94. 1,2,4-Trichlorobenzene																								

CONTAMINANT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
A.3. HYDROCARBONS WITH SPECIFIC ELEMENTS (Continued)																								
*95. Trichloroethanes (1,1,1 & 1,1,2)	X	X		X	X	X	X		X				X										X	X
96. 1,1,2-Trichloroethyelene (TCE)		X			X	X	X		X		X		X											X
97. Trichlorofluoromethane (Freon 11)									X				X											
98. 2,4,6-Trichlorophenol						X																	X	X
99. 2,4,5-Trichlorophenoxyacetic acid (2,4,5-T)						X	X		X													X	X	
100. 2,4,5-Trichlorophenoxypropionic acid (2,4,5-TP, or Silvex)						X	X		X															
101. Trichlorotrifluoroethane																								
*102. Trinitrotoluene (TNT)																								
103. Tris-(2,3-dibromopropyl) phosphate																								
*104. Vinyl chloride		X				X	X		X		X												X	X
A.4. OTHER HYDROCARBONS																								
1. Alkyl sulfonates	X	X	X																					
2. Cyclohexane						X	X		X															
3. 1,3,5,7-Cyclooctatetraene																								
4. Dicyclopentadiene (DCPD)	X	X		X	X		X		X															
5. 2,3-Dimethylhexane																								
6. Fuel oil		X			X		X		X					X										

CONTAMINANT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
A.4. OTHER HYDROCARBONS (Continued)																								
*7. Gasoline		X		X					X					X										
8. Jet fuels						X	X		X	X														
9. Kerosene																								
10. Lignin																								
11. Methylene Blue Activated Substances (MBAs)																								
12. Propane													X											
13. Tannin																								
14. 4,6,8-Trimethyl-1-nonene																								
15. Undecane																								
B.1. METALS AND CATIONS																								
*1. Aluminum														X										
2. Antimony		X			X	X	X				X		X											
*3. Arsenic					X					X			X				X			X		X	X	X
*4. Barium		X		X	X		X			X									X					
*5. Beryllium	X	X	X	X	X	X																		X
*6. Cadmium				X	X		X		X											X	X	X		X
7. Calcium																								
*8. Chromium		X	X	X	X	X															X	X	X	X
*9. Cobalt	X	X	X		X						X		X	X										

CONTAMINANT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
B.1. METALS AND CATIONS (Continued)																								
10. Copper						X	X					X												
*11. Iron					X	X								X										
*12. Lead									X		X									X				
13. Lithium							X		X				X	X										
14. Magnesium	X								X															
*15. Manganese					X	X			X															
*16. Mercury							X		X									X				X		
*17. Molybdenum																								
*18. Nickel	X		X	X	X				X					X						X				X
19. Palladium							X				X													
20. Potassium																								
*21. Selenium	X			X	X	X			X					X										
*22. Silver					X		X				X			X			X	X						
*23. Sodium																								
24. Thallium						X	X		X				X	X						X		X		
25. Titanium																								
*26. Vanadium			X		X	X	X		X		X													
*27. Zinc	X	X									X								X	X				

CONTAMINANT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
B.2. NONMETALS AND ANIONS																								
*1. Ammonia	X	X		X	X	X	X		X															
2. Boron																								
*3. Chlorides																								
*4. Cyanides	X	X	X	X					X															
*5. Fluorides							X		X															
*6. Nitrates																								
7. Nitrites																								
8. Phosphates																								
*9. Sulfates																								
10. Sulfites																								
TOTAL NUMBER OF CHEMICALS	43	46	13	38	37	62	53	2	67	6	17	4	16	18	6	5	3	4	7	21	20	14	31	38

Footnotes

[a] Compiled from a partial survey of literature conducted by Environ Corp., 1983.

"*" indicates that the chemical is known to exceed at least one State or Federal standard (see chapter 2, the section on Adverse Impacts of Chemicals, and app. A.4).

[b] Numerical key of toxic effects:

1. Eye irritation
2. Skin irritation
3. Allergic sensitization
4. Upper respiratory tract irritation
5. Lung/respiratory effects
6. Liver damage
7. Kidney damage
8. Pancreatic damage
9. Central nervous system (CNS) effects
10. Peripheral nervous system effects
11. Blood cell disorders
12. Immunological effects
13. Cardiovascular effects
14. Gastrointestinal effects
15 Cholinesterase inhibition
16. Methemoglobinemia
17. Skin damage
18. Visual damage
19. Endocrine effects
20. Reproductive effects
21. Embryotoxicity
22. Teratogenicity
23. Mutagenicity
24. Carcinogenicity

Source: Office of Technology Assessment. 1984.

APPENDIX F

APPENDIX F

GROUND WATER CONTAMINATION SITES
CASE STUDIES

Many ground water contamination cases in the Buried Valley Aquifer Systems have been the subject of investigation and cleanup actions. The investigation and enforcement responsibilities are shared by municipal officials, including the health officers, the NJ Department of Environmental Protection and the US Environmental Protection Agency. The cases covered in this appendix were identified exclusively from the files of the New Jersey Geological Survey (NJGS), which serves as an in-house consultant to other programs of the NJDEP with regard to complex ground water contamination cases. It was felt that cases involving the NJGS would constitute the most important ground water contamination incidents in the region.

Information in the case studies was derived from NJGS case files, discussions with the hydrogeologists on the cases, other public records and information on current activities of the NJDEP enforcement bureaus in the Northern and Metropolitan regions. Every effort has been made to minimize error of omission and commission. However, no undertaking can be perfect in such a complex field where new results are continuously arriving. Investigations costing hundreds of thousands of dollars are in progress, and the information presented here will become obsolete as new information becomes available. It is also possible that incomplete knowledge of each case may result in minor errors of fact.

Perhaps most important, every effort has been made to present findings of responsibility for pollution in terms that are supported by data. Terms such as "may be responsible" are common in the case studies. Often, a case will be concluded and cleanup obtained with no formal finding of fault. However, in most cases a responsible party will only make the necessary expenditures if a case against them is sound.

Whatever the sources of information, and no matter how thoroughly reviewed, the author is responsible for any errors in interpretation and reporting. To the extent that any errors were made, they were completely unintentional, and my apologies beforehand to any who might be misrepresented.

Terms used in this appendix are the same as those terms used in the report as a whole. Please refer to the glossary in the early part of this report.

ROCKAWAY VALLEY SUBREGION
MAJOR CONTAMINATION CASES

A152 SHELL GASOLINE STATION, ROCKAWAY TOWNSHIP July 1980

Overview--Located at Green Pond Road next to Interstate 80, west of the railroad line. Leakage of an unknown amount of gasoline affected the ground water near the station. Monitoring wells were installed. Samples indicated dissolved volatile hydrocarbons and industrial solvents. The extent of the contamination indicated a connection with the township's supply wells. Gradient of the ground water flow is apparently southeast toward the Beaver Brook valley-fill aquifer. Shell Oil has cooperated with township authorities and installed a treatment system, using granular activated carbon and air-stripping, for the township water system. Decontamination by way of pumping to treatment is continuing.

A155 ROCKAWAY TOWNSHIP WELL FIELD December 1979

1) Overview--Beaver Brook Aquifer contaminated by various volatile organic compounds. Ground water monitoring shows two or more contaminant plumes affecting the wells, including the Shell Station (A152). Well water is treated by a granular activated carbon and air stripping system. The site was placed on the National Priority List (Superfund) in December, 1982. Decontamination is continuing through treatment for public supply. The NJDEP investigation is continuing, while Superfund investigations are scheduled to begin in October 1985.
2) Location of the contaminated site--Southern portion of the Beaver Brook watershed, north of Interstate 80 and west of Ford Road.
3) Severity of contamination--Rockaway Township Well 6 has levels of TCE contamination at 200 ppb. The wells are also contaminated with gasoline additives (ethers). Well 7 exhibits levels of di-n-octyl phthalate of 42 ppb.
4) Extent of contamination/Ground water flow--All three of the Rockaway Township wells have been contaminated. Essentially the entire southern Beaver Brook buried valley aquifer is considered contaminated to nonpotable levels, requiring extensive treatment prior to consumption. The area consists of three Wisconsonan glacial beds, with a productive glacial aquifer at the base with up to 80 feet of coarse sand and gravel and high permeabilities, in which the Township wells are set. The second layer is glaciolacustrine clay and serves as an aquitard in the center of the buried valley. The clays are up to 60 feet thick but laterally discontinuous. The surface layer is interbedded sand and gravel up to 30 feet thick. The total glacial unit is approximately 170 feet thick. The bedrock is Precambrian gneiss with ground water flow through joints and fractures. Decomposed rock may exist between the glacial deposits and bedrock, impeding vertical infiltration.

The water table in the upper aquifer lies 20 to 30 feet below the surface, with flow toward Beaver Brook and Meadow Brook. The ground water in the deep aquifer, under pumping conditions, flows toward the well system from the north, west and southeast. Regional flow is

assumed to be from north to south along the line of the buried valley aquifer, and toward the valley from side slopes. The Ford Road area is unconfined (a condition that continues to the east) allowing easy percolation of pollutants to the confined aquifer where the Township wells are located. The radius of influence for the wells may be to either side of the glacial sediments in the valley.
5) Suspected and confirmed sources--Shell Oil has provided a treatment system for the Rockaway Township well field and may be considered a confirmed source. One additional source of gasoline contamination may be the Towne & Country station on the western edge of the buried valley.

The former Morton Thiokol facility is just east of Ford Road at the edge of the buried valley. Monitor well samples show that contamination is higher to the east of Ford Road than to the west (2500 ppb TCE versus 600 ppb TCE), indicating an eastern source of the contamination given the ground water flow to the northwest toward the well field. Keuffel & Esser Company, north and northwest of the Thiokol site along Ford Road, has discovered solvent contamination in the sediments above the confining layer, but the extent of contribution to the lower aquifer pollution, if any, is not known. Monitor wells at the Thiokol and Keuffel & Esser sites have TCE and chloroform contamination and a ground water flow direction toward the municipal wells. Gasoline and gasoline additive contamination is being investigated.
6) Mitigation actions--Underground tanks at the two gasoline stations have been removed as contaminant sources.
7) Decontamination actions--The pumping and air-stripping of the township wells constitute decontamination, but the higher concentration levels east of Ford Road indicate that pumping may actually pull more TCE contamination to the wells.
8) Continuing investigations--The NJDEP is continuing its investigations, and the Superfund program is scheduled to supply funds for additional research. An extensive ground water monitoring system is needed to determine the extent and source(s) of the TCE contamination.

A162 ROCKAWAY BOROUGH MUNICIPAL WELLS September 1981

1) Overview--Rockaway Borough's wells have been contaminated by organic chemicals to varying degrees. The borough installed a granulated activated carbon filtration system to bring the water to potable standards, after closing the system for four months in 1981. The wells were placed on the Superfund National Priority List in December, 1982. The Remedial Investigation/Feasibility Study under the Superfund program began in 1985 and was released to the public in August, 1986. Decontamination is continuing through pumpage to the treatment system.

2) Location of the contaminated site--The Rockaway Borough wells are located in the northeastern quadrant of the borough, north of the Rockaway River. There are three wells, numbered 1, 5 and 6.

3) Severity of contamination--Well 1 and Well 6 are the most severely affected of the wells. The contaminants include TCE, PCE, 1,1,2,2 tetrachloroethane, chlorobenzene and methylene chloride. TCE levels have been at or below 26.7 ppb. The PCE levels range from 10.2 ppb in Well 1 to 147 ppb in Well 6, though the peak level measured in Well 6 was 650 ppb. The PCE contaminant levels fluctuate considerably

up to approximately 300 ppb, generally. The remaining contaminants are less severe. As there are only three private wells in the borough, the main concern lies with the borough wells. Contamination of surface water in the Rockaway River and tributaries has not been identified except for methylene chloride at or less than 13.8 ppb. Subaqueous sediments contain toluene and methylene chloride. (Methylene chloride is both a common solvent and a very common laboratory contaminant.)

4) Extent of contamination/Ground water flow--The borough wells are located in an area of glacial sediments consisting of 50 feet of clay-rich till over 50 feet or more of stratified drift. NUS Corporation locates the borough in the middle of the terminal moraine, but geological evidence suggests that morainal material overlays valley-fill deposits from an earlier southward movement of the Wisconsin glacier. The till provides some protection for the lower aquifer. Well 5 draws from the lower aquifer and was a flowing artesian well when drilled. Wells 1 and 6 apparently are recharged by the river. (Well 1 is not in use currently.) Tetra Tech in 1979 defined the Rockaway River as gaining water from the aquifer in the borough and losing water to the aquifer downstream. Ground water movement, therefore, may be toward Wells 1 and 6 from the river, but more generally toward the river and also downgradient (to the east) within the lower aquifer. The full extent of the contaminated aquifer is not yet known. Wells 1 and 6 have a radius of influence of up to one-half mile, while Well 5 has a radius of influence exceeding one mile (indicating that Well 5 draws from a confined aquifer). As Wells 1 and 6 show the greatest contamination, the sources are most likely to be found within one-half mile.

5) Suspected and confirmed sources--There are no confirmed sources of pollution. Many possible sources exist, none of which are currently active (adding additional wastes to the source) according to a borough industrial survey. Note well that sites with proven contamination may be victims of the regional contamination rather than causes. Only further investigations can confirm suspects. The RI/FS resulted in some narrowing of the investigation by identifying one primary area for TCE, one primary area for PCE, and one secondary area. The two contaminants appear to have separate sources. No specific source was identified. The sites under investigation included the following:

a) Old dump 1800 feet north of the wells, which supposedly only accepted domestic and commercial wastes. Residential development was placed on the dump site after the 1950's.

b) Dye pits, long inactive and covered, once operated by Liondale Dye Plant.

c) Moretrench American, which once manufactured pumps. The use of solvents for metal degreasing is considered likely. Past disposal practices, as for most of the older industrial uses, are not known. NJDEP samples taken in 1981 indicate TCE contamination at 50 ppb.

d) A & A Fuel Oil Co. has large fuel storage tanks.

e) Pettit Paint Co. mixes and packages marine paints. There are underground and mixing tanks on the property. Prior to acquisition of the property by Pettit Paint, Thiokol manufactured jet engines and ballistics beginning in the mid-1950's. The use of solvents was likely. Rolling Mill, a foundry, used the site prior to Thiokol.

f) The Borough garage has handled a nominal amount of organic solvents and drums. Some contaminated soil has been removed.

g) A dump site exists behind the A & A Fuel Oil Co. Drums have been removed.

h) Stiles Rubber Company test results showed TCE contamination of 77.5 ppb and PCE contamination of 128 ppb in 1985.

i) Industrial area 1000 to 2000 feet northeast of the wells which includes some of the above sites. Older industries, since replaced, may have caused some of the contamination.

j) Sources of the Rockaway Township contamination could be implicated in Rockaway Borough's contamination if the Beaver Brook Aquifer is hydraulically connected to the Rockaway Valley Aquifer and ground water flows toward Rockaway Borough.

