WATER QUALITY OF THE POTOMAC-RARITAN-MAGOTHY AQUIFER SYSTEM IN THE COASTAL PLAIN, WEST-CENTRAL NEW JERSEY

By Elisabeth M. Ervin, Lois M. Voronin, and Thomas V. Fusillo

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BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY

Gordon P. Eaton, Director

For additional information
write to:

District Chief
U.S. Geological Survey
Mountain View Office Park
810 Bear Tavern Road
Suite 206
West Trenton, NJ 08628

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CONVERSION FACTORS, VERTICAL DATUM, AND ABBREVIATED WATER-QUALITY UNITS

Multiply	By	To Obtain
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer
foot per second (ft/s)	0.3048	meter per second
gallon per minute per foot (gal/min)/ft	0.2070	liter per second per meter of drawdown
gallons per minute (gal/min)	0.000063	cubic meters per second
foot squared per day (ft^2/d)	0.0929	meters squared per day
million gallons per day (Mgal/d)	3785	cubic meter per day

Temperature is given in degrees Celsius (°C), which can be converted to degrees Fahrenheit (°F) by the following equation:

$$°F = 1.8\ (°C) + 32$$

Sea level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929--a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

Abbreviated water-quality units used in this report: Chemical concentrations and water temperature are given in metric units. Chemical concentration is given in milligrams per liter (mg/L) or micrograms per liter (μg/L). Milligrams per liter is a unit expressing the concentration of chemical constituents in solution as weight (milligrams) of solute per unit volume (liter) of water. One thousand micrograms per liter is equivalent to one milligram per liter. For concentrations less than 7,000 mg/L, the numerical value is the same as for concentrations in parts per million.

Concentrations of major ions represented in Stiff diagrams in some of the illustrations are in milliequivalents per liter (meq/L).

Specific electrical conductance of water is expressed in microsiemens per centimeter (μS/cm) at 25 °C (degrees Celsius). This unit is equivalent to micromhos per centimeter (μmho/cm) at 25 °C, formerly used by the U.S. Geological Survey.

Readers who are unfamiliar with hydrologic terms are directed to the following glossaries and sources of information: Heath (1984), Freeze and Cherry (1979), and Lohman and others (1972).

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ABSTRACT

The Potomac-Raritan-Magothy aquifer system includes some of the most productive and extensive aquifers in the Coastal Plain of New Jersey. In 1983, 68 percent of all water withdrawn from the Coastal Plain aquifers was from this aquifer system. This study, started in 1980 and conducted by the U.S. Geological Survey in cooperation with the New Jersey Department of Environmental Protection and Energy, was designed to define the areal and vertical distribution of chemical constituents, to determine downdip water quality, and to identify possible threats to the aquifer system as a result of pumping and other human activities. The study area comprises parts of Mercer, Burlington, Camden, Gloucester, and Salem Counties.

Predevelopment ground-water flow was from recharge areas along the outcrop of the Potomac-Raritan-Magothy aquifer system in Mercer and Middlesex Counties through the aquifer system; ground water ultimately discharged to the Delaware River. Pumping has altered this flow pattern. A large cone of depression is centered on Camden, N.J. As a result, the direction of ground-water flow has reversed in some parts of the Potomac-Raritan-Magothy aquifer system, particularly along the Delaware River, allowing estuarine water to flow into the aquifer system.

Ground-water quality in the Potomac-Raritan-Magothy aquifer system results from a combination of predevelopment and present-day flow patterns. Hydrochemical facies correlate to a large extent with prepumping flow patterns; water near the recharge areas is enriched with calcium, magnesium, and sulfate. Downdip, a zone of bicarbonate and sodium and potassium-rich water is present where the sediments of the Potomac-Raritan-Magothy aquifer system have not been flushed with fresh recharge water.

Concentrations of many constituents and values of chemical properties, such as dissolved solids, dissolved sodium, dissolved chloride, and dissolved iron, and pH, reflect the predevelopment regional recharge and discharge patterns. Water downdip in the Potomac-Raritan-Magothy aquifer system tends to contain higher concentrations of dissolved solids than water in the outcrop area and is, therefore, less desirable for human consumption. High concentrations of dissolved iron in the outcrop area (greater than 0.3 milligrams per liter) have resulted in the abandonment of many wells.

Potential threats to the quality of water in the Potomac-Raritan-Magothy aquifer system include flow of downdip saline water toward areas of large ground-water withdrawals; intrusion of salty or saline water from the Delaware River as a result of drought or rising sea level; possible migration of poor-quality water from Philadelphia in response to changes in potentiometric-head relations; and continued contamination of the aquifer system, especially by purgeable organic compounds, in and near the outcrop area.

INTRODUCTION

The confined sand and gravel aquifers of the Potomac Group and Raritan and Magothy Formations that comprise the Potomac-Raritan-Magothy aquifer system are used extensively as sources of water in much of the Atlantic Coastal Plain of New Jersey. Withdrawals of more than 220 Mgal/d from these aquifers during 1983 for public-supply, industrial, commercial, and agricultural use represent approximately 68 percent of total ground-water withdrawals from the Coastal Plain aquifers in New Jersey. The greatest water use in 1983 was in Camden County (fig. 1), where 97 percent of all pumped water came from the Potomac-Raritan-Magothy aquifer system (C.L. Qualls, U.S. Geological Survey, oral commun., 1986).

Total withdrawal from the Potomac-Raritan-Magothy aquifer system in New Jersey has increased significantly since the early 1900's; withdrawals nearly doubled from 1956 to 1973 (Luzier, 1980, p. 2). The increased withdrawal has caused the potentiometric surface to decline over much of the aquifer system. Declines in the potentiometric surface have, in turn, resulted in the movement of poor-quality water[1] toward areas of major ground-water withdrawal. Potential sources of poor-quality water include saline water from the Delaware River estuary, water from industrially contaminated reaches of the Delaware River, water from contaminated parts of the aquifer system, and naturally occurring saline water in downdip parts of the aquifer system (Harbaugh, 1980, p. 2).

The U.S. Geological Survey (USGS), in cooperation with the New Jersey Department of Environmental Protection (NJDEP), collected, analyzed, and compiled water-quality data for the Potomac-Raritan-Magothy aquifer system in parts of Burlington, Camden, Gloucester, and Salem Counties in west central New Jersey to determine water quality in the aquifer system and to examine the effects of pumping and human activities on water quality. The study area (fig. 1) encompasses approximately 880 mi^2. Emphasis was on water quality in the downdip part of the aquifer system, defined as the area of the aquifer system outside and southeast of the generalized outcrop area of the Potomac Group and the Raritan and Magothy Formations (fig. 1).

Purpose and Scope

This report describes the areal and vertical distribution of chemical constituents in the aquifer system in relation to past and present ground-water-flow conditions, the quality of water in the downdip part of the aquifer system, and the effects of human activities on water quality.

The report is based on water-quality data collected from 1980-86 in the study area. Data from 1985 and 1986 were collected during this study, whereas data from 1980-84 were compiled from other reports (Fusillo and Voronin, 1981; Fusillo and others, 1984).

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[1] In this report, poor-quality water is water that is not suitable for human consumption because of elevated concentrations of one or more chemical constituents that exceed State/Federal drinking-water regulations.

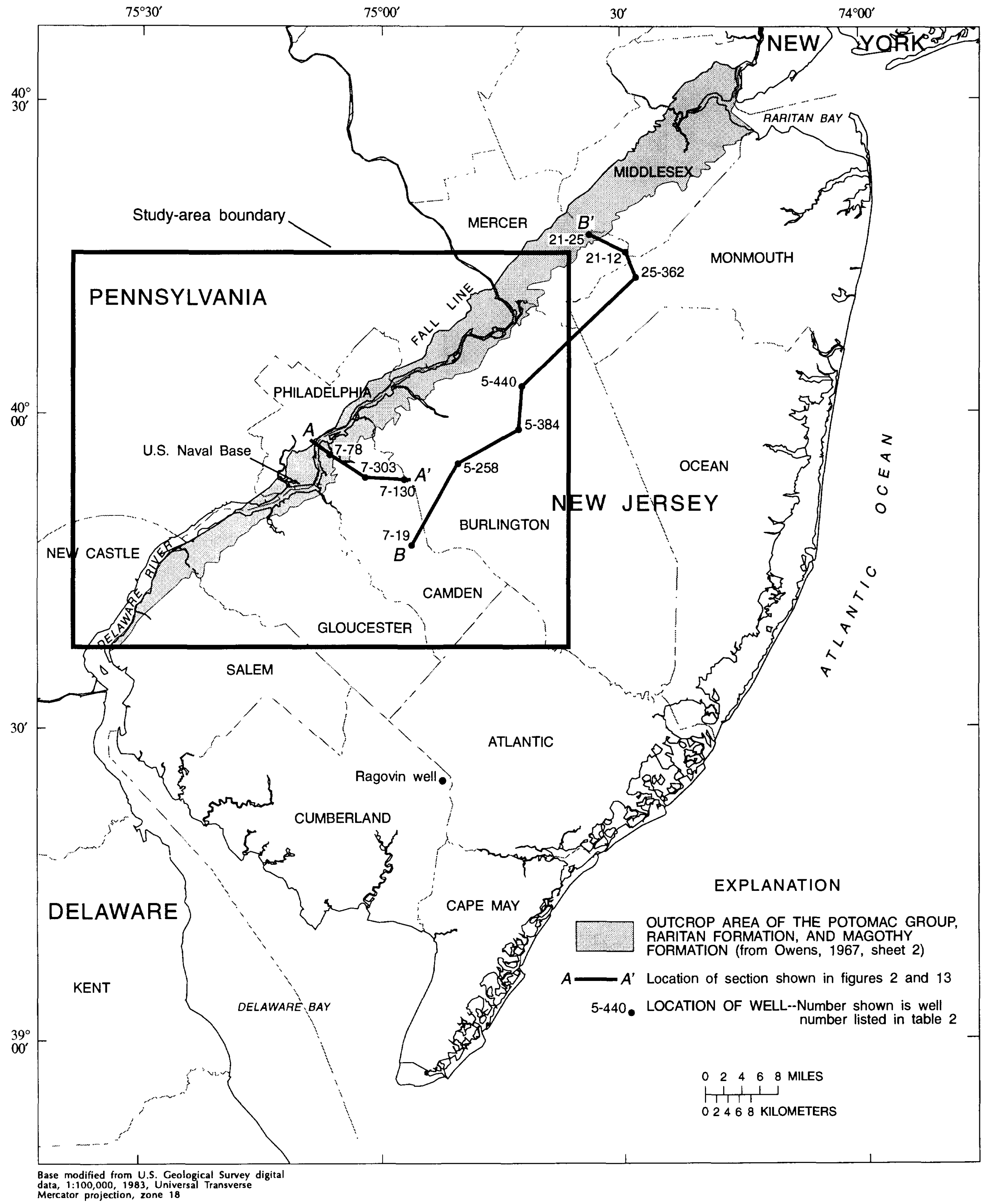


Figure 1.--Location of the study area.

Well-Numbering System

The well-numbering system used in this report is based on the numbering system used by the USGS in New Jersey and Pennsylvania. The well number consists of the county code and the sequence number of the well within the county. New Jersey county codes are numerical two digit codes: Burlington (05), Camden (07), Gloucester (15), Mercer (21), and Salem (33). Pennsylvania county codes are two-letter codes. In this report the only Pennsylvania county code used is for Philadelphia (PH). Examples of well numbers are 15-137 for the 137th well in Gloucester County, N.J., and PH-19 for the 19th well in Philadelphia County, Pa.

Previous Studies

The numerous studies on the ground-water resources of the Potomac-Raritan-Magothy aquifer system in New Jersey and surrounding areas include several countywide ground-water studies and regional studies that involved ground-water modeling. An overview of previous studies is presented below.

Thompson (1932) studied ground-water supplies, pumping rates, and the effect of pumping on ground-water quality of the Camden area. Graham and Kammerer (1952) studied the ground-water resources in the area of the U.S. Naval Base in Philadelphia and defined three aquifers and water-quality problems in the aquifers. Barksdale and others (1958) reported on the quality of water in the outcrop region of the aquifer system as compared to downdip water quality, especially in relation to cations and anions; these authors also discussed the occurrence and flow of highly mineralized ground water in Philadelphia and Camden Counties. Greenman and others (1961) studied the ground-water resources of the Coastal Plain in southeastern Pennsylvania and defined a gradual decline in the water quality of the aquifers in the Raritan and Magothy Formations (currently called the Potomac-Raritan-Magothy aquifer system) in Philadelphia County.

Vecchioli and Palmer (1962) studied the ground-water resources of Mercer County and reported on the water quality of the aquifer system. Rush (1968) described the water quality in Burlington County and recharge from the Delaware River to the aquifer system. Rosenau and others (1969) reported that the water quality in the Potomac-Raritan-Magothy aquifer system was highly variable in Salem County. Hardt and Hilton (1969) observed that water in the Potomac-Raritan-Magothy aquifer system in Gloucester County was suitable for public use in most of the county, owing to generally low concentrations of dissolved solids. Langmuir (1969) investigated the distribution of iron in the ground water of the Magothy and Raritan Formations in Camden and Burlington Counties. Farlekas and others (1976) reported that the water quality of the Potomac-Raritan-Magothy aquifer system in Camden County had changed over time (1923-70) as a result of human activities.

The intrusion of saline water has been a concern in and near the study area since the late 1950's, when Barksdale and others (1958) studied the potential for saltwater intrusion in the southern Coastal Plain. Other authors, including Seaber (1963), Parker and others (1964), Hardt and Hilton (1969), Rosenau and others (1969), Luzier (1980), and Schaefer (1983) have discussed this problem in relation to the Potomac-Raritan-Magothy aquifer system.

The Delaware Valley Regional Planning Commission (1979) listed 48 potential sources of ground-water contamination in the outcrop area of the aquifer system in Burlington, Camden, and Gloucester Counties; the 48 sites consisted of landfills, lagoons, and industrial storage areas. Luzier (1980) developed a single-layer, two-dimensional finite-difference digital model to simulate the response of the Potomac-Raritan-Magothy aquifer system to pumping stress. Harbaugh and others (1980) used Luzier's model of the Potomac-Raritan-Magothy aquifer system to simulate the effects of supplementing ground-water supplies with water from the Delaware River. McAuley and Kendall (1989) used data on the stable isotopes deuterium and oxygen-18 to trace induced recharge from the Delaware River into the Potomac-Raritan-Magothy aquifer system in the Camden area.

Acknowledgments

The authors are grateful for the cooperation of public officials, industry representatives, and individuals who provided information on their wells and allowed access for the collection of water samples.

HYDROGEOLOGIC SETTING

The Atlantic Coastal Plain in New Jersey is a region of mostly low relief that is characterized by broad plains and gently sloping hills and ridges. The Coastal Plain is underlain by a wedge-shaped mass of unconsolidated, stratified sediments composed of gravel, sand, silt, and clay. These sediments dip toward the Atlantic Ocean and range in thickness from nearly zero at the updip limit of the sediments at the Fall zone to 6,500 ft in Cape May County (Gill and Farlekas, 1976).

Geologic Formations of the New Jersey Coastal Plain

The formations of the Coastal Plain range in age from Cretaceous to Holocene, and lie unconformably on a basement complex composed largely of Precambrian and lower Paleozoic crystalline rocks. The geologic units of primary interest to this study are the Potomac Group, the Raritan and Magothy Formations, the Merchantville Formation, and the Woodbury Clay, all of Cretaceous age (table 1). These deposits, the oldest in the Coastal Plain, overlie the crystalline rocks of the Precambrian Wissahickon Formation and consist of sand and gravel interbedded with silt and clay units. The formations are exposed at or near the surface in a narrow band along the Delaware River in New Jersey and Pennsylvania (fig. 1). The sediments average 250 ft in thickness near the outcrop area and attain a maximum thickness in excess of 4,000 ft at Cape May (Gill and Farlekas, 1976). The formations contain a relatively high percentage of sand near the outcrop area (57 to 67 percent) in Camden County and less sand (37 percent) downdip (Farlekas and others, 1976, p. 18).

The Potomac Group is present at the base of the Coastal Plain stratigraphic section and in the Delaware River Valley from Trenton to Salem, N.J.; its geology and depostional history are similar to those of the overlying Raritan Formation (both are fluvial-continental deposits). The Potomac Group consists of alternating layers of unconsolidated sand, clay, and gravel.

Table 1.--Geologic and hydrogeologic units in the study area

[Modified from Zapecza, 1989, table 2]

SYSTEM	SERIES	GEOLOGIC UNIT	LITHOLOGY	HYDROGEOLOGIC UNIT	HYDROLOGIC CHARACTERISITICS
Quaternary	Holocene	Alluvial deposits	Sand, silt, and black mud	Undifferentiated	Surficial material, commonly hydraulically connected to underlying aquifers. Locally some units may act as confining units. Thicker sands are capable of yielding large quantities of water
		Beach sand and gravel	Sand, quartz, light-colored, medium- to coarse-grained, pebbly		
	Pleistocene	Cape May Formation	Sand, quartz, light-colored, heterogeneous, clayey, pebbly		
Tertiary	Miocene	Pensauken Formation		Kirkwood-Cohansey aquifer system	A major aquifer system. Ground water occurs generally under water-table conditions. In Cape May County the Cohansey Sand is under artesian conditions
		Bridgeton Formation			
		Beacon Hill Gravel	Gravel, quartz, light-colored, sandy		
		Cohansey Sand	Sand, quartz, light-colored, medium- to coarse-grained, pebbly; local clay beds		
		Kirkwood Formation	Sand, quartz, gray and tan, very fine- to medium-grained, micaceous, and dark-colored diatomaceous clay	Confining unit	Thick diatomaceous clay bed occurs along coast and for a short distance inland. A thin water-bearing sand is present in the middle of this unit
				Rio Grande water-bearing zone	
				Confining unit	
				Atlantic City 800-foot sand	A major aquifer along the coast
				Composite confining unit	Poorly permeable sediments
	Oligocene	Piney Point Formation [1]	Sand, quartz and glauconite, fine- to coarse-grained	Composite confining unit: Piney Point aquifer	Yields moderate quantities of water
	Eocene	Shark River Formation			
		Manasquan Formation	Clay, silty and sandy, glauconitic, green, gray, and brown, contains fine-grained quartz sand	Composite confining unit	Poorly permeable sediments
	Paleocene	Vincentown Formation	Sand, quartz, gray and green, fine- to coarse-grained, glauconitic, and brown clayey, very fossiliferous, glauconite and quartz calcarenite	Composite confining unit: Vincentown aquifer	Yields small to moderate quantities of water in and near its outcrop area
		Homerstown Sand	Sand, clayey, glauconitic, dark green, fine- to coarse-grained	Composite confining unit	Poorly permeable sediments
Cretaceous	Upper Cretaceous	Tinton Sand	Sand, quartz, and glauconite, brown and gray, fine- to coarse-grained, clayey, micaceous		
		Red Bank Sand		Composite confining unit: Red Bank Sand	Yields small quantities of water in and near its outcrop area
		Navesink Formation	Sand, clayey, silty, glauconitic, green and black, medium- to coarse-grained	Composite confining unit	Poorly permeable sediments
		Mount Laurel Sand	Sand, quartz, brown and gray, fine- to coarse-grained, slightly glauconitic	Wenonah-Mount Laurel aquifer	A major aquifer
		Wenonah Formation	Sand, very fine- to fine-grained, gray and brown, silty, slightly glauconitic	Marshalltown-Wenonah confining unit	A leaky confining unit
		Marshalltown Formation	Clay, silty, dark greenish-gray, glauconitic quartz sand		
		Englishtown Formation	Sand, quartz, tan and gray, fine- to medium-grained; local clay beds	Englishtown aquifer system	A major aquifer. Two sand units in Monmouth and Ocean Counties
		Woodbury Clay	Clay, gray and black, micaceous silt	Merchantville-Woodbury confining unit	A major confining unit. Locally the Merchantville Formation may contain a thin water-bearing sand
		Merchantville Formation	Clay, glauconitic, micaceous, gray and black; locally very fine-grained quartz and glauconitic sand		
		Magothy Formation	Sand, quartz, light-gray, fine- to coarse-grained. Local beds of dark-gray lignitic clay. Includes Old Bridge Sand Member	Potomac-Raritan-Magothy aquifer system: Upper aquifer	A major aquifer system. In the northern Coastal Plain, the upper aquifer is equivalent to the Old Bridge aquifer and the middle aquifer is equivalent to the Farrington aquifer. In the Delaware River Valley, three aquifers are recognized. In the deeper subsurface, units below the upper aquifer are undifferentiated
		Raritan Formation	Sand, quartz, light-gray, fine- to coarse-grained pebbly arkosic; contains red, white, and variegated clay. Includes Farrington Sand Member	Confining unit	
				Middle aquifer	
	Lower Cretaceous	Potomac Group	Alternating clay, silt, sand, and gravel	Confining unit	
				Lower aquifer	
Pre-Cretaceous		Bedrock	Precambrian and Lower Paleozic crystalline rocks, metamorphic schist and gneiss; locally Triassic sandstone and shale and Jurassic diabase are present	Bedrock confining unit	No wells obtain water from these consolidated rocks, except along Fall Line

[1]of Olsson and others, 1980

The Raritan Formation overlies the Potomac Group and is typically composed of light-colored, medium- to coarse-grained quartzose sand that contains some gravel and clay (Barksdale and others, 1958). The Woodbridge Clay is the predominant clay in this formation. In the outcrop area, adjacent to the Delaware River, the sediments of the Raritan Formation are highly variable vertically and horizontally.

The Magothy Formation, which lies unconformably on the Raritan Formation, typically consists of marine and nearshore deposits of dark-gray or black clay that contains alternating beds of white micaceous fine-grained sand (Barksdale and others, 1958).

The Merchantville Formation lies unconformably on the Magothy Formation and is conformably overlain by the Woodbury Clay. The Merchantville Formation is typically a green to black glauconitic micaceous clay that contains beds and lenses of quartzose or glauconitic sandy clay. The Woodbury Clay is composed of dark-gray to black clay. The unit is distinguished from the Merchantville Formation by a greater concentration of clay and a much lower concentration of glauconitic sand. Fossil evidence indicates that both formations are of marine origin (Owens and Sohl, 1969). The combined thickness of the Merchantville Formation and the Woodbury Clay is approximately 100 ft in the outcrop and more than 300 ft near the Atlantic Coast (Luzier, 1980).

Potomac-Raritan-Magothy Aquifer System

Many of the geologic formations in the Coastal Plain contain aquifers capable of yielding moderate to large quantities of water; however, the Potomac-Raritan-Magothy aquifer system is the largest and most productive of these. The aquifers contained in the Potomac Group and the Raritan and Magothy Formations generally are confined; however, the aquifers can be unconfined in parts of the outcrop area. The aquifers and the confining units might not correspond exactly to the geologic formations of similar names. At the Ocean and Atlantic County coastlines, a minimum of 2,000 ft of sediment separates the bottom of the Atlantic Ocean from the top of the Potomac-Raritan-Magothy aquifer system (Martin, 1990).

The Potomac-Raritan-Magothy aquifer system in the study area (fig. 1) has been subdivided into a major confining layer--the Merchantville-Woodbury confining unit--and three aquifer units, termed upper, middle, and lower aquifers (Zapecza, 1989; E.O. Regan, U.S. Geological Survey, written commun., 1986). A generalized hydrologic section through the aquifer system is shown in figure 2.

The Merchantville-Woodbury confining unit is poorly permeable and forms an extensive confining layer throughout the Coastal Plain. Significant volumes of water can be transmitted through the confining unit, however, if large differences in potentiometric head exist between overlying and underlying aquifers. This unit separates the Potomac-Raritan-Magothy aquifer system from the overlying Englishtown aquifer system. Where the Englishtown aquifer system is absent, the Merchantville-Woodbury confining unit separates the Wenonah-Mount Laurel aquifer from the Potomac-Raritan-Magothy aquifer system.

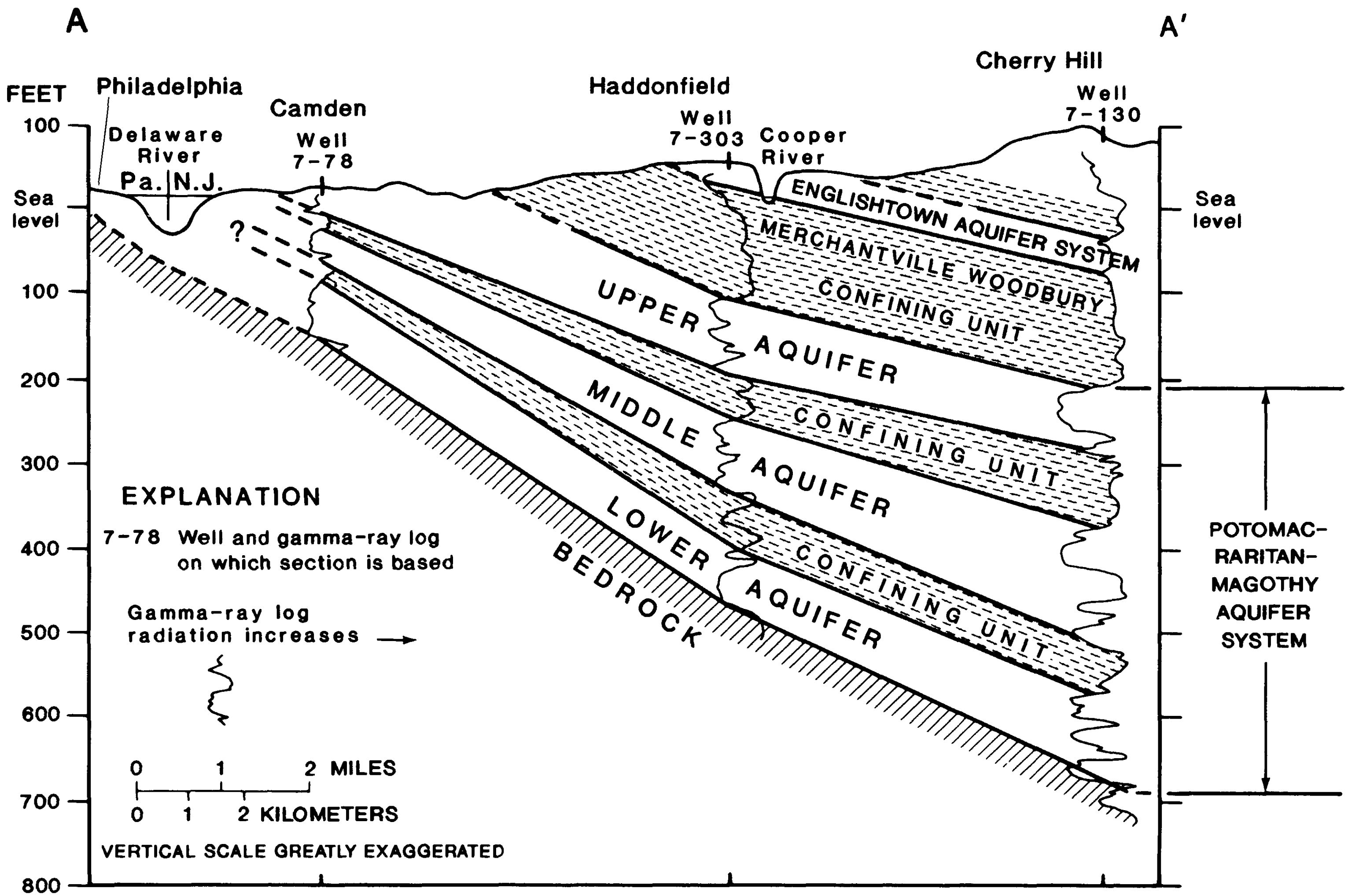


Figure 2.--Generalized hydrogeologic section A-A' through the study area. (Location of section shown in fig. 1.)

The upper aquifer is the most extensive of the three aquifers, and most nearly corresponds to the Magothy Formation. It crops out in a narrow band east of the Delaware River from Trenton to Penns Grove, N.J. In this area it is unconfined and is recharged directly by precipitation and by vertical leakage from discontinuous overlying post-Cretaceous sands and gravels. The upper aquifer is composed of coarse-grained sediments and thin, localized, clay beds. East of the outcrop, the upper aquifer is confined beneath the Merchantville-Woodbury confining unit. The thickness of the upper aquifer ranges from 100 ft near the outcrop in Salem County to 350 ft in the northeastern Coastal Plain (Zapecza, 1989).

The confining unit between the upper and middle aquifers ranges in thickness from 20 ft in Camden and Gloucester Counties to 50 ft in Burlington County. The general thickness of the confining unit is 50 ft in the outcrop area; in the southeastern part of the study area, the thickness ranges from 150 to 200 ft (Zapecza, 1989).

The middle aquifer crops out in a narrow band adjacent to and beneath the Delaware River. This aquifer is unconfined in Burlington County and in Pennsylvania; elsewhere in New Jersey, it is confined. The percentage of sand and the thickness of the middle aquifer are variable. The unit also contains silt and clay layers (Zapecza, 1989). The middle aquifer ranges in thickness from a few feet to 230 ft and the sand content ranges from 60 to 100 percent.

The confining unit between the middle and the lower aquifers consists of very fine-grained silts and clays; it is generally less than 50 ft thick over half of its mappable extent (Zapecza, 1989). Near the river, the silts and clays of this unit are less than 50 ft thick (H.E. Gill and G.M. Farlekas, U.S. Geological Survey, written commun., 1970). The confining unit thickens downdip in a nonuniform manner, as a result of lensing, to a total thickness of greater than 100 ft (Zapecza, 1989). The limited extent of this confining unit and the similarity in heads in the middle and lower aquifers (Walker, 1983) indicate the presence of a hydraulic connection between the two aquifers.

The lower aquifer contains sediments of the Raritan Formation and the Potomac Group. In Salem County, the lower aquifer appears to be equivalent to the lower hydrologic zone of the Potomac Group (Zapecza, 1989). This aquifer is the most limited in extent of the three aquifers, and it is not known to crop out in New Jersey. E.O. Regan (U.S. Geological Survey, written commun., 1986) confirmed that the lower aquifer is present beneath the Delaware River and provides a connection between the Potomac-Raritan-Magothy aquifer system in Pennsylvania and New Jersey. In the northern part of the study area, near Mount Holly, N.J., the lower aquifer thins and pinches out against the crystalline basement rock. The updip extent of the lower aquifer is shown on plates 1C-7C. The percentage of sand ranges from 37 to 100, and the average sand content exceeds 70 percent. The lower aquifer attains a maximum thickness of 250 ft in Camden and Gloucester Counties (Zapecza, 1989).

Aquifer Characteristics

The Potomac-Raritan-Magothy aquifer system yielded more than 80 x 10^9 gallons throughout the Coastal Plain in 1983 (C.L. Qualls, U.S. Geological Survey, oral commun., 1986). The average yield of 106 large-diameter wells (diameter 12 inches or greater) in Camden County is 1,085 gal/min, and the average specific capacity is 29.3 (gal/min)/ft (Farlekas and others, 1976, p. 38). The results of aquifer tests in Burlington, Camden, and Gloucester Counties indicate that the transmissivity of individual aquifers ranges from 2,300 to 31,000 ft^2/d (Hantush, 1960). The storage coefficient ranges from 3.3×10^{-5} to 4.0×10^{-3} (Gill and Farlekas, 1976).

Predevelopment Ground-Water Flow

Regional ground-water flow before development was controlled by recharge to two areas of the outcrop at high altitudes in Mercer and Middlesex Counties (figs. 3 and 4) (Barksdale and others, 1958) and by areally distributed leakage from the Englishtown Formation through the Merchantville-Woodbury confining unit (H.E. Gill and G.M. Farlekas, U.S. Geological Survey, written commun., 1969). Maps of the simulated predevelopment potentiometric surfaces are shown in figures 3 to 5 for the upper, middle, and lower aquifers, respectively. These maps are based on results from the Regional Aquifer System Analysis (RASA) model (Martin, 1990). Water-level altitudes exceeded 70 ft above sea level in the middle and upper units in the recharge areas. In the outcrop area, local flow patterns were complex because of variations in topography and geology. Much of the precipitation entering the unconfined aquifer in low-lying areas was discharged into streams crossing the outcrop area.

The simulated predevelopment flow patterns in the Potomac-Raritan-Magothy aquifer system are supported by carbon-14 dating (Winograd and Farlekas, 1974). The distribution of carbon-14 concentrations within the aquifer system approximated the prepumping potentiometric contours shown in figures 3 to 5.

Before development, leakage through the Merchantville-Woodbury confining unit was the major source of recharge to the aquifer system between Trenton, N.J., and Wilmington, Del. (H.E. Gill and G.M. Farlekas, U.S. Geological Survey, written commun., 1969). Simulated heads in the overlying Englishtown and Wenonah-Mount Laurel aquifers are greater than 80 and 100 ft above sea level, respectively, near Lindenwold, Camden County (Martin, 1990). Downward vertical flow through the Merchantville-Woodbury clay would be possible as a result of the potentiometric-head differences of 60 and 80 ft between the Englishtown aquifer system and Wenonah-Mount Laurel aquifer, respectively, and the Potomac-Raritan-Magothy aquifer system. Under predevelopment conditions, potentiometric heads in the three aquifers of the Potomac-Raritan-Magothy aquifer system were within 10 feet of each other (Martin, 1990); therefore, under the prepumping scenerio, the aquifers can be considered as a single hydrologic unit.

In predevelopment flow-budget simulations for the upper aquifer (Martin 1990), discharge to the Delaware River is exceeded only slightly by downward flow to the middle aquifer. Similar simulations demonstrate that discharge to the Delaware River exceeds all other outflow from the middle and lower aquifers.

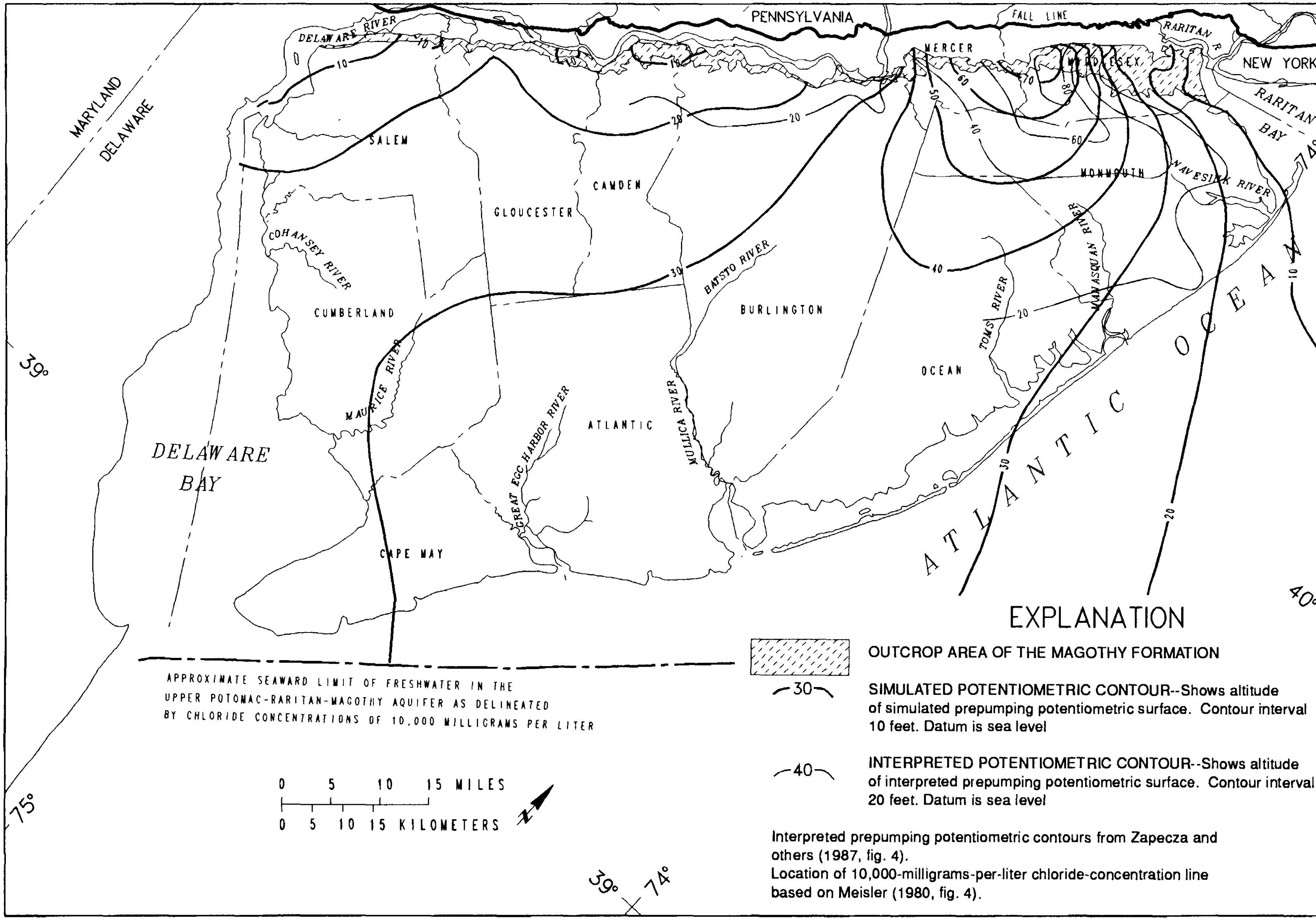


Figure 3.--Simulated and interpreted predevelopment potentiometric surfaces the upper aquifer,in Potomace-Raritan-Magothy aquifer system, 1983. (Modified from Martin, 1990, fig. 32)

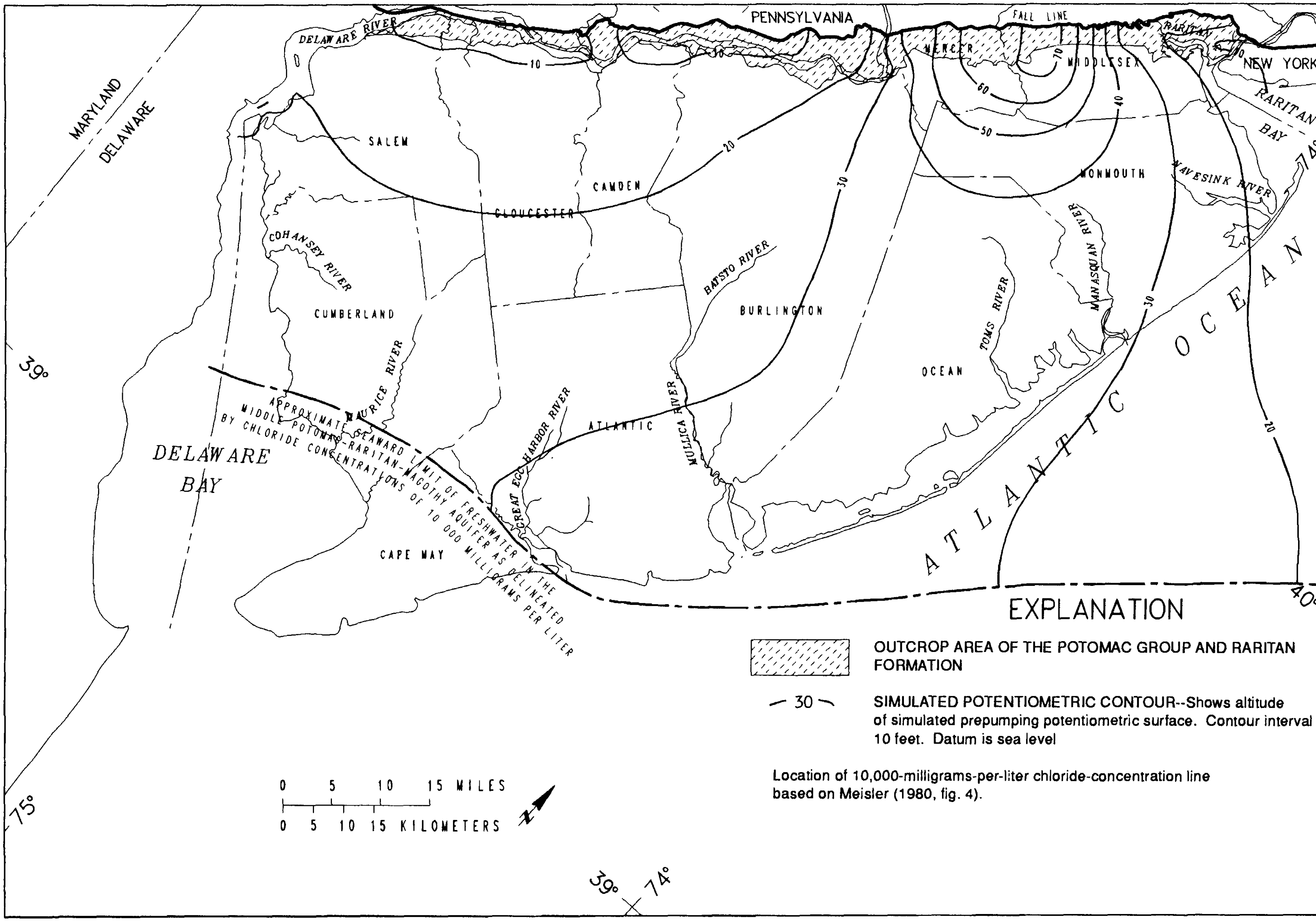


Figure 4.--Simulated predevelopment potentiometric surface in the middle aquifer, Potomac-Raritan-Magothy aquifer system, 1983. (Modified from Martin, 1990, fig. 31)

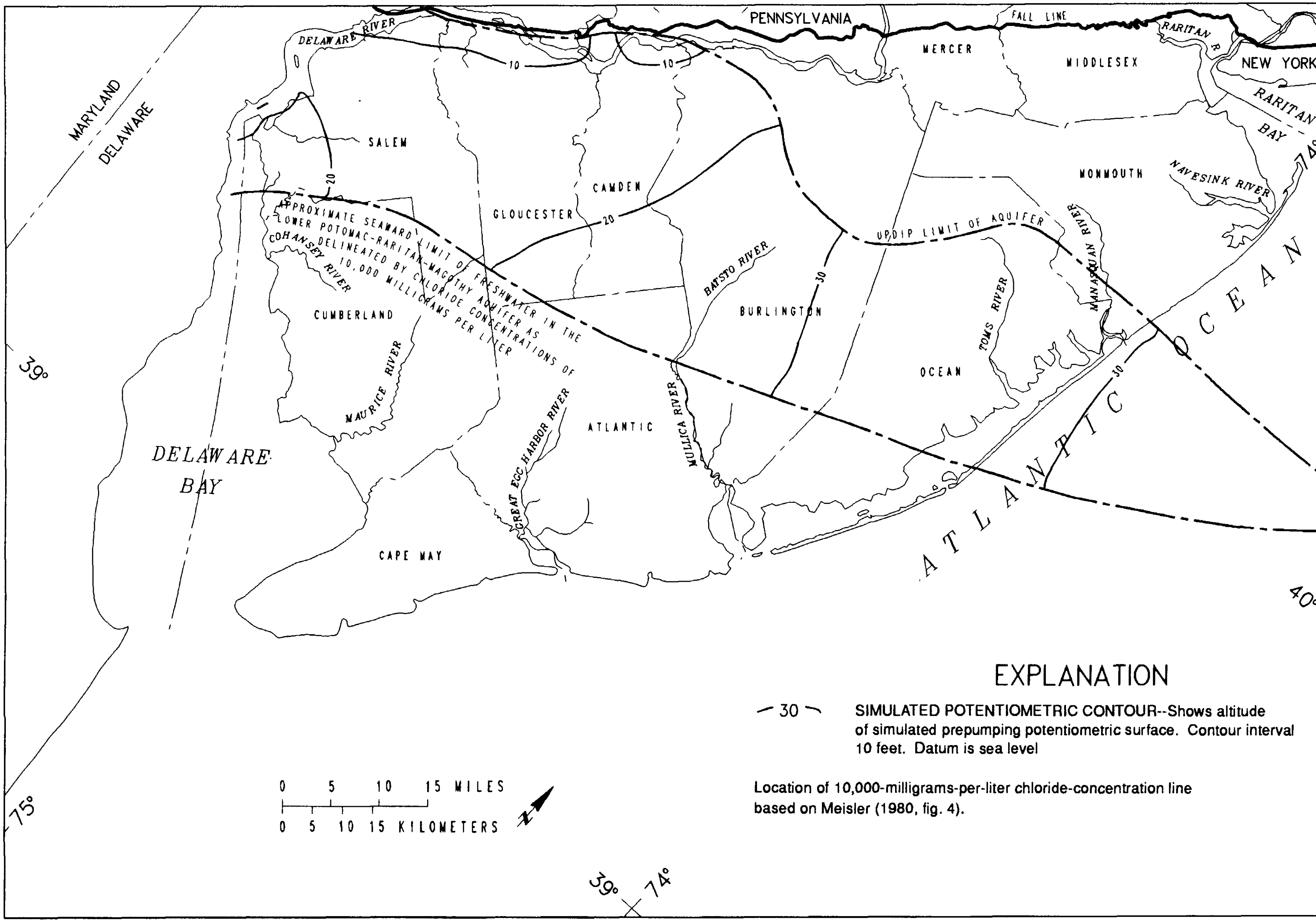


Figure 5.--Simulated predevelopment potentiometric surface in the lower aquifer, Potomac-Raritan-Magothy aquifer system, 1983. (Modified from Martin, 1990, fig. 30)

Present-Day Ground-Water Flow

Ground-water withdrawals have significantly changed the distribution of potentiometric heads in the aquifer system. Average yearly withdrawals from the upper, middle and lower aquifers from 1920-80 in Burlington, Camden, and Gloucester Counties are shown in figure 6. These ground-water withdrawals have reversed the flow patterns in much of the aquifer system, especially in and near the outcrop area.