6) Mitigation actions--The source is assumed to be inactive, based on industrial surveys by the borough and the NJDEP. Therefore, there is no apparent source to close. Mitigation primarily has involved treatment of the public water supply, which simultaneously protects the residents and decontaminates the aquifer. The treatment system is very effective and was selected as the preferred treatment alternative under the RI/FS.

7) Decontamination actions--Diversion to the treatment system.

8) Continuing investigations--An extensive investigation program is underway to determine the sources of the contamination within the primary and secondary source areas identified by the RI/FS. This investigation is through the Superfund program, with the NJDEP serving as lead agency. More difficult than source identification is the determination of the relative contributions to the contamination.

A163 DOVER MUNICIPAL WELL 4 December 1980

1) Overview--Water quality in Hooey Street (now named Rutan Drive) well (Well 4) degraded by organic chemicals. Sampling of nearby wells indicated that the contamination may be local. Well 4 is a National Priority List site through Superfund. Investigation has begun through Superfund, and is continuing through NJDEP.

2) Location of the contaminated site--Rutan Drive, in the southeast portion of Dover.

3) Severity of contamination--Well 4 had 118 ppb of 1,1,1 trichloroethane and 122 ppb of PCE in 1981. Oil was found in Well 2 (not used) in 1985 but was suspected to be the result of dumping rather than ground water contamination. Wells 1, 3, and 5 exhibit low levels of volatile organic chemicals (10 to 20 ppb in 1985), near A-280 action levels. Wells 1, 3, and 5 are not in the same vicinity as Well #4 and the contamination problems are not considered connected.

4) Extent of contamination/Ground water flow--The Well 4 contamination is similar to that of Denville Well 3, which may have drawn the plume affecting Dover Well 4 once the latter well was shut down. VOC levels at Well 4 dropped from 170 ppb to 70 ppb by 1985, indicating that the plume may have moved.

The contamination of Wells 1, 3, 5, and Wharton's Well 3 are similar and may have a common source.

5) Suspected and confirmed sources--New Jersey Natural Gas owns property adjacent to Well 4 used for coal gasification. See I-90. Significant pollution on site makes NJ Natural Gas a probable contributor to the contamination of Well 4. Howmet (Alloy), Howmet (Dover Casting) and the Denville Well 3 were identified as being within the radius of influence for Well 4 by Dover's consultants after a 1985 pump test. Howmet's

consultants disagree. (See I-210 and I-211).

Near Wells 1, 3 and 5, the DAYCO facility is considered a possible source of low level VOC pollution, and is confirmed as the source of oil contamination beneath their site. DAYCO is presently considered a likely source of contamination at Wells 1, 3 and 5 but not at Well 4.

6) Mitigation actions--NJ Natural Gas and Howmet (Austenal) must initiate a remedial investigation/feasibility study toward remediation of their pollution. The Dover Well 4 is the subject of a Superfund study. In response to a 15 July Spill Fund Directive, Howmet and NJ Natural Gas have agreed to pay an aggregate of $700,000 for an RI/FS of Dover Well #4. See A-237 for a description of action near Wells 1, 3 and 5.

7) Decontamination actions--No decontamination actions are in place at Well 4.

8) Continuing investigations--Investigations continue at all sites.

A237 COMMUNITY TRANSIT (DAYCO), DOVER 1984

1) Overview--A loss of 6000 gallons of diesel fuel from an above ground tank was discovered 400 feet from the Dover well field. Seven monitor wells and a recovery well were installed and are in operation. Recovery is complicated by the presence of a building and foundation. Monitor and recovery wells are located inside and outside of the building. The investigation by NJDEP is continuing.

2) Location of the contaminated site--Richboynton Road Industrial Complex in Dover, adjacent to and east of the Dover Water Works Park.

3) Severity of contamination--An estimated 6,000 gallons of diesel fuel were discharged from an above ground tank. Some contaminated soils were removed. The remainder of the fuel created a plume with product up to one foot in depth on the water table aquifer. Ground water at the site also exhibits low levels of halocarbons similar to the contamination in the Dover Wells 1, 3 and 5 (2 to 10 ppb, considerably lower than the 1981 levels of 20 to 80 ppb), consisting of TCE and 1,1,1 trichloroethane.

4) Extent of contamination/Ground water flow--The oil plume is limited to the DAYCO property, extending west in a plume 20 feet wide and 40 feet long under a building toward (but not reaching) the Dover well field. The contamination site is more readily affected by Well 5 pumping than by Well 3. Local ground water flow is to the west toward the well field and the Rockaway River when Well 5 is pumping, and southwest when Well 5 is off.

The full extent of the halocarbon contamination (unrelated to the diesel fuel) is not known. The site geology consists of a Precambrian gneiss valley filled with glacial drift to the north along the slope, up to 40 feet of clay on the valley floor, and a medium sand and gravel aquifer and coarse till above the clay. The wells are set in the upper strata. The ground water velocity is approximately 7 feet/day in the aquifer, with a transmissivity of 80,000 gpd/ft and hydraulic conductivity of 420 ft/day. Because of the velocity, DAYCO's consultant suggested that the dissolved constituents likely migrated from the site.

5) Suspected and confirmed sources--Community Transit, a lessee to DAYCO, is the source of the diesel fuel contamination. NJDEP has recommended a full industrial survey and analysis of the industrial

complex along the Rockaway River from the Dover well field to Wharton's Well 3, to discover the source(s) of the VOC contamination. The industrial park was occupied by DAYCO-Hose Division through 1981, then L.E. Carpenter and five other lessees. Community Transit leased property during 1984.
6) Mitigation actions--150 yards of oil contaminated soil were removed in 1984. 62 gallons were removed through oil booms, and additional gallonage was removed via the recovery wells and removal of contaminated soils. These actions were taken by DAYCO when Community Transit delayed action. The tank itself was removed. Dover Well 3 has been used only intermittently during summer months since the spill. The recovery wells act to contain the plume from further progress toward the well field.
7) Decontamination actions--The recovery well has operated to create a cone of depression and remove oil from the ground. By late 1985, the recovery had declined to 1.5 gpd of oil. DAYCO's consultant estimated that 100 to 200 gallons of oil remained at that time.
8) Continuing investigations--The DAYCO oil spill investigation is completed. The investigation for sources of the halocarbon contamination had not begun as of early 1986.

A238 TOWNE & COUNTRY GAS, ROCKAWAY TOWNSHIP 1984

1) Overview--Exxon leases a gasoline station owned by Towne & Country and discovered gasoline contamination on site during the course of hydrogeological examinations for the Rockaway Township Zoning Board of Adjustment. No free product was discovered but high VOC levels existed (xylene at 7,300 ppb, ethylbenzene at 2,100 ppb, benzene at 90 to 200 ppb, methylene chloride at less than 200 ppb). Definition of the plume, which has traveled off-site, is not complete. Investigation continuing.
2) Location of the contaminated site--Green Pond Road at the entrance to Interstate 80, northwest quadrant, across from the Shell Station (A-152) and southwest of the Rockaway Township well field (A-155).
3) Severity of contamination--Total VOC levels exceed 20,000 ppb in the most severe cases. No free floating product was discovered on site, but a strong odor is evident at the water table, 43 to 48 feet below grade. Gasoline contamination at 1 ppm was discovered near the two dispensing islands and approximately 140 ppb near two underground gasoline tanks.
4) Extent of contamination/Ground water flow--The contamination extends north of the Towne & Country site, but a precise delineation does not exist. The Shell Station across Green Pond Road exhibits similar contaminants. The site geology consists of glacial drift deposited over bedrock. The bedrock is greater than 60 feet below grade. Fine to medium sands exist to approximately 50 feet, underlain by silty fine sands. General ground water flow is northeast at perhaps 1/3 foot per day, consistent with conclusions at the Shell site. The ground water flow direction was confirmed by a synoptic water level and ground water quality survey of all monitor wells at the Shell and Towne & Country sites in late 1984. The gasoline contamination near the dispensing islands was 15 to 20 feet deep, according to Exxon's consultants, indicating limited spills.
5) Suspected and confirmed sources--The NJDEP suspects prior gasoline contamination from the Towne & Country station. The gasoline tanks that tested tight were excavated and removed by Exxon in 1984. Consultants

for Exxon inferred that some excursions of contamination from the Shell site to the Towne & Country site may have occurred. Towne & Country denies responsibility, given tank integrity test results. Sampling from monitor wells indicates less than 10 ppb VOCs upgradient of the site, over 20 ppm directly downgradient, and somewhat lower levels between the site and the Shell Station. A monitor well was installed at an adjacent property north of the Towne & Country site in 1985. Plume definition continues.
6) Mitigation actions--The underground gasoline tanks were removed and tested tight. No actions have been taken to halt movement of the plume.
7) Decontamination actions--None.
8) Continuing investigations--The NJDEP continues to define the plume and the level of responsibility for remediation. Enforcement continues.

A WHARTON BOROUGH WELL 3 1981

1) Overview--Wharton Borough reported a finding of 3 ppm oil and grease, 2 ppb TCE and 1.9 PCE in Well 3, which was removed from use due to objectionable odors reported by consumers. The borough suggested that a nearby oil storage facility could be the source. NJDEP retested the well in early 1982 and found no oil and grease at detectable levels, nor petroleum hydrocarbons. The Thatcher Glass well and a nearby monitor well had the same results. Case closed in 1982. Wharton has continued to avoid use of the well due to hydrocarbon odors and plans to install a treatment system for the well.

A280 DENVILLE TOWNSHIP WELLS 1981

1) Overview--Denville wells 3 and 6 have been contaminated by VOCs such as PCE (up to 19 ppb) and 1,1,1 trichloroethane (up to 50 ppb), first discovered in 1981. Possible sources include Howmet Turbine Components Corp, Dover Casting Division and Alloy Division, and McWilliams Forge. Denville is presently installing a treatment system while investigating the source(s) of the contamination. Howmet has agreed to help fund the treatment system, with no acknowledgment of responsibility for the contamination.
2) Location of the contaminated site--Next to the southwestern corner of Denville in Randolph Township next to Dover.
3) Severity of contamination--The primary chemicals of concern are PCE and 1,1,1 trichloroethane. Denville has taken Well 6 off-line voluntarily until the treatment system is installed (Well 3 has not been in use). September 1985 levels included 11 ppb of PCE and 34 ppb of 1,1,1 trichloroethane. One sample in 1985 also exhibited 4.5 ppb of carbon tetrachloride which has not been verified to date. Resampling for carbon tetrachloride was expected. In a high flow pump test, the level of VOCs was below 40 ppb.
4) Extent of contamination/Ground water flow--The full extent of contamination is not known. The geology in the area consists of a surface aquifer and a confined aquifer separated by an aquitard of clay and silt. According to Denville's consultant, the confined conditions extend to the Dover Well 4 site to the northwest. The aquitard is thick

in the Denville well field area but changes to a complex layering/ lensing downstream (north) at the narrow valley where the Rockaway Borough Well 4 is located. A pumping test of Denville Well 3 led Denville's consultants to exclude McWilliams Forge as a likely contaminant source, though the 4000 foot radius of influence observed did reach to the McWilliams Forge property in the deep aquifer. Denville's consultant concluded that the Howmet site surface aquifer is fully connected to the deep aquifer pumped by Denville Well 3, based on the same test. Average transmissivity of the aquifer was measured at 40,930 gpd/ft2, with a storage coefficient of 3.1 X 10-4.
5) Suspected and confirmed sources--Howmet (Dover Casting Div.) has confirmed over 19 VOCs in excess of 100 ppb and 4 in excess of 1,000 ppb in the ground water. The latter are 1,1 dichloroethylene, 1,1 dichloroethane, p-dichlorobenzene and 1,1,1 trichloroethane (15,970 ppb). The contaminants found in Denville Well 3 are also in test pits and both the shallow and deep aquifer at Howmet. Denville's consultant concluded that pumping of Well 3 induces recharge of the deep aquifer from the surface aquifer and cited Howmet as a probable source. The NJ Natural Gas site has 8 VOC over 1,000 ppb, including 1,2 dichloroethane at 67,000 ppb. McWilliams Forge had TCE contamination up to 1717 ppb and other VOCs at less than 50 ppb in 1983, and was a TCE user with a 40 gpd discharge of TCE to two unlined lagoons. Levels at McWilliams Forge have dropped below 10 ppb TCE. No source for the Denville contamination has been confirmed as of early 1986. Consultants to Denville conducted a pumping test to help define the aquifer characteristics and determine the potential for induced flow of contaminated ground water to the wells.
6) Mitigation actions--Denville has installed an air stripping system to treat the wells for potable use, at a cost of $570,000. Howmet Turbine Components Corporation voluntarily contributed $430,000 toward the system.
7) Decontamination actions--None as of early 1986.
8) Continuing investigations--NJDEP and Denville are continuing their investigations.

I57 L.E. CARPENTER, WHARTON May 1979

1) Overview--Company had an unlined sludge lagoon and underground chemical storage. There is a body of xylene solvent floating on the water table beneath the site and high-level dissolved organic contamination with the aquifer beneath the site. An administrative consent order was signed in January 1982. The sludge lagoon was removed in the spring, 1982. A program for removal of both floating and dissolved product is being prepared after repeated delays. Floating product recovery began on 11 May 1984. A new Administrative Consent Order has been issued to L.E. Carpenter and its parent company, DAYCO Corporation. Investigation by NJDEP continuing.
2) Location of the contaminated site--Eastern side of Wharton, north of the Rockaway River along the river, next to Thatcher Glass. L.E. Carpenter produces vinyl wall coverings.
3) Severity of contamination--NJDEP samples of a surface impoundment revealed several heavy metals, xylene, styrene, nonane, cumane, 1,1,2 trichloroethylene, dibromomethane, mesitylene, p-cymene, butylbenzene,

heptane, toluene, octane, TCE, chloroform and benzene. Ground water samples contained both free floating product and dissolved contaminants such as 1,1,2 TCE, TCE, toluene, ethylbenzene, styrene, dibromomethane, propylbenzene, xylene, cumene, mesitylene, cymene, chlorobenzene, nonane, PCE, perchloroethane, chlorobenzene and several heavy metals, all of which are known discharges from L.E. Carpenter. Total VOCs ranged up to 11 ppm. In addition, up to 16.8 ppm of PCBs were found in ground water. The contamination became evident when consultants to the Rockaway Valley Regional Sewerage Authority began work on the main sewer interceptor through the property.

1986 monitor well samples show maximum contamination levels of 130 ppb toluene, 3,000 ppb ethylbenzene, 59,000 ppb m-xylene, 43,000 ppb o-xylene. Free product floating on the water table exceeded 10 feet in places during 1984, with over 55,000 square feet coverage of free product.

4) Extent of contamination/Ground water flow--The site is adjacent to the Rockaway River. Two consultants have shown opposite flow conditions between the river and the surface aquifer. A NJDEP site analysis in 1979 noted that water level in pits fluctuated with the river, indicating a direct connection.

The site geology consists of alluvial soil over glacial material, primarily stratified deposits north of the Rockaway River and morainal material to the south. The NJDEP is concerned that contamination of the deep aquifer could result in flow of contaminants along the buried valley without regard to the river itself as a hydraulic boundary. Nearby public wells (Dover Wells 1, 3, and 5--5500 feet downstream; Wharton Wells 1 and 2--4000 feet upstream; Wharton Well 3--4500 feet downstream) apparently draw a maximum of 50 per cent of their recharge from the river when shallow and a maximum of 20 per cent when deep.

5) Suspected and confirmed sources--L.E. Carpenter is considered a known and sole source for the site contamination. Wastes including polyvinyl chloride were discharged both to a surface impoundment and to a subsurface disposal system between 1963 and 1970. 1979 NJDEP inspections found very poor waste management practices. An abandoned supply well near the river could provide a conduit for contamination to migrate to the lower aquifer. Buried drums also existed on site along with a former sludge lagoon, a filter bed, a long trench with waste liquids, many pits, film on the river banks, old storage tanks, evident tank spillage and three discharge pipes to the river. L.E. Carpenter in 1979 suggested that former tenants were primarily responsible and also suggested only removing the lagoon sludge and not implementing a ground water monitoring or recovery program.

6) Mitigation actions--An Administrative Consent Order was signed in 1982 based on a 1975 site inspection and continuing investigations beginning in 1979. The ACO called for a ground water monitoring plan and removal of all solid and liquid wastes. An amendment to the ACO was signed in 1983 to define the vertical and horizontal extent of the contamination, remove any free product, and decontaminate the site. 4,000 cubic yards of sludge were removed from the impoundment in 1982, and the removal of free product began in 1984. However, the other steps were not taken, nor was removal of free product completed by 1986. Over $1 million was spent by late 1984.

7) Decontamination actions--Removal of free product using a well skimmer with passive flow of free product to the well resulted in 2833 gallons removed by early 1986, with up to 2 feet of product remaining. One

consultant for the firm proposed an active recovery well to remove free product, but L.E. Carpenter chose to use passive flow and another consultant who eventually recommended an active well also. The firm opposed any offsite investigations or remediation in 1984.
8) Continuing investigations--A directive was issued on 13 May 1986 to require L.E. Carpenter to sign a new Administrative Consent Order, which in turn requires L.E. Carpenter to conduct a Remedial Investigation, Feasibility Study, Remedial Action Plan and site cleanup under a strict schedule, with financial assurances from the company allowing the NJDEP to complete the work if the company reneges. The NJDEP has committed to using public cleanup funds if L.E. Carpenter does not sign the new ACO, and would then seek reimbursement for triple damages from the firm. The site also was placed on the National Priority List in 1985 over the objections of L.E. Carpenter.

I67 CESSNA AIRCRAFT CO., BOONTON TWP May 1979

1) Overview--Plating wastes from on-site operations were discharged for many years into an unlined lagoon. Ground water contamination has resulted and extends to the property boundary and a surface water body. Many monitor wells have been installed and a sampling program implemented. NJDEP received a hydrogeological report which delineates the extent of ground water contamination. Cessna has agreed to decontaminate the ground water. Plans are proceeding. NJDEP investigation continues.
2) Location of the contaminated site--Powerville Road, Boonton Township.
3) Severity of contamination--A plume of 1,1,1 trichloroethane was identified by Cessna's consultants as extending 400 feet downgradient and 150 feet wide from a one-quarter acre lagoon where wastewater was disposed. Levels of 5 to 10 mg/1 (5,000 to 10,000 ppb) contaminant were measured at peak. By 1982, levels had decreased to 202 ppb total volatile organic chemicals. Consultants to Cessna suggested that the pollution might be moving through the site in a "slug." In 1985 the NJDEP identified ground water contamination consisting of chloroform, TCE, trichloroethane and methylene chloride under the northern end of the property.
4) Extent of contamination/Ground water flow--Contamination from the lagoon affects
the Cessna property at the southeastern portion of the facility. Ground water contamination also exists at the northern part of the facility and under the Johanson Manufacturing property next door. The source of the contamination in the northern section is unknown, but Cessna apparently is not contributing to Johanson's contamination since ground water flow is from Johanson to Cessna. Potable wells exist near and on the site.
5) Suspected and confirmed sources--Cessna did operate the wastewater lagoon and percolation tanks. In addition, Johanson Manufacturing also discharged volatile organic compounds to an unlined lagoon upgradient of Cessna. The relative contribution of each firm will be difficult even given the results of ongoing investigations.
6) Mitigation actions--The wastewater lagoons of Cessna and Johanson are no longer in operation.
7) Decontamination actions--Cessna had resisted site analysis. However, in December 1983 and January 1984, Cessna removed all contaminated soils

and wastes from the lagoon area to an approved offsite location. Cessna will begin ground water decontamination procedures as soon as NJDEP issues a permit for the decontamination. The permit is expected to be issued in the near future.
8) Continuing investigations--NJDEP has approved a cleanup plan submitted by Cessna which addresses ground water pollution in the southern part of the facility. The plan provides for Cessna to further evaluate the pollution at the northern portion of the site. Decontamination of the ground water will be carried out under the terms of the NJPDES permit.

I68 RADIO FREQUENCY LABS, INC., BOONTON TWP May 1979

1) Overview--Unlined lagoons received plating waste discharges for many years. In 1981, RFL discontinued plating waste discharges. Monitor wells were installed in 1980. Sampling indicated ground water contamination, chiefly volatile organic chemicals. Nearby potable wells were sampled and found clean. RFL received a NJDPES permit which formalized the ground water monitoring program. Organic chemicals were detected in a stream crossing the property at the ppb range. The lagoon was cleaned in 1983 to eliminate the source of the contamination.
2) Location of the contaminated site--RFL is located along Powerville Road in Boonton Township, next to Cessna.
3) Severity of contamination--The wastewater lagoon created a plume containing high levels of 1,1,1 trichloroethane, toluene, TCE, PCE, and lower levels of 1,1,2,2 tetrachloroethane, o-xylene, copper, lead, iron, zinc, nickel, silver and chromium. Minor contamination of the soil also occurred, from dumping by ARC/Cessna. The lagoon sediments contain heavy metals but almost no VOCs.
4) Extent of contamination/Ground water flow--Four monitoring wells have been installed. Three wells show low or no contamination. One of these (Well 4) is on the ARC/Cessna property. Well 2, between the lagoon site and a nearby stream (150 feet away), exhibits high levels of TCE and 1,1,1 trichloroethane. Ground water flow is toward the stream, which exhibits low levels of contamination. The bedrock is 25 to 45 feet below grade with glacial outwash above, with the most permeable layers of sand and gravel near the surface.
5) Suspected and confirmed sources--The soil contamination by Cessna is minor. The ground water contamination has been traced to the 0.1 acre lagoon used by RFL. The lagoon was in use for 10 years, accepting 3,000 gallons per day from 1973 to 1980.
6) Mitigation actions--Use of the lagoon ended in 1983, eliminating the source of the contamination. Contaminated soils and sludges were removed from the lagoon in 1984.
7) Decontamination actions--No ground water decontamination required.
8) Continuing investigations--Sampling on a quarterly basis is required under the NJDPES-GW permit.

I90 NEW JERSEY NATURAL GAS (CPU), DOVER April 1981

1) Overview--This site was formerly used to manufacture illuminating gas from coal. Hydrogeologic studies (1982-84) show that the site's soils and ground water are contaminated by coal gasification wastes. The ground water contamination extends off-site. NJDEP is reviewing a modified remedial action plan prepared by the company's consultant. Investigation continuing.
2) Location of the contaminated site--NJ Natural Gas is on the northern corner of Blackwell and Carroll Streets, just east of the Dover border and not far from Dover's Well 4 on Rutan Street.
3) Severity of contamination--Extensive contamination with benzene, toluene and other base neutrals exists. The total VOC level exceeds 10,000 ppb in some locations. An on-site well exhibited significant benzene and naphthalene contamination in 1983. Off-site contamination includes soil contamination on the banks of the Rockaway River, nearby.
4) Extent of contamination/Ground water flow--The site consists of fill over unsorted glacial till, a silty, fine sand, a thick, semi-confining silt, and sand. Surficial ground water flow is south-southwest toward the Rockaway River, explaining the bank contamination. The consultant to NJNG found that the semi-confining silt was not impermeable but served as a good confining layer due to an upward hydraulic gradient. However, consultants to Dover indicate a concern that leakage to the lower aquifer, which is used by the Dover Well 4 only 400 feet away, could occur, especially if Well 4 is put back on line. A 1985 pump test of Well 4 caused a significant drawdown of the deep monitor well. NJDEP noted that an on-site abandoned deep well could also allow the movement of pollutants from the surface aquifer to the lower aquifer. A deep monitor well exhibited contamination of the lower aquifer in excess of 100 ppb total VOCs, according to a NJNG consultant. NJDEP has required further definition of the lower aquifer contamination. Contamination of the river is possible due to the flow of heavily contaminated ground water.
5) Suspected and confirmed sources--NJ Natural Gas operated the facility to produce gas from coal from the 1900's to the 1950's. Coal tar was created as a byproduct. Samples of coal tar yield benzene at levels of 420,000 ppb, toluene at 1,100,000 ppb, and also ethylbenzene, naphthalene, and acenaphthene.
6) Mitigation actions--The site is no longer actively used for coal gasification and has not been for decades. No additional contamination is occurring. No specific mitigation actions have been taken to reduce the flow of contaminants to the lower aquifer or the Rockaway River.
7) Decontamination actions--NJ Natural Gas has proposed the use of a biodegradation system which would pump shallow ground water through an above-ground reactor and reintroduce it on-site, aerated and inoculated with bacteria to digest the contaminants subsurface. The NJDEP has raised significant concerns with the effectiveness of biotreatment, the need for much larger ground water withdrawals to neutralize off-site flows, and the lack of treatment for off-site and deep aquifer contamination. A risk assessment has been required.
8) Continuing investigations--NJDEP is continuing to assess decontamination proposals of NJ Natural Gas. On 5 July 1986 the NJDEP cited NJ Natural Gas as a potentially responsible party to the

contamination of Dover Well #4. NJ Natural Gas agreed to pay $350,000 for an RI/FS of Dover Well #4. The possibility of public funds being used for decontamination exists, with eventual assessment of costs to the property owner.

I125 PICATINNY ARSENAL, ROCKAWAY TOWNSHIP December 1980

1) Overview--Ground water conditions are under investigation by federal scientists (USGS and U.S. Army). Ground water contamination, consisting of heavy metals and VOCs, has been found near lagoons and landfills. The lagoons were closed and repairs made to prevent further contamination. Investigation continuing.
2) Location of the contaminated site--North of Route 15 on the Rockaway Township/Jefferson Township boundary, at the eastern slope of Green Pond Mountain south of Picatinny Lake. The Arsenal employs 6,400 people in research and development for a full variety of armament items, including nuclear and radiological material research.
3) Severity of contamination--The highest contamination levels exceed 25,800 ppb of total VOCs, with maximum levels of 542 ppb of 1,2-trans-dichloroethylene, 386 ppb of PCE, 25,194 ppb of TCE. The VOCs were first detected by testing in 1981. Monitor wells exceed potable levels of total dissolved solids, sodium, chloride, sulfur, cadmium, lead, iron, manganese, cyanide, selenium and chromium. Iron and manganese are natural contaminants. Toluene and benzene also were detected near two underground tanks.
4) Extent of contamination/Ground water flow--The site geology consists of glacial deposits overlying Kittatiny Limestone from Picatinny Lake south and overlying Precambrian bedrock north of Picatinny Lake. The glacial deposits are primarily till north of the lake and primarily stratified drift south of the lake, with the till decreasing south of the lake and the stratified drift increasing to over 200 feet thick. The stratified drift is mostly coarse grained with a relatively high permeability and a transmissivity of 25,000 to 50,000 gpd/ft. The water table aquifer is generally 10 feet below the surface. A confining unit appears south of Picatinny Lake and increases in thickness to the south (to approximately 150 feet) as the glacial sediments increase in thickness and the bedrock elevation drops. A confined sand and gravel aquifer exists between the confining unit and the limestone. Ground water flow from the site is to the southwest (at an estimated 1 foot/day in the water table aquifer) toward Green Pond Brook and the deep aquifer. Supply wells have a radius of influence of up to 1200 feet. Four wells are commonly used, two are used infrequently, and six are abandoned. The wells are drilled to 110 to 120 feet. Estimated water use is 0.5 mgd, with an estimated dependable yield of 1.3 mgd based on USGS calculations. The terminal moraine occupies the southwestern tip of the Arsenal property.