The potentiometric surfaces in the upper, middle, and lower aquifers in 1983 are shown in figures 7 to 9. In the upper and middle aquifers, the potentiometric surface in the recharge area in Mercer and Middlesex Counties is above sea level and has changed little since 1900 (figs. 3 to 5). A regional cone of depression--the result of ground-water withdrawals for public supply, industry, and irrigation--is present in all three aquifers of the Potomac-Raritan-Magothy aquifer system in central Camden and southwestern Burlington Counties. This cone is located where overlying aquifers, such as the Englishtown aquifer system, appear to be leaking. The associated potentiometric heads at this location in the aquifer system are more than 80 ft below sea level. The decline in potentiometric heads in this area represents a change of 90 to 100 ft from simulated predevelopment conditions (figs. 3 to 5).

Another major cone of depression is in the middle aquifer in southwestern Salem County, where water levels have declined to 70 ft below sea level near Artificial Island. Several smaller cones of depression (figs. 7 to 9) indicate locally large withdrawals from the aquifer system.

Changes in the distribution of potentiometric heads have resulted in a reversal of the predevelopment ground-water-flow directions adjacent to the Delaware River. The 1983 potentiometric surfaces and data from other sources (Greenman and others, 1961; Barksdale and others, 1958) indicate that flow patterns have changed and that ground water presently is flowing southeast from the river into the aquifer system, especially in areas of extensive pumping. Changes in flow directions in the upper, middle, and lower aquifers also are evident from simulations of 1978 ground-water-flow conditions (Martin, 1990). Results of these simulations demonstrate that the aquifer system receives recharge from the Delaware River and verify that pumping is responsible for most of the outflow from the aquifer system.

Results of simulations by Vowinkel and Foster (1981) indicate that the area of greatest inflow from the Delaware River during 1973-78 was the area adjacent to Camden, where recharge to the aquifer system was approximately 39 ft^3/s in 1973 and 42 ft^3/s in 1978. In addition, inflow along the river in the northeastern part of Gloucester County was approximately 34 ft^3/s in 1973 and in 1978.

Reversal of flow directions--especially near the Potomac-Raritan-Magothy aquifer system outcrop area--affects the quality of water in the aquifer system. Contaminated water could be drawn into these aquifers from parts of the outcrop area on the New Jersey and Philadelphia sides of the river. The inflow of water from the Delaware River to the aquifer system could dilute contaminated water being drawn in from the outcrop area.

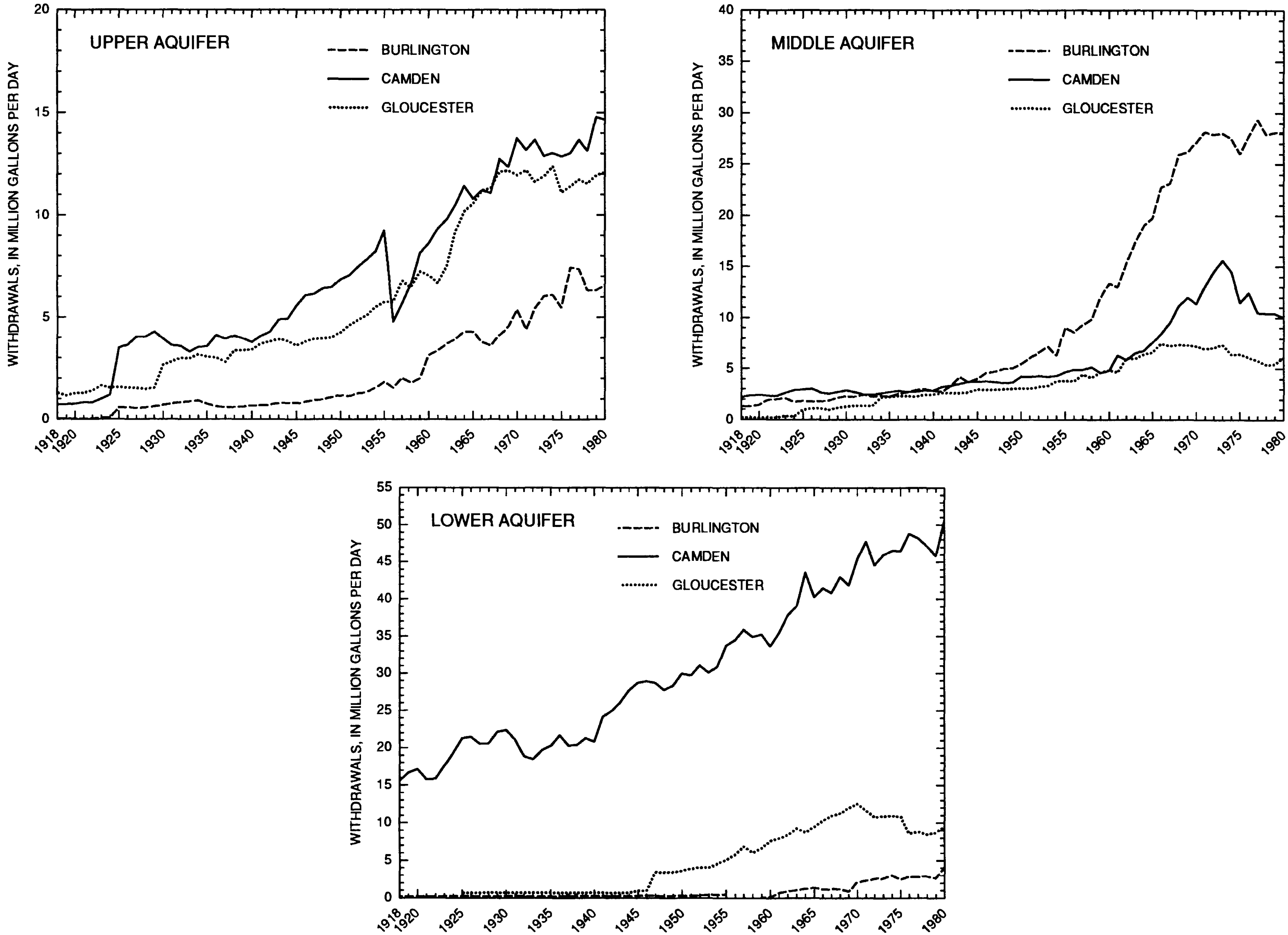


Figure 6.--Average yearly ground-water withdrawals from the Potomac-Raritan-Magothy aquifer system in Burlington, Camden, and Gloucester Counties, New Jersey, 1920-80.

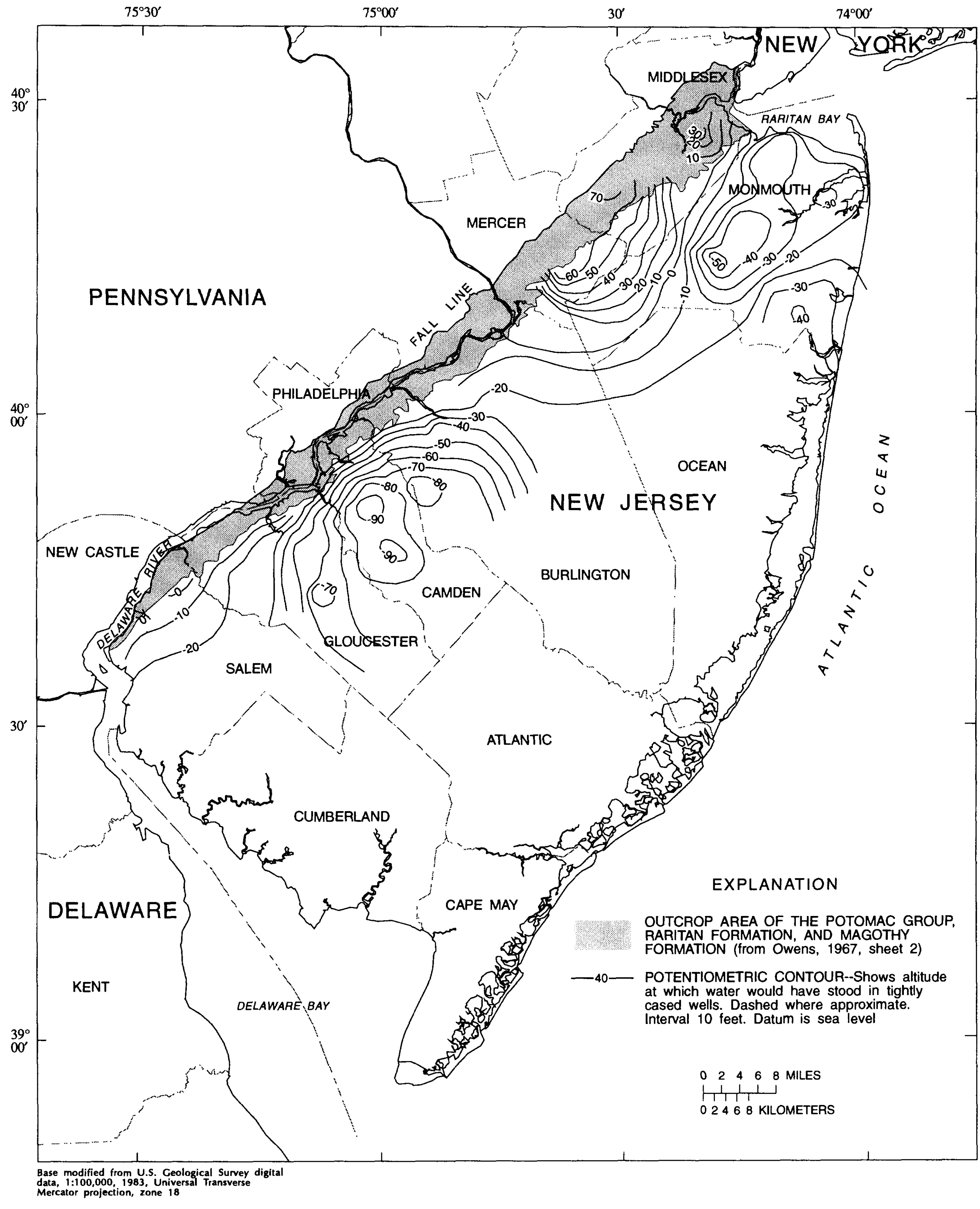


Figure 7.--Potentiometric surface in the upper aquifer, Potomac-Raritan-Magothy aquifer system, 1983. (Modified from Eckel and Walker, 1986, pl. 3.)

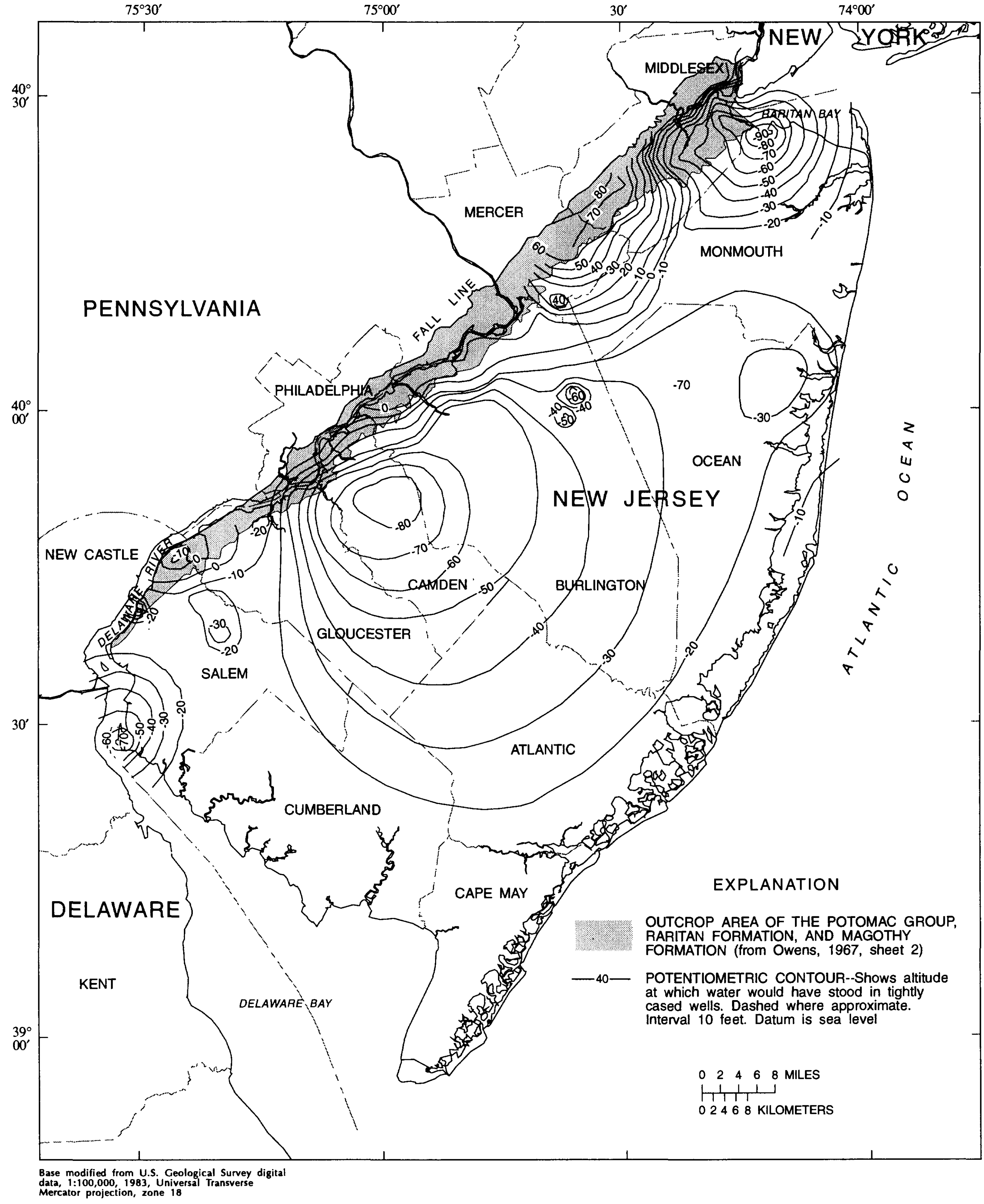


Figure 8.--Potentiometric surface in the middle aquifer, Potomac-Raritan-Magothy aquifer system, 1983. (Modified from Eckel and Walker, 1986, pl. 4.)

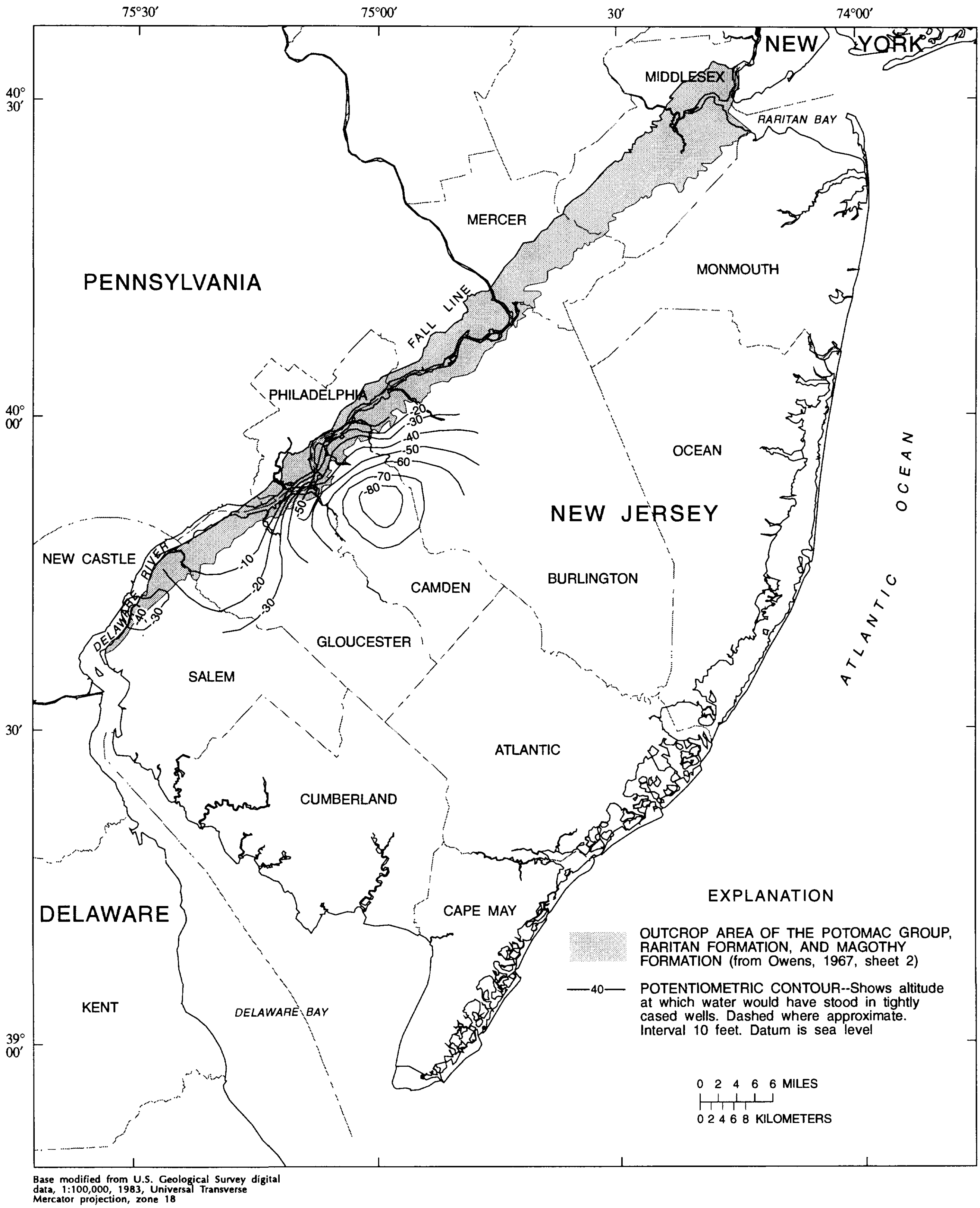


Figure 9.--Potentiometric surface in the lower aquifer, Potomac-Raritan-Magothy aquifer system, 1983. (Modified from Eckel and Walker, 1986, pl. 5.)

The Potomac-Raritan-Magothy aquifer system can be divided into two regimes of flow--the active-flow area and an area of little flow in the downdip area. The active-flow area is that part of the aquifer system in which formation water has been flushed by fresh regional recharge in the predevelopment flow system. Flow paths downdip are long relative to the flow paths updip and little flushing of the formation water has occurred. Water in this downdip zone of little flow has been in the aquifers for a longer time than water in the recharge areas and contains higher concentrations of dissolved solids than does water in the active-flow area.

WATER QUALITY

Water-quality data for the Potomac-Raritan-Magothy aquifer system used in this report were collected during three sampling periods: June through December 1980, July through December 1982, and July 1985 through January 1986. A total of 356 wells was sampled; because some wells were sampled several times, a total of 503 water samples were collected. The wells sampled are in the outcrop area of the Potomac-Raritan-Magothy aquifer system from Trenton to Pennsville, as well as downdip in the confined part of the aquifer system.

The water samples collected during 1980-86 were analyzed for major and common inorganic ions, dissolved metals, nutrients, dissolved organic carbon (DOC), and purgeable organic compounds (POC's) at the USGS Central Laboratory in Arvada, Colo. Water samples were scanned for POC's by use of a gas chromatograph according to methods 601 and 602 of the U.S. Environmental Protection Agency (USEPA) (U.S. Environmental Protection Agency, 1982) at the USGS laboratory in Trenton, N.J. Water samples in which one or more compounds were detected were sent to the USGS Central Laboratory for additional analysis of POC's by means of gas chromatography/mass spectrometry.

The ground-water-quality data collected during 1980-82, as well as historic data for the study area, are reported in Fusillo and Voronin (1981) and Fusillo and others (1984). The latter report also summarizes chloride-concentration and specific-conductance data for wells sampled more than once. Surface-water-quality data are published in Hochreiter (1982).

Records of wells sampled in 1985 and 1986 for this study are listed in table 2 (at end of report). Some wells were previously assigned to different aquifers; changes in aquifer codes from those previously published by Fusillo and others (1984), based on later hydrostratigraphic studies of the Potomac-Raritan-Magothy aquifer system (E.O. Regan, U.S. Geological Survey, written commun., 1986; Zapecza, 1989), are listed in table 3 (at end of report). A statistical summary of water-quality data collected from 1985-86 is presented in table 4. Water-quality data for the sampling period 1985-86 (common constituents, trace elements, nutrients, and POC's) are listed in tables 5-8 (at end of report). The locations of wells at which samples were collected from the upper, middle, and lower aquifers are shown in figures 10-12. Water-quality data are stored in the USGS National Water-Data Storage and Retrieval System (WATSTORE).

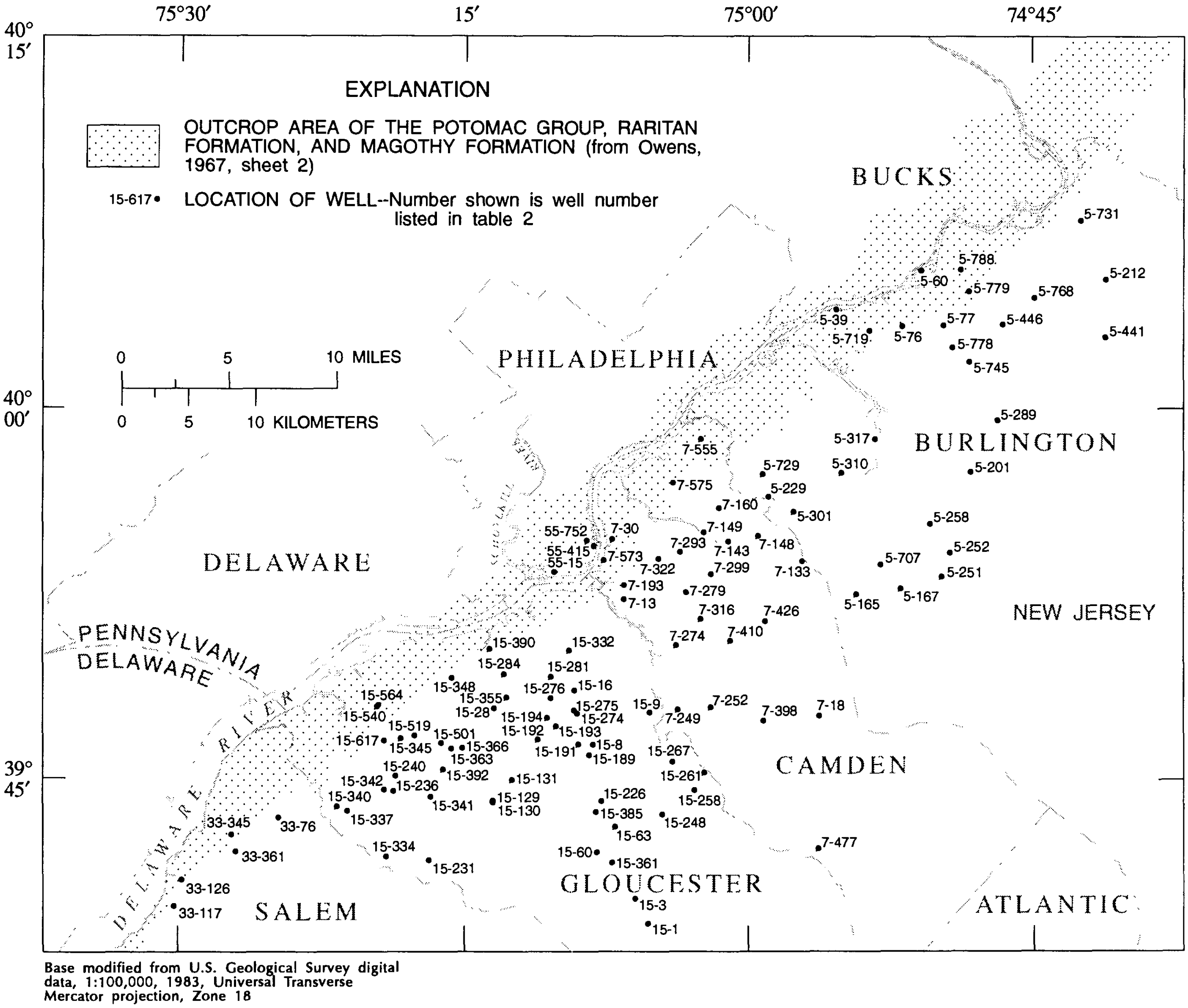
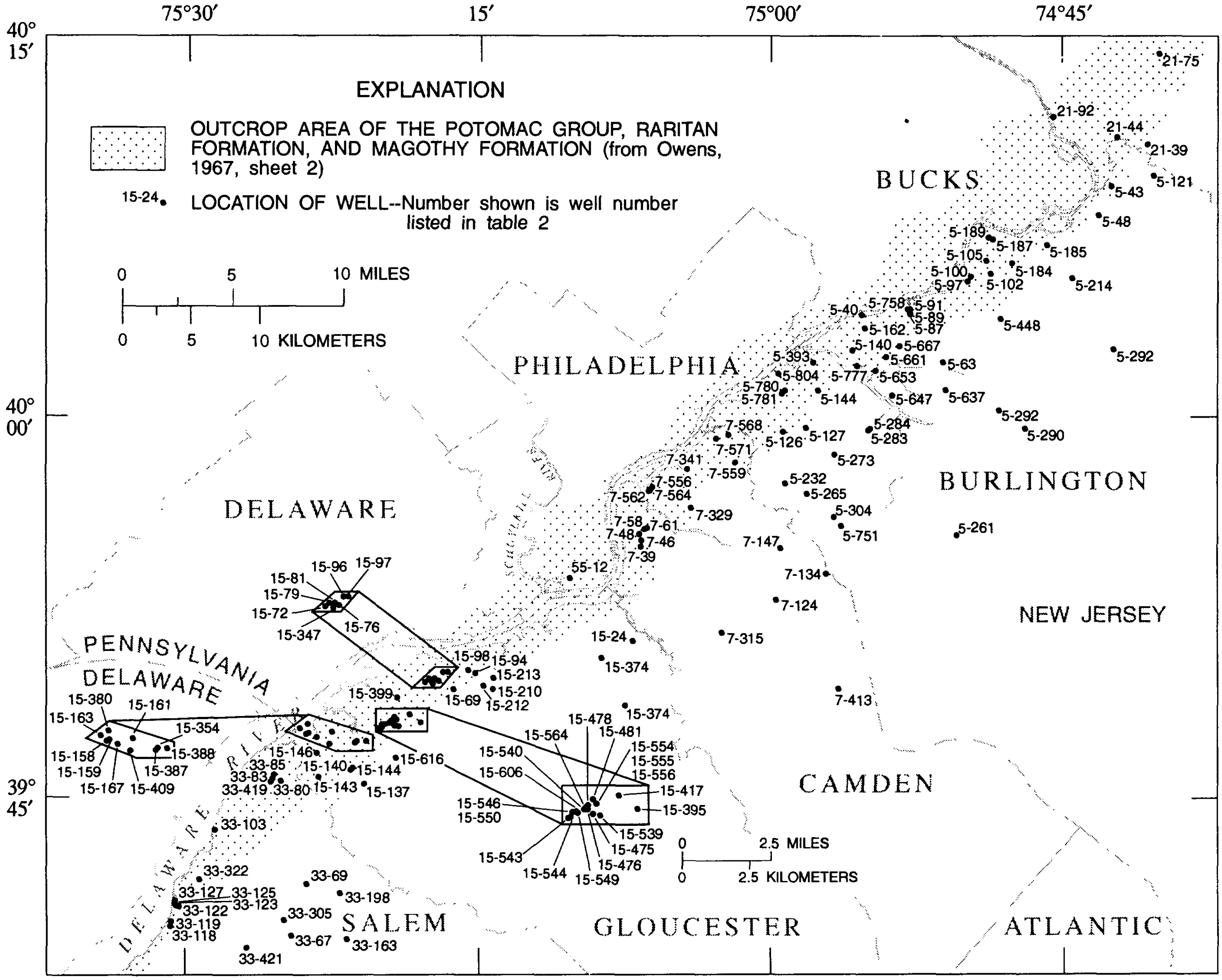


Figure 10.--Location of wells for which water-quality data are available, upper aquifer, Potomac-Raritan-Magothy aquifer system.



Base modified from U.S. Geological Survey digital data, 1:100,000, 1983, Universal Transverse Mercator projection, Zone 18

Figure 11.--Location of wells for which water-quality data are available, middle aquifer, Potomac-Raritan-Magothy aquifer system.

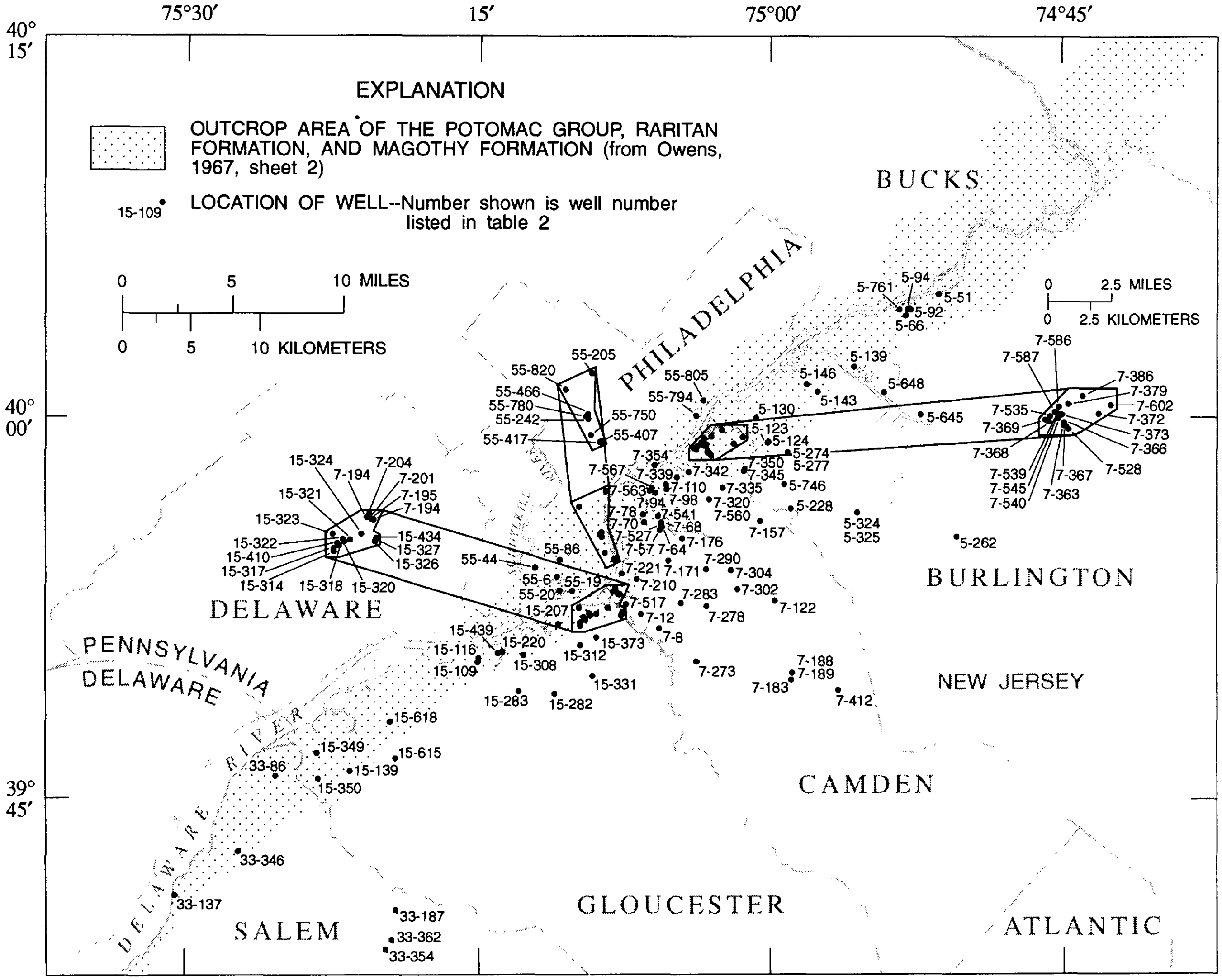


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Figure 12.--Location of wells for which water-quality data are available, lower aquifer, Potomac-Raritan-Magothy aquifer system.

Table 4.-- Statistical summary of analyses of water from the Potomac-Raritan-Magothy aquifer system, 1985-86

[°C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius; µg/L, micrograms per liter; *, residue on evaporation at 180 degrees Celsius; **, sum of constituents; <, less than; concentrations in milligrams per liter of dissolved constituent except as noted]

Dissolved constituent or characteristic	Number of samples	Minimum	25th Percentile	Median	75th Percentile	Maximum
Temperature (°C)	117	13.00	14.50	15.50	16.50	22.00
Specific conductance, field (µS/cm)	107	84.00	178.00	252.00	520.00	1,210.00
Specific conductance, lab (µS/cm)	116	58.00	184.25	259.00	508.25	1,080.00
pH, field (units)	117	4.20	6.00	6.70	7.65	9.30
pH, lab (units)	116	3.90	5.82	6.60	7.40	9.00
Alkalinity, field (as $CaCO_3$)	111	0	37.00	82.00	137.00	456.00
Alkalinity, lab (as $CaCO_3$)	116	<1.00	17.00	68.50	124.00	438.00
Dissolved oxygen	113	0	.20	.3	.55	8.70
Hardness ($CaCO_3$)	116	11.00	31.00	62.00	91.50	448.00
Hardness, noncarbonate (as $CaCO_3$)	67	0	1.00	24.00	44.00	240.00
Sodium	116	2.50	7.22	16.50	48.75	230.00
Potassium	116	1.30	3.10	5.15	6.60	32.00
Calcium	116	2.80	7.40	16.00	25.00	96.00
Magnesium	116	.44	2.70	4.60	9.17	65.00
Silica	116	1.50	7.92	8.75	10.00	24.00
Chloride	116	1.30	6.42	16.50	41.75	170.00
Sulfate	116	<.20	9.70	23.00	42.00	210.00
Fluoride	116	<.10	<.10	.20	.47	2.10
Iron, total (µg/l)	112	<10.00	110.00	445.00	250.00	54,000.00
Iron, dissolved (µg/L)	115	<3.00	30.00	300.00	100.00	58,000.00
Manganese, total (µg/L)	111	<10.00	20.00	70.00	480.00	7,500.00
Manganese, dissolved (µg/L)	115	<1.00	22.00	57.00	430.00	7,400.00
Dissolved organic carbon	104	.40	<1.00	1.50	2.62	15.00
Phenol (µg/L)	108	<1.00	<1.00	3.00	5.00	68.00
Dissolved solids *	115	55.00	113.00	148.00	274.00	634.00
Dissolved solids **	113	32.00	110.00	150.00	295.00	3,600.00
Aluminum (µg/L)	116	<10.00	<10.00	20.00	30.00	750.00
Arsenic (µg/L)	115	<1.00	<1.00	<1.00	<1.00	49.00
Barium (µg/L)	116	16.00	40.00	64.00	88.25	510.00
Beryllium (µg/L)	116	<.50	<.50	<.50	.80	4.00
Cadmium (µg/L)	116	<1.00	<1.00	<1.00	<1.00	6.00
Chromium (µg/L)	116	<10.00	<10.00	<10.00	<10.00	960.00
Chromium, hexavalent (µg/L)	116	<1.00	<1.00	<1.00	<1.00	980.00
Cobalt (µg/L)	116	<3.00	<3.00	<3.00	6.00	130.00
Copper (µg/L)	116	<10.00	<10.00	<10.00	<10.00	110.00
Lead (µg/L)	116	<10.00	<10.00	<10.00	<10.00	30.00
Lithium (µg/L)	116	<4.00	<4.00	7.00	11.00	47.00
Molybdenum (µg/L)	115	<10.00	<10.00	<10.00	<10.00	<10.00
Strontium (µg/L)	116	36.00	130.00	330.00	725.00	4,200.00
Vanadium (µg/L)	116	<6.00	<6.00	<6.00	<6.00	8.00
Zinc (µg/L)	116	<3.00	5.00	13.50	33.25	240.00
Nitrate and nitrite nitrogen (as N)	116	<.10	<.10	<.10	.96	23.00
Nitrite nitrogen as N	116	<.01	<.01	<.01	<.01	1.20
Nitrogen,dissolved as N	44	.30	1.57	3.75	6.20	43.00
Ammonia nitrogen (as N)	116	<.01	.08	.21	.61	25.00
Ammonia and organic nitrogen (as N)	115	<.10	.30	.40	1.00	28.00
Ammonia nitrogen (as NH_4)	109	.01	.13	.28	.88	32.00
Orthophosphate phosphorus (as P)	114	<.01	<.01	.02	.07	.33

Water-quality data presented in this report were subject to standard laboratory quality-assurance procedures (Friedman and Erdmann, 1982; D.B. Peart, U.S. Geological Survey, written commun., 1985). Data collected before 1985 were subjected to similar quality-assurance techniques, as described in Fusillo and others (1984). All data were examined by means of quality-assurance checks, as described in Friedman and Erdmann (1982), Hem (1985), and Fishman and Friedman (1989).