Building 24 has a plume of TCE (the most mobile constituent) extending 1500 feet downgradient. TCE has also been detected in the confined aquifer, induced from the water table aquifer by the pumping of two supply wells. The total vertical extent of the contamination is not known, but the plume exhibits the more severe and extensive problems. Building 95 has a plume which exceeds drinking water standards for total dissolved solids, cadmium, manganese, selenium, chromium, TCE, PCE, and

1,1,1 TCEA. TCE in this plume is usually less than 100 ppb, while PCE levels range to 386 ppb and 1,1,1 TCEA has been measured at over 1700 ppb. The areal and vertical extent of this plume is not as well defined but the gradient is relatively flat with a 0.2 ft/day flow. Both buildings are within the same general area, approximately one-half mile southwest of Picatinny Lake.

5) Suspected and confirmed sources--The Army identified seven possible sources of contamination: (1) explosives dumping from 1926-1945; (2) unexploded ordnance near the Lake Denmark testing area; (3) unexploded ordnance at Picatinny Lake from a fire; (4) an unlined pit used for toxic chemicals including cyanides and flouracetates; (5) tetryl wastes in two unlined pits dumped prior to 1945 (explosives); (6) three garbage landfills in the southwestern section; (7) several small, unlined lagoons used for metal plating shop wastes, including two used for 20 years. Chromium, copper and lead would be expected contaminants. The 1981 Army investigation led to steps to remove the lagoons and develop a new treatment system. The manganese contamination was suscribed to dissolved manganese from the bottom of Lake Picatinny which entered the ground water through percolation.

Building 24 (metal plating) and Building 95 (metal plating and etching) and their associated lagoons have been confirmed as sources of heavy metal and VOC contamination. Two underground storage tanks are suspected to have contributed to the Building 24 plume with toluene and xylene. The landfill area is also considered a contamination site.

6) Mitigation actions--Apparently the unlined lagoons were discontinued in favor of settling tanks and the discharge of treated wastes to Bear Swamp Brook. Additional discharges to the ground water from existing dump sites have not been ceased.

7) Decontamination actions--None.

8) Continuing investigations--The Army and the USGS continue to investigate the site toward the development of a remedial plan. A ground water monitoring system is in place. The NJDEP has asked for an investigation of the tetryl disposal pits and for radiological materials.

I126 RADIATION TECHNOLOGY, ROCKAWAY TWP April 1981

1) Overview--Radiation Technology finished wood products using cobalt radiation to bind a plastic, protective coating. Organic chemicals were detected in potable/process water wells. Shallow test pits were sampled and contaminants found. Monitor wells were drilled in late 1983 and a sampling program began under a consent order signed in July, 1983. The NJDEP investigation continues. Radiation Technology is on the National Priority List under the Superfund program.

2) Location of the contaminated site--Lake Denmark Road on the eastern shore of Lake Denmark.

3) Severity of contamination--1982 ground water samples indicated levels of methylene chloride to 1500 ppb, TCE to 23 ppb, and trifluorotoluene to 33,000 ppb. 1984 samples also showed vinyl chloride, 1,1 dichloroethylene, 1,1 dichloroethane, trans-1,2 dichloroethylene, 1,1,1 TCEA, Freon 113, and 1,1,2 TCEA, with a total VOC level of over 9,500 ppb. Production Wells 2 and 6 of Radiation Technology were found to be severely contaminated in 1981 and condemned. The highest measured

contamination levels were in 1981, at 166,237 ppb of methylene chloride, while the TCE levels peaked at 811 ppb in 1982.
4) Extent of contamination/Ground water flow--The site geology consists of 10 to 13 feet of unconsolidated glacial till over weathered bedrock, with a water table aquifer at 8 to 10 feet. Complete bedrock is found at 20 to 30 feet. Ground water flow is to the west toward Lake Denmark. The monitor wells in bedrock yield 1 to 2 gpm. The monitor wells in the overburden yield 5 to 10 gpm. The site has a very low permeability and gradient. The extent of contamination is unknown.
5) Suspected and confirmed sources--The site has an extensive industrial history. Reaction Motors sold the site to Thiokol Chemical in 1958, and Radiation Technology rented the site from 1968 to 1972 and purchased 15 acres of the site 1972 and the remainder in 1978. Consultants to Radiation Technology claim that any of the users (or all) could have been the source, although aerial photographs of the site reveal poor housekeeping practices of chemical drums by Radiation Technology.
6) Mitigation actions--Activated carbon filters were installed at Radiation Technology in 1981 to bring internal water supplies to potable status. No active source has been identified.
7) Decontamination actions--A pit was dug to bedrock and was successful in reducing methylene chloride levels drastically in the pit water. A passive decontamination system consisting of to long interceptor drains pumping to an aerating lagoon has been suggested by Radiation Technology for treatment.
8) Continuing investigations--NJDEP has not succeeded in gaining action from Radiation Technology since 1983. On 5 July 1986 the NJDEP cited Radiation Technology as a source of the ground water contamination and requested $600,000 to conduct an RI/FS. The Superfund program has released a Request for Proposal which includes the installation of monitor wells as part of an extensive hydrogeologic investigation.

I141 JOHANSON MFG. CO., BOONTON TWP August 1980

1) Overview--An unlined lagoon received treated wastes from the electronics plant. Three monitor wells were sampled several times and contamination was found emanating from the lagoon. An administrative order issued June, 1982, required the company to assess the extent of contamination. Additional monitor wells have been installed. An investigation is continuing as required by a NJPDES permit.
2) Location of the contaminated site--400 Rockaway Valley Road, Boonton Township, next to the Cessna facility, along Stickle Brook.
3) Severity of contamination--1979 samples from the ground water supply for the plant exhibited TCE, chloroform and methylene chloride at levels in excess of 50 ppb. One well was removed from potable use. A 1980 analysis of the unlined holding pond revealed cyanide, copper and silver contamination. High levels of phenols were in the three septic systems. One septic system showed 56 ppb of butyl benzene and 1789 ppb toluene.
4) Extent of contamination/Ground water flow--The geology of the site includes a gneiss bedrock with an overburden of 0 to 134 feet. The lagoon site has 70 feet of overburden. There is rapid percolation to the ground water 15 to 19 feet below grade. A contamination plume exists which is spreading in 360 degrees but more to the northwest, the direction of ground water flow and the location of the highest pollution

levels. The overburden consists of over 40 feet of medium to very coarse sand, which is highly permeable and serves as an aquifer recharge zone. The plume had moved over 70 feet from the lagoon by 1984, toward a private residential well northwest of the lagoon. The NJDEP suspects that the contamination may have moved off-site to the Cessna property. 1984 samples of the ground water exhibit contamination with the above named compounds plus bromodichloromethane, carbon tetrachloride and 1,1,1 trichloroethane.
5) Suspected and confirmed sources--Johanson operated an electroplating facility. Instead of discharging treated wastewater to surface water, as specified in its permit of 1967, Johanson discharged to ground water through three septic systems and the unlined lagoon. Johanson has not disputed the nature of the discharge but does dispute the NJDEP's findings on its severity.
6) Mitigation actions--NJDEP required Johanson to eliminate the discharge of non-domestic wastewater to the septic systems. Eight monitor wells were added to the three existing monitor wells. Johanson was ordered to apply for a NJPDES ground water permit, which established requirements for the monitoring system.
7) Decontamination actions--The NJDEP directed the development of a complete monitoring and decontamination plan.
8) Continuing investigations--Johanson has contested the NJDEP conclusions on the extent of the pollution. Continued investigations are required under the NJPDES-GW permit. Johanson has agreed to conduct additional ground water investigations including the testing of ground water wells on Cessna's property to determine the extent of offsite contamination.

I210 HOWMET (ALLOY DIV.), DOVER August 1981

1) Overview--Buried drums were found at Howmet (Dover Casting Division) during the course of a sewer line inspection. Subsequent investigation showed illegal discharges of industrial wastes had occurred. (See Howmet (Dover Casting)). Investigation continuing.
2) Location of the contaminated site--Roy Street in Rockaway Township.
3) Severity of contamination--Monitor wells at Howmet-Dover Casting show 1,1,1 TCEA in three wells from 1.7 to 43.1 ppb, TCE in one well from 5.7 to 40 ppb, and chloroform less than 10 ppb in one well.
4) Extent of contamination/Ground water flow--The full extent of the contamination is not known. Ground water flows generally south toward the Rockaway River. The site geology consists of glacial outwash, well sorted, with a water table from 2.5 feet below the surface near the river to 17 feet below the surface at the far side of the site.
5) Suspected and confirmed sources--Howmet (Alloy) operated two lagoons and a leach field, accepting discharges from a chemical analysis lab and detergent wash of nickel alloy pellets.
6) Mitigation actions--None cited.
7) Decontamination actions--None cited.
8) Continuing investigations--NJDEP and the consultant for both Howmet sites continue their investigations.

I211 HOWMET (DOVER CASTING DIV.), DOVER August 1981

1) Overview--Buried drums were found during the course of a sewer line inspection. Subsequent investigation showed that illegal discharges of industrial wastes had occurred. A private hydrogeologic study to determine contamination effects and remedial actions required by the NJDEP are in progress. (See Howmet (Alloy)).
2) Location of the contaminated site--Next to the Howmet (Alloy) site closer to Dover.
3) Severity of contamination--Test pits near septic leaching systems showed PCE, toluene and dichloromethane. The well at Howmet had TCE levels of 13 ppb and 1,1,1 TCEA of 9 ppb. The leach ponds contained total VOCs of over 3000 ppb in 1981 and over 300 ppb in 1982. 1984 tests of the leaching systems revealed peak contamination (total VOCs) of nearly 8,000 ppb including almost 7,000 ppb of 1,1,1 TCEA, TCE at 159 ppb, and PCE at 312 ppb. Other areas contained less total VOCs but far more TCE. The lower aquifer unit has contamination of nearly 500 ppb, with 1,1,1 TCEA at 326 ppb, TCE at 50 ppb and PCE at 53 ppb.
4) Extent of contamination/Ground water flow--The Dover Well 4 is located approximately 3500 feet and a Denville well field is located approximately 1000 feet from Howmet (Dover Casting). Contamination of these wells includes 1,1,1 TCEA, PCE and TCE. Pumping tests performed at these well fields indicated that Howmet (Dover Casting) is located within the radius of influence of approximately 4100 feet (the consultant to Howmet disagrees that the radius of influence is that large). The site geology consists of two aquifers, both stratified drift deposits, segregated by an aquitard. Consultants to Denville indicate the existence of coarse sands and gravels from the surface to 10 to 40 feet down, followed by silty sand to a 60 foot depth, clay to 120 feet deep, and sand and gravel (the lower aquifer) to 140 feet deep.

Contamination of the lower aquifer confirms that flow can be induced from one to the other. This flow has been confirmed through the Dover Well 4 pump test with monitoring at the NJ Natural Gas site, and also at the Howmet site through pumping from one-half mile away. Dover Well 4 induces flow in directions other than the regional trend, as exhibited by the low contamination levels at the start of the pump tests and the twenty-fold increase in VOC levels during the test. Howmet's consultant has postulated that ground water flow is upward from the lower aquifer to the upper during non-pumping conditions. Normal ground water flow is east toward the Rockaway River.

The upper aquifer is contaminated with VOCs and heavy metals (e.g. lead, nickel, manganese, hexavalent chromium and total chromium above drinking water or ground water standards). The lower aquifer contains significant levels of VOCs.

Howmet consultants have claimed that a ground water divide exists between Howmet and the Denville Well 3 due to simultaneous pumping of wells at both sites, but this is not confirmed or accepted by the NJDEP.
5) Suspected and confirmed sources--Howmet (Dover Casting) makes nickel and cobalt based engine parts. Three leaching fields were used for wastewater disposal. The NJDEP concluded in 1985 that Howmet contributed at least partially to contamination of both the Dover Well 4 and the Denville Well 3, immediately across the Rockaway River.
6) Mitigation actions--Howmet and Denville have reached an agreement whereby Howmet will pay for the installation of an air stripping water treatment system for Well 3.

7) Decontamination actions--The NJDEP approved a remedial plan based on further investigation by Howmet, which plan Howmet began implementing late in 1985. Howmet is presently pumping from two recovery wells with air stripping units located on-site.
8) Continuing investigations--Howmet will be issued an Administrative Consent Order in the near future. Negotiations were in progress in mid-1986 with Howmet and other potential responsible parties to pay for a remedial investigation/feasibility study on Dover Well 4. Howmet subsequently agreed to split the $700,000 cost of an RI/FS for Dover Well #4 with NJ Natural Gas.

I MCWILLIAMS FORGE, ROCKAWAY BORO 1983

1) Overview--McWilliams Forge was found to have ground water contamination of up to 1700 ppb of TCE in the shallow aquifer and had been pumping over 1 MGD from shallow and deep aquifers without an allocation permit. An administrative consent order from the NJDEP has required the installation of monitor wells and a water treatment system to remove the TCE during the period of pumping for site dewatering to construct a new building foundation. The monitor wells are incorporated into a ground water monitoring permit. Pumping for site dewatering concluded in 1985. Current status unknown.
2) Location of the contaminated site--Franklin Avenue, on the east side of the Rockaway River just downstream from Denville.

ROCKAWAY VALLEY SUBREGION
MINOR CONTAMINATION CASES

A90 DOVER CHRISTIAN NURSING HOME, DOVER October 1979

Overview--Gasoline vapors in the basement of the nursing home resulted in a complaint to the NJDEP. An independent gasoline station nearby (Freeway Gasoline) failed tank integrity tests on four of its five tanks. The owner claimed that only 80 gallons had been lost from the tanks. Tanks at the neighboring Exxon station all passed the integrity test. Approximately 2500 gallons were recovered by a well installed between the Freeway Gasoline station and the nursing home and monitoring wells were installed. By May, 1981, no free product remained on the water table and the case was closed.