Ten replicate samples were collected as part of the quality-assurance program. The data for these samples are presented along with the other water-quality data in tables 5 to 8. In addition, three USGS Standard Reference Water Samples (SRWS) were sent to the Central Laboratory as water-quality samples from this project. These SRWS consisted of two trace-elements standards and one standard for major constituents. On the basis of results of duplicate samples and SRWS, the analyses of water-quality samples collected during 1985-86 were considered acceptable.

Regional Variations

The chemical quality of the water in the Potomac-Raritan-Magothy aquifer system is affected by the chemical composition of precipitation, the mineral composition of the aquifers and confining units, the past and present ground-water-flow patterns, the residence time in the aquifer, and human activities.

The earliest recorded chemical analysis of water from the Potomac-Raritan-Magothy aquifer system was done in 1899 on water from the "Camden Supply" (Myers, 1899, p. 148), presumably from the Morris well field of the Camden City Water Department. This analysis showed that the water contained 32 mg/L of total solids, 5.7 mg/L of chloride, and 0.02 mg/L of nitrate nitrogen. Thompson (1932) reported results of a chemical analysis of water from the Morris well field in 1924, in which concentrations of 77 mg/L of total dissolved solids, 7.0 mg/L of chloride, and 2.7 mg/L of nitrate nitrogen were determined. The increase in concentrations of all three constituents in the water from the Morris well field probably resulted from induced infiltration of water from the adjacent Delaware River. Few additional data are available on the predevelopment water quality of the aquifer system; however, the current (1988) water quality in the confined, pumped parts of the aquifer system is assumed to be similar to predevelopment water quality in many areas because (1) the sources of water for the wells tapping the confined part of the aquifer generally are either the deep part of the system or the regional recharge areas, (2) newly recharged water from the Delaware River generally is intercepted by well fields before it can migrate downdip, and (or) (3) newly recharged water from the Delaware River has not had time to reach downdip wells.

Differences in the major-ion chemistry between young ground water near predevelopment recharge areas in Mercer and Middlesex Counties and old water farther from these predevelopment recharge areas are illustrated by ground-water data for wells along section B'-B (fig. 1). The relative ages of the water from these wells were calculated by carbon-14 dating techniques (Winograd and Farlekas, 1974). Natural conditions were approximated by selection of wells minimally affected by present-day pumping.

Stiff diagrams (Hem, 1985) of the ionic composition of water from these wells illustrate changes in water chemistry along section B'-B (fig. 13). The most recent data are diagrammed for each well. Concentrations of dissolved solids generally increase with time as water flows through the system. Water near the regional recharge areas in Mercer and Middlesex Counties is a sodium-calcium-sulfate water that contains low concentrations of dissolved solids, as represented by water from well 21-25 (fig. 13). As the water flows through the aquifer, the dissolved-solids concentration increases. In addition, calcium carbonate dissolves from shells and calcareous deposits (such as clay marls), and the water becomes a calcium bicarbonate type, as represented by water from well 5-384 (fig. 13). Regional trends discussed by Winograd and Farlekas (1974) indicate that pH also increases with the relative age of the water as a result of the dissolution of calcium carbonate in the aquifer.

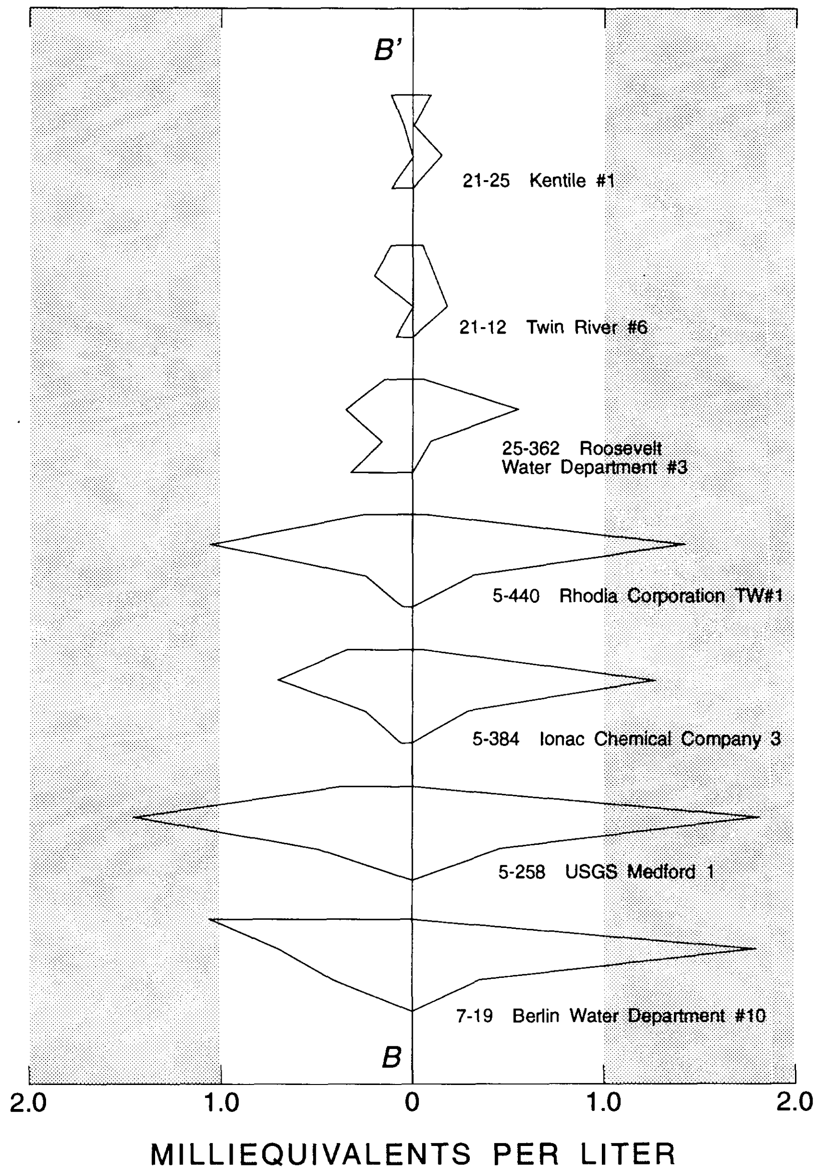
The subcrop of the Potomac-Raritan-Magothy aquifer system south of Trenton, N.J., acted as a regional discharge area under prepumping conditions. With development in the upper and middle aquifers, shallow, local ground-water-flow systems were superimposed on the regional system. These local systems have a greater effect on water quality in the subcrop area than in the confined-aquifer areas. Water samples from wells in this area contained low concentrations of dissolved solids (<150 mg/L) as a result of local recharge and short residence times in the aquifer, compared to the long residence times that are characteristic of a regional flow path.

Hydrochemical Facies

Hydrochemical facies provide an indication of the chemical character of surface water and ground water (Back, 1966, p. A11); they commonly are used to characterize regional ground-water quality, especially in relation to ground-water-flow patterns. Cation facies are defined as the percentage of calcium and magnesium compared to the sum of the major cations. Anion facies are defined as the percentage of chloride and sulfate compared to the sum of the major anions (Back, 1966, p. A15). Hydrochemical facies are expressed in milliequivalents per liter. Facies are affected by the ground-water-flow system, residence time of water in the aquifer, and chemical interactions between water and aquifer material. In addition, facies can be affected by the introduction of contaminants into the ground-water system and by microbial processes.

Hydrochemical facies for the upper, middle, and lower aquifers of the Potomac-Raritan-Magothy aquifer system are shown in figures 14-19. Data for hydrochemical-facies maps are from the 1980-86 sampling period and represent the most recent data from wells sampled more than once during that period. Hydrochemical-facies maps were contoured according to the definition of hydrochemical facies given in Back (1966, p. A15). Hydrochemical facies were subdivided further to include 25-percent and 75-percent cation or anion contours. Stiff diagrams were constructed from the same data set for selected wells within each facies designation.

Five zones of fairly distinct ground-water chemistry related to hydrologic regimes are defined by the hydrochemical facies in the study area. These correspond to (1) zones of recharge, (2) zones of active ground-water flow, (3) zones of discharge, (4) zones of saltwater intrusion, and (5) a zone of little flow. A transition zone is present in some areas between the zone of active ground-water flow and the zone of little flow.



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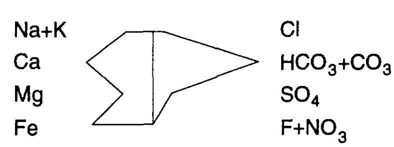


STIFF DIAGRAM--Shows distribution of major-ion concentrations, in milliequivalents per liter. Number beside diagram is well number and local identifier name

Figure 13.--Chemical evolution of ground water along section B'-B, (Location of section shown in fig. 1.)

Back (1966, p. A15) characterized the predevelopment recharge zones in Mercer and Middlesex Counties as dominated by a cation facies of calcium and magnesium (>90 percent Ca + Mg) and by an anion facies of chloride and sulfate (>90 percent Cl + SO_4). In this study, it was found that anion facies for recharge areas also can range from 50 to 90 percent Cl and SO_4. Although most of the regional recharge areas are outside the study area, some evidence of recharge water from Mercer and Middlesex Counties exists, as illustrated in the cation-facies maps in figures 14-16. Water from wells near Georgetown, Burlington County, in the upper aquifer (fig. 14)--where cation facies are greater than 90 percent--could indicate the recharge zone. In the middle aquifer, calcium and magnesium also dominate in the same area, although they do not exceed 90 percent (fig. 15).

The zone of active ground-water flow underlies a large area that includes most of northwestern Burlington County and the northwestern half of Camden County. In the zone of active ground-water flow, cation facies are characterized mainly by the calcium and sodium facies (50-90 percent Ca + Mg) in all three aquifers. Anions are characterized by a bicarbonate, chloride, and sulfate facies (10-50 percent Cl + SO_4). This zone becomes slightly smaller in area from the upper to the lower aquifer.

Ground water in regional discharge zones has been characterized by Back (1966, p. A15) as consisting mainly of the bicarbonate facies (<10 percent Cl + SO_4). Before flow patterns were disturbed by development, the regional discharge area was along the Delaware River. Post-development ground-water-quality data, however, provide little evidence of hydrochemical facies typical of discharge zones in these areas. The lack of discharge-zone facies is mainly a result of induced recharge from the Delaware River into the aquifers. The areas thought to be former discharge zones currently (1988) are characterized by anion facies typical of a recharge area: chloride, sulfate, and bicarbonate (50-90 percent Cl + SO_4), and chloride and sulfate, (>90 percent Cl + SO), and cation facies typical of active ground-water flow, calcium and sodium, (50-90 percent Ca + Mg). Back (1966, p. A5) notes that bicarbonate might increase as a result of dissolution of calcareous material as water flows through the Tertiary sediments near the regional recharge areas.

The zone of saltwater intrusion consists of areas that have been affected by salty and brackish water in the Delaware River and its estuary. Constituent concentrations in water from wells 15-140 and 15-118 in Gloucester County, shown in figures 15 and 16, respectively, are evidence of saltwater intrusion along the estuary. The sodium and potassium facies (<10 percent Ca + Mg) is the dominant cation facies in these areas. The chloride and sulfate facies is the dominant anion facies (>90 percent Cl + SO_4). In addition to the intrusion of saltwater into the Potomac-Raritan-Magothy aquifer system, ion-exchange processes could be partially responsible for the presence of sodium facies in this zone (Back, 1966, A15).

The zone of little flow is evident far downdip on the cation-facies maps for the upper, middle, and lower aquifers (figs. 14-16); it also can be seen on the anion-facies map for the upper aquifer (fig. 17) as an area of bicarbonate-rich water (<10 percent Cl + SO_4). The dominant cation facies is sodium and potassium (<10 percent Ca + Mg). Few data are available in this

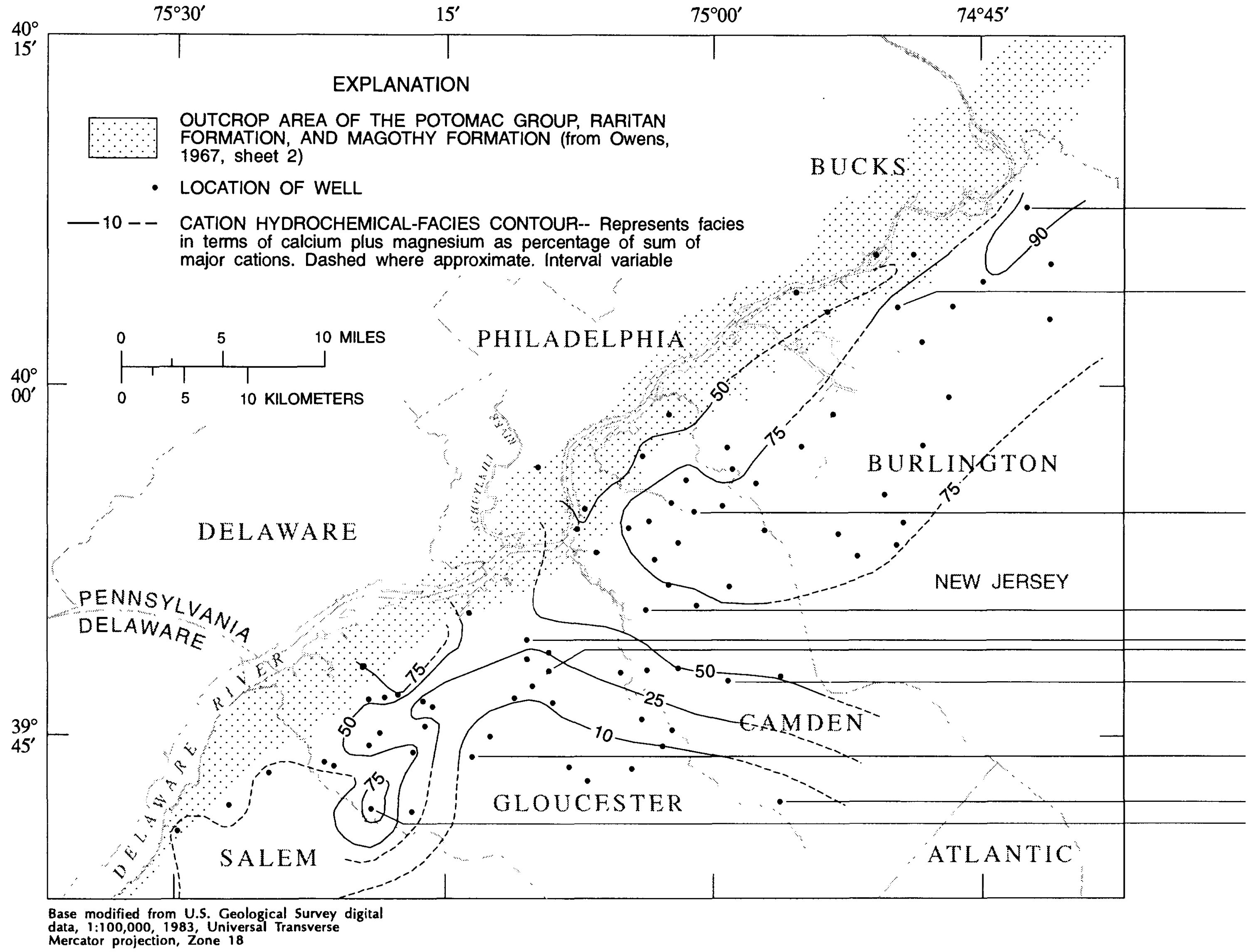
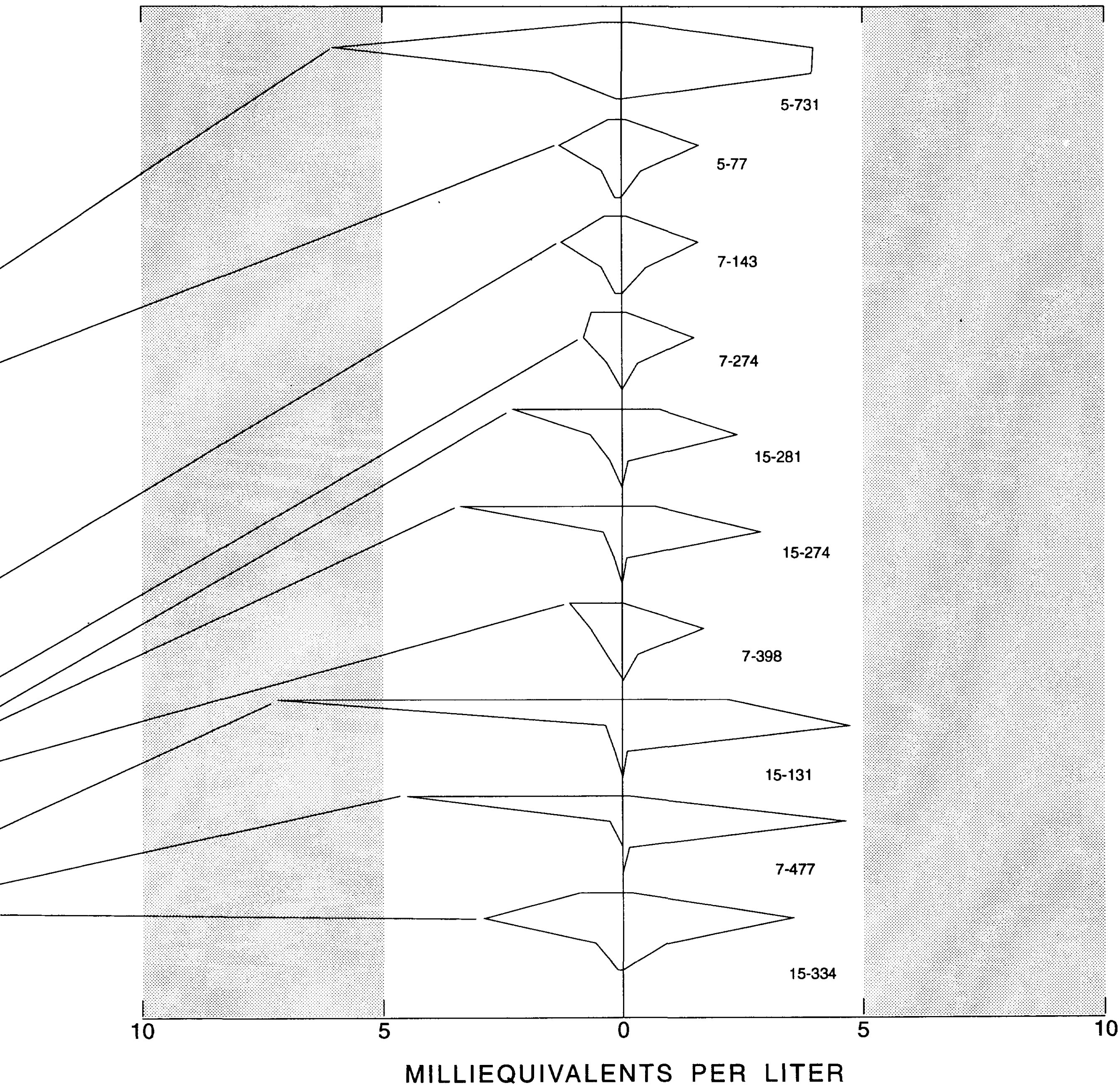


Figure 14.--Cation facies (calcium plus magnesium as percentage of sum of major cations), and associated Stiff diagrams, in water from the upper aquifer, Potomac-Raritan-Magothy aquifer system,1980-86.



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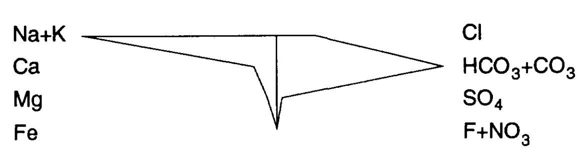


STIFF DIAGRAM--Shows distribution of major-ion concentrations, in milliequivalents per liter. Number beside diagram is well number

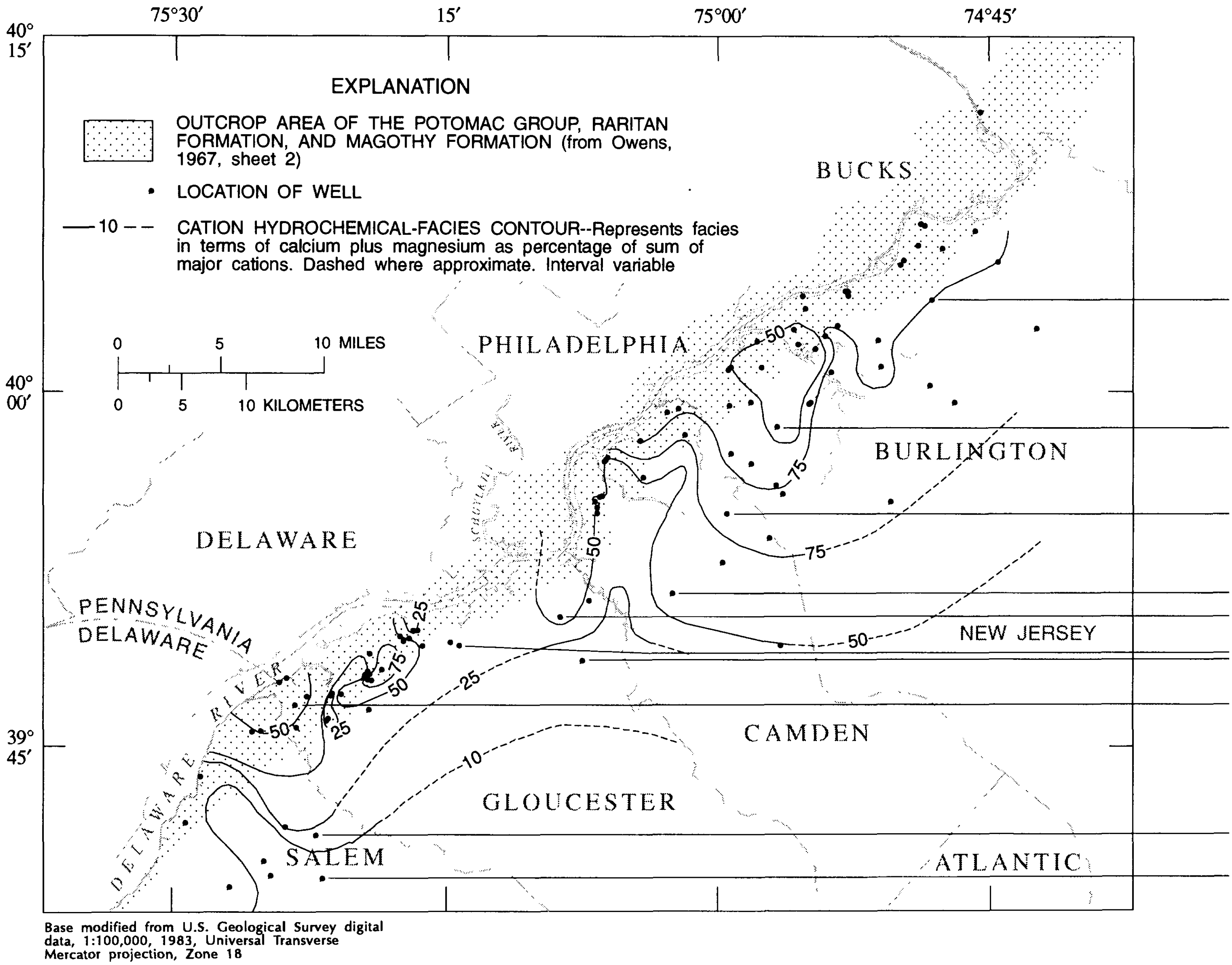
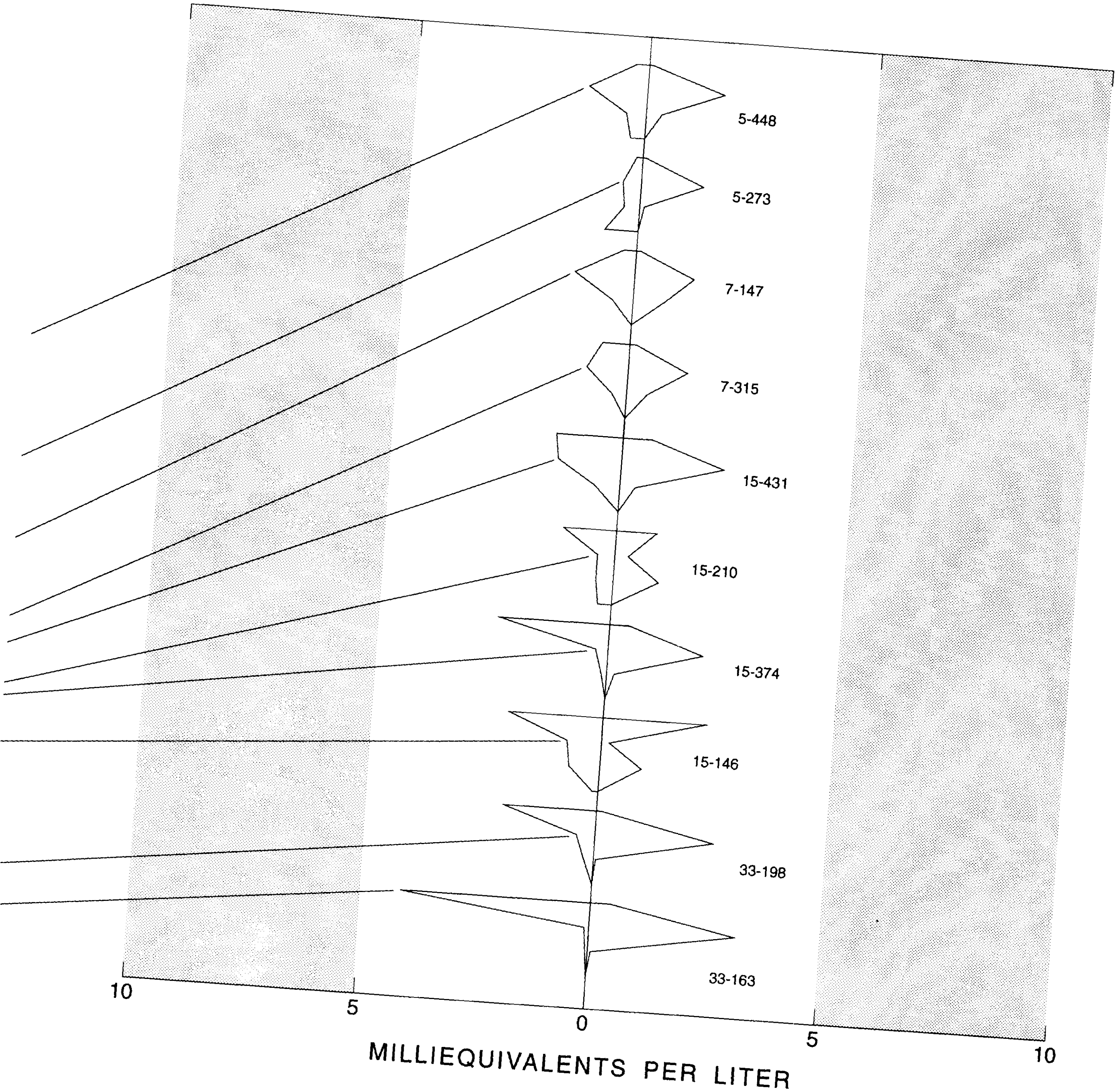
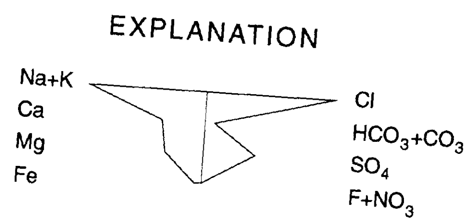


Figure 15.--Cation facies (calcium plus magnesium as percentage of sum of major cations), and associated Stiff diagrams, in water from the middle aquifer, Potomac-Raritan-Magothy aquifer system, 1980-86.





STIFF DIAGRAM--Shows distribution of major-ion concentrations, in milliequivalents per liter. Number beside diagram is well number

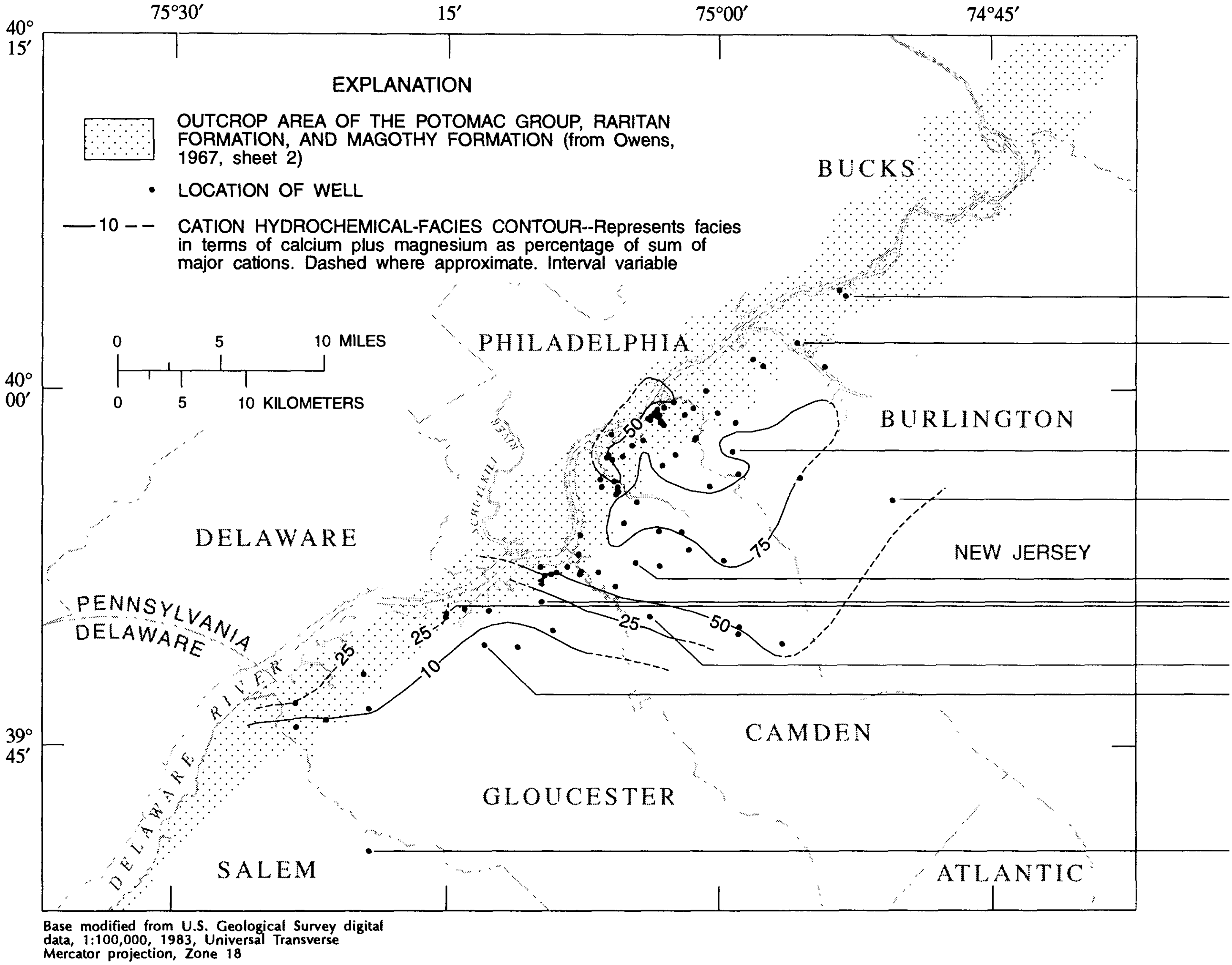
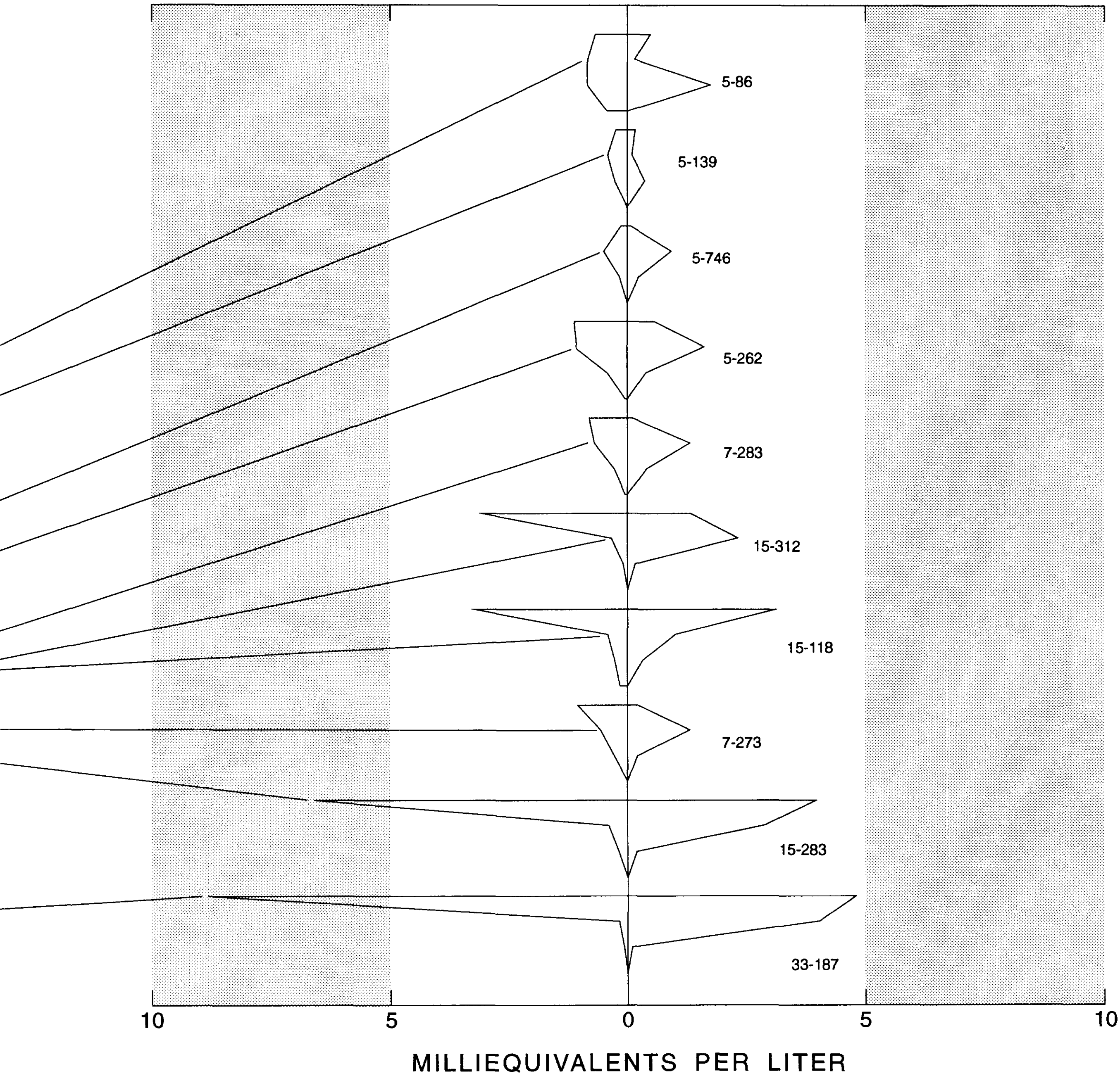


Figure 16.--Cation facies (calcium plus magnesium as percentage of sum of major cations), and associated Stiff diagrams, in water from the lower aquifer, Potomac-Raritan-Magothy aquifer system, 1980-86.



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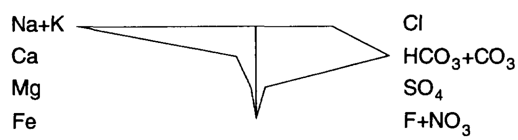
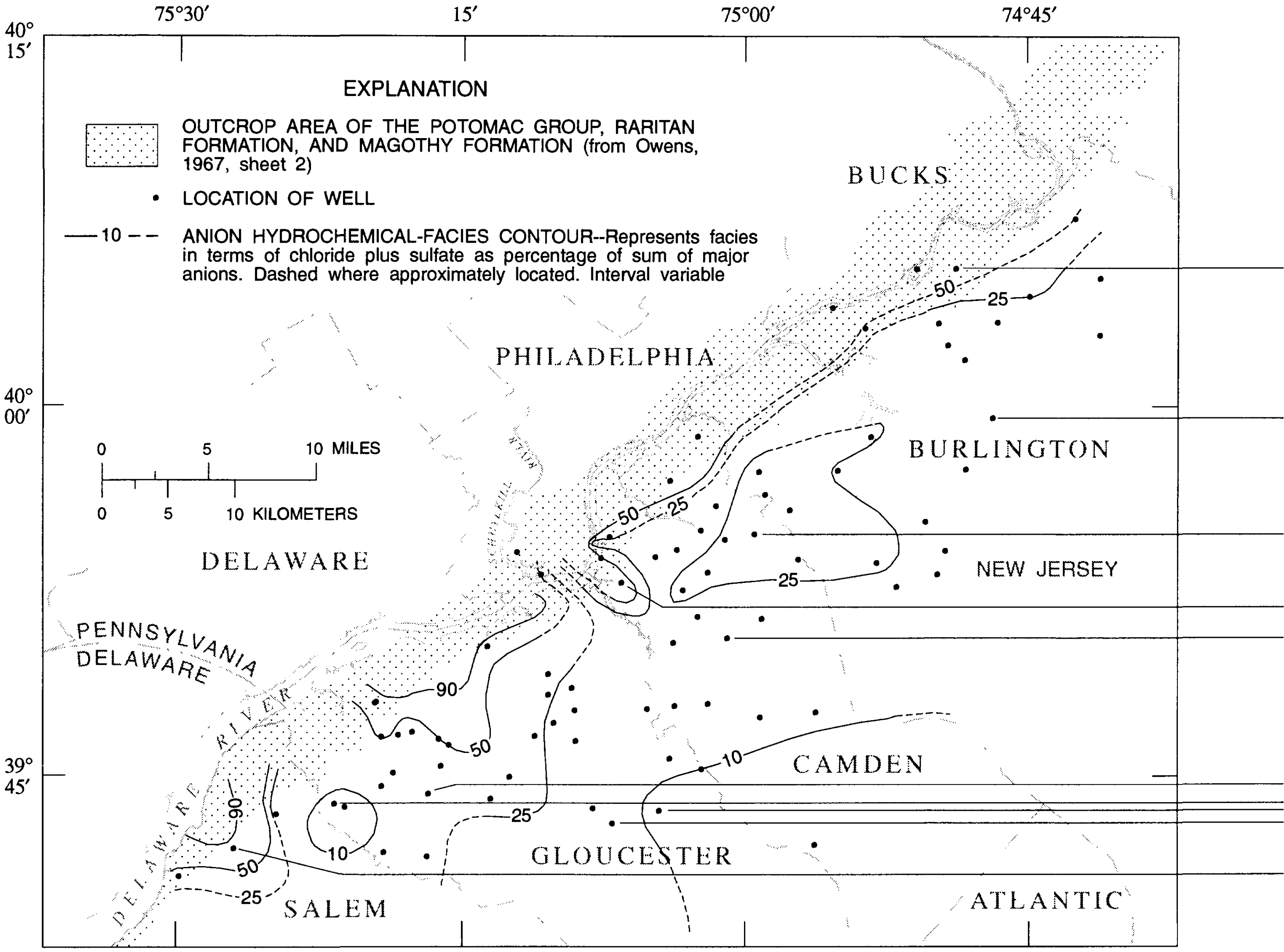
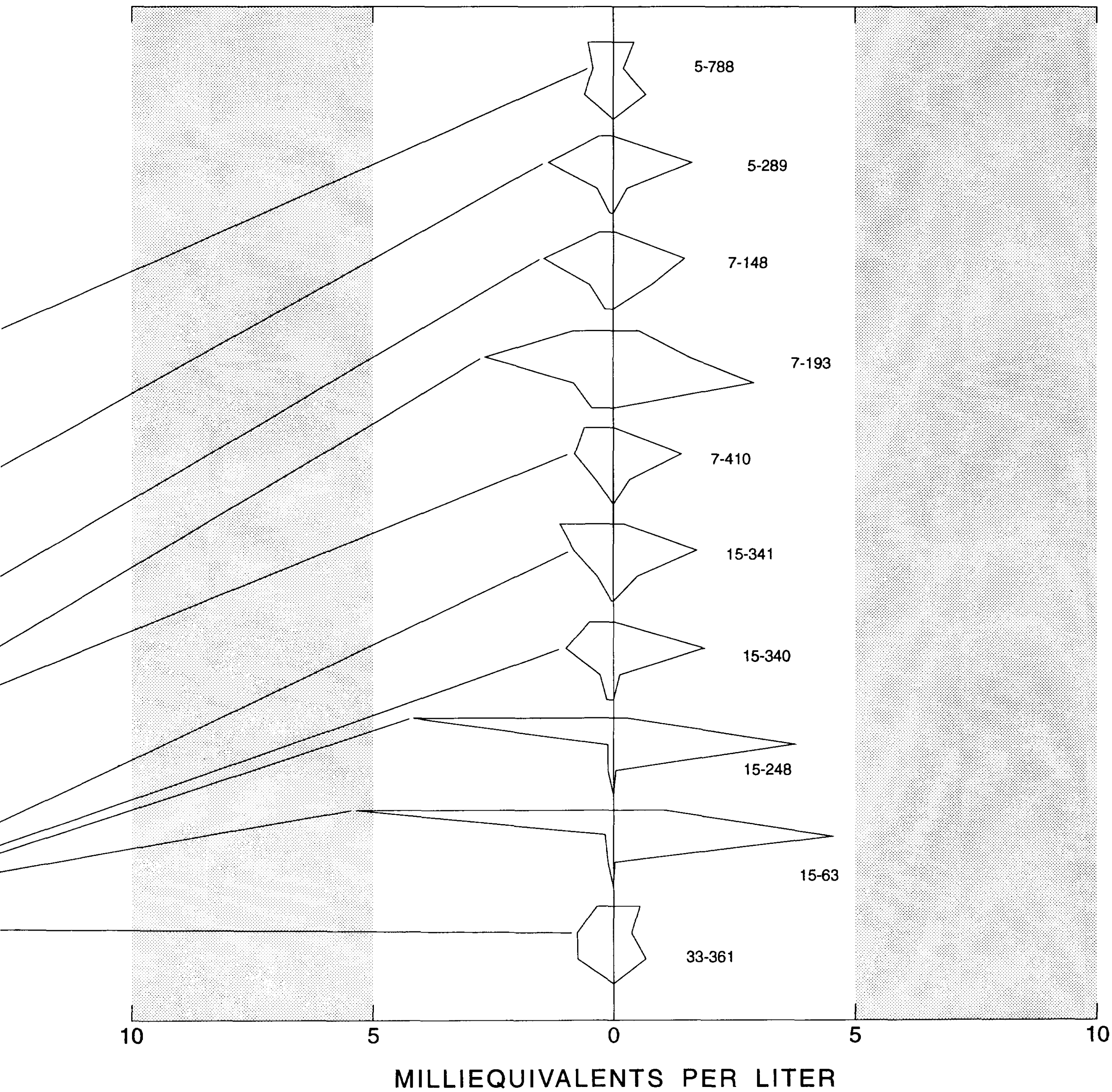


STIFF DIAGRAM--Shows distribution of major-ion concentrations, in milliequivalents per liter. Number beside diagram is well number

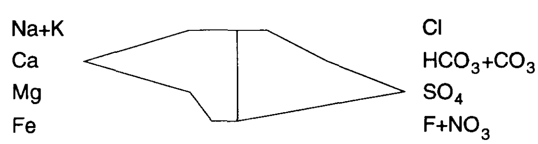


Base modified from U.S. Geological Survey digital data, 1:100,000, 1983, Universal Transverse Mercator projection, Zone 18

Figure 17.--Anion facies (chloride plus sulfate as percentage of sum of major anions), and associated Stiff diagrams, in water from the upper aquifer, Potomac-Raritan-Magothy aquifer system, 1980-86.