A93 ROCKAWAY VALLEY METHODIST CHURCH December 1979

Overview--The church has a shallow well with an occasional fuel oil odor. In December, 1978, there was a surface spill at the rear of the building. All other wells in the area are acceptable. Boring a deeper well was recommended. Case closed by NJDEP in January, 1980.

A116 EXXON STATION, TOWN OF BOONTON February 1980

Overview--Located on Washington and Monroe in the Town of Boonton. A loss of 5000 gallons was indicated by inventories, and gasoline odors occurred in five buildings. Eight observation wells and a gasoline recovery well were drilled. 500 gallons were recovered by April, 1980. Exxon installed a total of 16 wells. The Chevron station nearby refused to test its tanks, but did install two monitoring wells in 1981 which showed no free product in tests through 1982. Case closed in 1981 after a total recovery of 800 gallons.

A151 JERRY JONES MACK, ROCKAWAY TOWNSHIP October 1980

1) Overview--An oil spill occurred. Over 50 cubic yards of oil-contaminated soil were removed from the spill area and taken to an approved landfill. Water samples showed slight water degradation adjacent to the spill. Additional soil removal was necessary due to sloppy housekeeping. Monitoring of the situation continued.
2) Location of the contaminated site--Green Pond Road north of I-80.

A156 STEVE'S GETTY, DOVER April 1981

1) Overview--The Dover Health Department found a seepage pit behind the station. Analyses of liquids determined that the fluids were mostly oils, greases and water. The pit was disconnected and filled as required by NJDEP. The wastes were manifested and hauled to a reclaimer. Case closed by NJDEP September, 1981.
2) Location of the contaminated site

A171 GULF LAKE TELEMARK, ROCKAWAY TOWNSHIP December 1981

1) Overview--Several private, potable wells were affected by leakage of gasoline from underground tanks. Monitor wells were installed. Samples showed that the station is the source of the gasoline. Contaminants include gasoline and gasoline components, chiefly benzenes, toluenes and xylene (BTX). Spartan Oil of Dover manages the underground tanks. In July, 1982, NJDEP directed them to clean up the aquifer of BTX contamination and remove gasoline. A consent order was signed to that effect. The investigation is continuing.
2) Location of the contaminated site--Near Lake Telemark on Green Pond Road, in Rockaway Township.
3) Severity of contamination--Three private wells were found to be contaminated with gasoline fractions and free floating product. 53 ppb toluene and 935 ppb benzene were measured from a well near the site. Up to two feet of gasoline were observed in monitor wells.
4) Extent of contamination/Ground water flow--The contamination extends from the gasoline station northeast toward a small brook. The ground water flow is toward the north along Green Pond Road on a relatively flat gradient. The bedrock is granitic gneiss, approximately 5 feet below the surface.
5) Suspected and confirmed sources--The Gulf station is considered the source. Consultants to Spartan Oil questioned whether some contamination could be traced to underground tanks at a nearby tavern.
6) Mitigation actions--Two wells were established to pump at 0.65 gpm to contain the plume. The private wells were sealed and replaced. The three underground storage tanks were replaced in 1980 and 1981.
7) Decontamination actions--The recovery wells have caused the benzene and toluene plumes to contract, but two wells continued to show free product and high VOC levels as of mid-1985. The NJDEP requires the decontamination to continue until VOC levels are below 10 ppb.
8) Continuing investigations--Spartan Oil continues to cleanup the site under the 1984 Administrative Consent Order.

A FERNBROOK SCHOOL, RANDOLPH 1985

1) Overview--A 10,000 gallon underground tank for fuel oil leaked, with a loss of approximately 465 gallons. Some discharged to a storm sewer and some to ground water. The tank and contaminated soils were removed and a new tank installed with an improperly designed recovery well. Depth to the water table is 4.7 feet. No wells exist nearby. Monitor wells and recovery of any free product have been recommended by the

NJDEP. Investigation continues.
2) Location of the contaminated site--Memorial Lane, north of Route 10 and east of Mount Fern.

I42 THATCHER GLASS, WHARTON Summer 1976

1) Overview--Thatcher Glass discharged effluent through an old sewer line. The effluent migrated into the glacial deposits of the area. There have been complaints of oil/grease and odor in Wharton's Well 3, plus very low levels of TCE and PCE, though a 1982 test of Well 3 indicated no contamination detectable. Case closed by NJDEP July 1982.
2) Location of the contaminated site--Eastern side of Wharton Borough, on the Rockaway River at the north bank.
3) Severity of contamination--Unknown. Wharton's Well 3 continues to exhibit petroleum odors causing the borough to minimize its use and consider treatment. Thatcher Glass may not be the cause.
4) Extent of contamination/Ground water flow--not known
5) Suspected and confirmed sources--none
6) Mitigation actions--none
7) Decontamination actions--none
8) Continuing investigations--Wharton continues to investigate Well 3. No additional action by NJDEP.

I209 GARDEN STATE TRANSIT, ROCKAWAY TWP July 1982

1) Overview--Garden State Transit was found to have discharged wastewater into its septic system. Samples from the septic system showed petroleum hydrocarbons and volatile organics. Investigation continuing.
2) Location of the contaminated site--The site is just north of Interstate 80, due south of the Rockaway Township well field, on the next road east of Route 513.
3) Severity of contamination--The septic system was found to have 5011 ppb of petroleum hydrocarbons and 2400 ppb total VOCs, including 1900 ppb of benzene compounds, 336 ppb heptane/toluene and 86 ppb methylene chloride. Many spills of diesel fuel had occurred to Beaver Brook.
4) Extent of contamination/Ground water flow--The full extent of the ground water contamination is not known. A required monitor well was not installed until late 1985. Ground water flow is assumed to be toward the east and Beaver Brook.
5) Suspected and confirmed sources--Two sources of contamination exist. Non-domestic wastes were discharged to the septic system. Frequent diesel fuel spills occurred in the parking lot from buses that were allowed to overfill. Both are from Garden State Transit Lines.
6) Mitigation actions--Under order from the NJDEP, Garden State Transit pumped out the septic tank and sealed the floor drains to eliminate the continuing discharge to ground water. Only domestic wastes are allowed.
7) Decontamination actions--A plan has not been established.
8) Continuing investigations--The case has been transferred to the NJ Site Evaluation Unit for an evaluation under ECRA. Garden State Transit has indicated a desire to sell the property. NJDEP action continues.

I241 PACIFIC VEGETABLE OIL, BOONTON May 1982

1) Overview--PVO was involved in making margarine and other vegetable oil products. Food processing tanks, drums of chemicals, spillages and other sources of contamination were seen on site. PVO has cleaned up some of these sources, but some still remain. Monitor wells were installed and sampled. Both surface and ground water contamination have been found. The proposed sale of the site has resulted in an ECRA evaluation. Investigation continuing.
2) Location of the contaminated site--The site is north of Division Street, west of Wootton Street and east of Spruce Street in Boonton, near the railroad and on Crooked Brook upstream of the Penick site.
3) Severity of contamination--1984 well samples found benzene levels of 57 ppb to 386 ppb, and some phenols, nickel and pesticides. Nickel and dieldrin were found in two streams.
4) Extent of contamination/Ground water flow--Soil contamination is extensive. The ground water flows very slowly to the south-southeast. The site has 10 to 15 feet of glacial till over granite gneiss bedrock. The Boonton Reservoir is not very distant from the site.
5) Suspected and confirmed sources--PVO purchased the site from Drew Chemical Corporation in 1971 and operated until 1980. Kay Corporation purchased PVO in 1980, ceased operation and started demolition in anticipation of sale. The site is confirmed as the source of the pollution. Sloppy housekeeping, abandoned drums, surface discharges of wastewater effluent and soil contamination were all found on site.
6) Mitigation actions--PVO agreed to remove the drums and contaminated soils, install additional monitor wells and clean up the surface water discharges. The NJDEP has recommended excavating test pits to ground water around all underground storage tanks on the site.
7) Decontamination actions--Removal of the drums and contaminated soils.
8) Continuing investigations--Continuing negotiations between the NJDEP and Kay Corporation occur to determine a cleanup investigation and plan.

I249 DREW CHEMICAL, BOONTON February 1982

1) Overview--Drums and spillages were obvious sources of contamination on this site. An investigation including the installation of monitor wells to assess ground water quality will be required. Investigation continuing.
2) Location of the contaminated site--East of Wootton Street and just north of Division Street, near Crooked Brook.
3) Severity of contamination--Soils on the site show high heavy metals, especially nickel. The existence of pesticides on the Pacific Vegetable Oil site (formerly owned by Drew Chemical) leads to similar concerns at Drew. Drums of wastes were found on site with very high nickel levels. Filter bed medium from vegetable refining processes was dumped on site.
4) Extent of contamination/Ground water flow--A 1983 consultant report determined that a borrow pit for Interstate 287 had been filled with drums (17), filter bed material, and metal junk. The borrow pit is in glacial ground moraine (till) of 25 to 75 feet thick over gneiss. The drums showed high nickel. The ground-water flow direction is not known. The full extent of wastes disposed on site is unknown, but the NJDEP

believes that over 2,500 cubic yards of fill may have been disposed on site.
5) Suspected and confirmed sources--The investigation of Drew was prompted by a cancer survey along Oklahoma Avenue in Montville near the Boonton border, which found a high cancer rate. Local private wells showed high copper levels. The Drew investigation did not find any link with the Montville health survey, but did confirm contamination on site.
6) Mitigation actions--The drums on site were manifested and removed.
7) Decontamination actions--None.
8) Continuing investigations--Drew Chemical agreed to submit a proposal to test the ground water and wastes disposed in the borrow pit fill area, in addition to the installation of monitor wells. However, by fall of 1986 the NJDEP had not received the proposal. NJDEP is preparing an Administrative Order to require Drew to further investigate the site and to implement remedial measures.

I250 JERSEY PLATING, BOONTON April 1982

1) Overview--This small plating industry discharges small amounts of plating wastes to a cesspool. The cesspool was pumped out and wastes will be pumped to a holding tank. Case closed March, 1983.
2) Location of the contaminated site--Boonton industrial area.

I327 U.S. GYPSUM, BOONTON 1984

1) Overview--Almost no information is available on this site.
2) Location of the contaminated site--Boonton, downgradient of the Drew Chemical Corporation site.
3) Severity of contamination--Soil samples from drilling on site and ground water samples from two monitor wells revealed no contamination, according to U.S. Gypsum consultants.
8) Continuing investigations--NJDEP rates this site a very low priority.

BOONTON COAL GAS FACILITY, BOONTON 1985

1) Overview--A coal gasification facility existed on the site from 1901 to the 1930's when it became a propane storage area until 1981. An investigation is underway to determine the existence and extent of coal gasification byproducts in the soil and ground water. No structures remain on the property. Investigation continuing.
2) Location of the contaminated site--Between Fanny Road and Interstate 287 near the Rockaway River, on the Boonton/Parsippany-Troy Hills border. Norda and Synthatron are located to the west of Fanny Road in the same area.
3) Severity of contamination--An old "tar well" exists on site and was found to have an oil sheen and strong odors from coal gasification residues. A tarry material covers the ground in some area. No evidence of contaminated ground water or odors was found at ground water seeps along a steep slope toward the east of the property.

4) Extent of contamination/Ground water flow--The site geology is not fully known, but is expected to consist of glacial deposits over a thin layer of Triassic shale with bedrock below that at perhaps 100 feet below the surface. The site is just south of the Ramapo Fault. A steep slope exists on the east side of the property to a ditch beside Interstate 287. Ground water flow is most likely to the east. Ground water seeps exist on the steep slope. The water table is at 15 to 30 feet below the surface on the upper portion of the property. The extent of ground water contamination, if any, has not been determined. The "tar well" is wide, brick lined and shallow.

5) Suspected and confirmed sources--Coal gasification facilities generally have residues of benzene, toluene, naphthalene, phenols and cyanide. Moreover, polynuclear aromatic hydrocarbons and high molecular weight aliphatic hydrocarbons are characteristic in most coal gas sites. The facility was originally owned by the Boonton Gas Light and Improvement Company, followed by Jersey Central Power and Light, New Jersey Natural Gas, and JCP&L.

6) Mitigation actions--Unknown if any needed.

7) Decontamination actions--Unknown if any needed.

8) Continuing investigations--JCP&L contracted for an investigation of the property for possible environmental hazards. The plan for this investigation has been approved by the NJDEP and is in progress.

UPPER LAMINGTON SUBREGION
MAJOR CONTAMINATION CASES

A SPARTAN OIL-GULF, ROXBURY TOWNSHIP 1986

1) Overview--Ground water at the site has water soluble gasoline constituents, as does a private well to the east. The latter well has a depth of 210 feet. The water table is a 7 feet below grade in coarse to fine sand and very fine gravel. An active BP station and an abandoned Sunoco are across the highway south of the Gulf. The Sunoco has abandoned buried gasoline tanks with fuel oil contamination of the soils. Ground water is also contaminated with gasoline at the abandoned Sunoco property. NJDEP has recommended ground water contour mapping, investigations of each potential source with monitor wells, testing of all supply wells in the area, and aquifer remediation. Investigation just began and continues. Additional monitor wells were installed around the Gulf site and the BP station will install three monitor wells.
2) Location of the contaminated site--Intersection of Route 10 and Eyland Avenue in Roxbury Township.

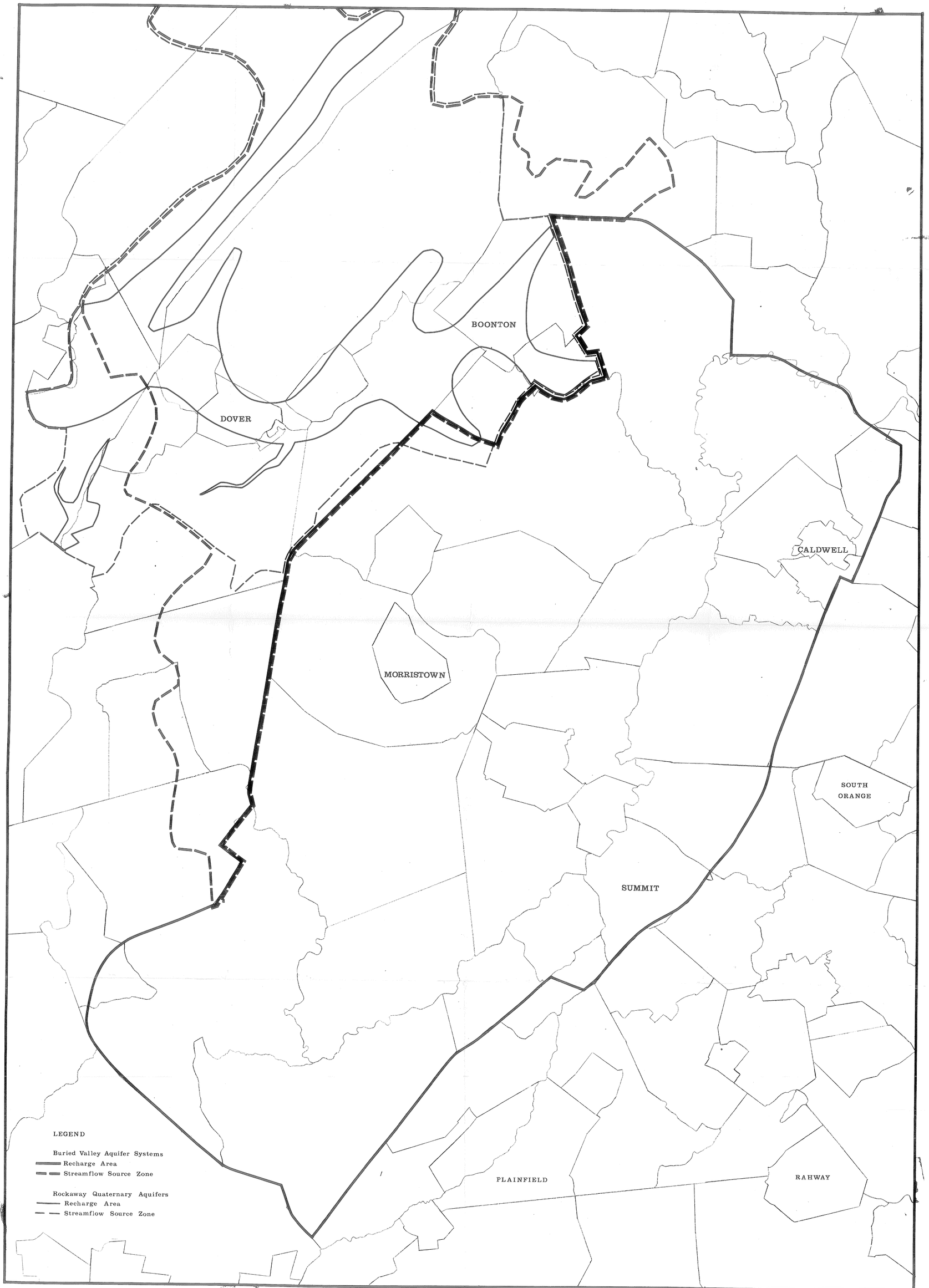
I225 LEDGEWOOD BAPTIST CHURCH, ROXBURY July 1981

1) Overview--The church wells and several other domestic wells were contaminated by volatile organic chemicals. Several septic systems used by small businesses were sampled and found to contain VOCs. All of these septic systems have been pumped. In addition, the gasoline stations in the area have been tested for integrity and were not leaking. There are many abandoned underground fuel tanks located in the area in addition to many other possible sources of contamination. Monitor wells have been recommended. Investigation continuing.
2) Location of the contaminated site--The contaminated wells are all located near Route 40 and Main Street in Ledgewood, near the Ledgewood/Mt Arlington Road, on the west side of the buried valley aquifer in Roxbury Township.
3) Severity of contamination--Contamination levels were very high for several private wells. Contaminants included nine VOCs at greater than 100 ppb and four over 1000 ppb. The most concentrated were chloroform, bromoform, and TCE. Bromoform concentrations exceeded 10,000 ppb at one site in 1981. In 1984, contamination levels had declined significantly but still exceeded 400 ppb of VOCs. In 1985 the NJDEP informed the Roxbury Water Company that samples of its Well 3 indicated contamination with three VOCs, the highest of which was tetrachloroethane at 39 ppb. Resampling of the well is required.
4) Extent of contamination/Ground water flow--The Ledgewood Baptist Church was the first contaminated well discovered. At least five other wells were also severely contaminated. The ground water flow is apparently from the northeast to the southwest. The site is over a buried valley aquifer extending from the Rockaway River watershed to the

Upper Lamington River watershed.
5) Suspected and confirmed sources--No confirmed sources exist. However, the prime suspected source was an auto body shop (Ken's Auto Body), followed by a transmission repair business (Ledgewood Transmission) and a gasoline station (Vantage Gas).
6) Mitigation actions--Two improperly operating septic systems were removed and one was cleaned in 1983. All underground storage tanks were tested. One unused underground tank was cleaned and filled with sand. Monitor wells were recommended by the NJDEP. The church and one of the businesses removed their private wells from service for potable water.
7) Decontamination actions--None as of early 1986.
8) Continuing investigations--Roxbury Water Company must resample its Well 3 and determine the source of contamination.

THE BURIED VALLEY AQUIFER SYSTEMS

FIGURE G-1. SOLE SOURCE AQUIFER DESIGNATED AREAS



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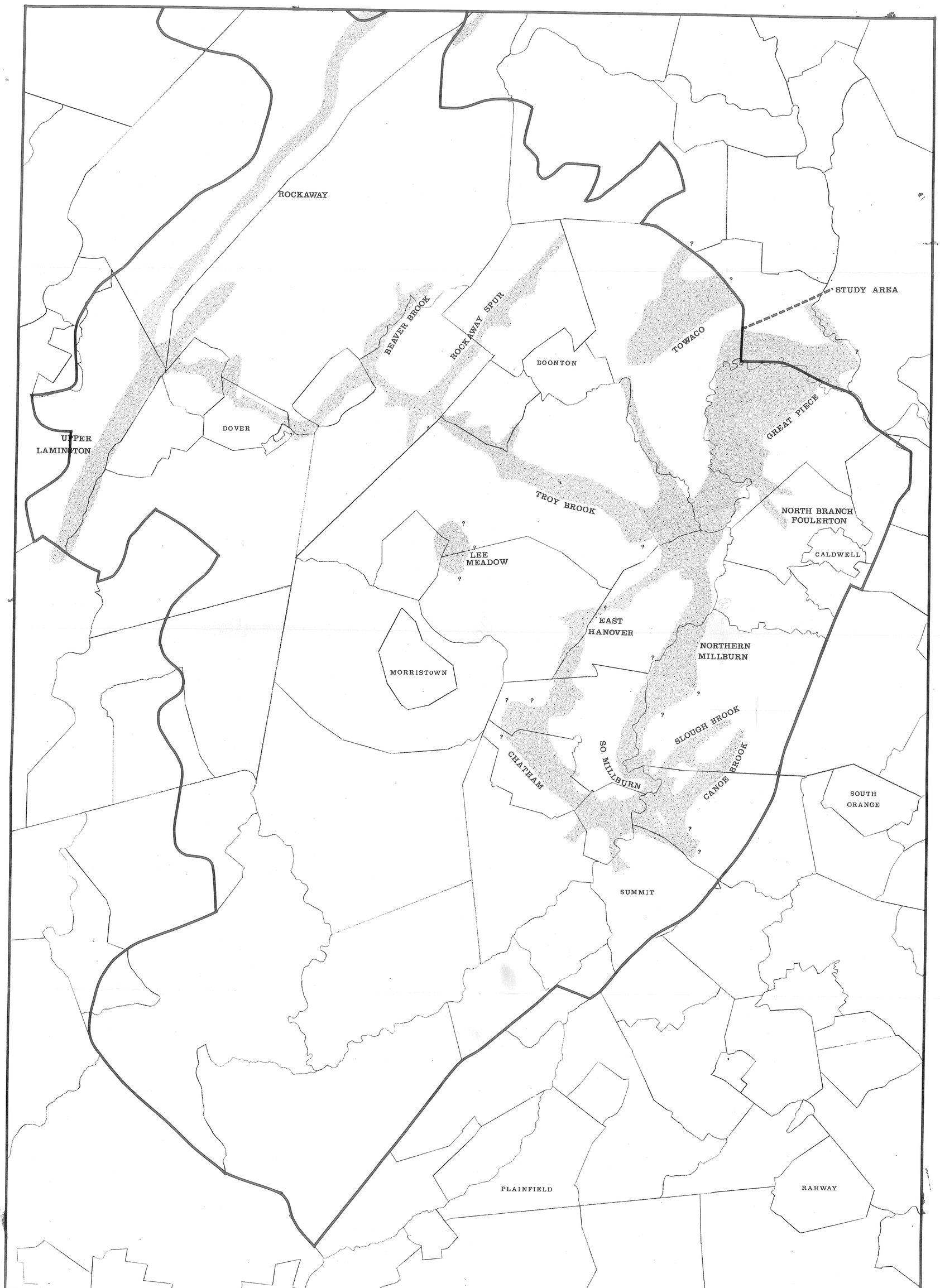
SOURCE: PRC, 1985; CDM, 1985

THE BURIED VALLEY AQUIFER SYSTEMS

FIGURE G-2. DELINEATION OF BURIED VALLEYS



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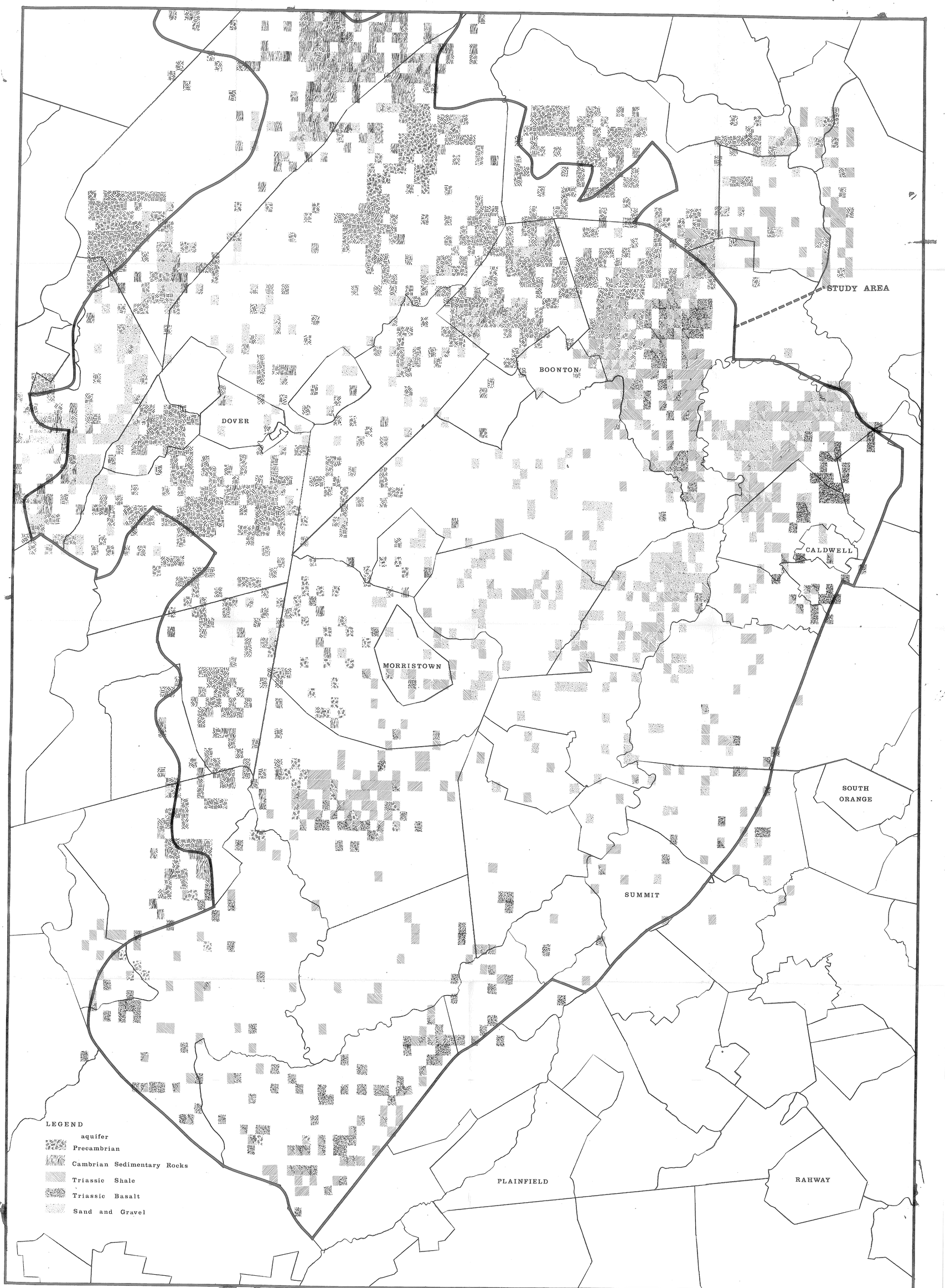
1 mile

Sources: Vecchioli, Nichols, and Nemickas, 1967; Nichols, 1968b; Geraghty and Miller, 1978, 1978; NJGS, 1986; Geonics, 1978, 1979a,b; US ACE, 1979.