EXPLANATION



STIFF DIAGRAM--Shows distribution of major-ion concentrations, in milliequivalents per liter. Number beside diagram is well number

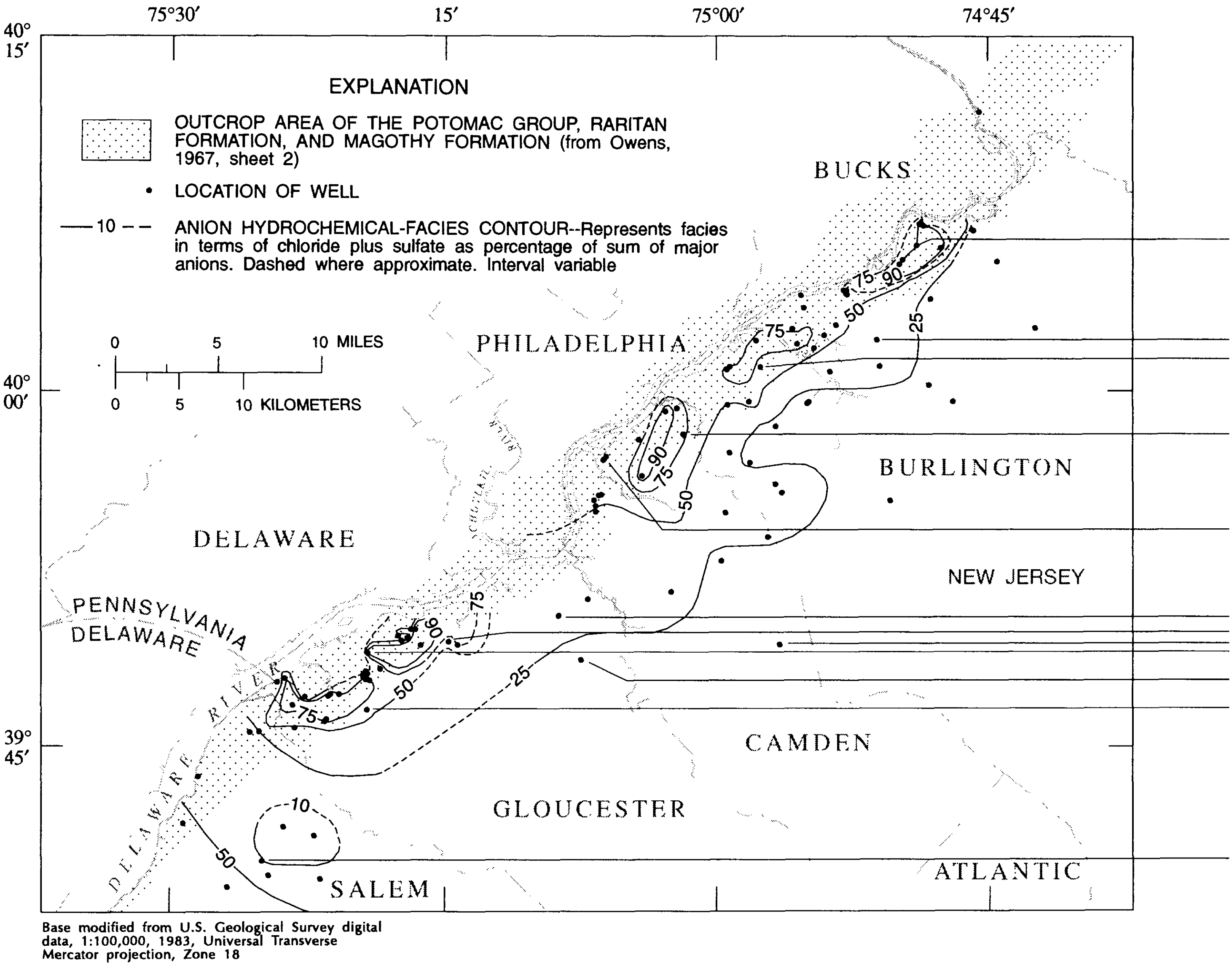
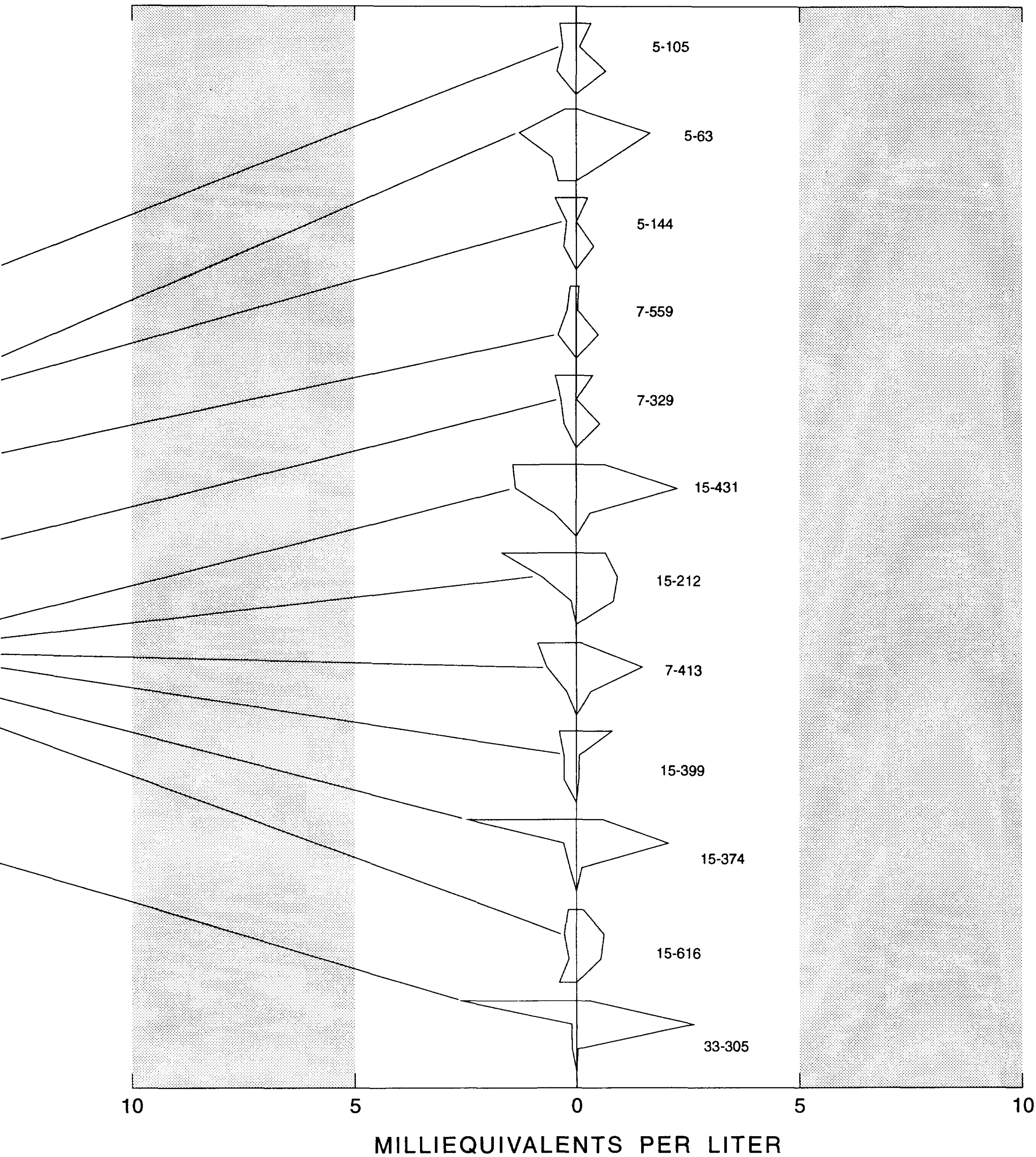
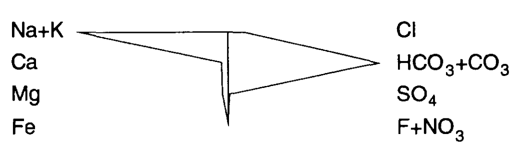


Figure 18.--Anion facies (chloride plus sulfate as percentage of sum of major anions), and associated Stiff diagrams, in water from the middle aquifer, Potomac-Raritan-Magothy aquifer system, 1980-86.



EXPLANATION



STIFF DIAGRAM--Shows distribution of major-ion concentrations, in milliequivalents per liter. Number beside diagram is well number

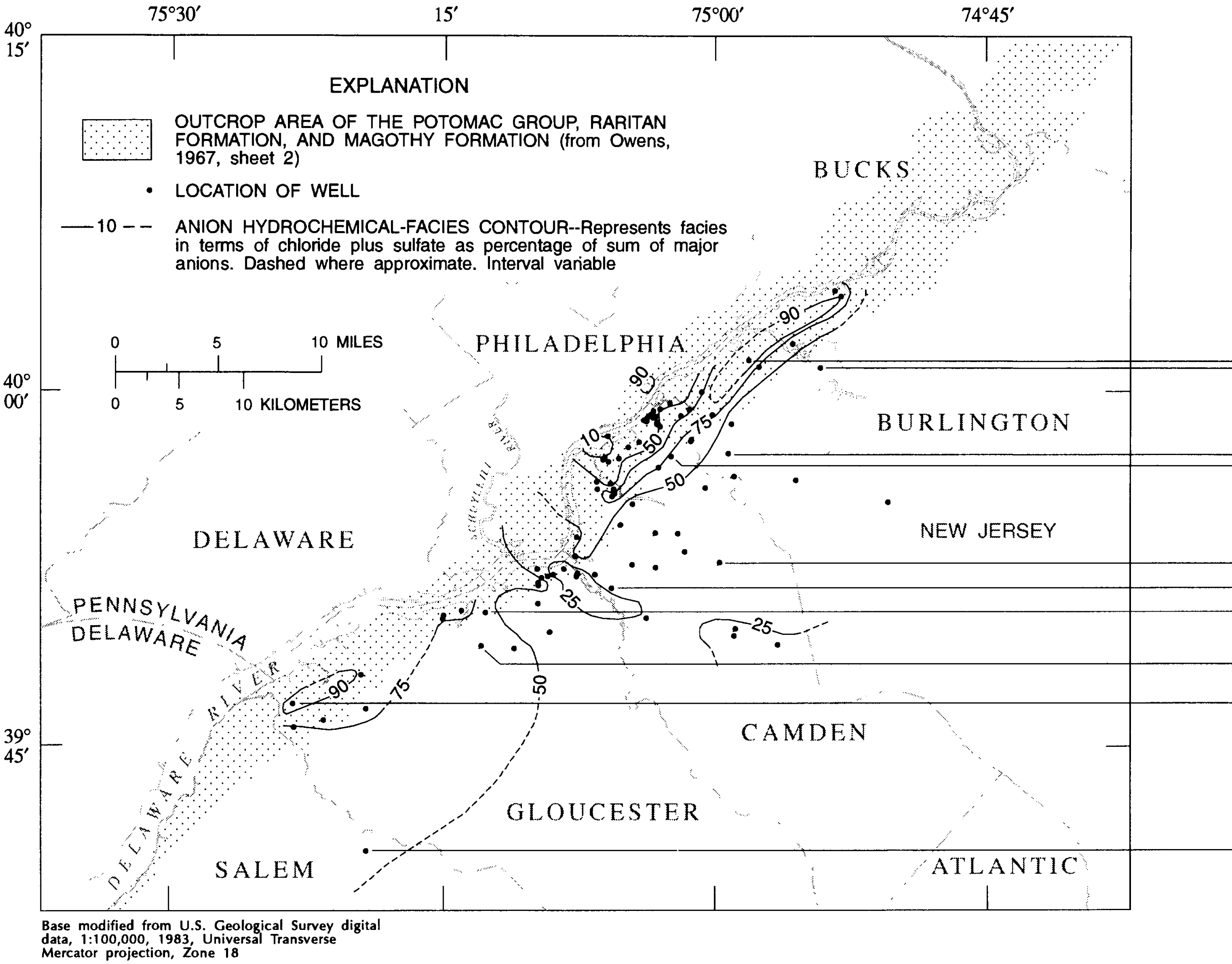
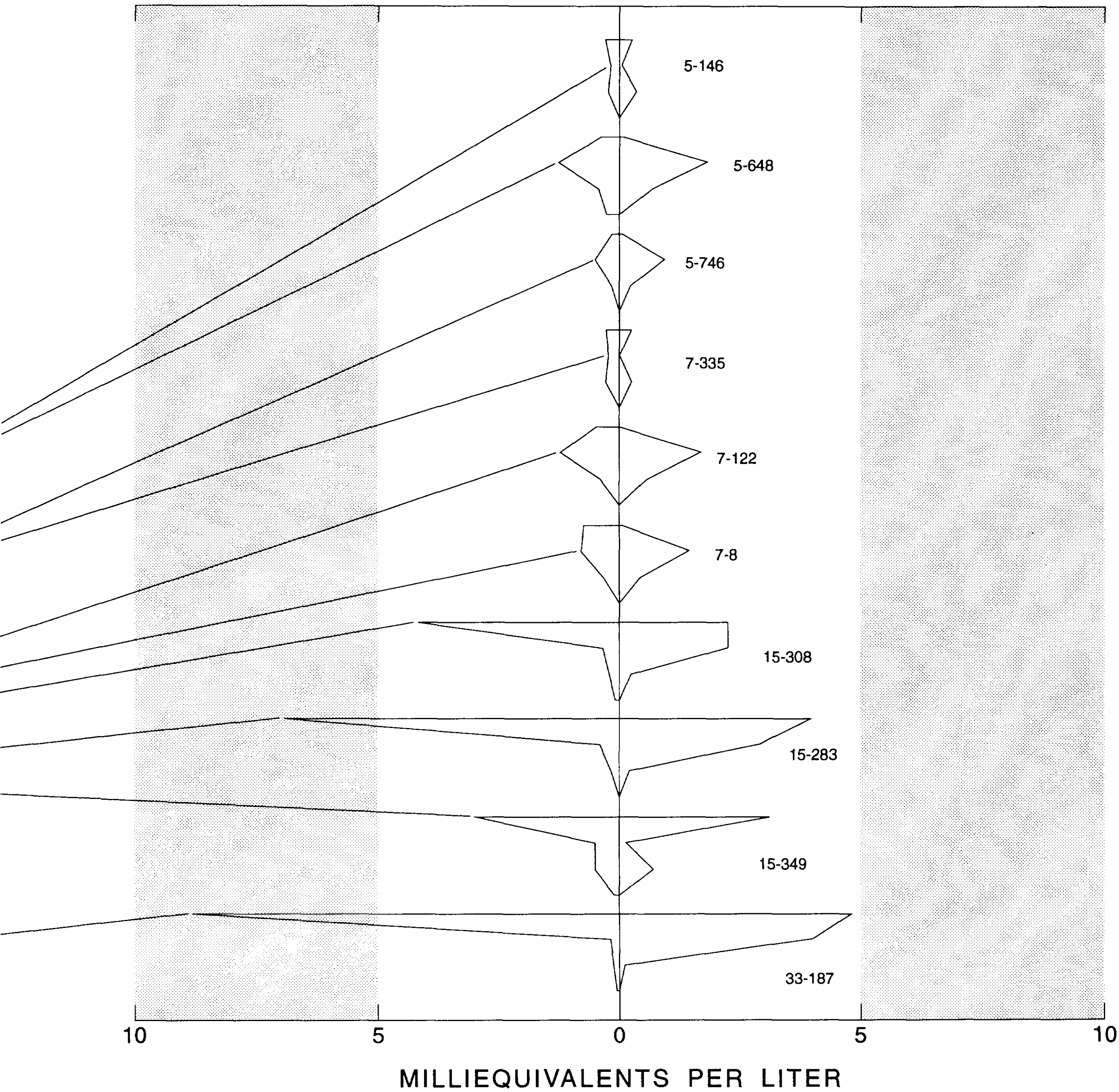
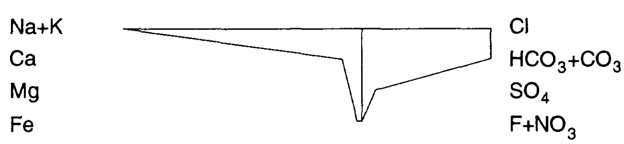


Figure 19.--Anion facies (chloride plus sulfate as percentage of sum of major anions), and associated Stiff diagrams, in water from the lower aquifer, Potomac-Raritan-Magothy aquifer system, 1980-86.



EXPLANATION



STIFF DIAGRAM--Shows distribution of major-ion concentrations, in milliequivalents per liter. Number beside diagram is well number

zone to define the quality of this downdip water because the water generally is not of suitable quality for drinking. The Stiff diagrams for water from wells 7-477 and 15-131 in Camden and Gloucester Counties, respectively (fig. 14), illustrate the major-ion chemistry of the zone of little flow.

A transition zone might exist between the zone of active ground-water flow and the zone of little flow. This zone is evident in figures 14 through 16 as a band of water enriched in the sodium and calcium cation facies (10-50 percent Ca + Mg) in the northeastern part of Gloucester County, the central part of Camden County, and the central and southwestern parts of Burlington County.

In general, cations trend from calcium- and magnesium-rich recharge waters updip to sodium- and potassium-rich waters downdip. Anions trend from sulfate- and chloride-rich recharge waters updip to bicarbonate-rich waters downdip. Water near recharge areas tends to be enriched in calcium and magnesium and to contain some sulfate. As the water moves through the active-flow system, concentrations of sodium and bicarbonate increase, whereas concentrations of sulfate, calcium, and magnesium decrease. Water at the end of a long flow path or far downdip in the aquifer tends to be sodium- and bicarbonate-rich.

Areal Distribution of Chemical Constituents

Areal distribution patterns for dissolved solids, dissolved sodium, dissolved chloride, dissolved iron, and pH in the upper, middle, and lower aquifers of the Potomac-Raritan-Magothy aquifer system are shown in figures 20 through 34, respectively. Data illustrated were collected from 1980 through 1986 and represent the most recent data from wells sampled more than once during that period. Statistical summaries are included in the discussion of each constituent. These statistics might be spatially autocorrelated because well locations are biased toward cities and public-supply wells. In addition, because the data are not normally distributed, the median probably is a better representation of the central tendency than is the mean.

Dissolved Solids

The concentration of dissolved solids is used widely as a general indicator of the amount of soluble material, including inorganic salts, organic material, and other residue in water (Hem, 1985, p. 157). Concentrations of dissolved solids in ground water are affected by interactions with aquifer material, by chemical and biological processes, by the length of time the water is in the flow system, or by contamination from human activities. Commonly, the longer the water is in contact with the aquifer matrix and confining units, the higher the dissolved-solids concentration is. In general, elevated concentrations of dissolved solids resulting from local ground-water contamination are considerably different from regional background concentrations and are relatively easy to identify. The USEPA Secondary Maximum Contaminant Level (SMCL) for dissolved solids in drinking water is 500 mg/L (U.S. Environmental Protection Agency, 1986). The distribution of dissolved solids in each aquifer is shown in figures 20-22.

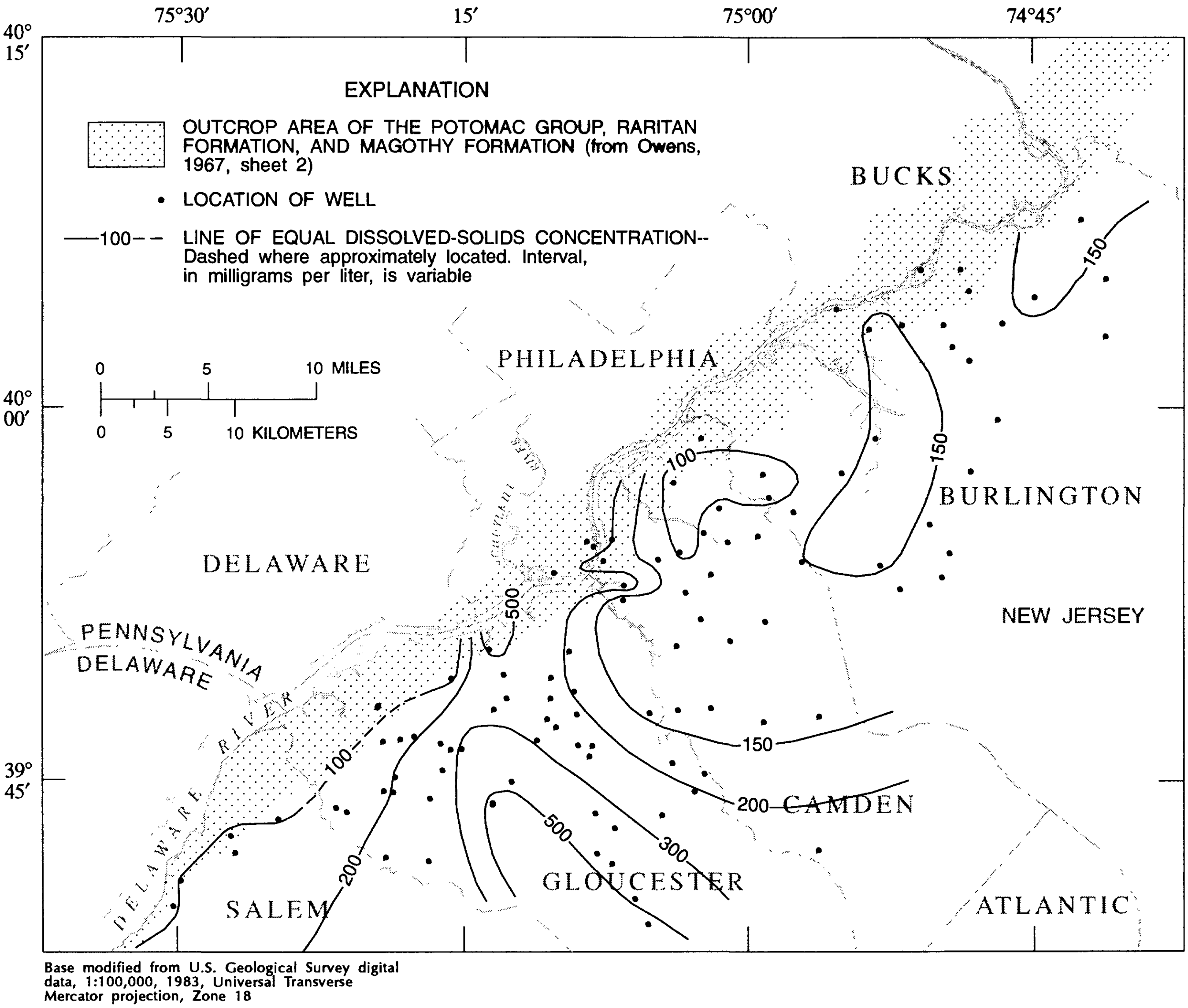
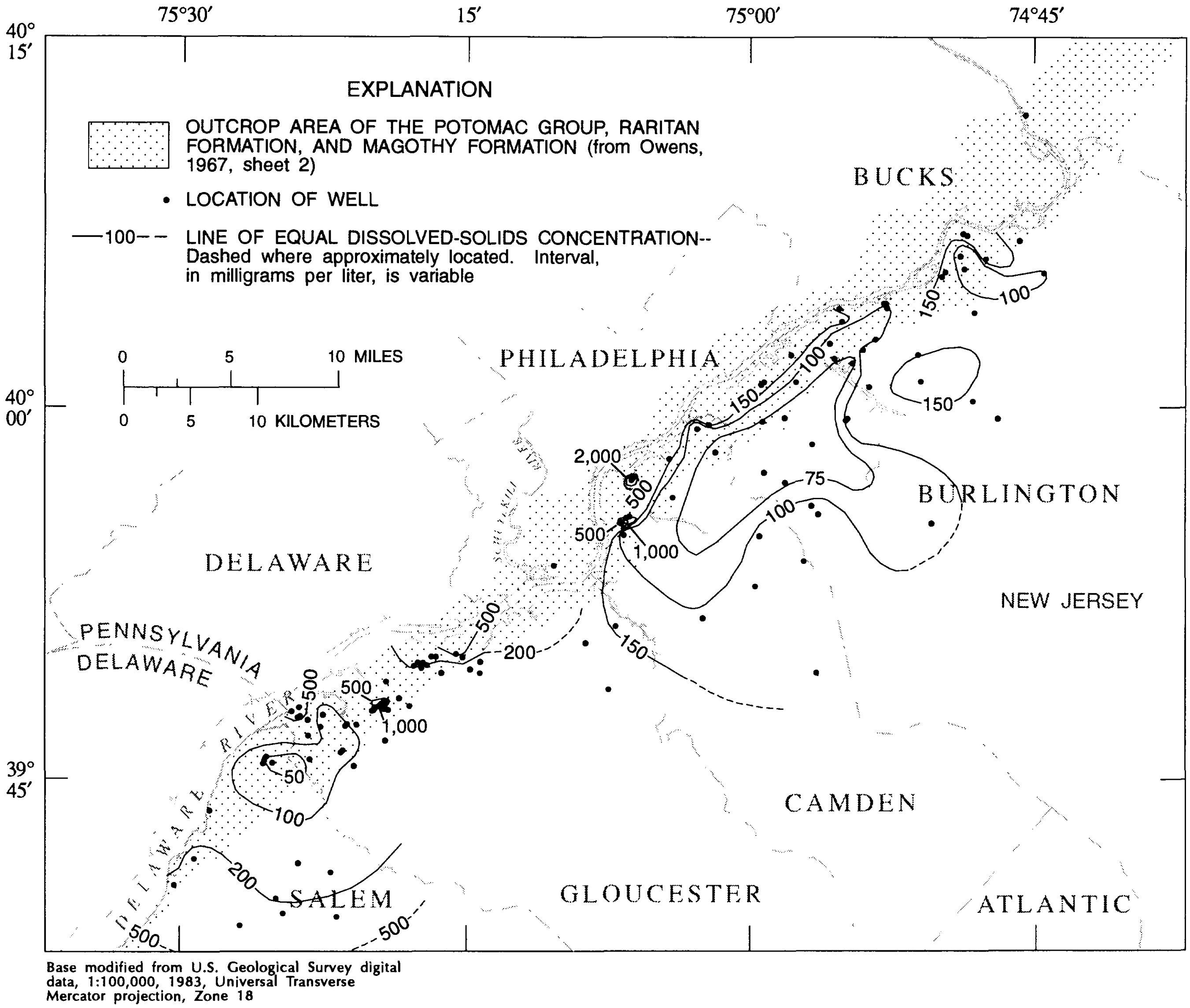


Figure 20.--Generalized distribution of dissolved solids in water from the upper aquifer, Potomac-Raritan-Magothy aquifer system, 1980-86.



Base modified from U.S. Geological Survey digital data, 1:100,000, 1983, Universal Transverse Mercator projection, Zone 18

Figure 21.--Generalized distribution of dissolved solids in water from the middle aquifer, Potomac-Raritan-Magothy aquifer system, 1980-86.

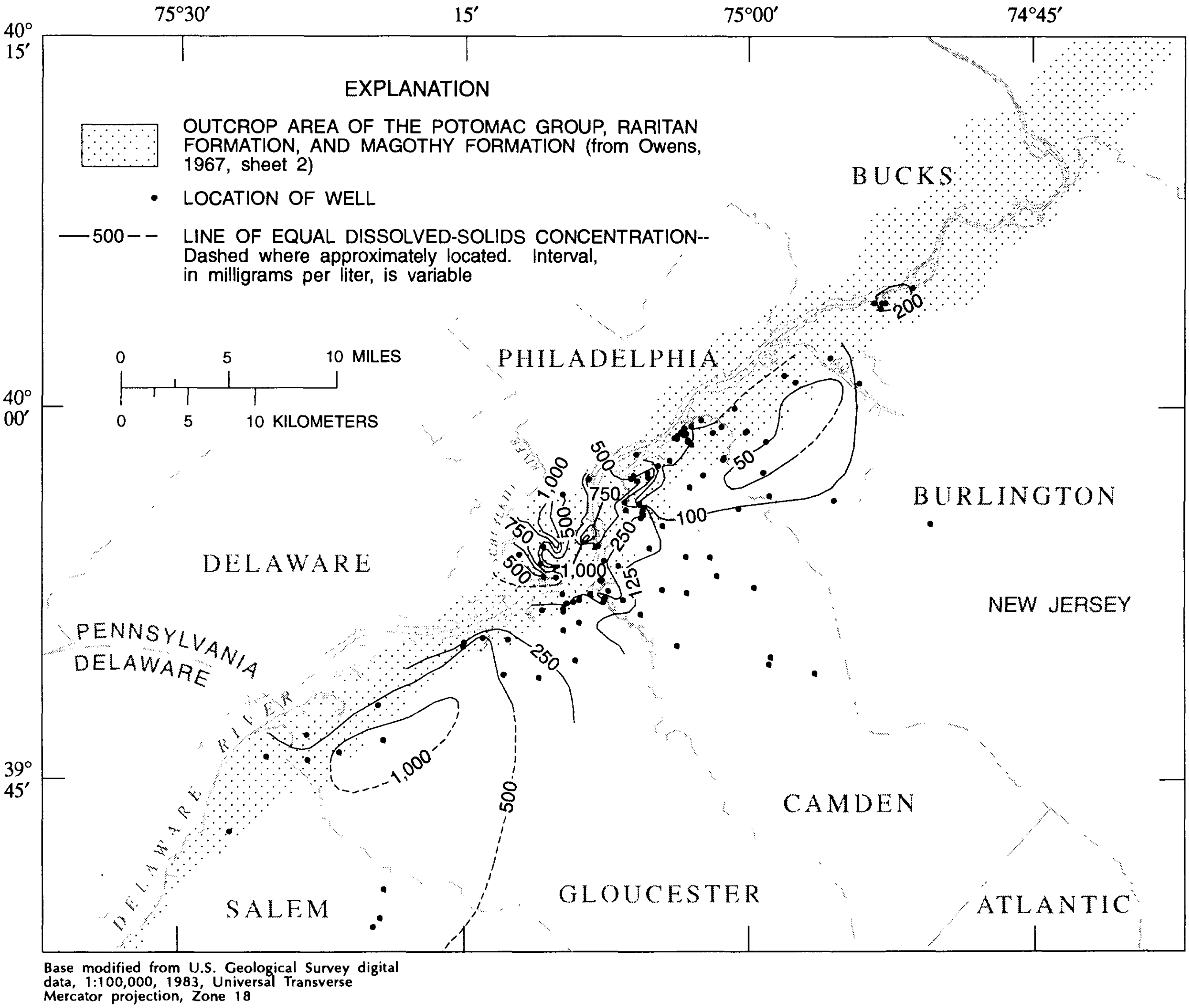
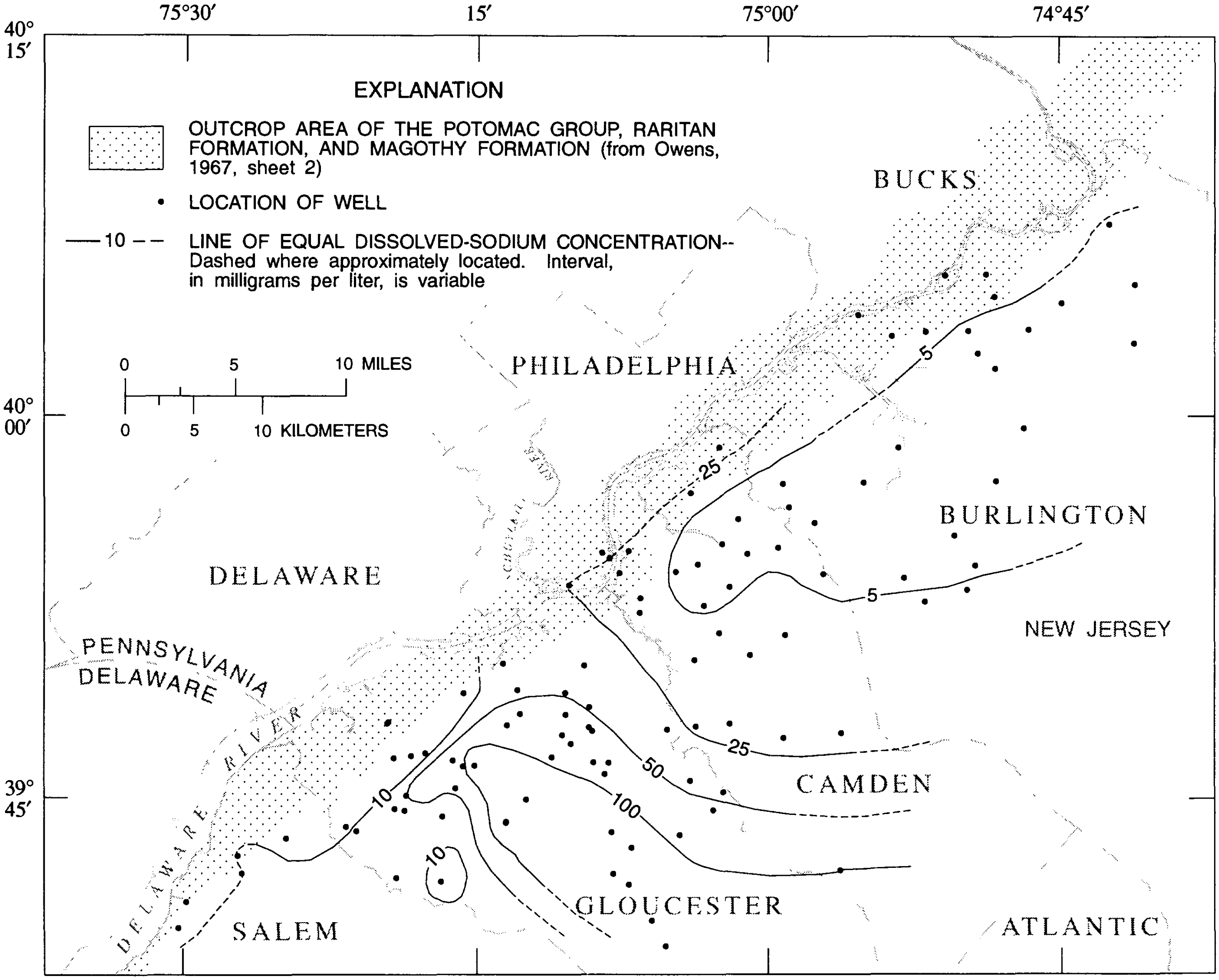


Figure 22.--Generalized distribution of dissolved solids in water from the lower aquifer, Potomac-Raritan-Magothy aquifer system, 1980-86.



Base modified from U.S. Geological Survey digital data, 1:100,000, 1983, Universal Transverse Mercator projection, Zone 18

Figure 23.--Generalized distribution of dissolved sodium in water from the upper aquifer, Potomac-Raritan-Magothy aquifer system, 1980-86.

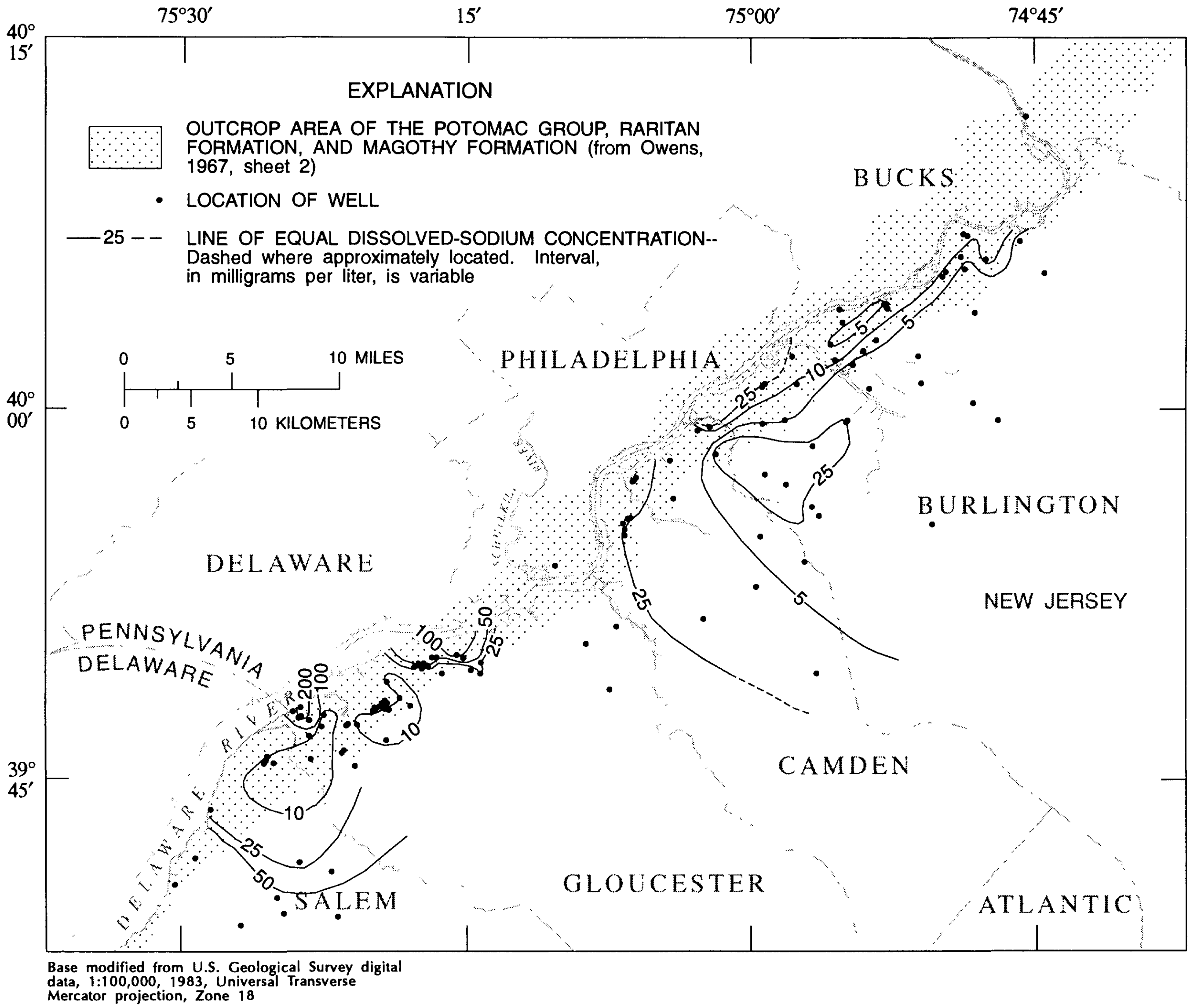


Figure 24.--Generalized distribution of dissolved sodium in water from the middle aquifer, Potomac-Raritan-Magothy aquifer system, 1980-86.