THE BURIED VALLEY AQUIFER SYSTEMS

FIGURE G-3. AQUIFERS TAPPED BY WELLS DRILLED SINCE 1947



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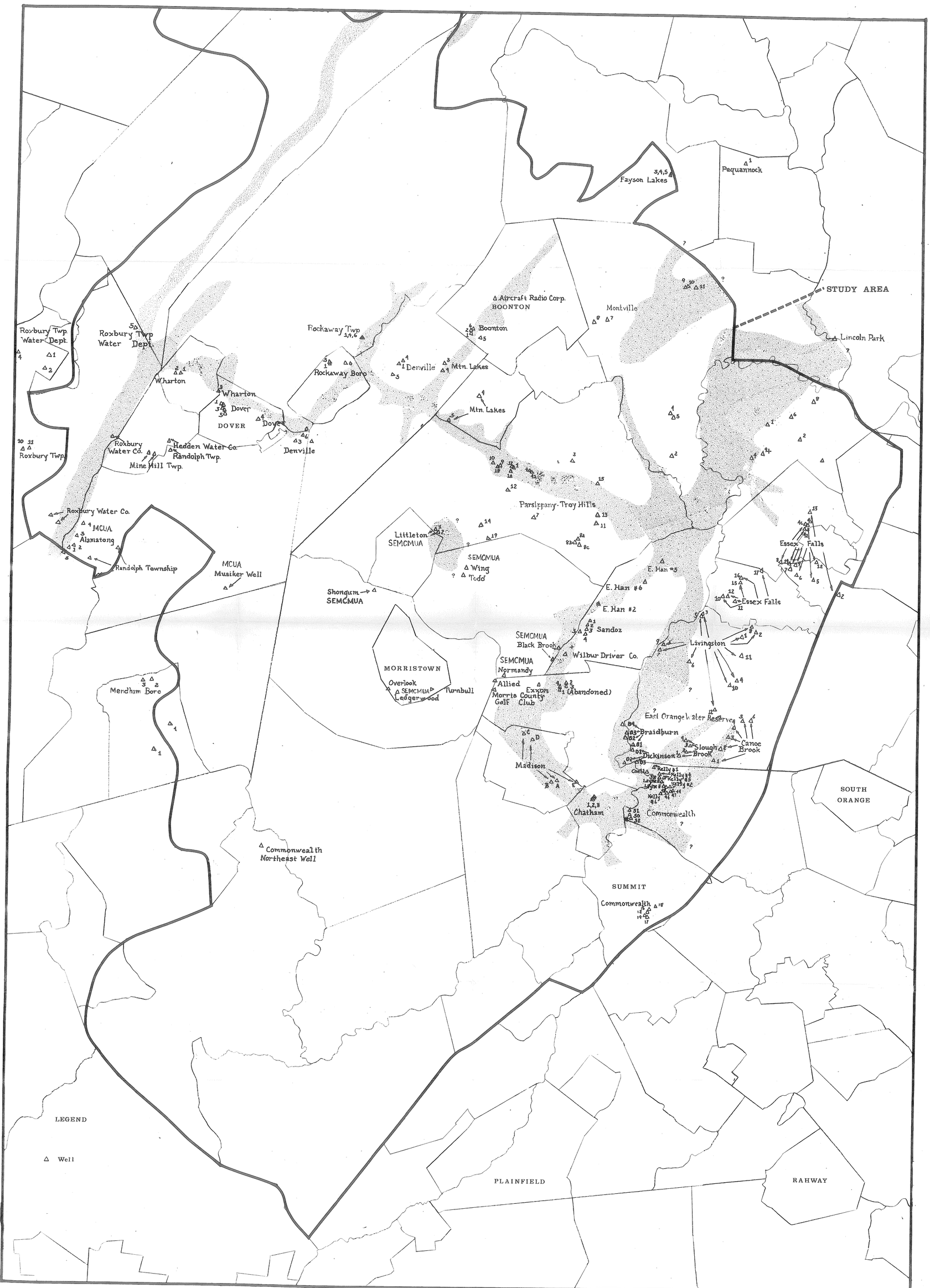
Source: NJ DEP, Well Permits.

THE BURIED VALLEY AQUIFER SYSTEMS

FIGURE G-4. MAJOR PRODUCTION WELLS



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1 mile

Sources: Vecchioli, Nichols, and Nemickas, 1967; Nichols, 1968b; Geraghty and Miller, 1975, 1978; NJGS, 1986; Geonics, 1978, 1979a,b; US ACE, 1979.

THE BURIED VALLEY AQUIFER SYSTEMS

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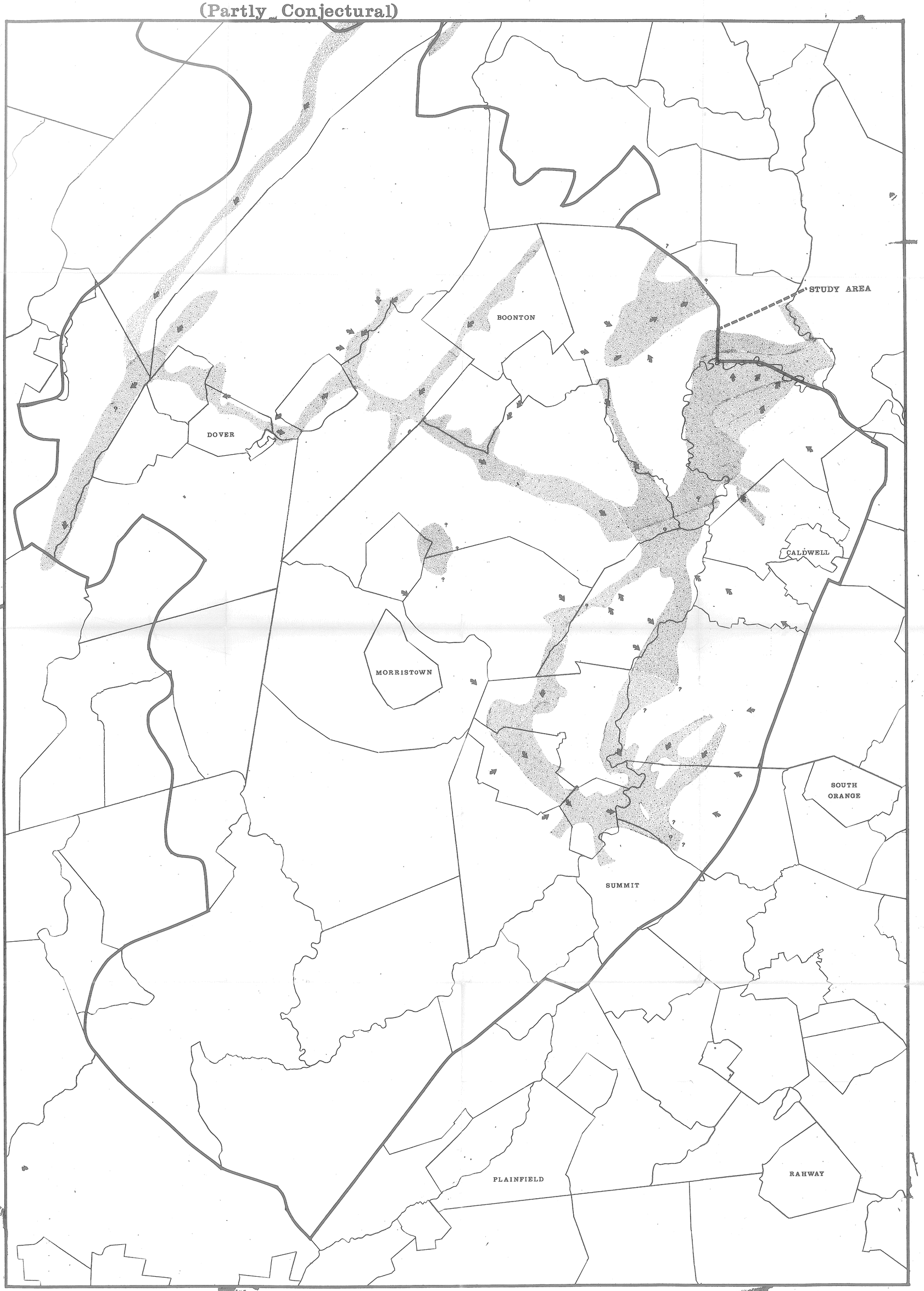
FIGURE G-5. REGIONAL GROUND WATER FLOW
(Partly Conjectural)



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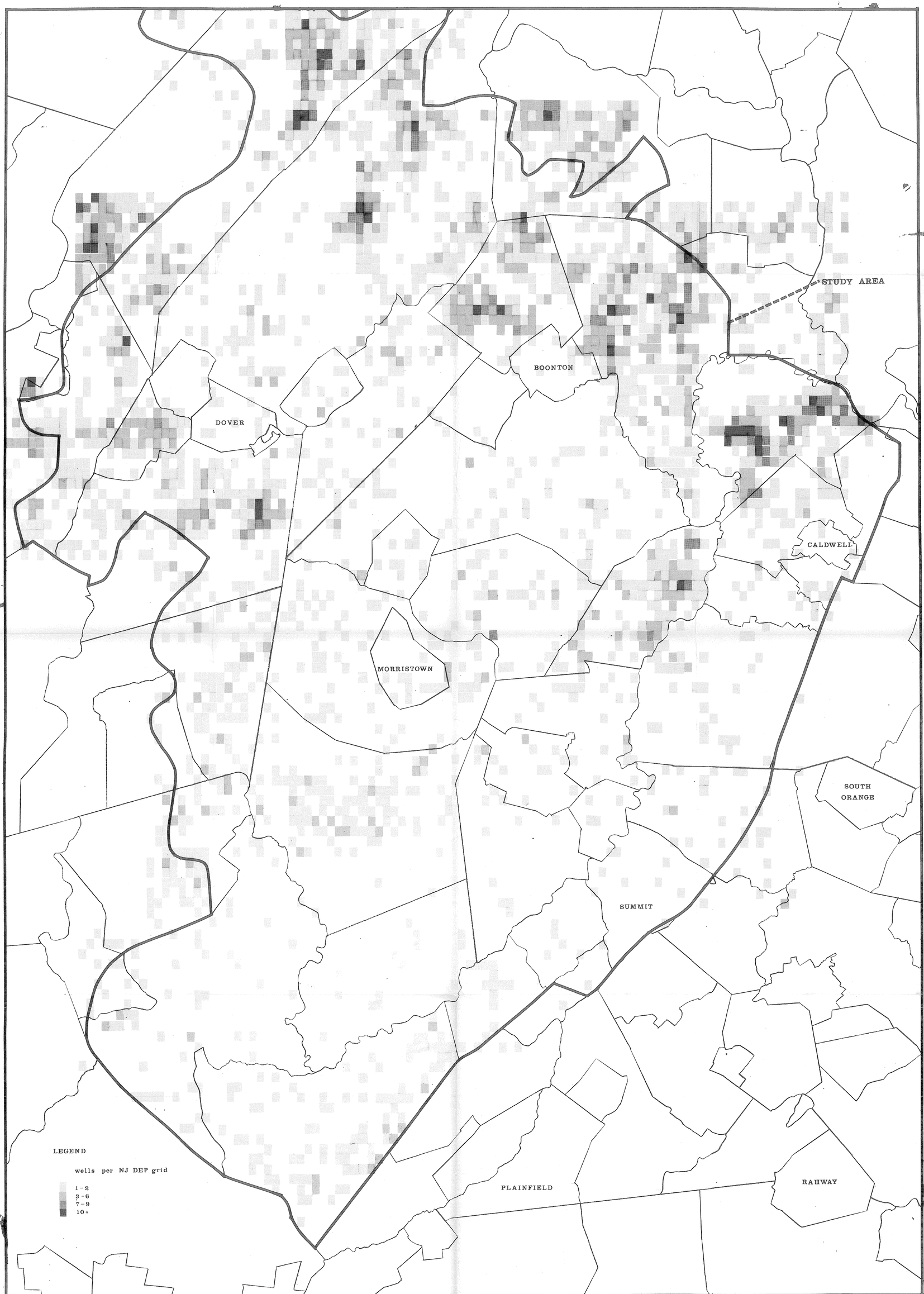
1 mile

Sources: Vecchioli, Nichols, and Nemickas, 1967; Nichols, 1968b; Geraghty and Miller, 1975, 1979; NJGS, 1986; Geonics, 1978, 1979a,b; US ACE, 1979.

THE BURIED VALLEY AQUIFER SYSTEMS

FIGURE G-6. WELLS DRILLED SINCE 1947



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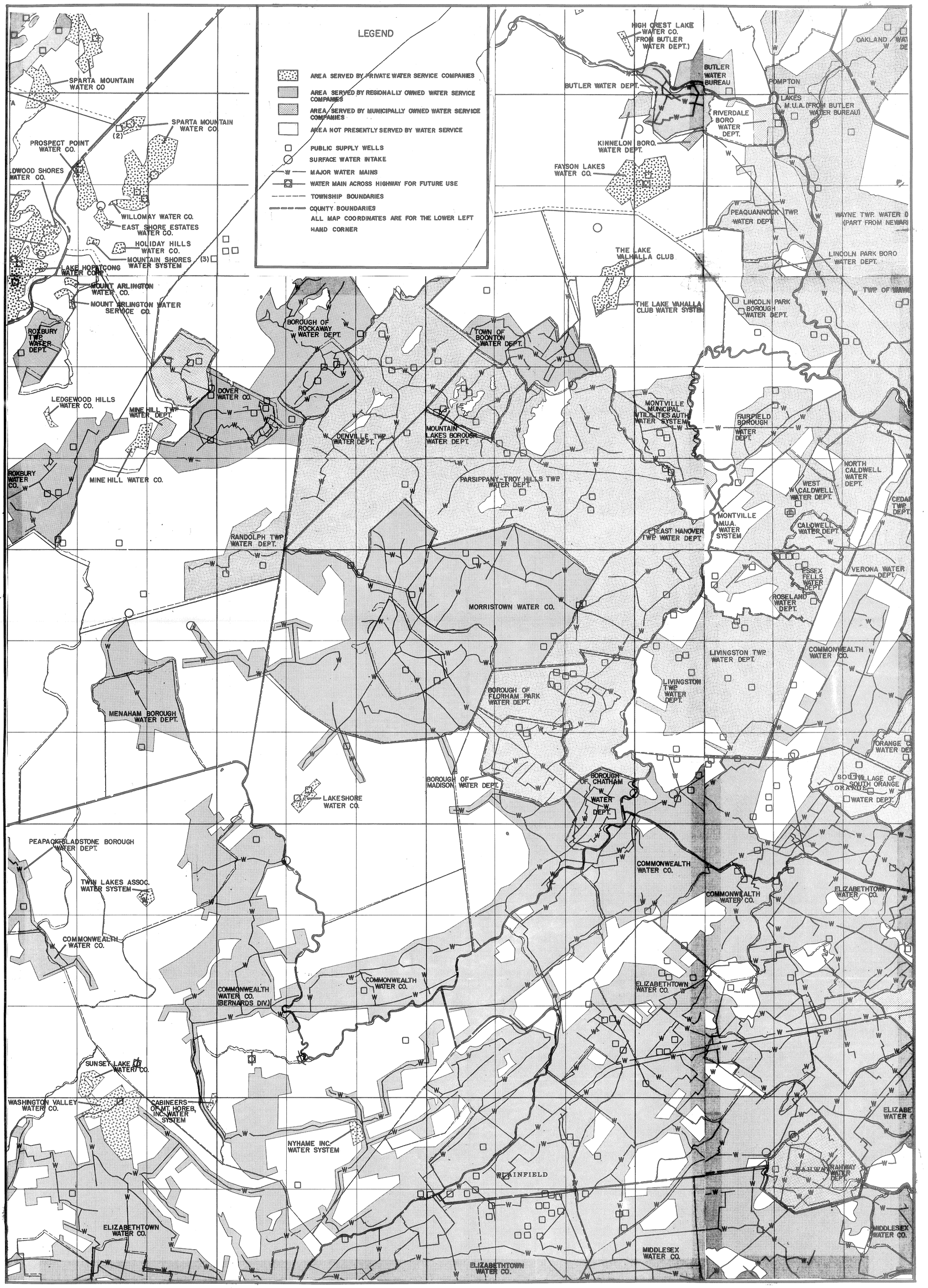
Source: NJ DEP, Well Permits.