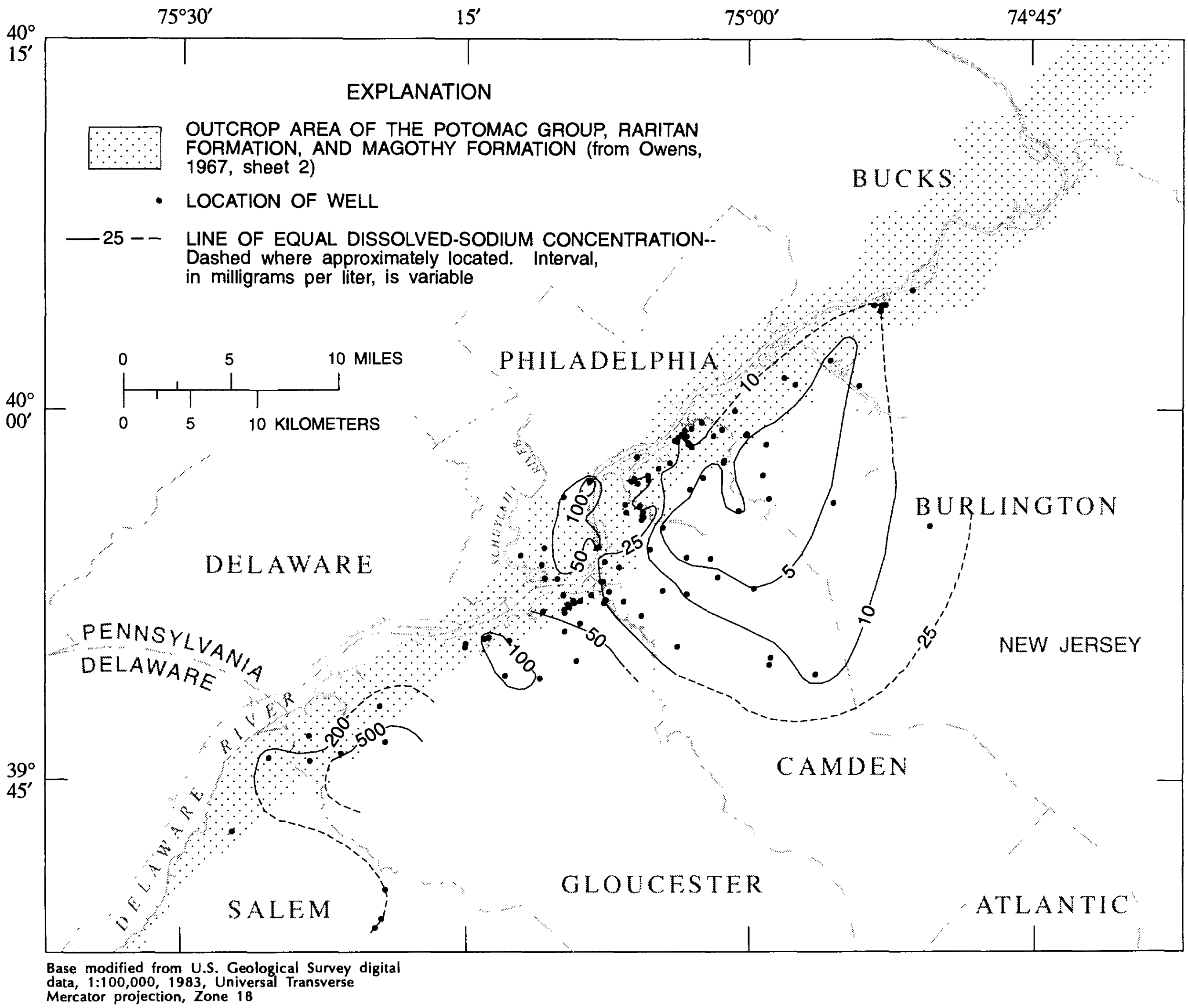


Figure 25.--Generalized distribution of dissolved sodium in water from the lower aquifer, Potomac-Raritan-Magothy aquifer system, 1980-86.

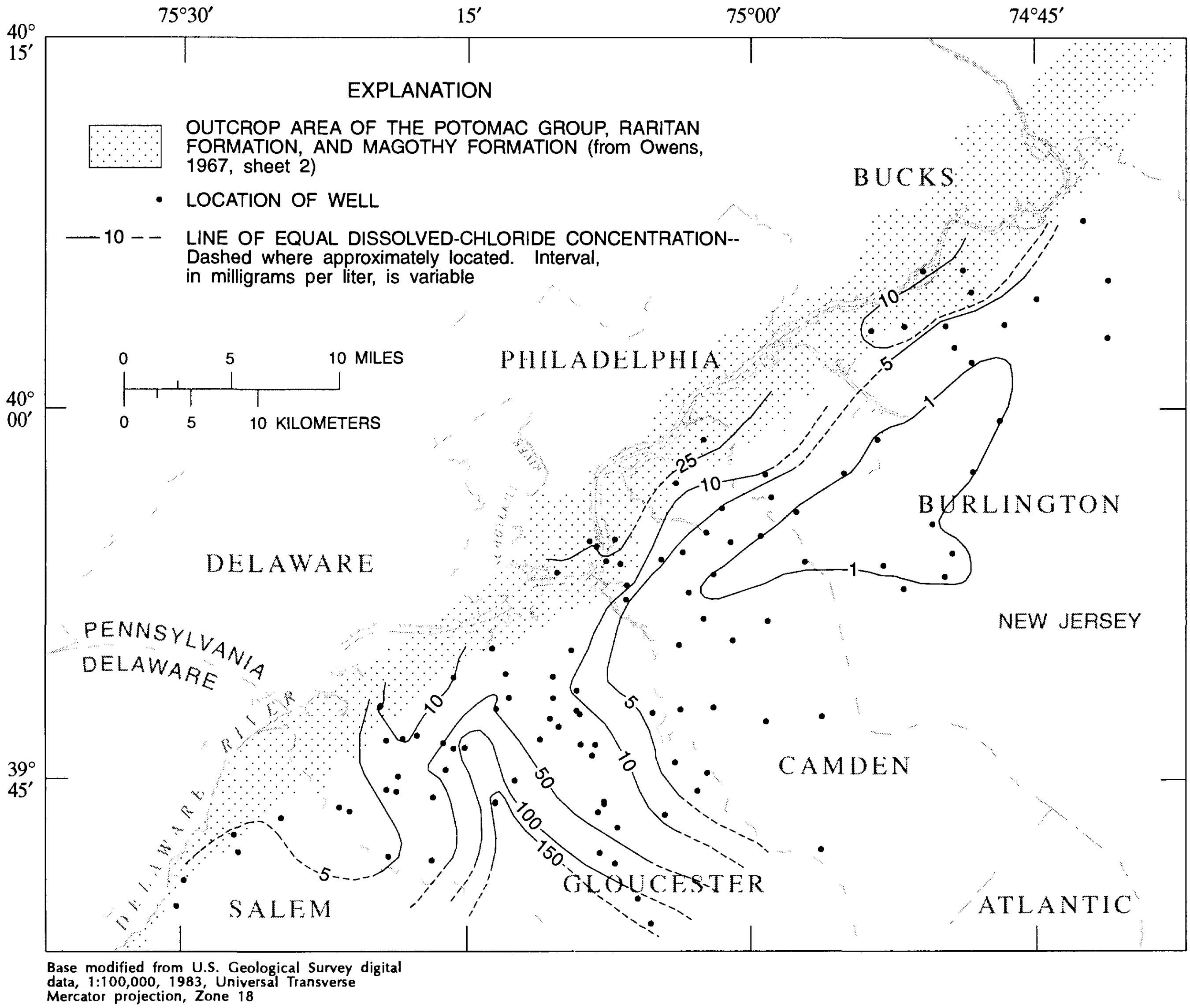


Figure 26.--Generalized distribution of dissolved chloride in water from the upper aquifer, Potomac-Raritan-Magothy aquifer system, 1980-86.

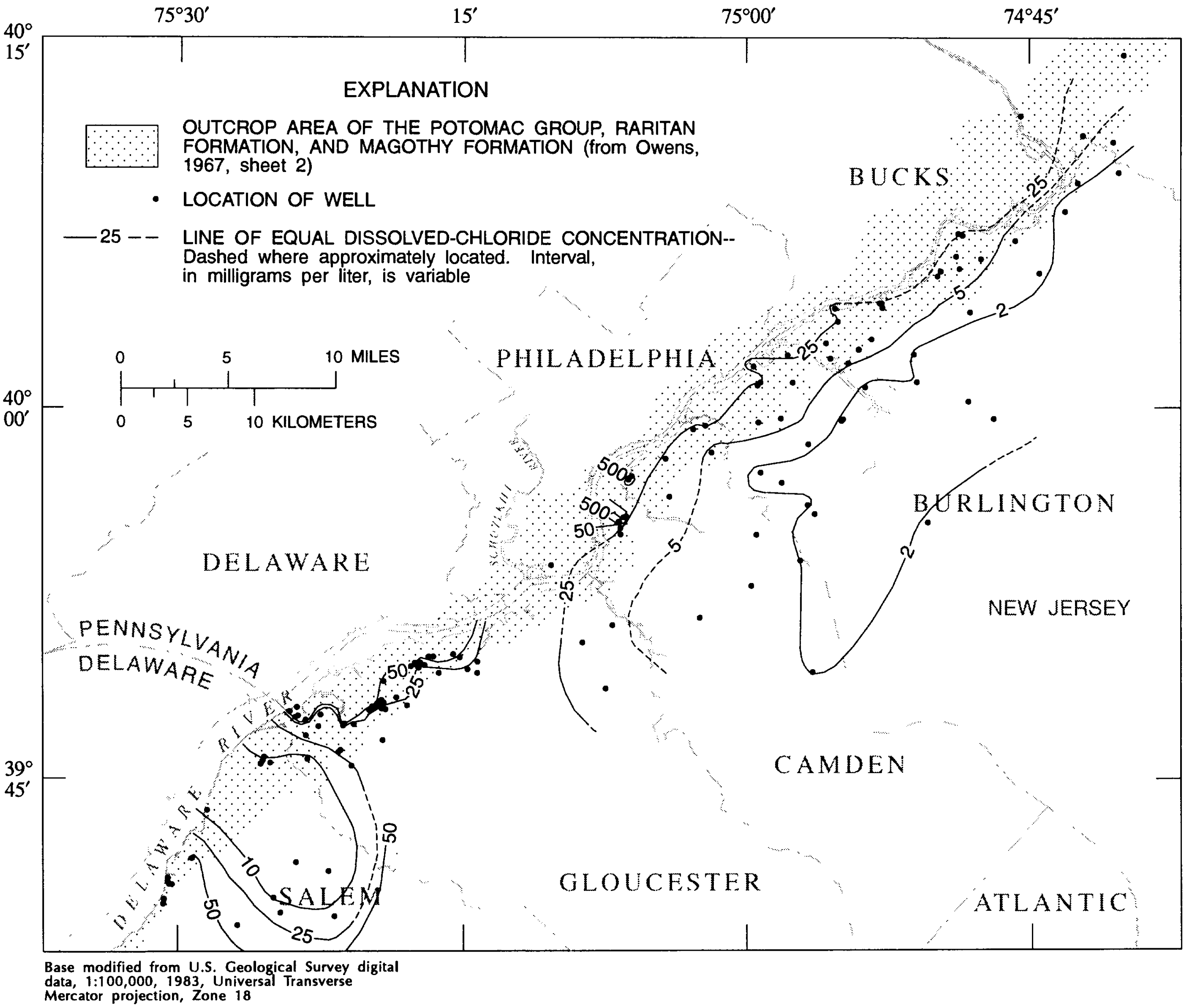


Figure 27.--Generalized distribution of dissolved chloride in water from the middle aquifer, Potomac-Raritan-Magothy aquifer system, 1980-86.

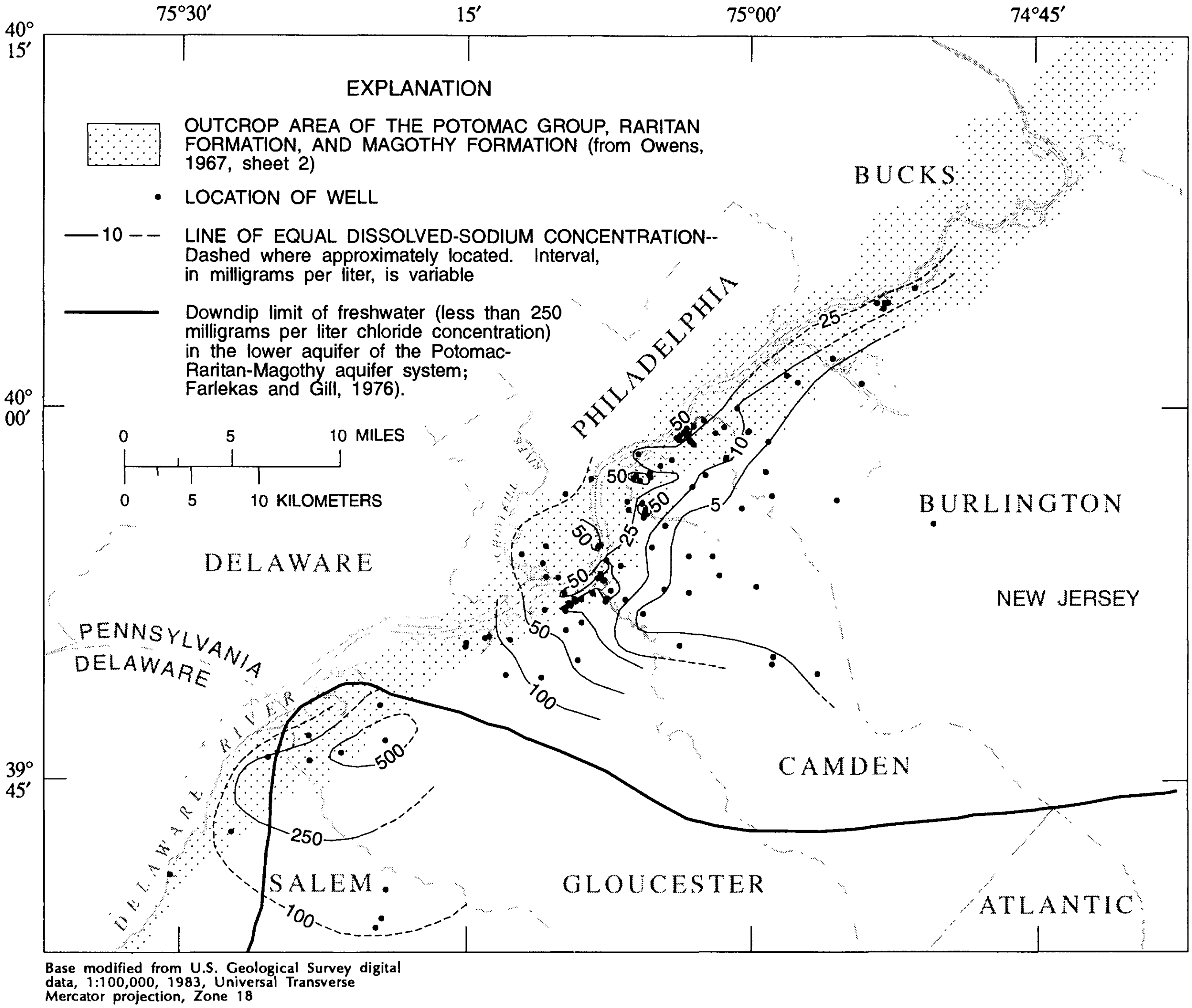
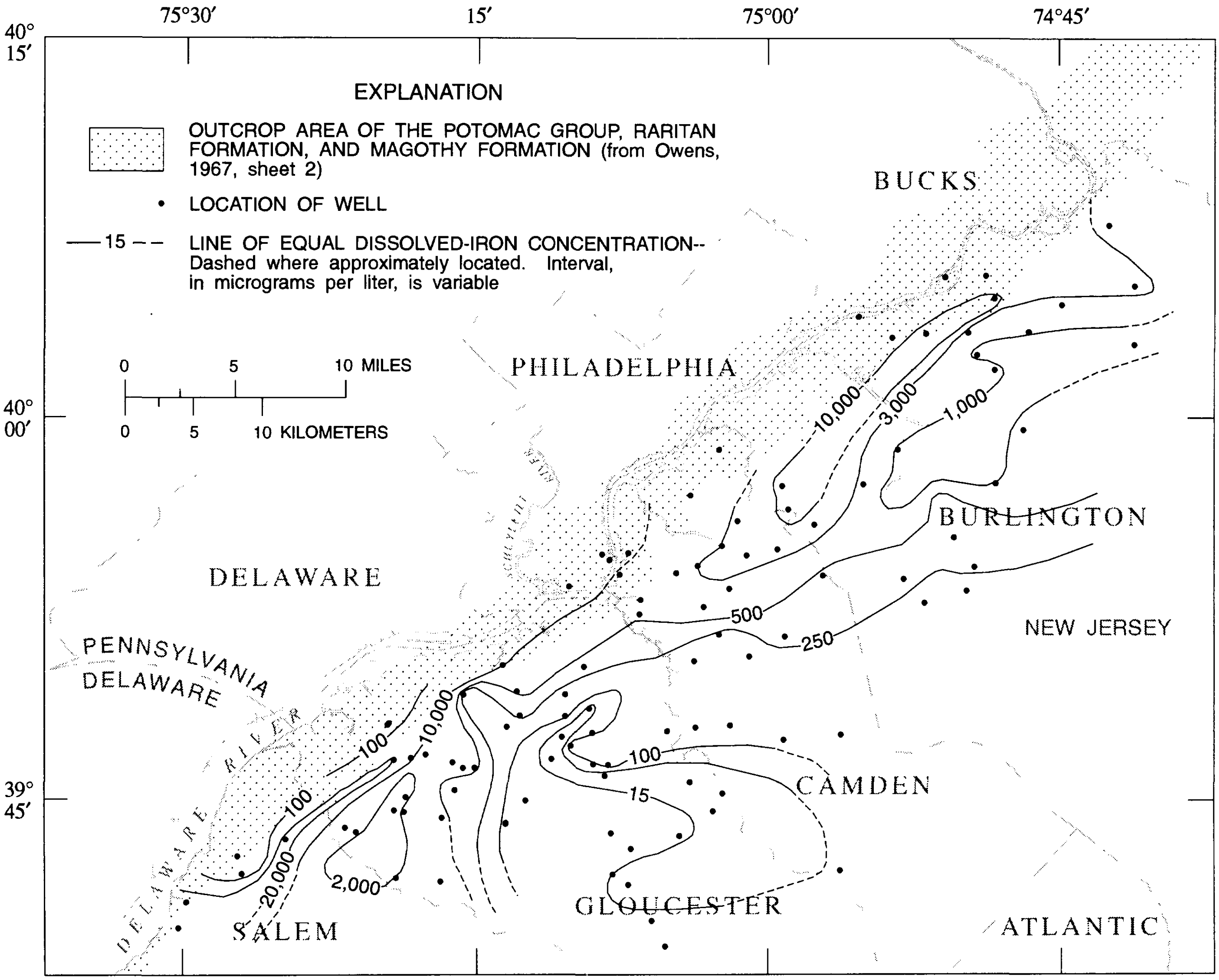


Figure 28.--Generalized distribution of dissolved chloride in water from the lower aquifer, Potomac-Raritan-Magothy aquifer system, 1980-86.



Base modified from U.S. Geological Survey digital data, 1:100,000, 1983, Universal Transverse Mercator projection, Zone 18

Figure 29.--Generalized distribution of dissolved iron in water from the upper aquifer, Potomac-Raritan-Magothy aquifer system, 1980-86.

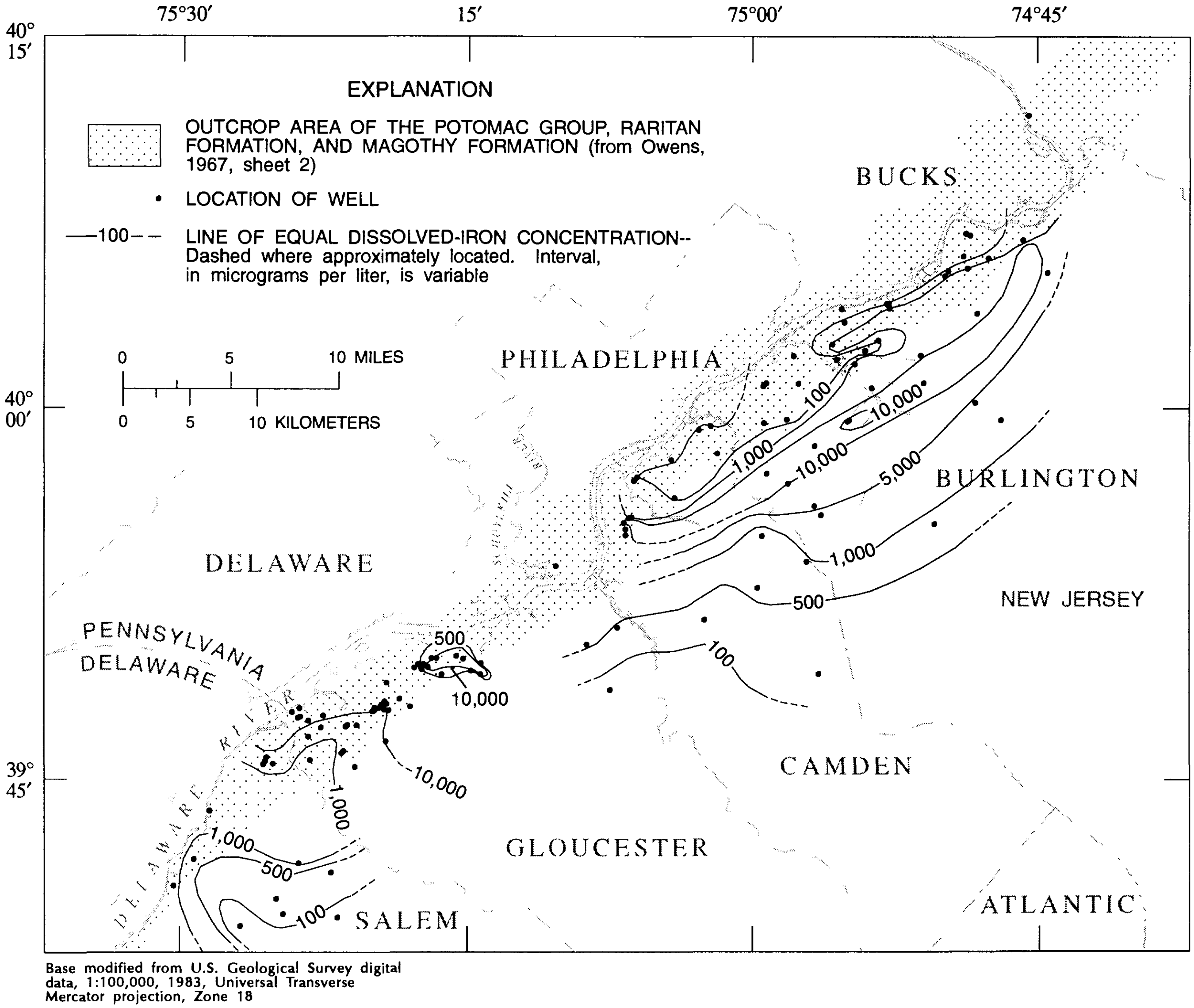


Figure 30.--Generalized distribution of dissolved iron in water from the middle aquifer, Potomac-Raritan-Magothy aquifer system, 1980-86.

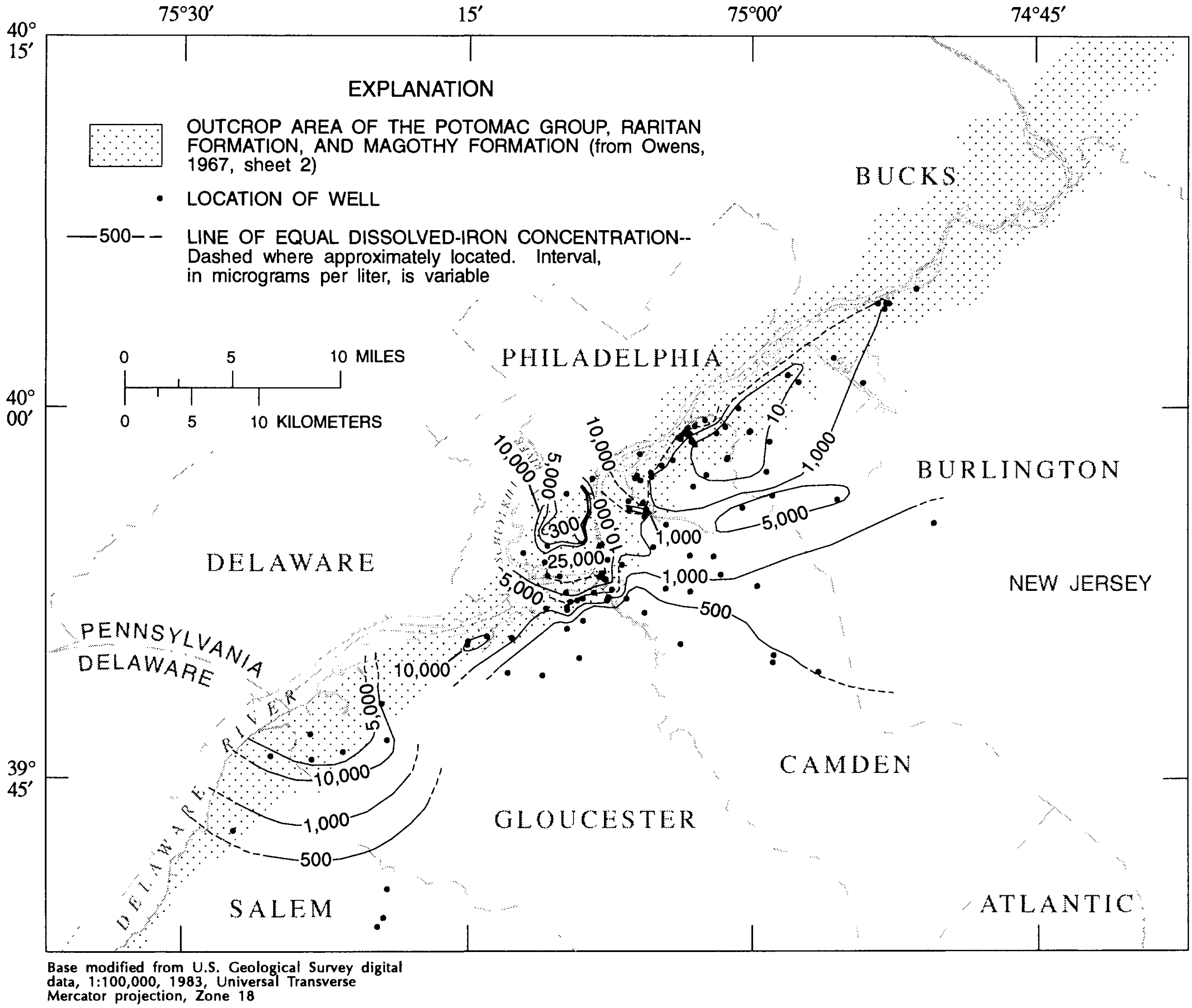


Figure 31.--Generalized distribution of dissolve iron in water from the lower aquifer, Potomac-Raritan-Magothy aquifer system, 1980-86.

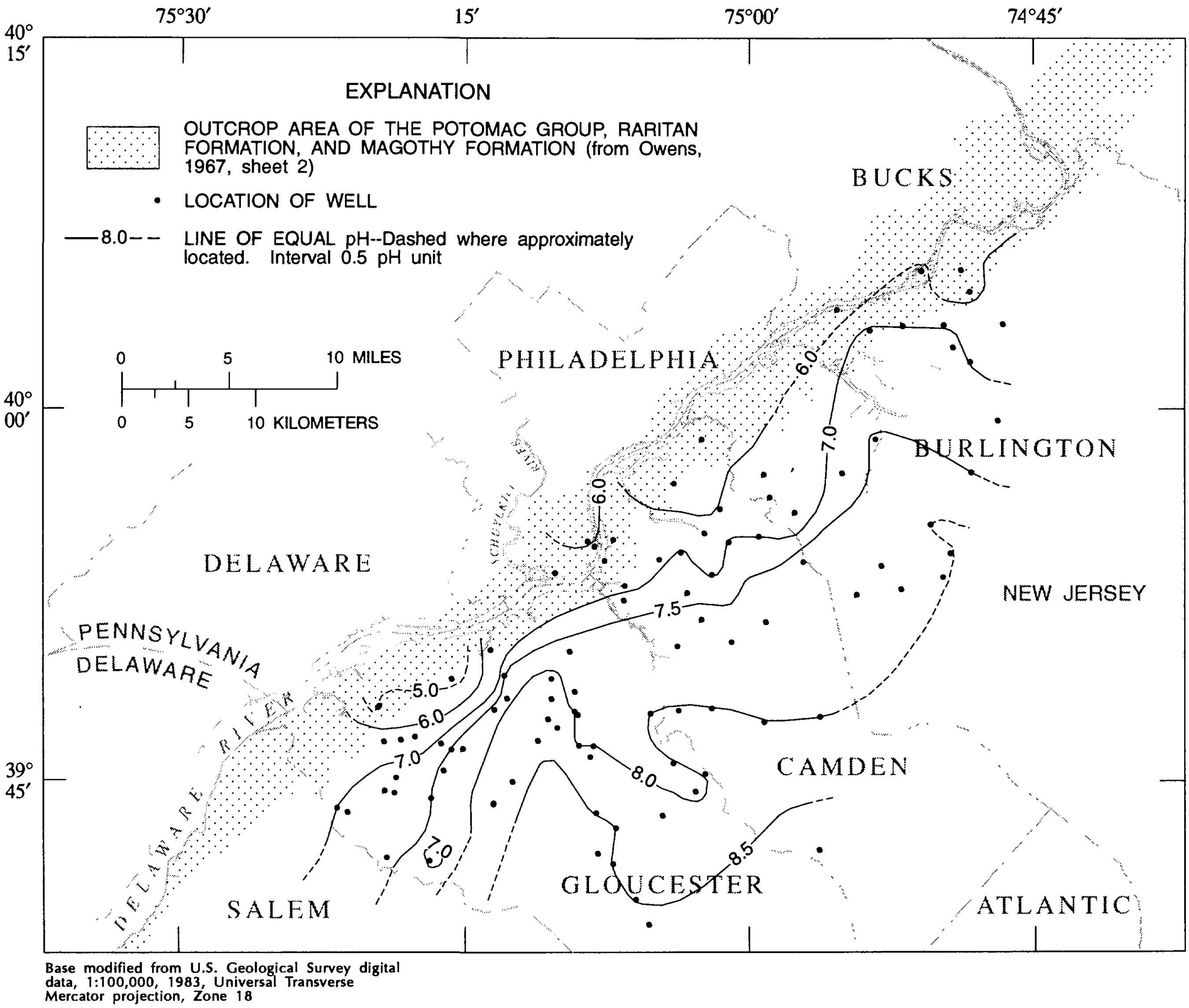
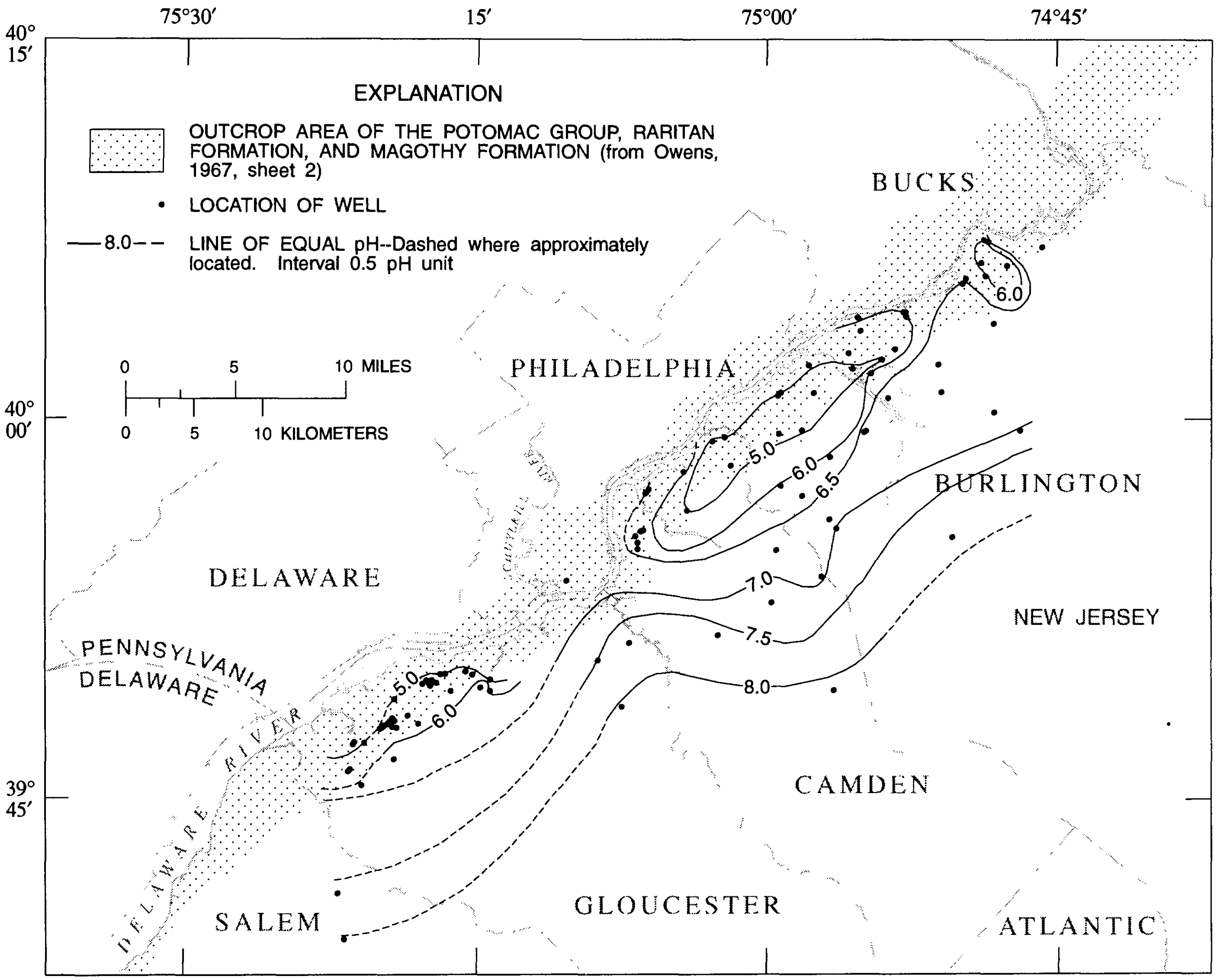


Figure 32.--Areal variations in pH of water from the upper aquifer, Potomac-Raritan-Magothy aquifer system, 1980-86.



Base modified from U.S. Geological Survey digital data, 1:100,000, 1983, Universal Transverse Mercator projection, Zone 18

Figure 33.--Areal variation in pH of water from the middle aquifer, Potomac-Raritan-Magothy aquifer system, 1980-86.

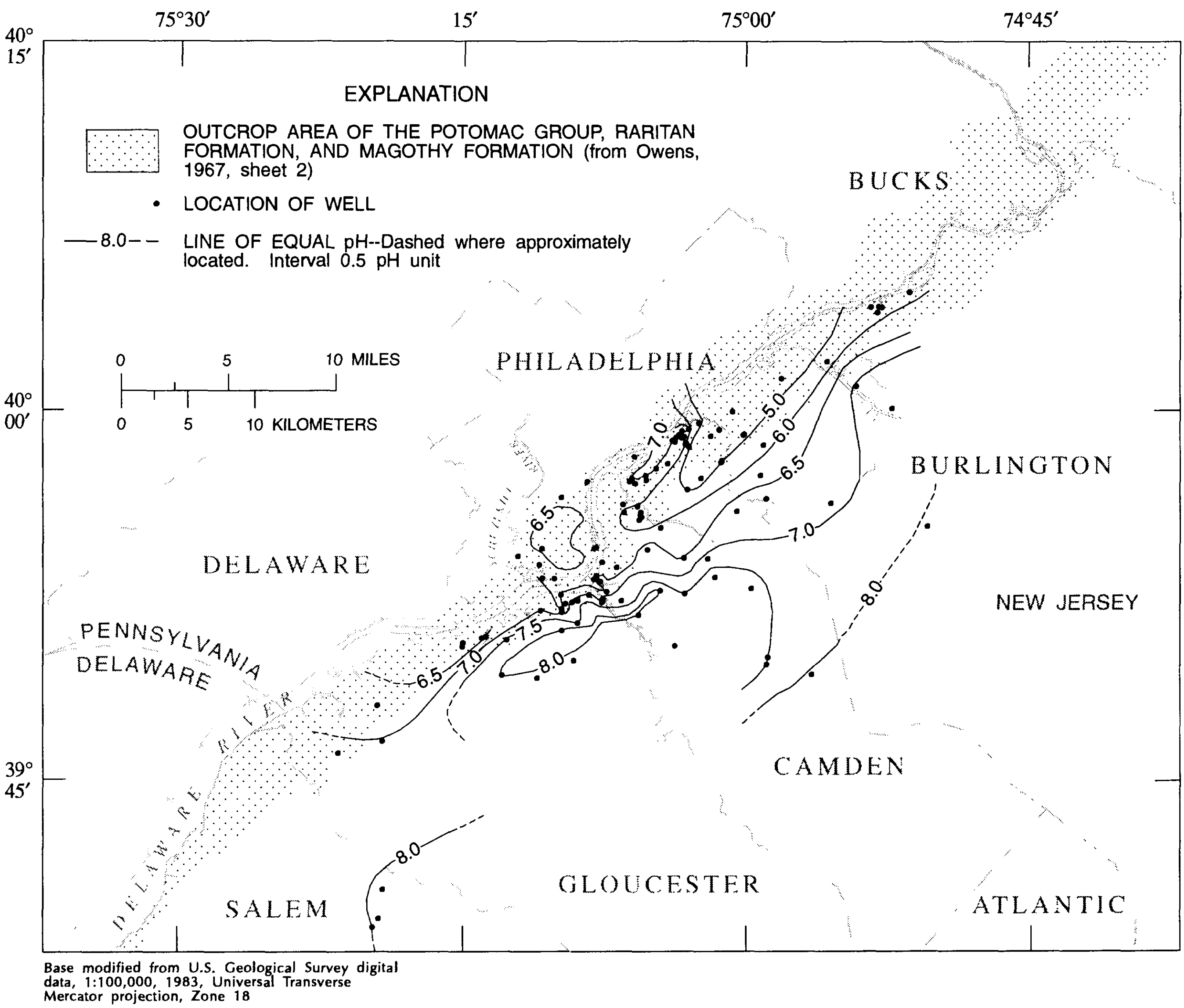


Figure 34.--Areal variations in pH of water from the lower aquifer, Potomac-Raritan-Magothy aquifer system, 1980-86.

Water from wells in the upper aquifer of the Potomac-Raritan-Magothy aquifer system can contain greater than 500 mg/L dissolved solids. In general, dissolved-solids concentrations, which ranged from 100 to 150 mg/L in Burlington and Camden Counties, increased southwestward to 250 to 500 mg/L in Gloucester County. This pattern is largely the result of the direction of ground-water flow. Water from several wells in or near the outcrop area of the upper aquifer, particularly from wells 15-390 and 5-731, contained elevated concentrations of dissolved solids that probably result from contamination as a result of human activities.

The distribution pattern of dissolved solids in the middle aquifer of the Potomac-Raritan-Magothy aquifer system is similar to that in the upper aquifer; concentrations increased, in approximately the same ranges, from Burlington and Camden Counties southwestward to Gloucester County. Leakage from the upper aquifer to the middle aquifer could affect water quality in northern Camden and northwestern Burlington Counties in the area where dissolved-solids concentrations were less than 75 mg/L. Contamination from human activities could cause the elevated dissolved-solids concentrations at some wells (7-562, 7-564, 7-566) that tap the middle aquifer near the Delaware River that were anomalously high in relation to concentrations at surrounding wells. These anomalous concentrations were near a landfill in Camden, and in Logan Township, Gloucester County.

Concentrations of dissolved solids in the lower aquifer tended to increase from northeast to southwest in the study area, from 150 mg/L in Burlington County to greater than 500 mg/L in southwestern Gloucester and Salem Counties. Possible leakage from overlying aquifers could be the cause of an area of dissolved-solids concentrations less than 100 mg/L in northern Burlington County and northern Camden County. This area (fig. 22) directly underlies an area of relatively low dissolved-solids concentrations in the middle aquifer. In Gloucester and Salem Counties, near the Delaware River, areas affected by saline-water intrusion are characterized by dissolved-solids concentrations greater than 500 mg/L. It is unclear whether this area of high concentration is the result of intrusion of brackish water from the Delaware Estuary or flow of saline water from downdip in the aquifer.

A statistical summary of dissolved-solids-concentration data is presented below.

Aquifer	Number of analyses	Concentration of dissolved solids in milligrams per liter			
		Minimum	Mean	Maximum	Median
Upper	107	52	293	4,480	146
Middle	125	25	305	6,060	147
Lower	116	46	260	1,530	188

Of the 107 dissolved-solids concentrations determined for water from the upper aquifer, 5.6 percent exceeded the SMCL of the USEPA (1986) of 500 mg/L. For the upper aquifer, less than 1 percent of the samples contained concentrations greater than 1,000 mg/L. For the middle and lower aquifers, 13.6 percent and 12.9 percent of the samples, respectively, contained concentrations greater than 500 mg/L. For the middle and lower aquifers, concentrations in 4.8 percent and 1.7 percent of the samples, respectively, exceeded 1,000 mg/L.

Sodium

Sodium is a common dissolved constituent in ground waters. Natural sources of sodium are saltwater intrusion; ion exchange of calcium for sodium on clays; geologic sources, such as evaporite deposits; and weathering of rocks. Human-related inputs of sodium include road salt, septic-tank effluents, some industrial wastes, and some agricultural chemicals and wastes. A limit of 50 mg/L is recommended by the State of New Jersey (1982) as a secondary standard (NJGW2) for ground-water quality.

The distribution of dissolved sodium in each aquifer is shown in figures 23-25. Several patterns are evident in all three aquifers of the Potomac-Raritan-Magothy aquifer system. In Burlington County, dissolved-sodium concentrations were low, generally below 5 mg/L, in water from the confined part of the aquifer system. In Camden County, concentrations in water from the confined part of the system increased to 25 mg/L. In the outcrop areas of Burlington and Camden Counties, concentrations of dissolved sodium were higher than confined parts of the aquifer, possibly as a result of human activity or inflow from the Delaware River. For all aquifers in the Potomac-Raritan-Magothy aquifer system, the 25-mg/L equal-concentration line for dissolved sodium corresponded closely to the northern part of the Camden-Gloucester County line. Water from areas in all three aquifers was found to contain sodium concentrations that exceeded 50 mg/L.

In water from the upper aquifer in central Gloucester County, sodium concentrations ranged from 50 mg/L to greater than 100 mg/L; although variable, concentrations generally were less than 50 mg/L. In water from the middle aquifer, sodium concentrations in most of Salem County were greater than 50 mg/L, except in the northeastern corner of the county and in and near the outcrop area. Water from other areas of the middle aquifer generally contained sodium in concentrations less than 50 mg/L. Isolated areas of elevated sodium concentrations were apparent near wells 15-98 and 15-380 (fig. 24). In water from the lower aquifer, sodium concentrations greater than 50 mg/L appeared to be more extensive than in the other aquifers. Water from wells in the lower aquifer in Salem and Gloucester Counties contained sodium concentrations greater than 50 mg/L, with the exception of some wells in northeastern Gloucester County. Water from wells in the lower aquifer in the Philadelphia area also contained elevated concentrations of dissolved sodium, possibly related to contamination from human activity. A statistical summary of dissolved-sodium-concentration data shown in figures 23-25 is presented below.

Aquifer	Number of analyses	Concentration of dissolved sodium in milligrams per liter			
		Minimum	Mean	Maximum	Median
Upper aquifer	108	1.8	40	230	15
Middle aquifer	125	1.8	35.8	670	12
Lower aquifer	119	2.4	47.5	540.0	21.0

The percentages of water samples containing dissolved-sodium concentrations greater than 50 mg/L are 29.6, 20.8, and 19.3 percent for the upper, middle, and lower aquifers, respectively.

Chloride

Chloride is one of the major anions in ground water. Sources are similar to those for sodium and generally are natural; however, chloride in ground water can result from human activity such as sewage disposal and road salting. The SMCL of the USEPA (1986) for chloride is 250 mg/L (U.S. Environmental Protection Agency, 1986). The distribution of dissolved chloride in each aquifer is shown in figures 26-28. Chloride-distribution patterns generally are similar for all three aquifers in Burlington and Camden Counties. In the confined part of the aquifer system in these areas, chloride concentrations were low, typically less than 5 mg/L. In the outcrop areas, chloride concentrations were slightly higher than confined areas of the aquifer. The chloride distribution was variable among aquifers in Gloucester and Salem Counties, and in other areas where localized contamination is possible.

In the upper aquifer, dissolved-chloride concentrations did not exceed 250 mg/L anywhere within the study area. In the central part of Gloucester County, however, chloride concentrations in some water samples from the upper aquifer were greater than 100 mg/L. Concentrations in Salem County were less than 50 mg/L.

The water in the middle aquifer indicated possible contamination at several wells, notably well 7-562 and well 7-48 (in the City of Camden), both in Camden County; and well 15-163 in Logan Township, in Gloucester County. Water from these wells contained chloride in concentrations higher than those in the surrounding area. With the exception of these wells, chloride concentrations exceeded the SMCL of the USEPA (1986) in only a few places in the middle aquifer. An area of low chloride concentration (less than 10 mg/L) was evident in the upper and the middle aquifers in southwestern Gloucester County and northeastern Salem County. The low chloride concentrations could result from leakage between the upper and middle aquifers and (or) a localized, anomalously high rate of ground-water recharge. More rainfall may be infiltrating in this area. Rainwater, which generally ranges in chloride concentration from less than 1 to 10 mg/L (Feth, 1981, p. 11), may be causing a dilution effect in chloride concentrations relative to the more typical chloride range in that area of 10-50 mg/L.

In the lower aquifer, dissolved-chloride concentrations increased from northeast to the southwest in the study area and exceeded 100 mg/L in Gloucester and Salem Counties; however, chloride concentrations exceeded the SMCL of the USEPA (1986) in only one area in the southwestern corner of Gloucester County. Unlike the upper and middle aquifers, the lower aquifer is not characterized by an area of low chloride concentration (less than 10 mg/L) in or near the outcrop area in southwestern Gloucester County and northeastern Salem County.

A statistical summary of dissolved-chloride-concentration data for the aquifer system is presented below.

Aquifer	Number of analyses	Concentration of dissolved chloride in milligrams per liter			
		Minimum	Mean	Maximum	Median
Upper aquifer	110	0.7	22.8	170	10
Middle aquifer	141	.7	45.3	780	16
Lower aquifer	123	1.9	56.1	830	22

In the upper aquifer, none of the chloride concentrations in water from the wells sampled exceeded 250 mg/L. In the middle and lower aquifers, chloride concentrations in 3.5 and 4.1 percent of the samples, respectively, exceeded 250 mg/L.

Iron

The solubility of iron in ground water depends on the pH and the oxidation state of the water. Dissolved iron can be found in two oxidation states, ferrous (Fe^{+2}) or ferric (Fe^{+3}), but iron in ground water generally is in the reduced, ferrous state. Ferric iron commonly forms compounds of low solubility, whereas ferrous iron is soluble under ground-water conditions where the iron ion can gain orbital elections (a reduction reaction).

Elevated dissolved-iron concentrations are responsible for the most persistent water-quality problems associated with ground water from the Potomac-Raritan-Magothy aquifer system. Iron concentrations in ground water can be increased indirectly by contamination. Microbiological decomposition of organic wastes from sources, such as leaky sewers, septic systems, landfills, and municipal and industrial wastewater disposal, consumes oxygen (Langmuir, 1969, p. 21) and leads to reducing conditions in the ground water; under these conditions, dissolved iron concentrations can be as high as 1,000 mg/L. The decomposition process also can release hydrogen ions into the ground-water system, lowering the pH and thereby promoting the leaching of iron from iron-bearing minerals in the aquifer matrix. Dissolved-iron concentrations exceeding 0.3 mg/L also can be found in some outcrop areas where (1) normally oxygen-rich waters have been depleted in oxygen by the presence of clay layers and (or) (2) infiltration of oxygen-rich precipitation has been hindered by impervious surfaces, such as pavement and roads.

Confinement of ground water enhances the development of reducing conditions and the production of highly soluble ferrous ions (Paulachok, 1991). The USEPA (1986) SMCL for iron is 0.3 mg/L (U.S. Environmental Protection Agency, 1986).

The distribution of dissolved iron in water from each aquifer is shown in figures 29-31. Water from most outcrop areas of the three aquifers contained iron in concentrations greater than 0.3 mg/L. Many wells have been abandoned as a result of clogging screens and pumps by iron. Dissolved-iron concentrations less than 0.3 mg/L were found in water from the downdip, confined parts of the aquifers in Burlington, Camden, Gloucester, and Salem Counties.

In northwestern Burlington County and northeastern Camden County, concentrations of dissolved iron were lower in water from the unconfined parts of the middle and lower aquifers near the outcrop area than in water from other parts of the aquifer system. Water from the middle aquifer contained iron in concentrations less than 0.1 mg/L, mostly in the outcrop area. The concentration in water from the lower aquifer also was less than 0.1 mg/L, but these low concentrations extended farther downdip in the confined part of the system than in the middle aquifer. Few wells are screened in the upper aquifer in northeastern Camden and northwestern Burlington Counties, but several wells screened in the upper aquifer yielded water with lower concentrations of dissolved iron than wells screened in the rest of the aquifer.

The area of water with low concentrations of dissolved iron corresponds to an area of high concentrations of dissolved oxygen, low concentrations of dissolved solids, and low pH in the middle and lower aquifers (figs. 30 and 31). In water from the middle aquifer in this location, concentrations of dissolved oxygen ranged from 1.0 mg/L to 8.5 mg/L. In water from the lower aquifer, concentrations of dissolved oxygen were similar to concentrations in the middle aquifer, but were as high as 9.3 mg/L. Because dissolved-oxygen concentration is measured in the field and the samples are subject to oxygenation during pumping, dissolved-oxygen concentrations less than 0.5 mg/L associated with high iron concentrations are suspect.

Low iron concentrations in this area appear to result from the mixing of anoxic ground water containing high iron concentrations with oxygen-rich ground water leaking downward through confining units that are thin or otherwise ineffective barriers to ground-water flow, as discussed previously in "Hydrogeologic Setting." The oxidation of dissolved iron in ground water causes precipitation of iron oxides (such as $Fe(OH)_3$) and release of hydrogen ions, which results in a lowering of pH.

A statistical summary of dissolved-iron-concentration data for water from the aquifer system is presented below.

Aquifer	Number of analyses	Concentration of dissolved solids in milligrams per liter			
		Minimum	Mean	Maximum	Median
Upper aquifer	107	<0.003	6.3	220.0	0.3
Middle aquifer	125	<.003	15.5	360.0	.99
Lower aquifer	119	<.003	7.9	70.0	2.20

Dissolved-iron concentrations in 50 percent of the 107 water samples from the upper aquifer analyzed for iron exceeded the SMCL of the USEPA (1986). Concentrations in 64 and 70 percent, respectively, of the 125 and 119 water-quality samples from the middle and lower aquifers exceeded the SMCL of the USEPA (1986).

Manganese

The chemistry of manganese is similar to that of iron. In general, as the concentration of dissolved iron in ground water increases, the concentration of dissolved manganese increases. Manganese oxides and hydroxides commonly are present in sediments during deposition. The SMCL of the USEPA (1986) for dissolved manganese is 50 μg/L (U.S. Environmental Protection Agency, 1986).

Maps illustrating the distribution of dissolved manganese were not prepared for the entire study area, although a discussion of the manganese distribution in the Camden-Philadelphia area is presented in "Effects of human activities." Summary statistics for water-quality data for iron and manganese are presented below.

[Fe, dissolved iron; Mn, dissolved manganese; 300, U.S. Environmental Protection Agency (1986) Secondary Maximum Contaminant Level, in micrograms per liter, for dissolved iron; 50, U.S. Environmental Protection Agency (1986) Secondary Maximum Contaminant Level, in micrograms per liter, for dissolved manganese; >, greater than; <, less than]

		Number and percentage of ground-water samples in which concentrations of iron and manganese were above or below indicated concentrations							
	Number of analyses	Fe >300 Mn >50		Fe >300 Mn <50		Fe <300 Mn >50		Fe <300 Mn <50	
Aquifer		Number	Percent	Number	Percent	Number	Percent	Number	Percent
Upper	98	26	26	26	26	5	5	41	42
Middle	127	70	55	12	9	24	19	21	16
Lower	125	73	58	16	12	18	14	18	14

Water samples from more than 50 percent of the sampled wells tapping the middle and lower aquifers contained concentrations of dissolved iron greater than the SMCL of the USEPA (1986) of 300 μg/L; water from these wells also contained dissolved manganese in concentrations greater than the SMCL of the USEPA (1986) of 50 μg/L. Although various processes affect the relation between these two chemical species, elevated concentrations of dissolved iron are found in conjunction with high concentrations of dissolved manganese in many instances.

Hydrogen-ion activity (pH)

pH is the negative base-10 logarithm of the hydrogen-ion activity, expressed as moles per liter (Hem, 1985, p. 61). In most natural ground waters, pH ranges from 6.0 to 8.5. The SMCL of the USEPA (1986) for pH is a range of 6.5 to 8.5 (U.S. Environmental Protection Agency, 1986). The chemical reaction of dissolved carbon dioxide with water is one of the principle reactions that affects pH. The atmosphere is a major source of carbon dioxide in ground water. Carbon dioxide reacts with water and hydrogen ions to produce carbonic acid, bicarbonate, and carbonate. Species produced from this reaction depend on the initial pH of the water and its buffering capacity (Stumm and Morgan, 1981, p. 558). Temperature also has a strong effect on hydrogen-ion activity: As temperature increases, pH decreases.

The distribution of pH in water from each aquifer is shown in figures 17-19. These maps illustrate field-measured pH values. Generally, pH increased with increasing distance downdip from the outcrop area. A pH of less than 6.5 was not found at distances greater than 2 mi downdip from the outcrop area in water from any of the three aquifers. Values of pH above and below the SMCL of the USEPA (1986) can be found in part of the outcrop area as a result of contamination from human activity.

A statistical summary of pH data for the aquifer system is presented below.

Aquifer	Number of analyses	pH Minimum	pH Maximum	pH Median
Upper aquifer	100	4.2	9.3	7.5
Middle aquifer	103	3.9	8.2	6.0
Lower aquifer	118	4.1	8.9	6.6

The percentages of samples that exceeded the SMCL of the USEPA (1986) for pH are 14.5, 66.0, and 43.2 percent for water from the upper, middle, and lower aquifers, respectively. The median pH of water from the upper aquifer (7.5) indicates that water from the upper aquifer is more alkaline than waters from the other two aquifers. In addition, the median pH of water from the middle aquifer was more acidic than the lower limit of the SMCL of the USEPA (1986).

Trace elements

Trace elements commonly are present at concentrations of less than 1.0 mg/L in ground water, in contrast to the major ions, which commonly are present at higher concentrations. Contamination from human activity can account for elevated concentrations of trace elements. USEPA Maximum Contaminant Levels (MCL's) exist for some of these constituents.

Concentrations of trace elements in water from the aquifers of the Potomac-Raritan-Magothy aquifer system typically were less than the MCL of the USEPA (1986), as shown in table 9. The trace element that most frequently exceeded the MCL is cadmium. Percentages of samples from the upper, middle, and lower aquifers in which MCL's were exceeded, however, were small (1.1, 1.5, and 4.0 percent, respectively). Elevated concentrations could be related to localized contamination.

Nitrogen

The anionic forms of nitrogen are nitrite (NO_2^-) and nitrate (NO_3^-). The major cationic form of nitrogen is ammonium (NH_4^+). Chemical properties of the above species differ greatly. In ground water, nitrate is more stable than is nitrite; nitrate commonly is transported along with ground-water flow. Ammonium cations tend to sorb onto mineral surfaces and form strong soluble complexes with metal ions, which are common in wastewater.

Sources of nitrogen in ground water include precipitation, fossil-fuel-combustion products, fertilizers, and industrial and domestic wastewaters. Transformations among the nitrogen species in ground water commonly are mediated by microbial action. The MCL of USEPA (1986) for nitrate nitrogen is 10 mg/L (U.S. Environmental Protection Agency, 1986). Although no MCL or SMCL for ammonia in drinking-water supplies has been promulgated by the USEPA, the State of New Jersey (1982) set the secondary standard (NJGW2) for ammonia at 0.5 mg/L.

Table 9.--Trace elements in water from the Potomac-Raritan-Magothy aquifer system, 1980-86, in relation to laboratory detection limits and U.S. Environmental Protection Agency Maximum Contaminant Levels

[MCL, U.S. Environmental Protection Agency limits; μg/L, micrograms per liter]

Constituent	Laboratory detection limit	USEPA MCL	Total number of analyses	Number above laboratory detection limit	Number above USEPA MCL
Arsenic	1 μg/L	50 μg/L			
Upper aquifer			57	35	0
Middle aquifer			91	45	1
Lower aquifer			92	46	0
Barium	2 μg/L	1,000 μg/L			
Upper aquifer			83	83	0
Middle aquifer			98	98	0
Lower aquifer			85	84	0
Cadmium	1 μg/L	10 μg/L			
Upper aquifer			88	46	1
Middle aquifer			132	72	2
Lower aquifer			99	56	4
Chromium (hexavalent)	1 μg/L	50 μg/L			
Upper aquifer			51	3	0
Middle aquifer			81	12	2
Lower aquifer			80	11	1
Lead	10 μg/L	50 μg/L			
Upper aquifer			86	23	0
Middle aquifer			122	31	2
Lower aquifer			96	30	0

In water from the Potomac-Raritan-Magothy aquifer system, nitrate concentrations greater than the MCL of USEPA (1986) are uncommon, but concentrations of ammonia greater than the NJGW2 are common in and near the outcrop of the aquifer system, as shown in figures 35 through 37. The upper aquifer is tapped by the fewest wells at which nitrate and ammonia concentrations exceeded the MCL of USEPA (1986) and the NJGW2 standard, respectively (fig. 35). The percentages of nitrate concentrations in water from wells in the middle aquifer (fig. 36) that exceeded the MCL of USEPA (1986) were larger than those in water from wells in the other aquifers, especially in Gloucester County. Ammonia concentrations greater than 10 mg/L were found in water from wells near the City of Camden and in Gloucester County. Data for water from the lower aquifer (fig. 37) indicate no wells at which nitrate concentrations were greater than the MCL of USEPA (1986); ammonia concentrations greater than 10 mg/L in water from the lower aquifer generally were found in wells located in the outcrop area in Camden County and northeastern Gloucester County.

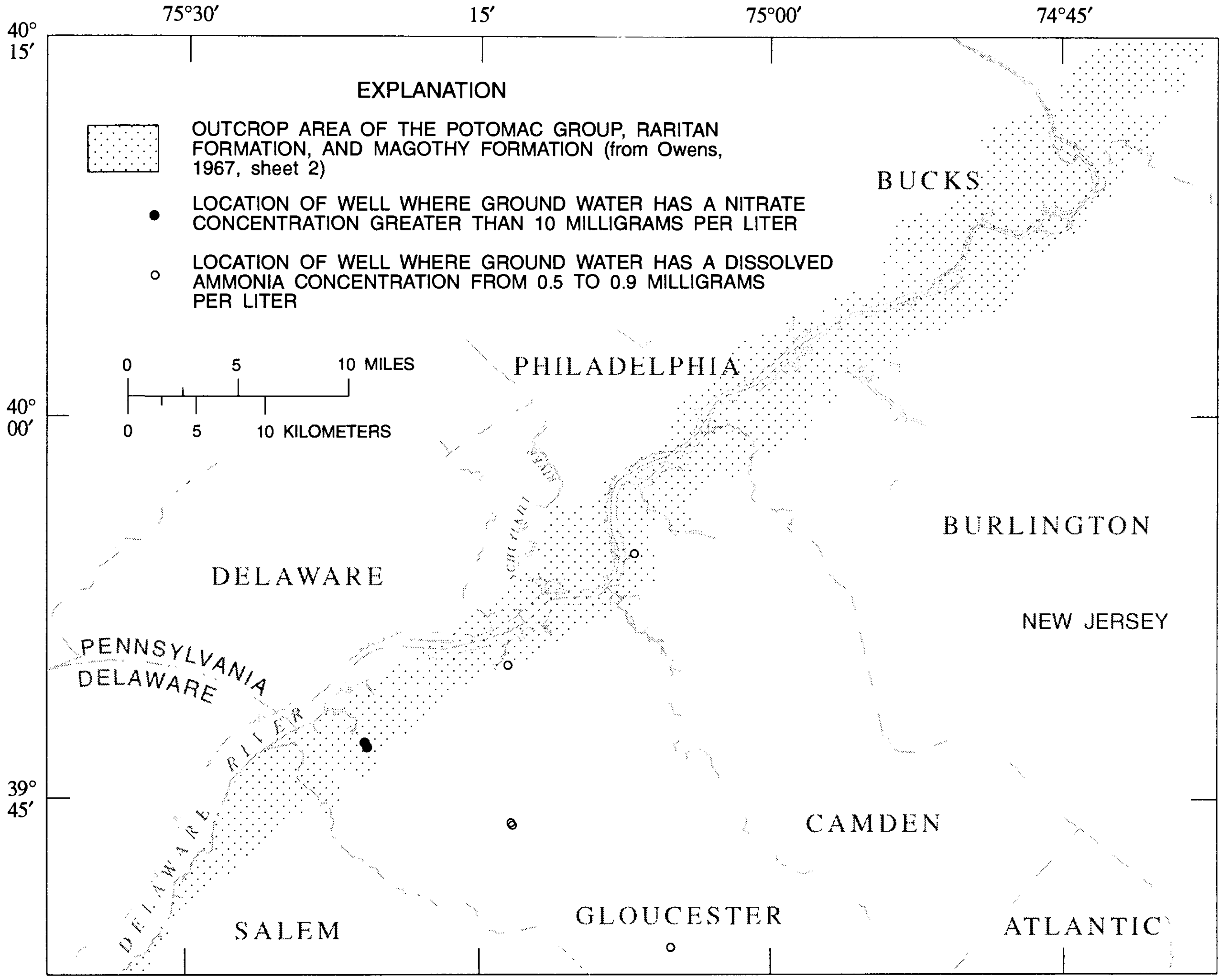
Presence of Saline Water

Saline water is introduced into the Potomac-Raritan-Magothy aquifer system by (1) migration of water containing high concentrations of dissolved solids from downdip in the aquifer system as a result of differences in recharge and changes in tidal fluctuations (Feth, 1981, p. 6) and as a result of pumping, and (2) induced infiltration of saline water from the Delaware River estuary. Schaefer (1983) identified four locations near the study area as areas where saline water has a significant effect on ground-water quality: Woodstown Borough and surrounding areas, Clayton Borough and surrounding areas, the area between Paulsboro and Gibbstown, and the area between Penns Grove and Salem City (fig. 1). Updip flow of saline water in response to changes in recharge rate and pumping stresses is the likely cause of the presence of saline ground water in Woodstown and Clayton Boroughs; intrusion of saline water from the Delaware River estuary is the cause in the other areas.

Downdip Saline Water

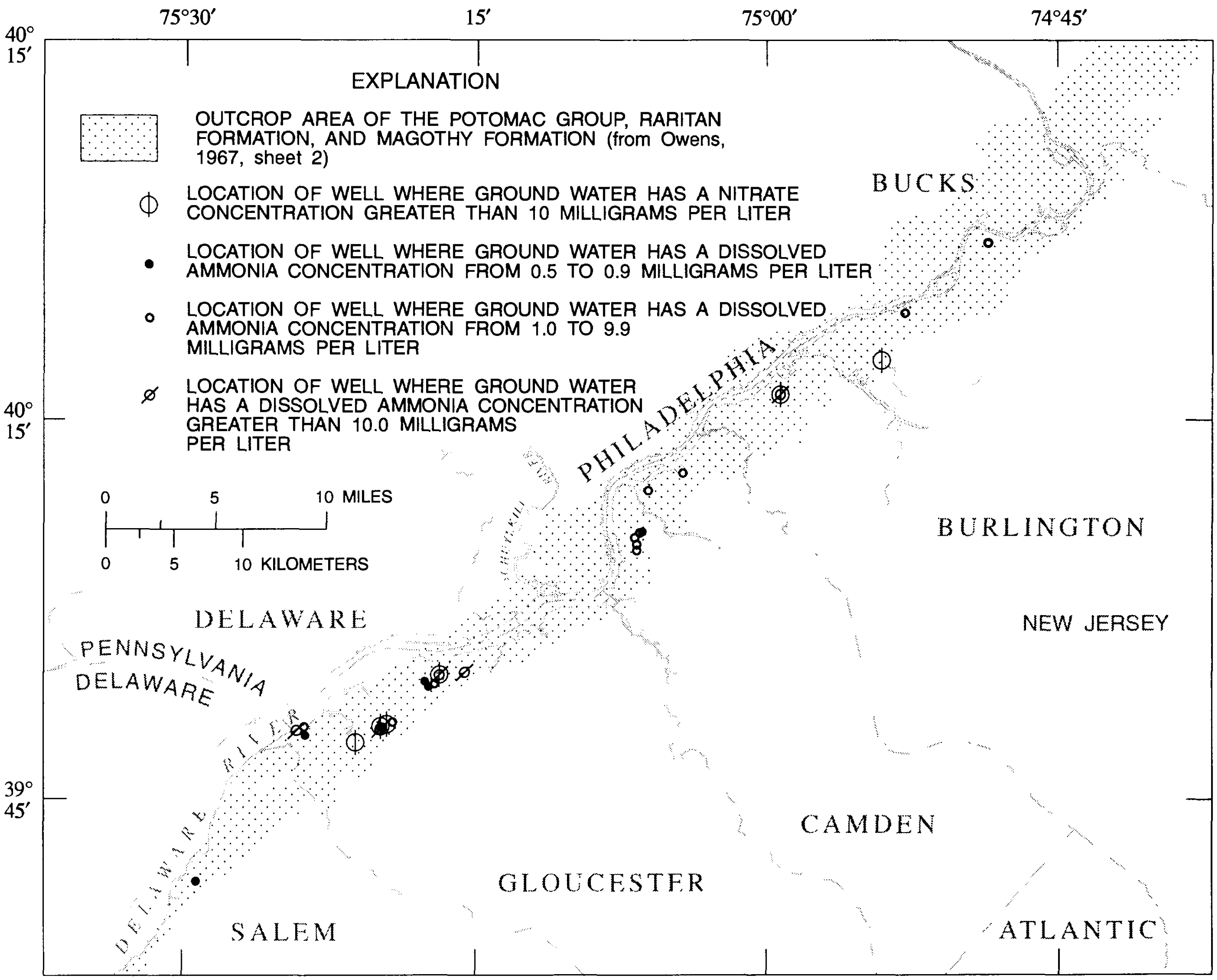
The interface between fresh and saline water is characterized by a broad transition zone in which chloride concentrations range from 250 to 18,000 mg/L. In the Coastal Plain of New Jersey, the transition zone is approximately 1,500 ft thick vertically, and extends, in map view, 10 to 15 mi from the 5,000-mg/L isochlor (line of equal chloride concentration) to the 18,000-mg/L isochlor (Meisler and others, 1984, p. 16). The location of the 250-mg/L isochlor in the southern Coastal Plain for the lower aquifer of the Potomac-Raritan-Magothy aquifer system is shown in figure 28. The interface is farther inland in the lower and middle aquifers than in the upper aquifer because the upper aquifer has been more thoroughly flushed with freshwater recharge than have the middle or lower aquifers (Meisler and others, 1984, p. 6).

Back (1966) presented several theories on the origin of the saline waters in the northern Atlantic Coastal Plain. In marine formations such as the Magothy Formation, which was deposited under nearshore conditions and corresponds to the upper aquifer of the Potomac-Raritan-Magothy aquifer system, incomplete flushing of the sediments by recharge water could produce



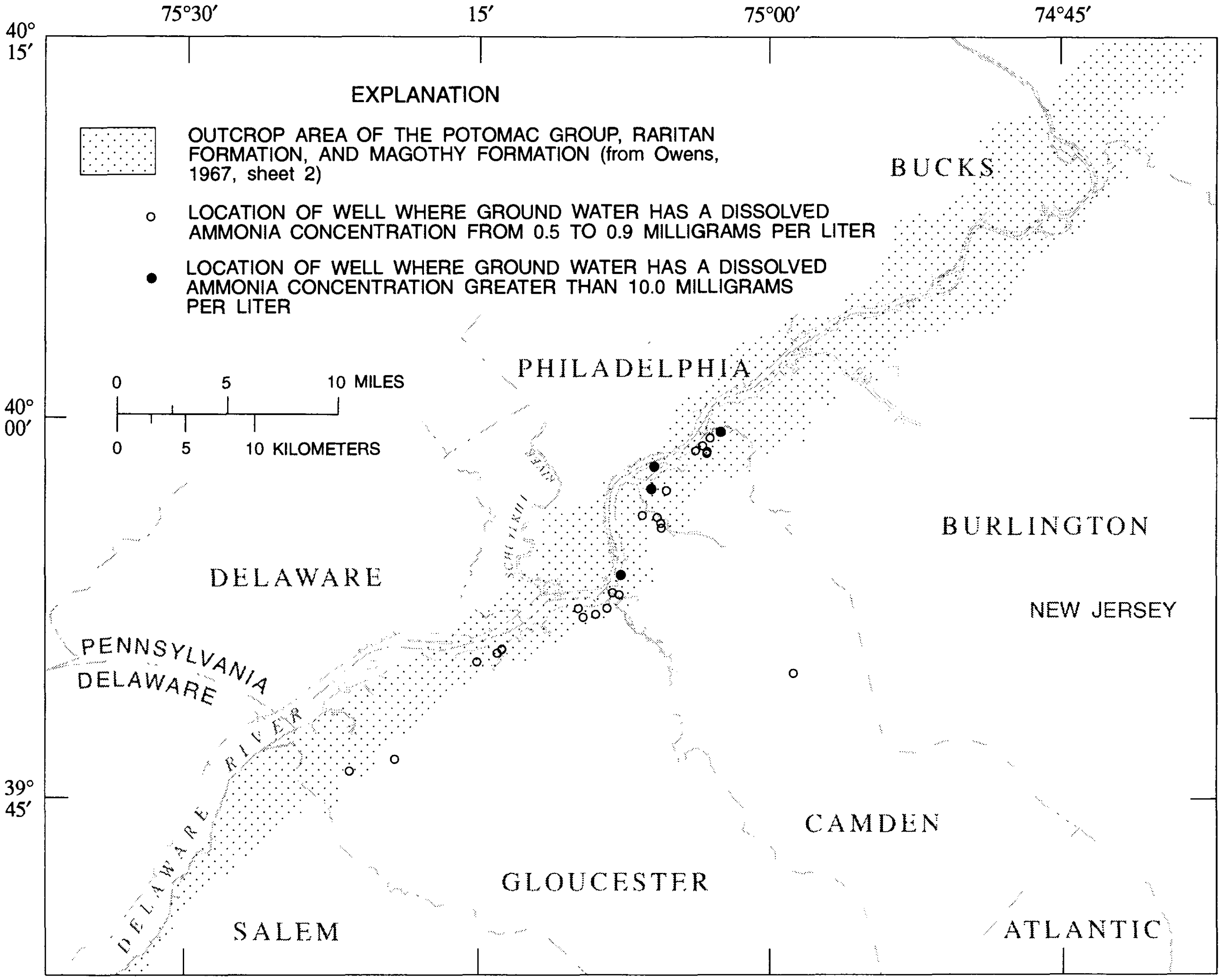
Base modified from U.S. Geological Survey digital data, 1:100,000, 1983, Universal Transverse Mercator projection, Zone 18

Figure 35.--Concentrations of dissolved ammonia and nitrate in water from the upper aquifer, Potomac-Raritan-Magothy aquifer system, 1980-86.



Base modified from U.S. Geological Survey digital data, 1:100,000, 1983, Universal Transverse Mercator projection, Zone 18

Figure 36.--Concentrations of dissolved ammonia and nitrate in water from the middle aquifer, Potomac-Raritan-Magothy aquifer system, 1980-86.



Base modified from U.S. Geological Survey digital data, 1:100,000, 1983, Universal Transverse Mercator projection, Zone 18

Figure 37.--Concentrations of dissolved ammonia in water from the lower aquifer, Potomac-Raritan-Magothy aquifer system, 1980-86.

higher concentrations of dissolved solids downdip than are present in seawater. Other sources of saline water are mineral dissolution and ion concentration by clay filtration (Back, 1966, p. A9) and intrusion of saline water as a result of sea-level fluctuations (Back, 1966; Meisler and others, 1984).

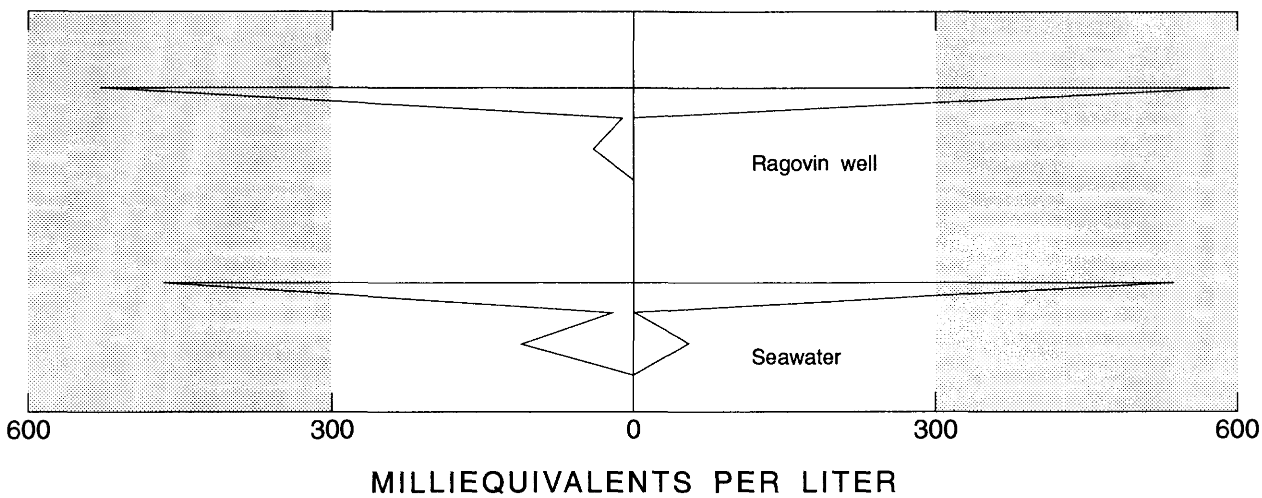
The composition of the downdip saline water is different from that of seawater. Meisler and others (1984, p. 22) noted that saline waters in the Northern Atlantic Coastal Plain contain much larger concentrations of calcium, sodium, and chloride and smaller concentrations of potassium, sulfate, and bicarbonate than does seawater. The chemistry of downdip saline water from the New Jersey part of the Coastal Plain is similar to that of water in the Northern Atlantic Coastal Plain, except that it contains less calcium.

Meisler and others (1984, p. 22) describe the waters that constitute the transition zone in the Coastal Plain from Virginia to New Jersey as a mixture of sodium bicarbonate-type freshwater, sodium calcium chloride brine, and seawater. Deviation from mixing curves, in which chloride concentration is plotted as a function of various major ions, indicates that the third source could be seawater (Meisler and others, 1984, p.22). Ion exchange also might affect the chemistry of water in the transition zone.

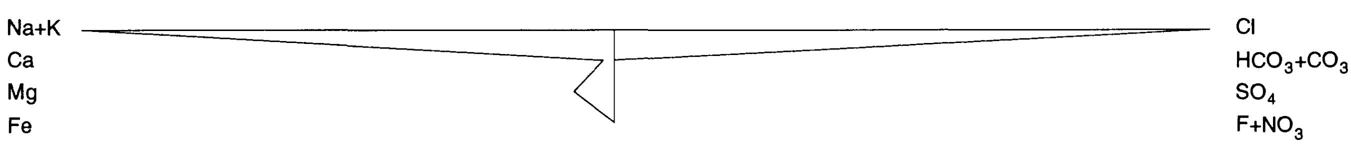
Facies maps of the study area (figs. 14-19) illustrate, as previously mentioned, a downdip zone of little flow. Water in this zone in the upper aquifer (fig. 14) is characterized by the sodium- and potassium-cation facies and the bicarbonate-anion facies. Wells in the lower aquifer are near the freshwater/saline-water interface because of the shape of the interface, and the quality of water from some of these wells indicates an increased contribution from saline water. The concentration of dissolved chloride was greater than that of bicarbonate in water from wells 15-283 and 33-183 (fig. 16). In contrast, bicarbonate predominated over dissolved chloride in water from well 15-131 in the upper aquifer (fig. 14) in Harrison Township, Gloucester County. These data indicate that the downdip water could be mixing with saline water to form a transition zone in this area. Stiff diagrams for the Ragovin well, which is located outside the study area in Cumberland County (fig. 1), and for seawater are shown in figure 38. In water collected from the Potomac-Raritan-Magothy aquifer system from this multiple-screen well, sodium, potassium, and chloride were the dominant ions, but some magnesium also was present. Concentrations of sodium, potassium, and chloride were greater than those in seawater. Water samples from the Ragovin well contained less calcium than the sodium calcium chloride brine described by Meisler and others (1984) as one end member of waters in the transition zone.

Intrusion of Saline Water From the Delaware River Estuary

In many estuaries, freshwater floats on the saline water, which forms a blunt wedge thinning toward the upstream part of the estuary as a result of density differences. In the Delaware River estuary, however, waters are fairly well mixed by tides and by ship propellers, and a blunt wedge-shaped front probably does not exist (Parker and others, 1964). Differences in salinity of only 5 to 10 percent between the surface and the bottom waters of the estuary are common.



EXPLANATION



STIFF DIAGRAM--Shows distribution of major-ion concentrations, in milliequivalents per liter.

Figure 38.--Stiff diagrams showing ionic composition of water from the Ragovin well, Cumberland County, New Jersey, and of seawater.

Freshwater contributions--from reservoirs and flow control on the upper Delaware River and input from streams--keep the saltwater front, which is defined as the 250-mg/L isochlor by the Delaware River Basin Commission (1983), near the Pennsylvania-Delaware State line most of the time. Under drought conditions in November 1964, the 250-mg/L isochlor encroached as far upstream as the Cities of Camden and Philadelphia (Anderson and others, 1972). During this time, saline water was adjacent to aquifer recharge areas and appears to have entered the Potomac-Raritan-Magothy aquifer system. Although no long-term effect on the City of Camden's water supply was noted, this episode is indicative of the vulnerability of the aquifer system to the intrusion of saline water from the estuary. One objective of the Delaware River Basin Commission is to maintain a sufficiently high freshwater flow in the Delaware River estuary so that the maximum 30-day average salinity of the river does not exceed 180 mg/L at river mile 98.0 (Delaware River Basin Commission, 1983). River mile 98.0 is about 6 miles upstream from the confluence with the Schuylkill River. Results of flow simulation (Luzier, 1980; Vowinkel and Foster, 1981) indicate that the Delaware River is recharging the Potomac-Raritan-Magothy aquifer system along some reaches. If regulation of freshwater flows on the upper Delaware River during drought or rising sea level is insufficient to maintain the saltwater front at its current position, ground-water contamination by saline-water intrusion could result where aquifer recharge areas are adjacent to the river.

Major factors affecting the position of the saltwater front in the Delaware River estuary are surface-water withdrawals, sea-level changes, tides, wind conditions, and the geometry of the river channel. A postulated sea level rise of 1.25 to 1.7 ft by the year 2075 (Hoffman and others, 1983) also could cause the position of the saltwater front to move upriver.

Effects of Human Activities

The effects of human activities on the water quality of the Potomac-Raritan-Magothy aquifer system have been caused by changes to the ground-water-flow system resulting from pumpage (previously discussed) and the introduction of contaminants to the aquifers from point and nonpoint sources. Areas of local contamination are in the outcrop area (H.E. Gill and G.M. Farlekas, U.S. Geological Survey, written commun., 1969) and near pumping centers where cones of depression are well-developed. Elevated concentrations of dissolved solids, sodium, chloride, trace elements, and nitrogen in the three aquifers, inferred to be the result of contamination from human activity, were discussed in the section on "Dissolved Constituents."

Effect of Ground-Water Pumpage on the Migration of Contaminants from the Pennsylvania Side of the Aquifer System

Ground-water withdrawals from the Potomac-Raritan-Magothy aquifer system have not only created large, regional cones of depression in all three aquifers, but also have caused the reversal of flow directions adjacent to the Delaware River. In the late 1950's, Barksdale and others (1958, p. 121) predicted that contaminated ground water would move under the Delaware River to New Jersey if pumping ceased at the U.S. Naval Base in Philadelphia (fig. 1). Farlekas and others (1976, p. 48) noted that, in 1966, the U.S. Naval

Base substantially decreased withdrawals from the Potomac-Raritan-Magothy aquifer system, and the direction of flow changed. At present (1988), ground water in the Potomac-Raritan-Magothy aquifer system flows southeast from Philadelphia toward New Jersey (Eckel and Walker, 1986).

Predevelopment water quality in the wells at the U.S. Naval Base in Philadelphia and well 15-323 in New Jersey was similar. Over time, however, water on the Philadelphia side of the Delaware River became progressively more contaminated from industrial sources, as noted by Greenman and others (1961, p. 74). At the Naval Base, the concentration of dissolved sulfate in water from well PH-6 decreased by 30 percent during 1956-67, but increased substantially downdip in the aquifer system, possibly because of the development of the cones of depression and reversal of flow directions in the aquifer system in New Jersey. Results of recent (1980-86) water-quality analyses indicate that concentrations of some chemical constituents--in particular, sulfate and iron--have increased in water from wells in New Jersey near the Delaware River. Paulachok (1991) attributes a 30-percent increase in the average iron concentration in water from the lower aquifer of the Potomac-Raritan-Magothy aquifer system in Philadelphia from 1945-58 to 1979-80 to ongoing ground-water contamination.

The distributions of concentrations of dissolved solids, dissolved iron, dissolved manganese, dissolved sulfate, and pH in water from the lower aquifer of the Potomac-Raritan-Magothy aquifer system in the Philadelphia-Camden area for 1980-86 are illustrated in figures 39-43, respectively. These maps are more detailed than the corresponding maps in figures 20-34 and include additional water-quality data from wells in the Philadelphia area. Most of the data for wells in the Philadelphia area are from Paulachok (1991) for the period 1979-80.