THE BURIED VALLEY AQUIFER SYSTEMS

FIGURE G-7. WATER PURVEYOR SERVICE AREAS, 1976



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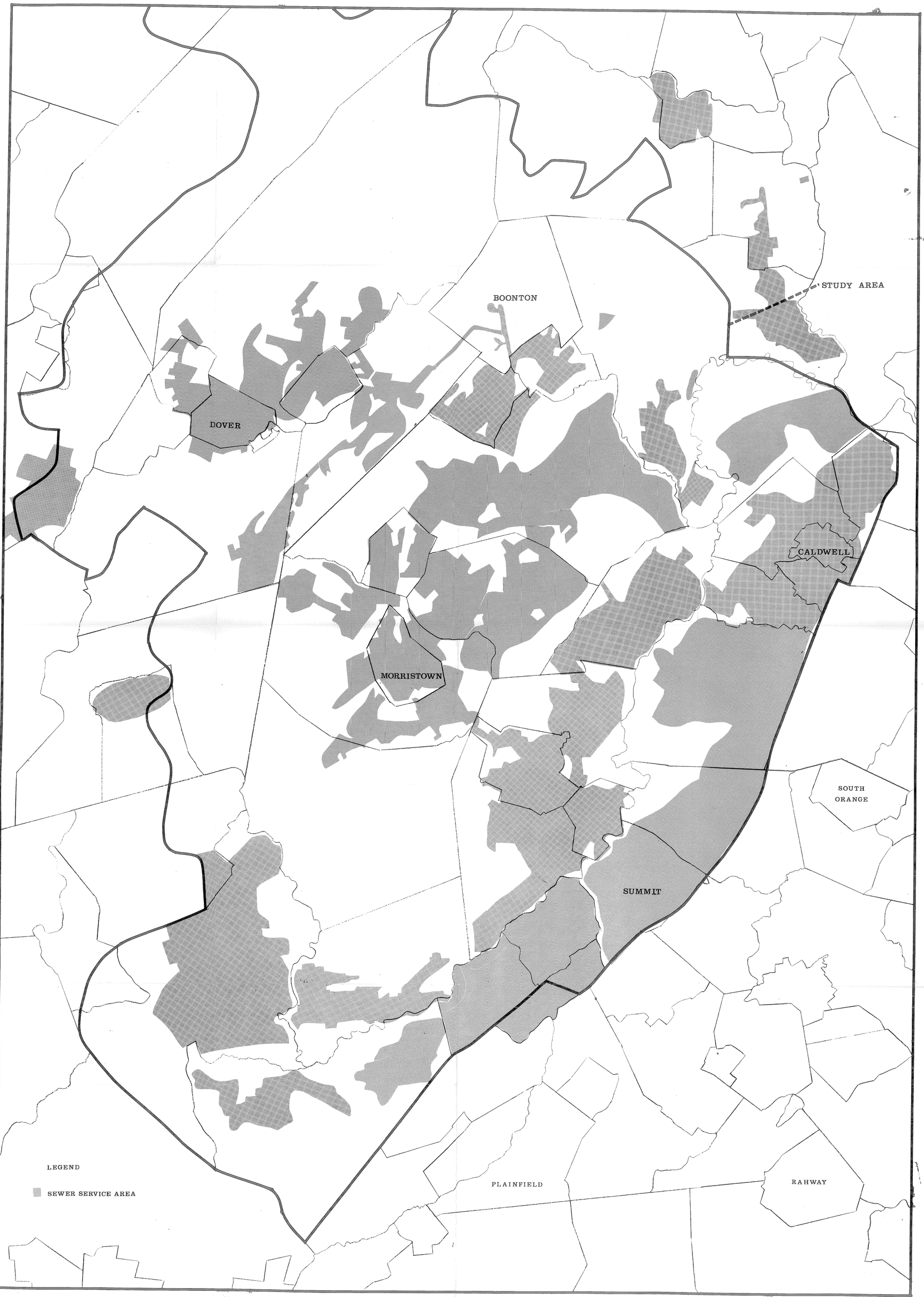
Source: NJ DEP Atlas Series, 1976.

THE BURIED VALLEY AQUIFER SYSTEMS

FIGURE G-8. PUBLIC SEWER SERVICE AREAS, 1985



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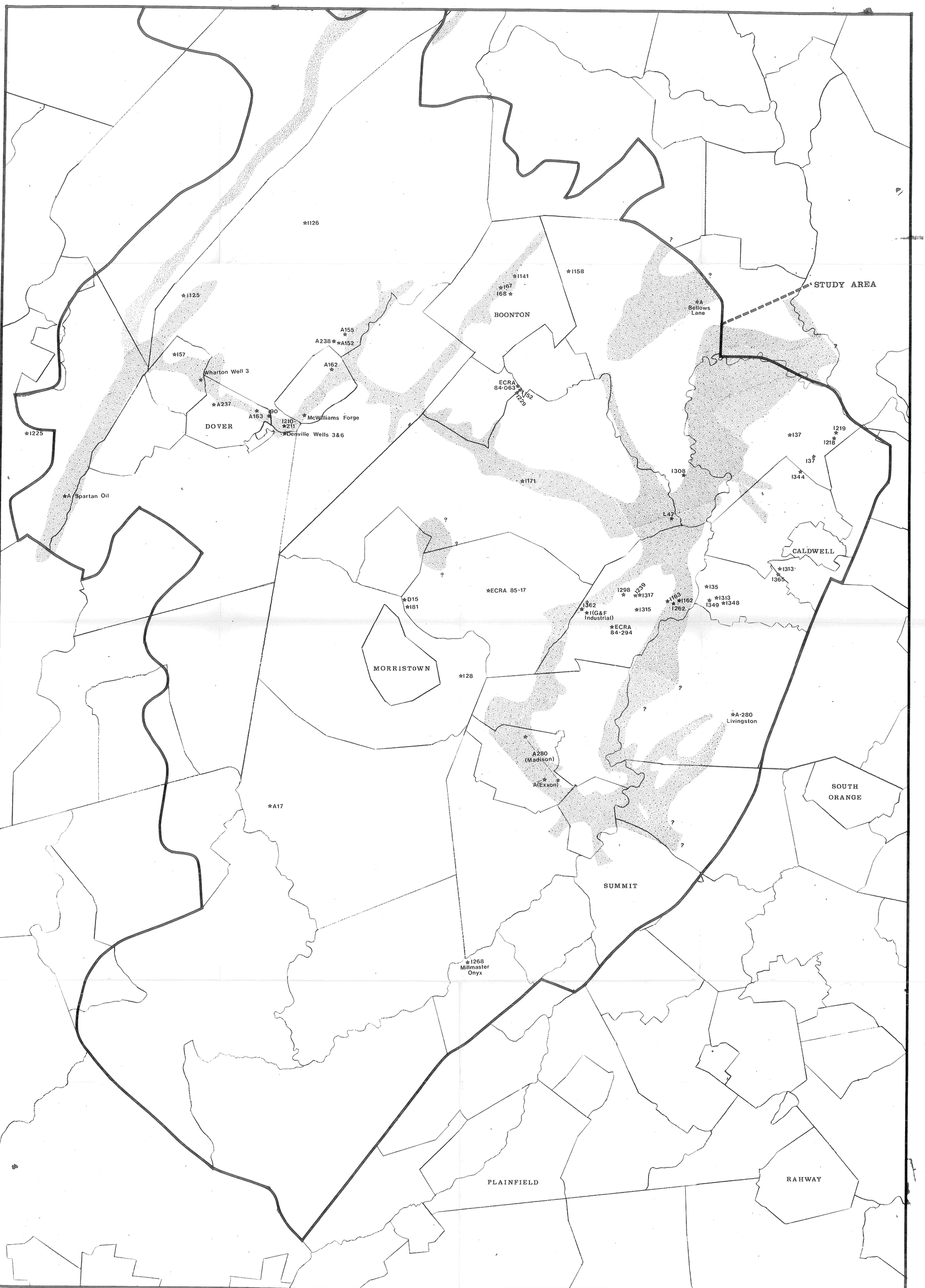
THE BURIED VALLEY AQUIFER SYSTEMS

FIGURE G-9. MAJOR GROUND WATER CONTAMINATION SITES



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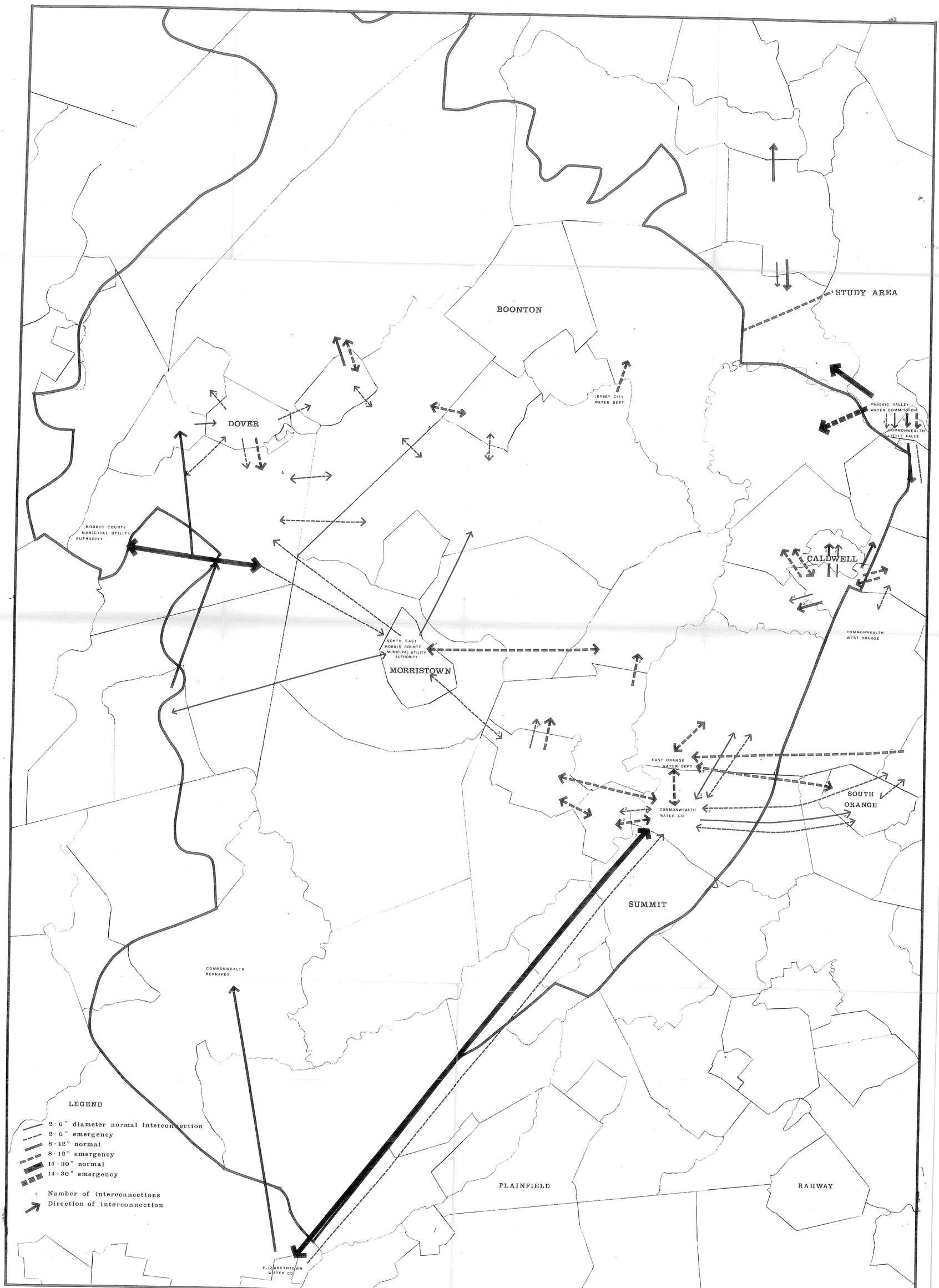
1 mile

Sources: Vecchioli, Nichols, and Nemickas, 1967; Nichols, 1968b; Geraghty and Miller, 1976, 1978; NJGS, 1986; Geonics, 1978, 1979a,b; US ACE, 1979.

THE BURIED VALLEY AQUIFER SYSTEMS

FIGURE G-10. WATER SUPPLY INTERCONNECTIONS



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SOURCE: NJDEP files, 1985