The distribution map of dissolved sulfate (fig. 43) shows that the 25-mg/L sulfate-concentration line extends downdip from the generalized outcrop area of the Potomac-Raritan-Magothy aquifer system in New Jersey. Farlekas and others (1976) place the 25-mg/L sulfate-concentration contour line just slightly into New Jersey on the basis of data collected from 1966 through 1971. Trends in constituent concentration over time for water from well 15-323 (fig. 1) are shown in figure 44. This well is in New Jersey, directly across the Delaware River from the U.S. Naval Base in Philadelphia; the period of water-quality record for this well is one of the longest for wells in the area. The graphs show that concentrations of all dissolved constituents have increased substantially; pH has decreased slightly.

In addition to the migration of contaminants from the Philadelphia side of the aquifer, increases in constituent concentrations could be partly a result of downward leakage of contaminated water through the outcrop area on the New Jersey side of the aquifer system.

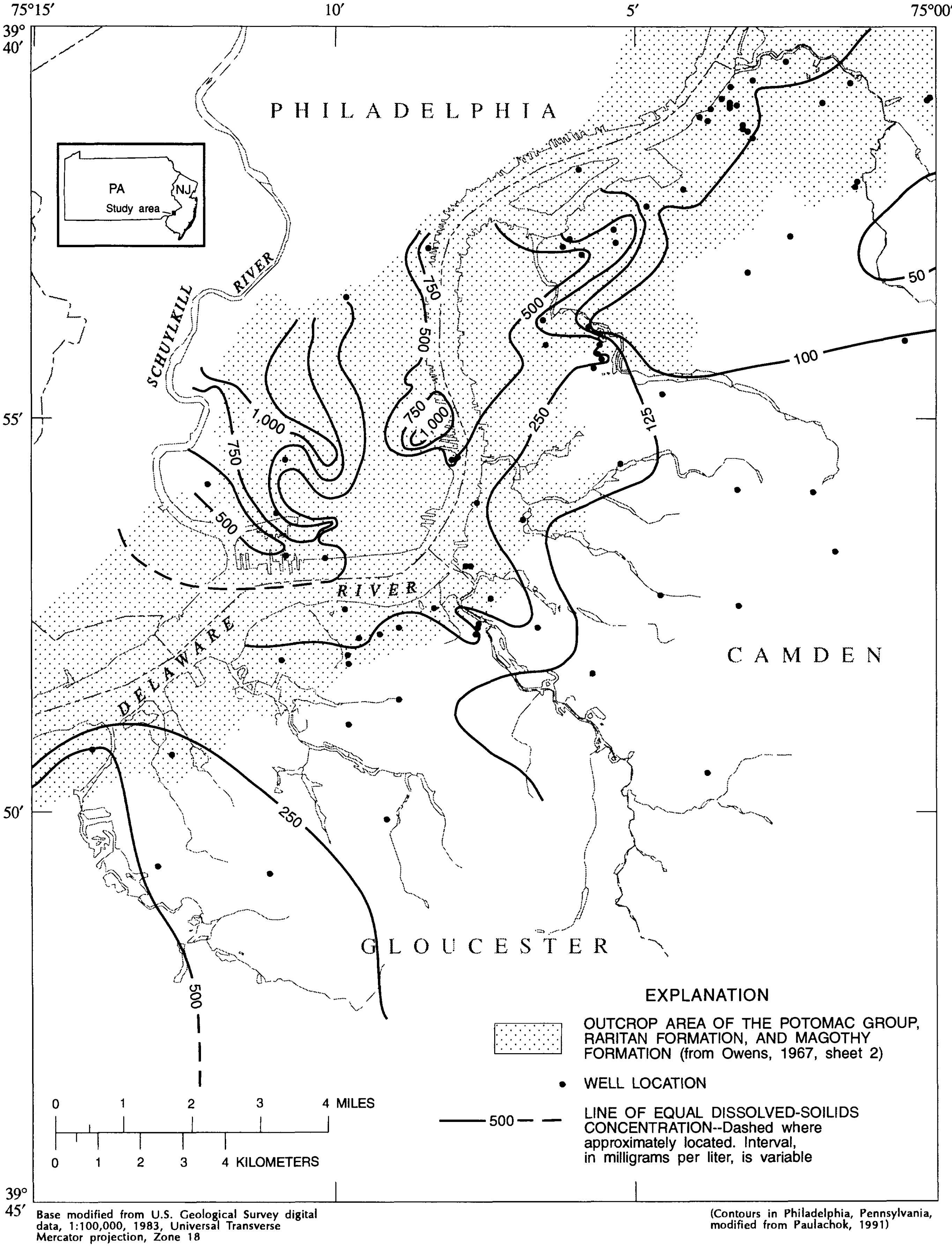


Figure 39.--Concentrations of dissolved solids in water from the lower aquifer, Potomac-Raritan-Magothy aquifer system, Philadelphia-Camden area, 1980-86.

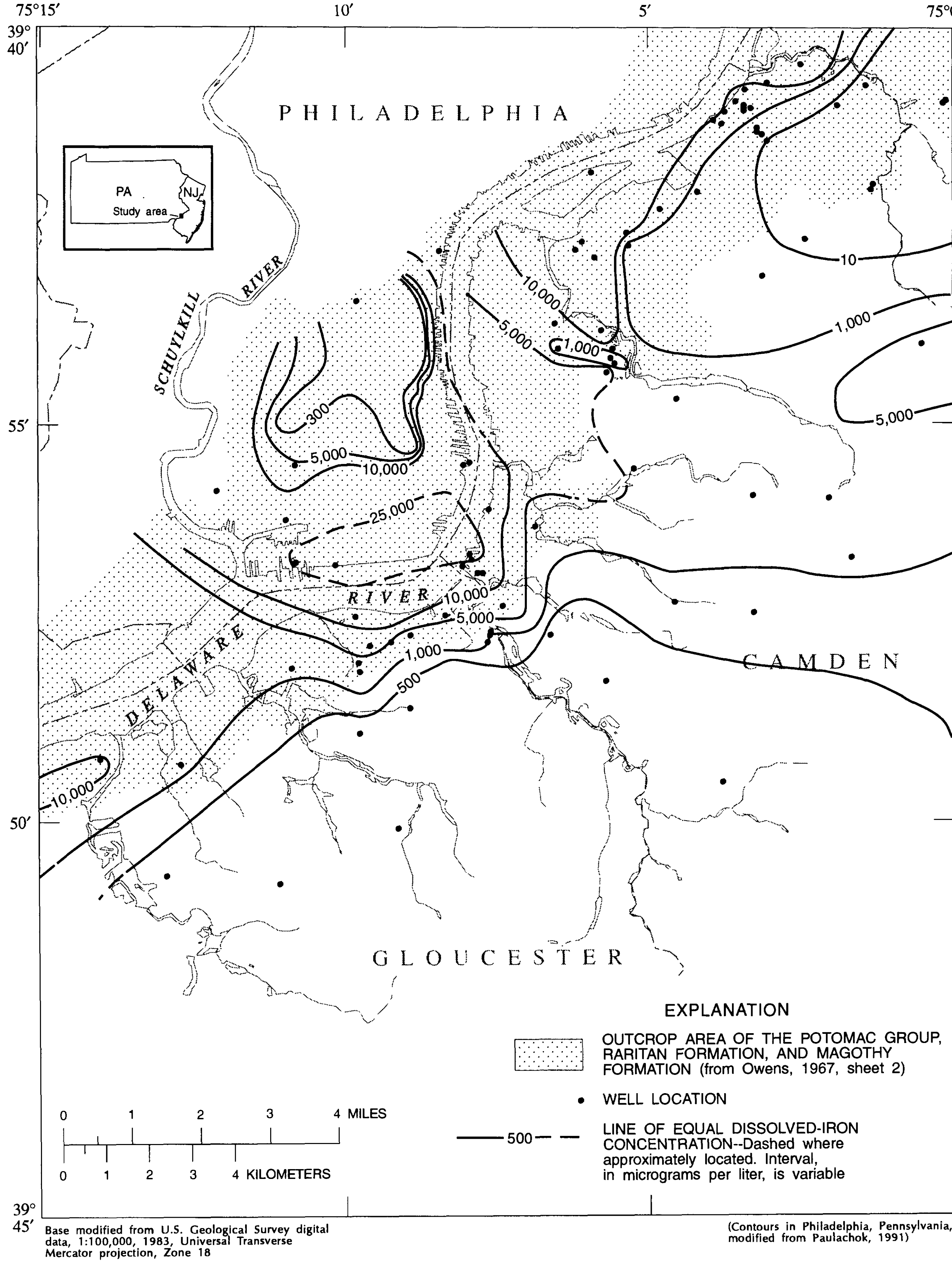


Figure 40.--Concentrations of dissolved iron in water from the lower aquifer, Potomac-Raritan-Magothy aquifer system, Philadelphia-Camden area, 1980-86.

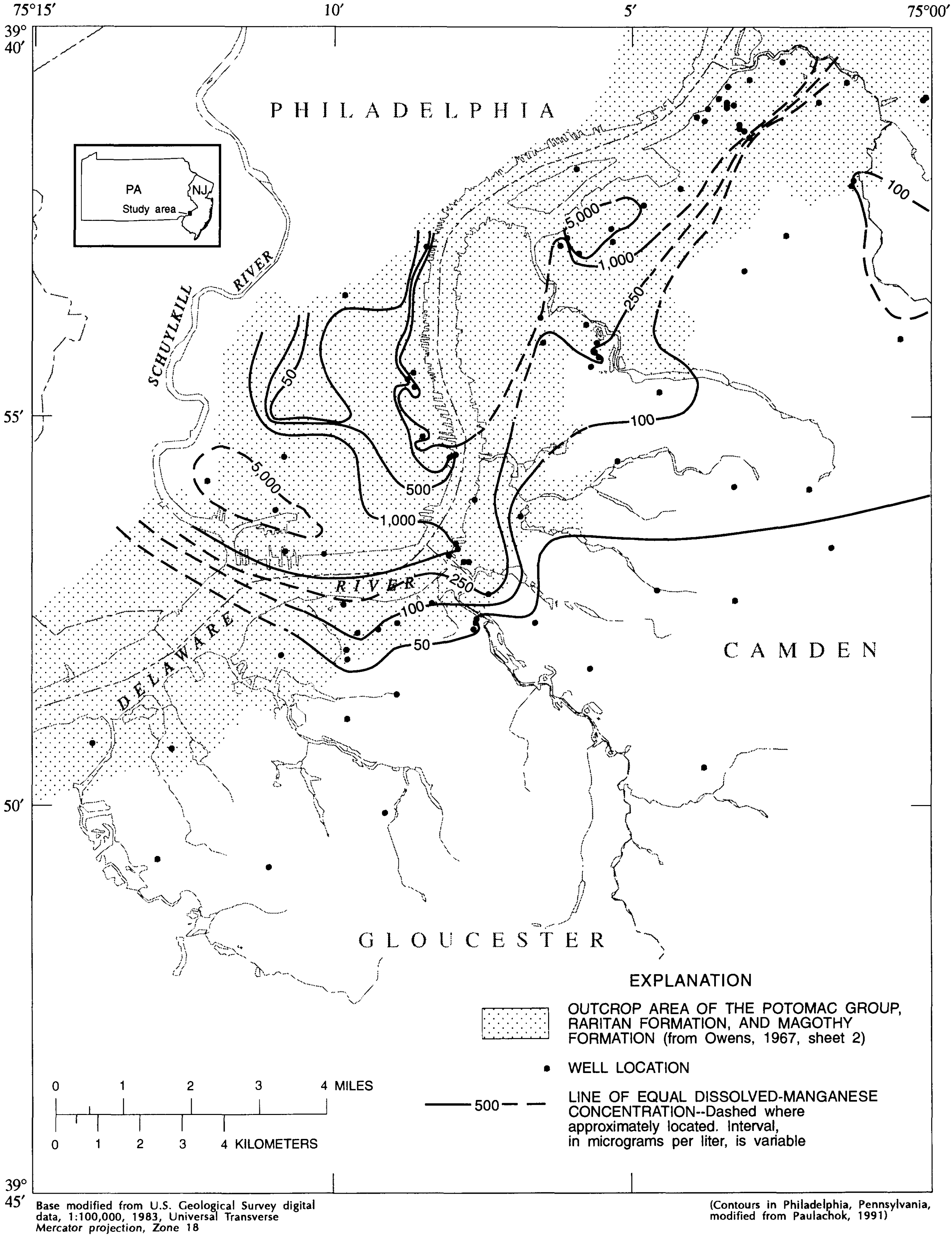


Figure 41.--Concentrations of dissolved manganese in water from the lower aquifer, Potomac-Raritan-Magothy aquifer system, Philadelphia-Camden area, 1980-86.

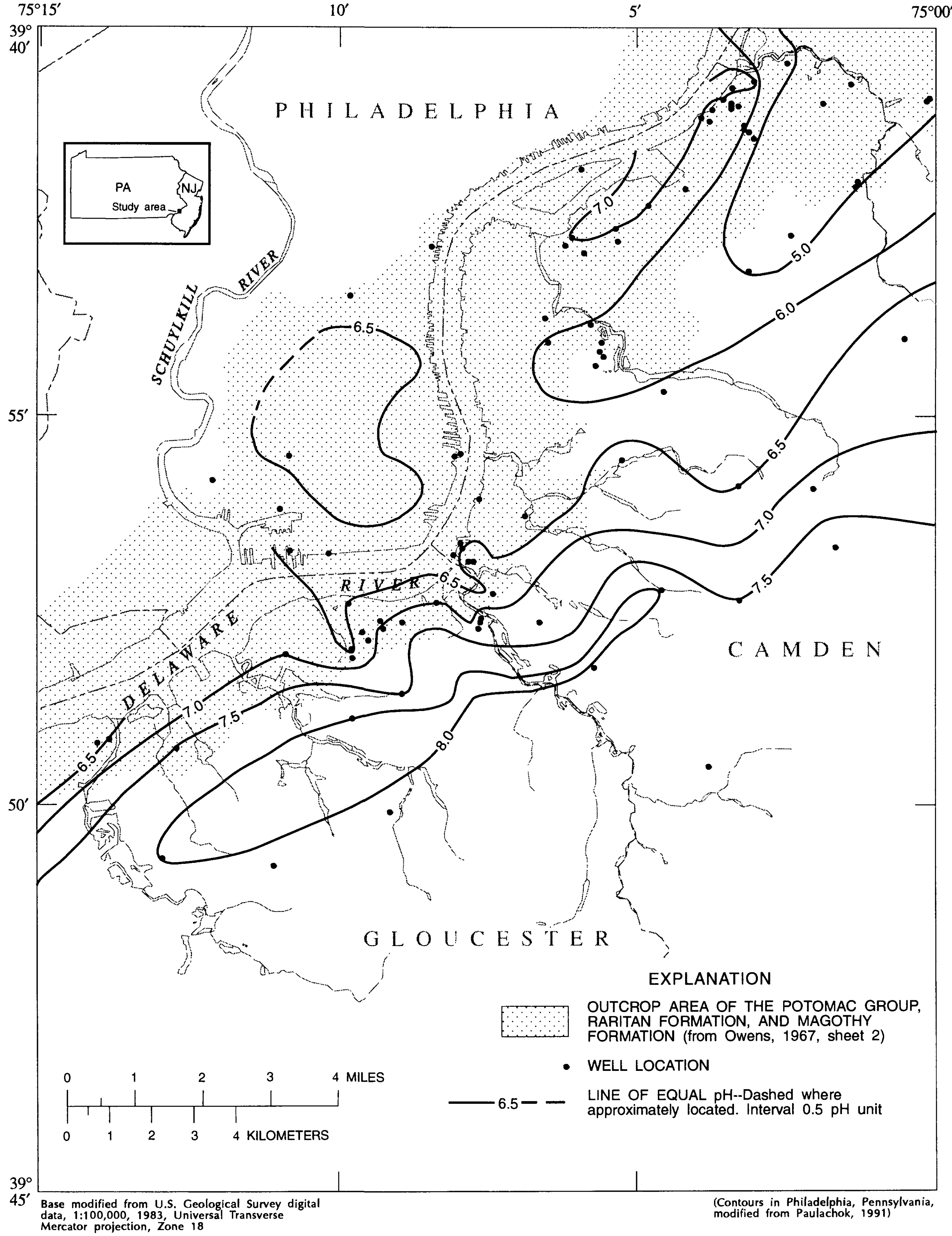


Figure 42.-- Areal variations in pH of water from the lower aquifer, Potomac-Raritan-Magothy aquifer system, Philadelphia-Camden area, 1980-86.

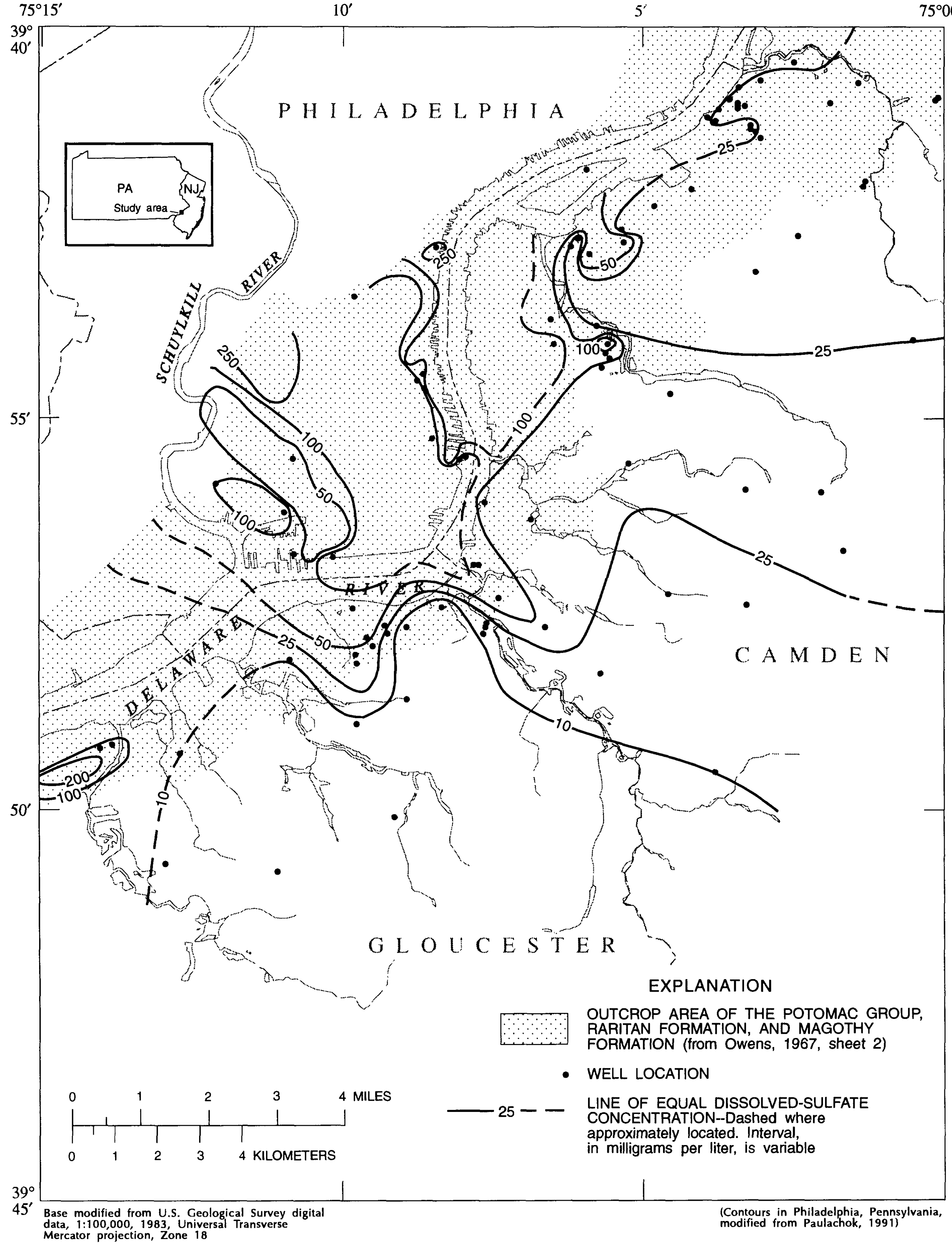


Figure 43.--Concentrations of dissolved sulfate in water from the lower aquifer, Potomac-Raritan-Magothy aquifer system, Philadelphia-Camden area, 1980-86.

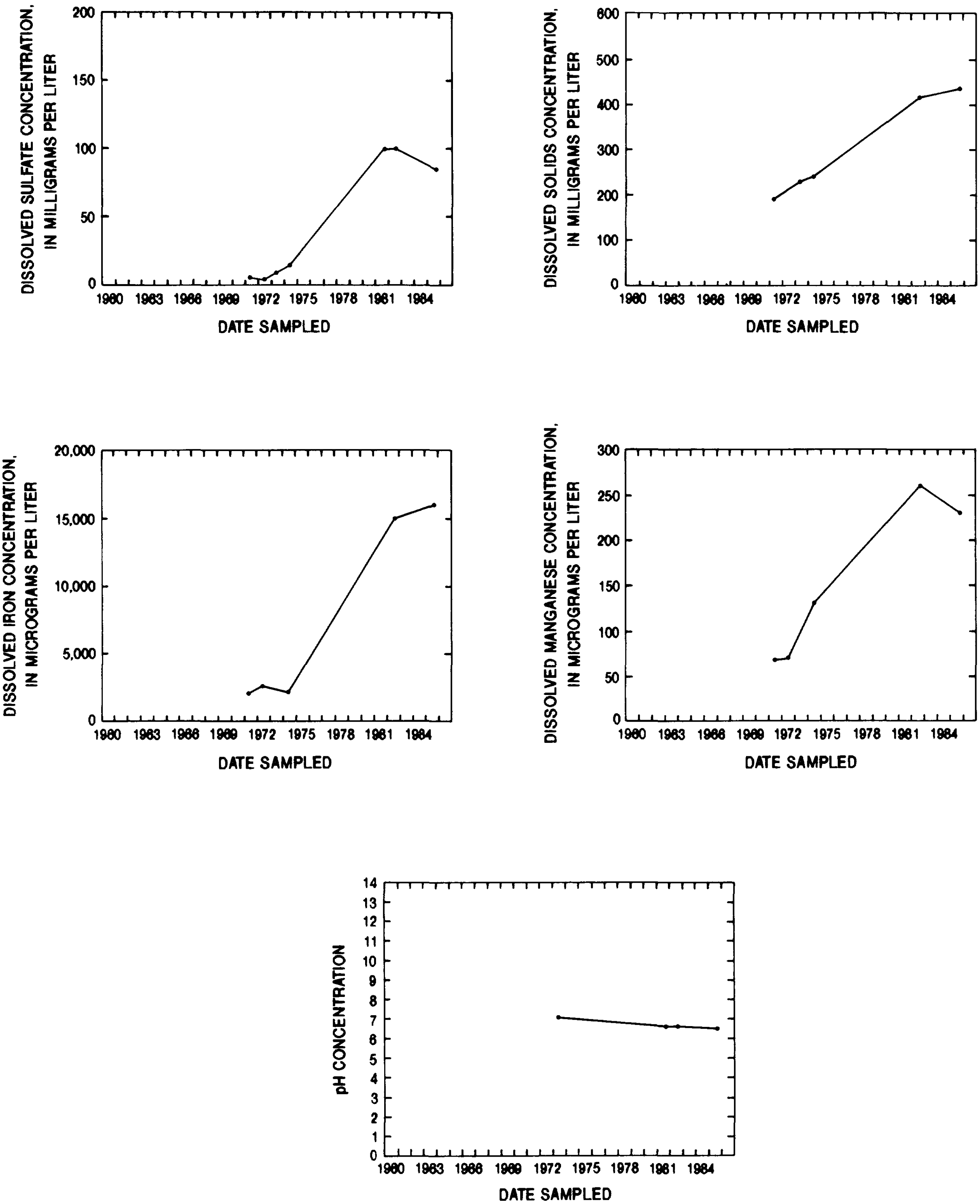


Figure 44.--Temporal change in selected water-quality characteristics of water from well 15-323. (Location of well shown in fig. 10.)

Presence of Purgeable Organic Compounds and Locations of Hazardous-Waste Sites

POC's are an operationally defined subset of compounds on the USEPA priority pollutant list (Keith and Telliard, 1979) that can be isolated and concentrated by purge and trap devices. Sources of POC's to ground water in the study area include surface spills of hazardous materials, waste lagoons, storage-tank leaks, landfills, ground-water recharge from contaminated surface water, and overland runoff. Data on POC's in ground water are presented on an aquiferwide basis in this report. Site-specific incidences of contamination are not examined; rather, an overview of the general distribution of POC's in the aquifer system is provided.

Wells in the Potomac-Raritan-Magothy aquifer system were sampled by the USGS for POC's in 1980, 1982, 1985, and 1986. Fusillo and others (1985) describe the distribution of these compounds in the aquifers in relation to the outcrop area of the aquifer system for the period 1980-82. The distribution of POC's was found to be limited mainly to water from the outcrop area of the aquifer system. Twenty percent of the water samples collected from 315 wells during 1980-82 contained detectable concentrations of POC's. The highest percentage of detections among the aquifers, 28 percent, was found in the lower aquifer. Detectable concentrations of POC's were found in 22 percent of the water samples from the middle aquifer and in 10 percent of the water samples from the upper aquifer. Concentrations of POC's greater than 100 $\mu g/L$ in water from the lower aquifer were attributed to the aquifer's position beneath the most heavily urbanized part of the outcrop area. In addition, contaminants are contributed through leakage from the middle aquifer, as indicated by superposition of concentrations greater than 100 $\mu g/L$ in the lower and middle aquifers. The outcrop of the upper aquifer is the least urbanized; and water samples from this area contained little or no contamination.

Water from 27 wells of the 103 wells sampled during 1985-86 contained detectable concentrations of POC's. Results similar to those found by Fusillo and others (1985) were obtained when these data were subdivided by aquifer. Detectable concentrations of POC's were found in water samples from 13 wells screened in the lower aquifer, 9 wells screened in the middle aquifer, and 5 wells screened in the upper aquifer. Distribution of total POC's in water from each aquifer in 1980-86 are shown in figures 45-47. Few samples from the middle and lower aquifers in which POC's were detected were from outside the outcrop area, whereas four samples from the the upper aquifer in which POC's were detected were from the downdip, confined part of the system. Distributions of trihalomethanes, aromatic organic compounds, and chlorinated solvents in water from the upper, middle, and lower aquifers are shown in figures 48-52.

A summary of data on POC's for 1980-86 is given in table 10. Compounds detected in water samples are trichloroethylene, chlorobenzene, benzene, and ethyl benzene. By comparison, Fusillo and others (1985) found that trichloroethylene, tetrachloroethylene, and benzene were the most frequently detected compounds in water from wells sampled during 1980-82. Differences in the spatial distribution of the data sets might account for variations in the most commonly found POC's. Sampling in 1980-82 was concentrated in and near

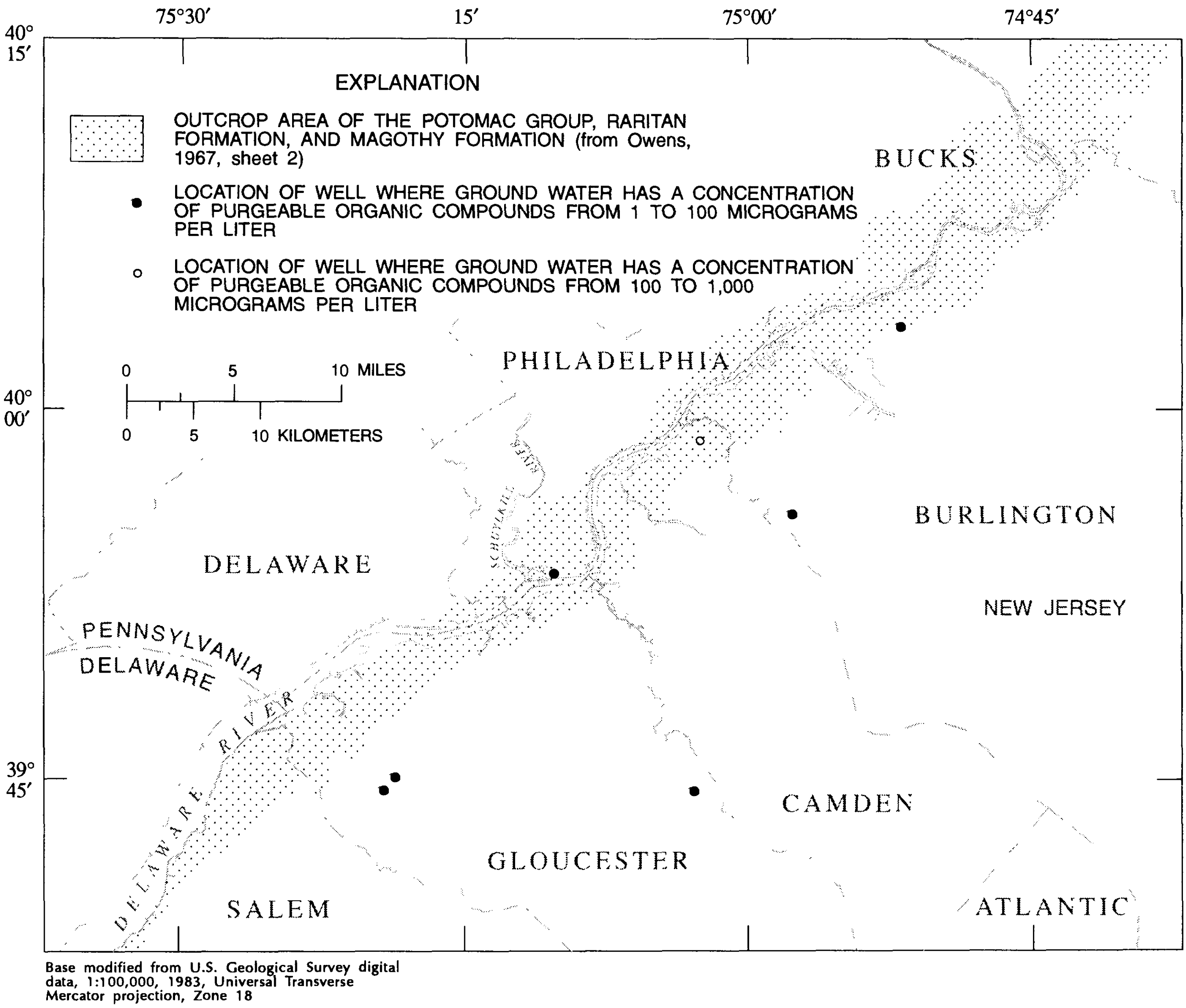


Figure 45.--Concentrations of total purgeable organic compounds in water from the upper aquifer, Potomac-Raritan-Magothy aquifer system, 1980-86.

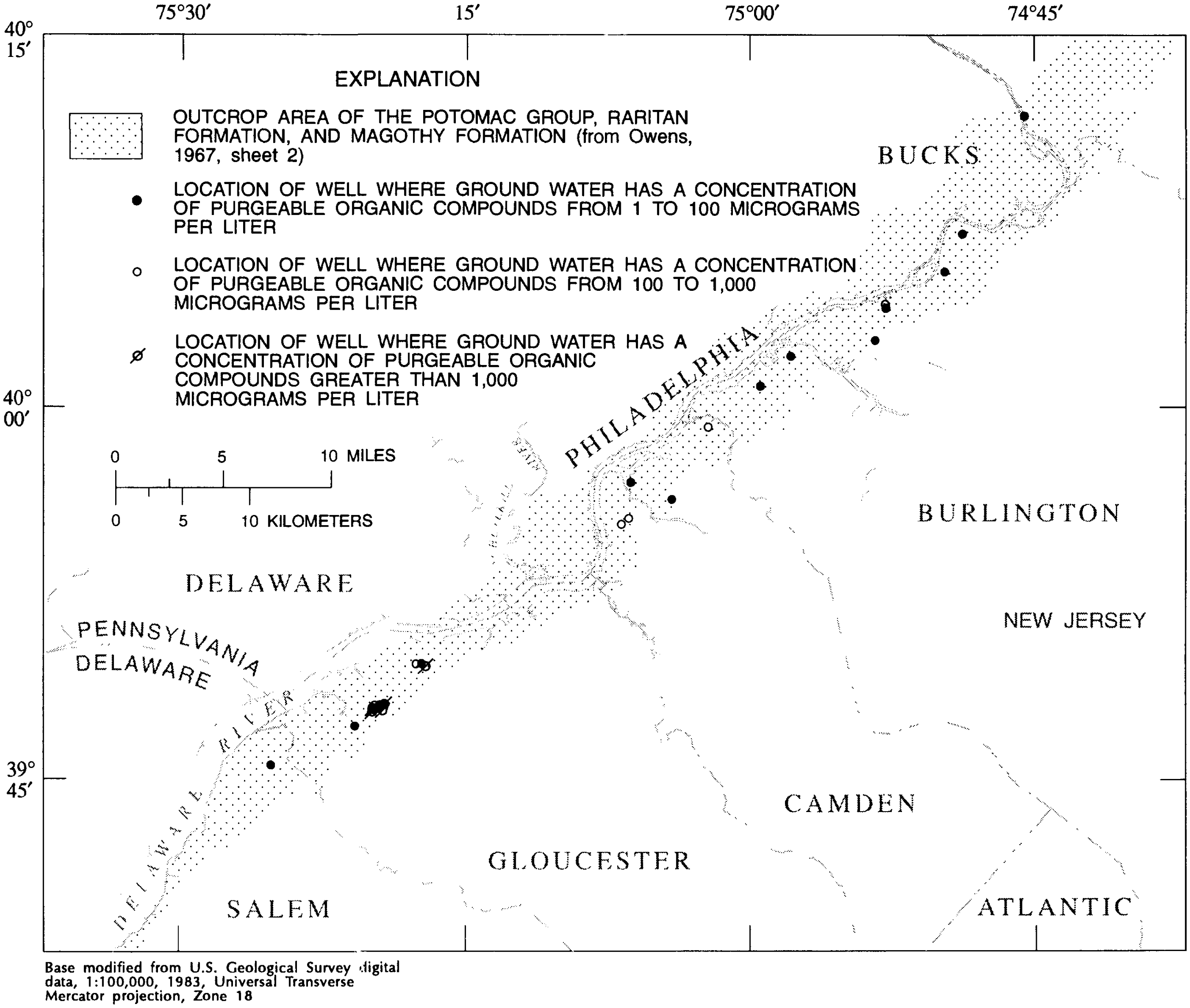
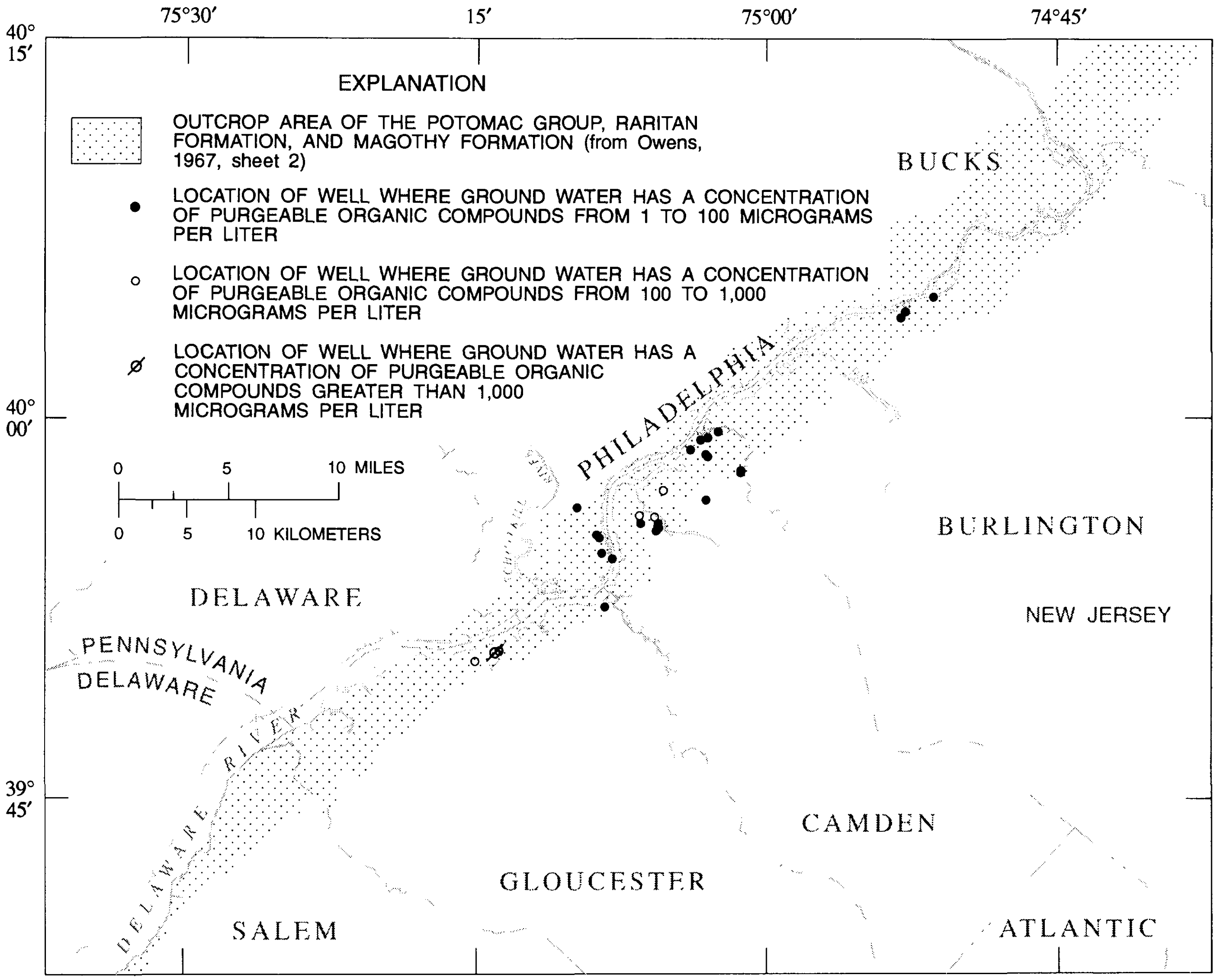


Figure 46.--Concentrations of total purgeable organic compounds in water from the middle aquifer, Potomac-Raritan-Magothy aquifer system, 1980-86.



Base modified from U.S. Geological Survey digital data, 1:100,000, 1983, Universal Transverse Mercator projection, Zone 18

Figure 47.--Concentrations of total purgeable organic compounds in water from the lower aquifer, Potomac-Raritan-Magothy aquifer system, 1980-86.

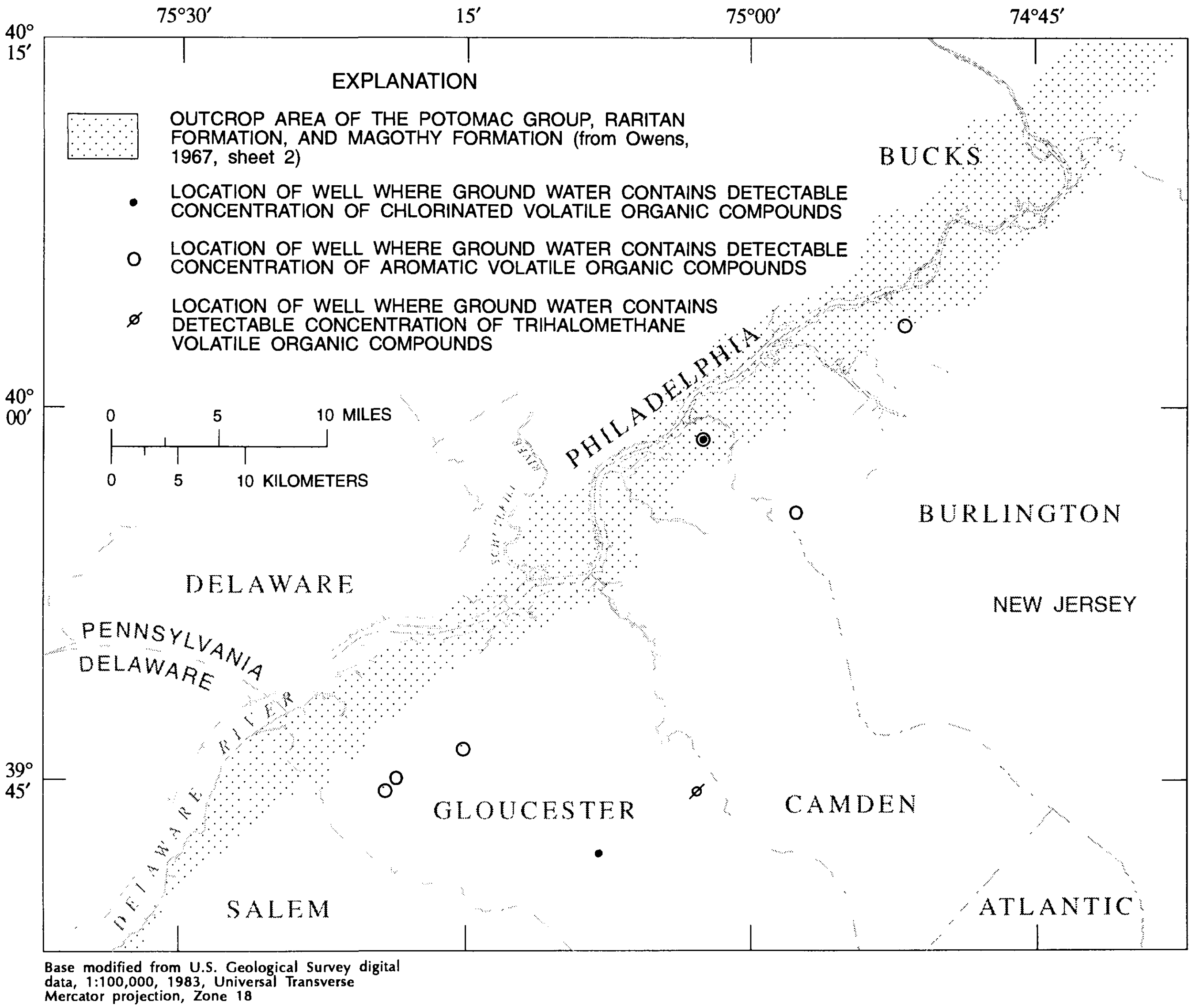


Figure 48.--Chlorinated solvents, aromatic organic compounds, and trihalomethanes in water from the upper aquifer, Potomac-Raritan-Magothy aquifer system, 1980-86.

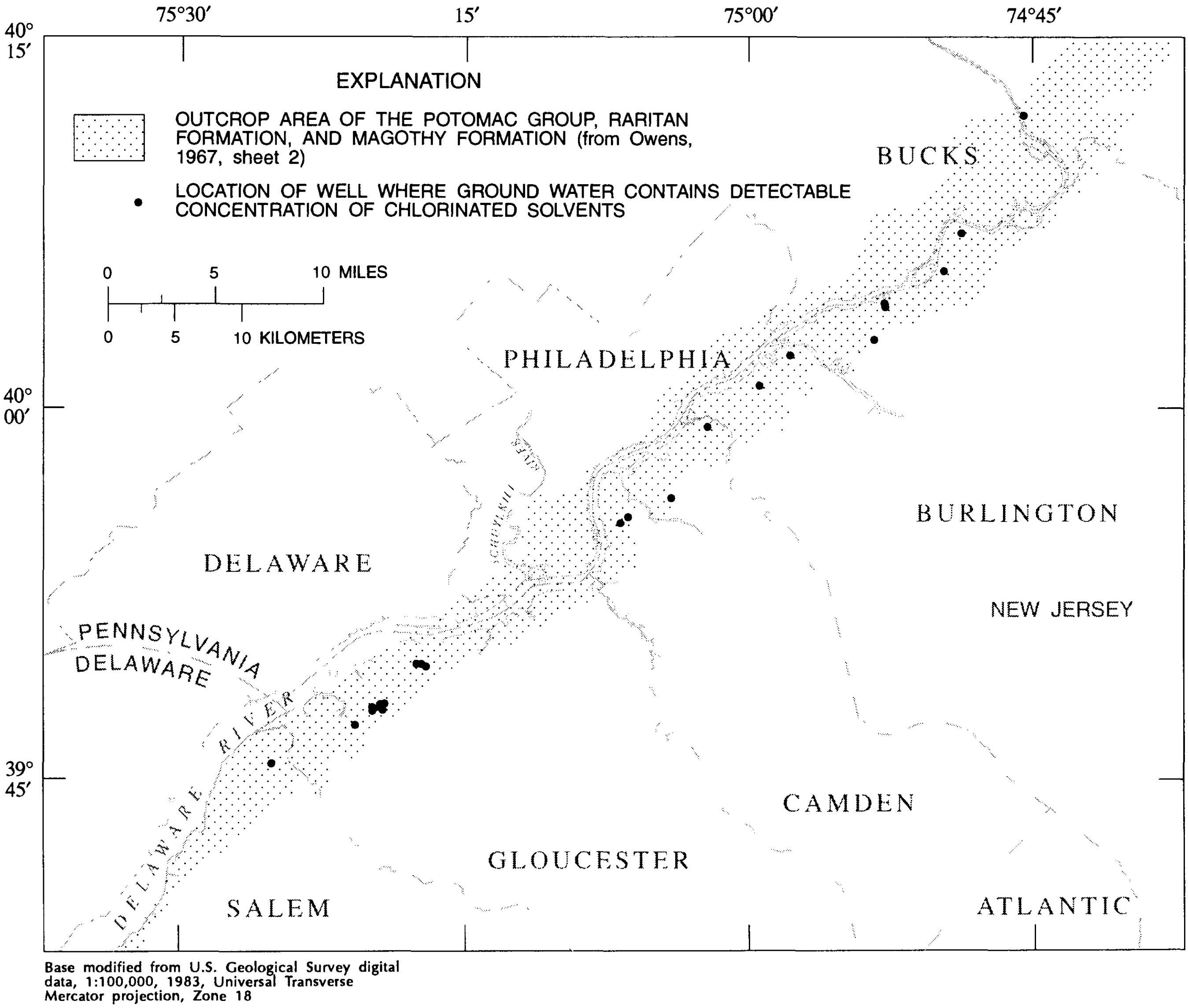


Figure 49.--Chlorinated solvents in water from the middle aquifer, Potomac-Raritan-Magothy aquifer system, 1980-86.

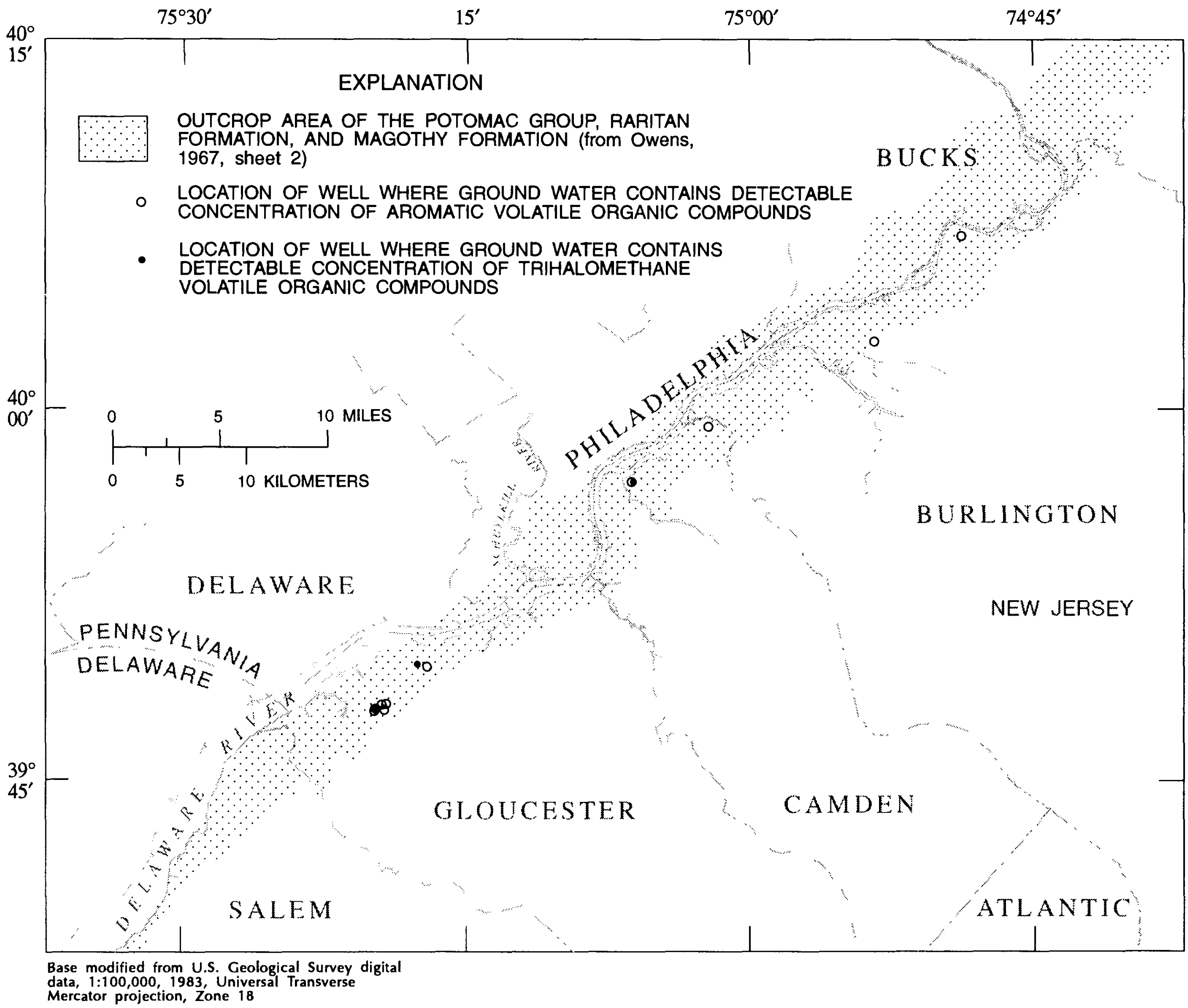
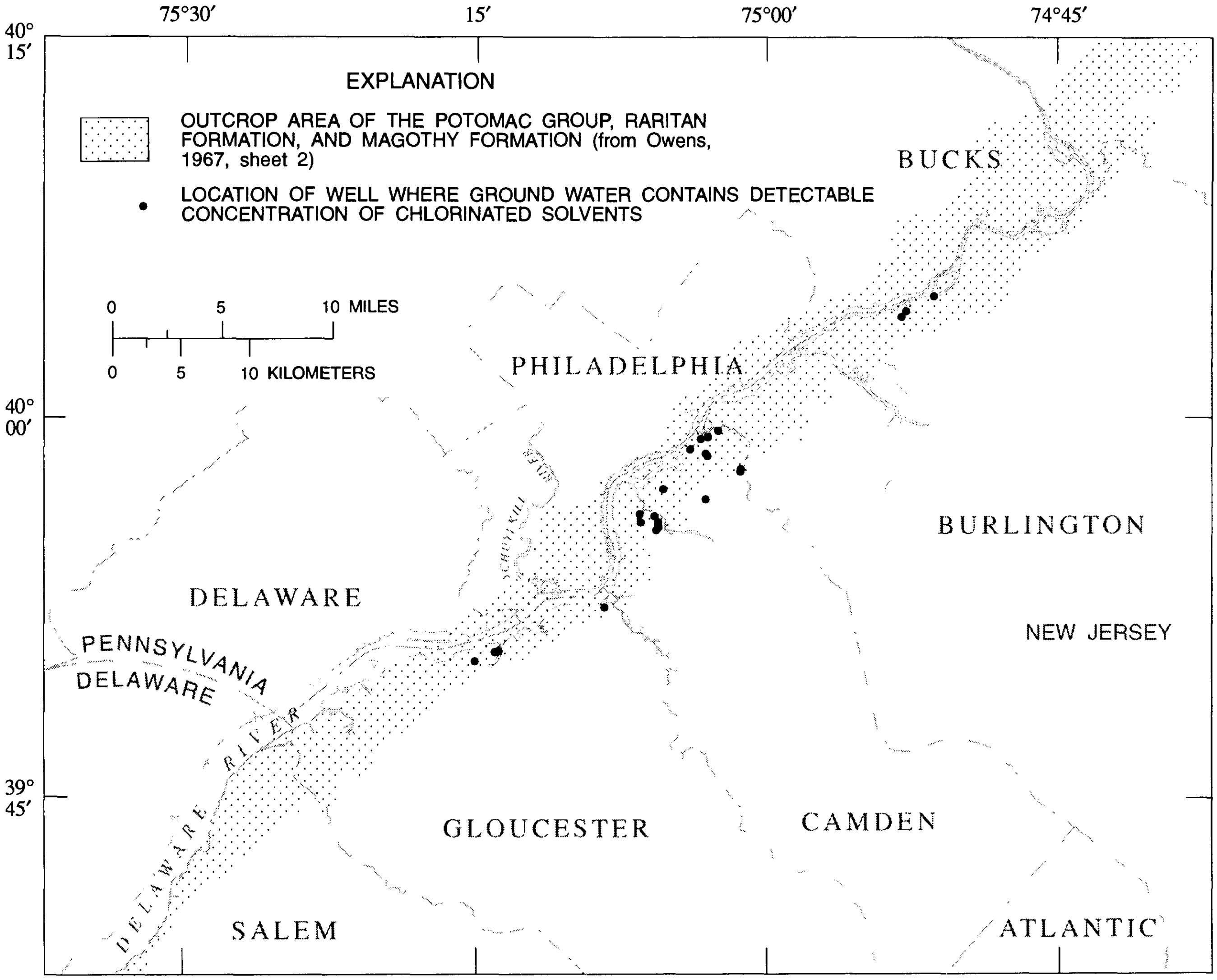


Figure 50.--Aromatic organic compounds and trihalomethanes in water from the middle aquifer, Potomac-Raritan-Magothy aquifer system, 1980-86.



Base modified from U.S. Geological Survey digital data, 1:100,000, 1983, Universal Transverse Mercator projection, Zone 18

Figure 51.--Chlorinated solvents in water from the lower aquifer, Potomac-Raritan-Magothy aquifer system, 1980-86.

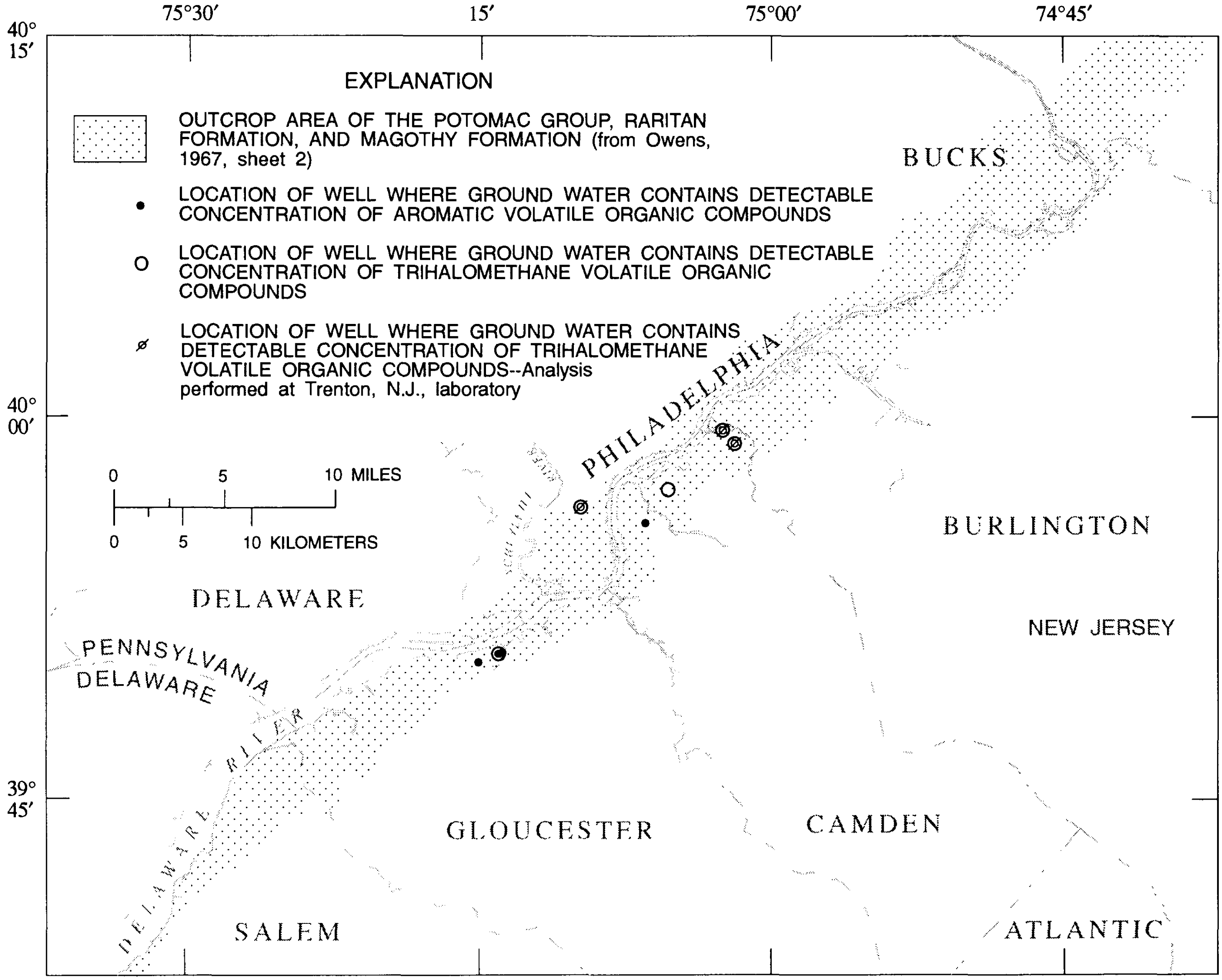


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Figure 52.--Aromatic organic compounds and trihalomethanes in water from the lower aquifer, Potomac-Raritan-Magothy aquifer system, 1980-86.

Table 10.--Summary of data on purgeable organic compounds in water from the Potomac-Raritan-Magothy aquifer system, 1980-86

[POC, purgeable organic compound; detection limit is 3 micrograms per liter; µg/L, micrograms per liter]

Compound name	Total number of samples	Samples containing POC concentrations greater than detection limit		POC concentration, in micrograms per liter	
		Number	Percentage	Median	Maximum
Benzene	356	31	8.7	57.0	43,000
Carbon Tetrachloride	355	4	1.1	145	380
Chlorobenzene	198	19	9.6	19	620
Chloroethane	178	1	<1	<3	7
Chloroform	354	17	4.8	8.4	2,700
Dichlorobromomethane	355	2	<1	6.8	8.8
Ethlybenzene	199	17	8.5	43	680
Methylenechloride	355	21	5.9	27	3,800
Tetrachloroethylene	355	29	8.2	12	820
Toluene	356	25	7.0	18	12,000
Trichloroethylene	355	46	13	26	5,040
Trichlorofluoromethane	198	2	1	14	25
Vinyl Chloride	178	13	7.3	21	393
1,1-Dichloroethylene	198	10	5.0	10.5	120
1,1-Dichloroethane	355	16	4.5	23	200
1,1,1-Trichloroethane	355	15	4.2	19	1,600
1,2-Dichloroethane	355	24	6.8	29.5	1,200
1,2-Dichloropropane	198	4	2	19.5	30
1,2-Dichloroethylene	355	30	8.4	30.5	5,480

the outcrop area of the Potomac-Raritan-Magothy aquifer system, whereas sampling in 1985-86 extended farther downdip. The six most prevalent POC's in ground water in the Philadelphia area, in descending order of concentration, are 1,1,1-trichloroethane, chloroform, tetrachloroethylene, trichloroethylene, 1,2-dichloroethane, and 1,2-dichloropropane (Paulachok, 1991).

The most extensively industrialized part of the study area overlies the outcrop of the Potomac-Raritan-Magothy aquifer system along the Delaware River. Aquifers beneath the outcrop area are among the most vulnerable to contamination in the aquifer system, because confining beds are thin or absent (Zapecza, 1984) and because potentiometric-head gradients are generally downward into the confined parts of the aquifers (Eckel and Walker, 1986).

The locations of seven National Priority List (NPL) sites, also known as Superfund sites, are shown in figure 53. Also shown are 105 additional hazardous-waste sites documented in New Jersey State files as of 1986 (Britton, 1984). Additional sites of potential ground-water contamination exist in the study area; the sites shown, however, have the potential for the greatest effect on the quality of water in the aquifers of the Potomac-Raritan-Magothy aquifer system because of their location in or near the outcrop area. Potential sites of ground-water contamination in Pennsylvania are not shown in figure 53; however, any such sites located in the outcrop area on the Pennsylvania side of the Delaware River also could potentially affect the quality of water in the aquifer system in New Jersey.

SUMMARY AND CONCLUSIONS

This report describes the regional ground-water quality in the upper, middle, and lower aquifers of the Cretaceous Potomac-Raritan-Magothy aquifer system in west-central New Jersey and documents vertical differences in water quality in the three aquifers.

Five types of ground-water zones were located by use of Back's (1966) concept of hydrochemical facies: zones of ground-water recharge, zones of active ground-water flow, zones of ground-water discharge, zones of salt-water intrusion, and a zone of little flow. These zones are related to the regional flow patterns in the Potomac-Raritan-Magothy aquifer system.

Distribution of selected chemical constituents (dissolved solids, dissolved sodium, dissolved chloride, dissolved iron) and pH in water from each aquifer were examined areally. In general, the water in the aquifer system was found to be suitable for human consumption and most other uses, except in areas where contamination is localized and in areas where dissolved-iron concentrations in and near the outcrops are elevated.

The distribution of sodium in water from the Potomac-Raritan-Magothy aquifer system indicates increasing concentrations toward the southwestern part of the study area. Water from wells in Burlington and Camden Counties generally contained low concentrations of sodium (<25 mg/L), although some samples from the outcrop area contained higher concentrations, indicating possible contamination and (or) saltwater intrusion. Areas in which concentrations exceeded the NJGW2 standard of 50 mg/L include parts of Gloucester County, Salem County, and Philadelphia. The largest extent of sodium concentrations greater than 50 mg/L was found in the lower aquifer.

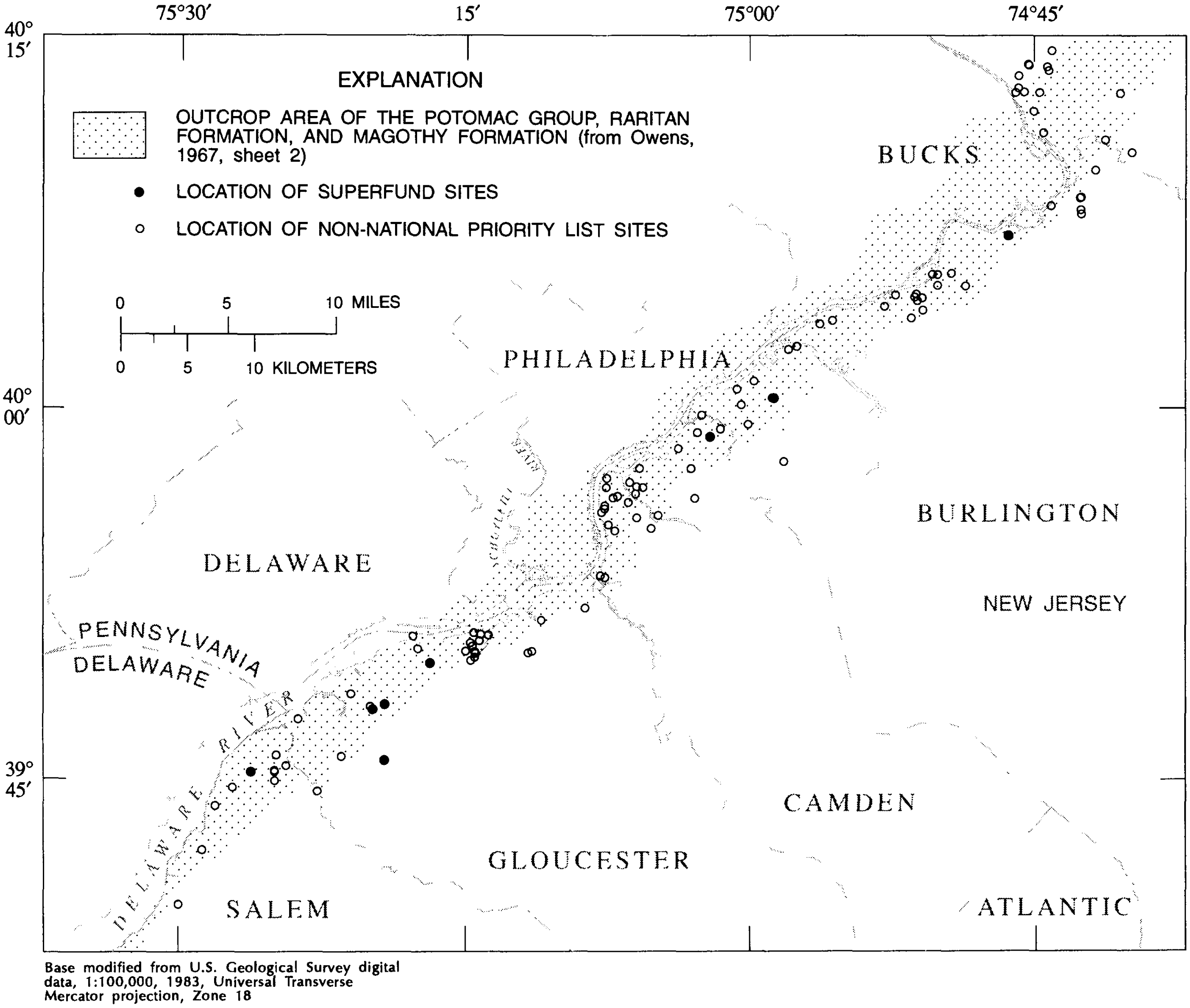

Figure 53.--National Priority List sites and other hazardous-waste sites within 1 mile of the Potomac-Raritan-Magothy outcrop area in New Jersey.

Chloride and dissolved-solids concentrations in a few samples in the study area exceeded the SMCL of the USEPA (1986) of 250 and 500 mg/L, respectively. Like concentrations of dissolved sodium, chloride and dissolved solids concentrations were elevated in water from wells in Gloucester and Salem Counties and in areas of possible contamination and (or) saltwater intrusion.

Dissolved-iron concentrations exceeded the SMCL of the USEPA (1986) of 300 μg/L in many of the water samples from the Potomac-Raritan-Magothy aquifer system, particularly those from the outcrop area. These high iron concentrations are a major ground-water-quality problem, and many wells have been abandoned in affected areas because screens or pumps have become clogged by iron. In general, dissolved-iron concentrations greater than 300 μg/L also indicate high dissolved-manganese concentrations in the water from the confined parts of the Potomac-Raritan-Magothy aquifer system. This relation holds true for the middle and lower aquifers.

The areal distribution of pH in water from the Potomac-Raritan-Magothy aquifer system shows that, in general, pH increases with increasing distance downdip from the outcrop area. Water in the upper aquifer is more alkaline than the water in the other aquifers and has fewer samples outside the SMCL of the USEPA (1986) range of 6.5 to 8.5. The pH of the majority of water samples from the middle and lower aquifers is less than 6.5 and, therefore, is outside the SMCL of the USEPA (1986) range.

Examination and interpretation of ground-water chemistry, ground-water-flow, and potentiometric-head relations reveals an anomalous area in the middle and lower aquifers in northeastern Camden County and northwestern Burlington County, where water is characterized by low dissolved-solids concentrations, low pH, high dissolved-oxygen concentrations, and low dissolved-iron concentrations. Vertical leakage of oxygen-rich ground water through the confining unit in the ground-water-flow system appears to be greater in this location than elsewhere in the study area. This oxygen-rich ground water probably is mixing with anoxic ground water and causing the precipitation of iron.

Examination of trace-element concentrations in water from the Potomac-Raritan-Magothy aquifer system indicates that these elements generally were present in concentrations less than MCL of USEPA (1986)'s. The most common trace-element contaminant was cadmium; however, the number of wells at which cadmium concentrations exceeded the MCL of USEPA (1986) was less than 5.

Nitrate concentrations greater than the MCL of USEPA (1986) of 10 mg/L were not common in water from the Potomac-Raritan-Magothy aquifer system; however, ammonia concentrations greater than 10 mg/L were common in samples. Most of the samples that contained ammonia concentrations greater than 10 mg/L are in or near the outcrop of the Potomac-Raritan-Magothy aquifer system and are indicative of localized contamination.

Elevated concentrations of dissolved manganese, dissolved iron, dissolved sulfate, and dissolved solids, and decreased pH values were found in water from the lower aquifer near Red Bank and Gloucester City, N.J., across the Delaware River from the U.S. Naval Base in Philadelphia. Poor-quality water could be migrating from the Philadelphia area under the Delaware River to the

New Jersey parts of the aquifers in response to changes in potentiometric head distribution, although the exact origin of the elevated concentrations is unknown. Other possible sources of elevated concentrations of dissolved manganese, dissolved iron, and dissolved solids include leaching of constituents from the aquifer matrix by ground water containing low concentrations of dissolved oxygen and low pH values and (or) downward migration of chemical constituents in ground water in the Potomac-Raritan-Magothy aquifer system outcrop.

Results of analyses for POC's in water from the Potomac-Raritan-Magothy aquifer system indicate that most samples in which POC's were detected were from wells in or near the outcrop of the aquifer system. Water samples from the lower aquifer had a higher incidence of POC with concentrations greater than 100 $\mu g/L$ than did samples from the other aquifers. This contamination is a result of the location of the outcrop of the aquifer beneath the most extensively urbanized section of the area, and leakage from the upper and middle aquifers through discontinuous confining units. Seven NPL sites are located in or within 1 mile of the generalized Potomac-Raritan-Magothy aquifer system outcrop.

Potential threats to the quality of the ground water in the Potomac-Raritan-Magothy aquifer system in the study area include (1) the flow of saline, downdip water toward production wells as a result of pumping; (2) the intrusion of saline water from the Delaware River estuary in response to drought or rising sea level; (3) the possible migration of poor-quality water underneath the Delaware River from Philadelphia in response to the regional cone of depression and changes in potentiometric-head relations; and (4) continued contamination of ground water in and near the outcrop as a result of human activities.

REFERENCES CITED

Anderson, P.W., Faust, S.D., and McCall, J.E., 1972, Impact of drought on New Jersey's water resources: Journal of the Irrigation and Drainage Division, American Society of Civil Engineers, v. 98, no. IR3, Proceedings Paper 9205, p. 375-385.

Back, William, 1966, Hydrochemical facies and ground-water flow patterns in the northern part of Atlantic Coastal Plain: U.S. Geological Survey Professional Paper 498-A, 42 p.

Barksdale, H.C., Greenman, D.W., Lang, S.M., Hilton, G.S., and Outlaw, D.E., 1958, Ground-water resources in the tri-state region adjacent to the lower Delaware River: New Jersey Department of Conservation and Economic Development Special Report 13, 190 p.

Britton, C.L., compiler, 1984, New Jersey ground-water pollution index: September 1974 - April 1984: New Jersey Geological Survey Open-File Report 84-1, 143 p.

Delaware River Basin Commission, 1983, Resolution 83-11--A resolution to amend the Comprehensive Plan relating to criteria for defining drought warning and drought conditions, and to a schedule of phased reductions in diversions, releases and flow objectives during such periods: West Trenton, N.J., Delaware River Basin Commission, June 29, 1983.

Delaware Valley Regional Planning Commission, 1979, 208 water quality management report on alternatives, Burlington, Camden and Gloucester Counties, New Jersey: Philadelphia, Pa., Delaware Valley Regional Planning Commission, 137 p.

Eckel, J.A., and Walker, R.L., 1986, Water levels in the major artesian aquifers of the New Jersey Coastal Plain, 1983: U.S. Geological Survey Water-Resources Investigations Report 86-4028, 62 p.

Farlekas, G.M., Nemickas, Bronius, and Gill, H.E., 1976, Geology and ground-water resources of Camden County, New Jersey: U.S. Geological Survey Water-Resources Investigations Report 76-76, 146 p.

Feth, J.H., 1981, Chloride in natural continental water--A review: U.S. Geological Survey Water-Supply Paper 2176, 30 p.

Fishman, M.J., and Friedman, L.C., 1989, Methods for determination of inorganic substances in water and fluvial sediments: U.S. Geological Survey Techniques of Water-Resources Investigations, book 5, chap. A1, 545 p.

Freeze, R.A., and Cherry, J.A., 1979, Ground water: Englewood Cliffs, N.J., Prentice-Hall, 604 p.

Friedman, L.C., and Erdmann, D.E., 1982, Quality assurance practices for the chemical and biological analysis of water and fluvial sediments: U.S. Geological Survey Techniques of Water-Resources Investigations, book 5, chap. A6, 181 p.

Fusillo, T.V., and Voronin, L.M., 1981, Water-quality data for the Potomac-Raritan-Magothy aquifer system, Trenton to Pennsville, New Jersey: U.S. Geological Survey Open-File Report 81-814, 38 p.

Fusillo, T.V., Hochreiter, J.J., Jr., and Lord, D.G., 1984, Water-quality data for the Potomac-Raritan-Magothy aquifer system in southwestern New Jersey, 1923-83: U.S. Geological Survey Open-File Report 84-737, 127 p.

_____ 1985, Distribution of volatile organic compounds in a New Jersey Coastal Plain aquifer system: Ground Water, v. 23, no. 3, p. 354-360.

Graham, J.B., and Kammerer, J.C., 1952, Ground-water resources of the United States Naval Base, Philadelphia, Pennsylvania: U.S. Geological Survey Open-File Report, unnumbered, 137 p.

Greenman, D.W., Rima, D.R., Lockwood, W.N., and Meisler, Harold, 1961, Ground-water resources of the Coastal Plain area of southeastern Pennsylvania: Pennsylvania Geological Survey Bulletin, 4th series, W 13, 375 p.

Hantush, M.S., 1960, Modification of the theory of leaky aquifers: Journal of Geophysical Research, v. 65, no. 11, p. 3713-3725.

Hardt, W.F., and Hilton, G.S., 1969, Water resources and geology of Gloucester County, New Jersey: New Jersey Department of Conservation and Economic Development Special Report 30, 130 p.

Harbaugh, A.W., Luzier, J.E., and Stellerine, Flavian, 1980, Computer-model analysis of the use of Delaware River water to supplement water from the Potomac-Raritan-Magothy aquifer system in southern New Jersey: U.S. Geological Survey Water-Resources Investigations Report 80-31, 41 p.

Heath, R.C., 1984, Basic ground-water hydrology: U.S. Geological Survey Water-Supply Paper 2220, 84 p.

Hem, J.D., 1985, Study and interpretation of the chemical characteristics of natural water (3d ed): U.S. Geological Survey Water-Supply Paper 2254, 263 p.

Hochreiter, J.J., Jr., 1982, Chemical-quality reconnaissance of the water and surficial bed material in the Delaware River estuary and adjacent New Jersey tributaries, 1980-81: U.S. Geological Survey Water-Resources Investigations Report 82-36, 41 p.

Hoffman, J.S., Keyes, D., and Titus, J.G., 1983, Predicting future sea level rise: Methodology, estimates to the year 2100, and research needs, 2d ed.: Environmental Protection Agency, Office of Policy and Resource Management, 121 p.

Keith, L.H., and Telliard, W.A., 1979, Priority pollutants I - a perspective view: Environmental Science and Technology, v. 13, no. 4, April 1979, p. 416-419.

Langmuir, Donald, 1969, Iron in ground waters of the Magothy and Raritan Formation in Camden and Burlington Counties, New Jersey: State of New Jersey Department of Conservation and Economic Development, Division of Water Policy and Supply Water Resources Circular 19, 49 p.

Lohman, S.W., and others, 1972, Definitions of selected ground-water terms--Revisions and conceptual refinements: U.S. Geological Survey Water-Supply Paper 1988, 21 p.

Luzier, J.E., 1980, Digital-simulation and projection of head changes in the Potomac-Raritan-Magothy aquifer system, Coastal Plain, New Jersey: U.S. Geological Survey Water-Resources Investigations Report 80-11, 72 p.

Martin, Mary, 1990, Ground-water flow in the New Jersey Coastal Plain aquifers: U.S. Geological Survey Open-File Report 87-528, 182 p.

McAuley, S.D., and Kendall, Carol, 1989, Use of deuterium and oxygen-18 to trace the induced infiltration of Delaware River water into the Potomac-Raritan-Magothy aquifer system, Camden area, New Jersey, in Pederson, G.L., and Smith, M.M., compilers, U.S. Geological Survey Second National Symposium on Water Quality--Abstracts of the technical sessions, Orlando, Florida, November 12-17, 1989: U.S. Geological Survey Open-File Report 89-409, p. 56.

Meisler, Harold, Leahy P.P., and Knobel, L.L., 1984, Effect of eustatic sea-level changes on saltwater-freshwater relations in the northern Atlantic Coastal Plain: U.S. Geological Survey Water-Supply Paper 2255, 28 p.

Meisler, Harold, 1989, The occurrence and geochemistry of salty ground water in the northern Atlantic Coastal Plain: U.S. Geological Survey Professional Paper 1404-D, 51 p.

Myers, W.S., 1899, Chlorine in the natural waters of the State, in Smock, J.C., ed., Annual report of the State Geologist for the year of 1899, Geological Survey of New Jersey, 192 p.

Owens, J.P., 1967, Engineering geology of the northeast corridor, Washington, D.C., to Boston, Massachusetts--Coastal Plain and surficial deposits: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-514-B, scale 1:250,000 and 1:1,500,000, 8 sheets.

Owens, J.P., and Sohl, N.F., 1969, Shelf and deltaic paleo-environments in the Cretaceous-Tertiary formations of the New Jersey Coastal Plain, in Subitzky, Seymour, ed., Geology of the selected areas in New Jersey and eastern Pennsylvania and guidebook of excursions--Geological Society of America and associated societies, November 1969, Annual Meeting, Atlantic City, N.J.: New Brunswick, N.J., Rutgers University Press, p. 235-278.

Parker, G.G., Hely, A.G, Keighton, W.B., Olmsted, F.H., and others, 1964, Water resources of the Delaware River basin: U.S. Geological Survey Professional Paper 381, 200 p.

Paulachok, G.N., 1991, Geohydrology and ground-water resources of Philadelphia, Pennsylvania: U.S. Geological Survey Professional Paper 2346, 79 p.

Rosenau, J.C., Lang, S.M., Hilton, G.S., and Rooney, J.G., 1969, Geology and ground-water resources of Salem County, New Jersey: New Jersey Department of Conservation and Economic Development Special Report 33, 142 p.

Rush, F.E., 1968, Geology and ground-water resources of Burlington County, New Jersey: New Jersey Department of Conservation and Economic Development, Division of Water Policy and Supply Special Report 26, 65 p.

Schaefer, F.L., 1983, Distribution of chloride concentrations in the principal aquifers of the New Jersey Coastal Plain, 1977-81: U.S. Geological Survey Water-Resources Investigations Report 83-4061, 56 p.

Seaber, P.R., 1963, Chloride concentrations of water from wells in the Atlantic Coastal Plain of New Jersey, 1923-61: New Jersey Department of Conservation and Economic Development, Division of Water Policy and Supply Special Report 22, 250 p.

Stumm, Werner, and Morgan, J.J., 1981, Aquatic chemistry--An introduction emphasizing chemical equilibria in natural waters: New York, John Wiley and Sons, 780 p.

Thompson, D.G., 1932, Ground-water supplies of the Camden area, New Jersey: New Jersey Department of Conservation and Economic Development, Division of Water Policy and Supply Bulletin 39, 80 p.

U.S. Environmental Protection Agency, 1982, Methods for organic chemical analysis of municipal and industrial wastewater: Environmental Monitoring and Support Laboratory, USEPA 600/4-82-057 (unpaged).

_____ 1986, Quality criteria for water, 1986: Washington, D.C., U.S. Environmental Protection Agency, Office of Water Regulations and Standards, USEPA-440/5-86-001, 398 p.

Vecchioli, John, and Palmer, M.M., 1962, Ground-water resources of Mercer County, New Jersey: New Jersey Department of Conservation and Economic Development Special Report 19, 71 p.

Vowinkel, E.F., and Foster, W.K., 1981, Hydrogeologic conditions in the Coastal Plain of New Jersey: U.S. Geological Survey Open-File Report 81-405, 39 p.

Walker, R.L., 1983, Evaluation of water levels in major aquifers of the New Jersey Coastal Plain, 1978: U.S. Geological Survey Water-Resources Investigations Report 82-4077, 56 p.

Winograd, I.J., and Farlekas, G.M., 1974, Problems in ^{14}C dating of water from aquifers of deltaic origin--An example from the New Jersey Coastal Plain, in Isotope techniques in ground water hydrology: Vienna, International Atomic Energy Agency, v. 2, p. 69-93.

Zapecza, O.S., 1989, Hydrogeologic framework of the New Jersey Coastal Plain: U.S. Geological Survey Professional Paper 1404-B, 49 p., 24 pls.

Table 2.--Records of wells sampled, Potomac-Raritan-Magothy aquifer system, 1985-86

Well number	Local well identifier	Municipality	Latitude	Longitude	Altitude of land surface (feet)	Screened interval[1] (feet)	Year drilled	Aquifer[2] unit	Use of[3] site	Use of[4] water
5- 39	NJ WC-DEL VALLEY WC 15	BEVERLY CITY	400404	745520	12	47 - 57	1951	MRPAU	W	P
5- 40	NJ WC-DEL VALLEY WC 16	BEVERLY CITY	400405	745517	18	39 - 51	1910	MRPAM	W	P
5- 60	BURLINGTON CITY WC 2	BURLINGTON CITY	400538	745053	21	33 - 49	1952	MRPAU	W	P
5- 76	HEAL, CHARLES	BURLINGTON TWP	400324	745152	50	59 - 80	1955	MRPAU	W	I
5- 89	TENNECO CHEM 7	BURLINGTON TWP	400409	745247	10	100 - 130	1971	MRPAM	W	N
5- 91	TENNECO CHEM 4	BURLINGTON TWP	400418	745250	14	82 - 112	1964	MRPAM	W	N
5- 97	HERCULES POWDER 1	BURLINGTON TWP	400524	744951	22	105 - 135	1946	MRPAM	W	N
5-100	HERCULES POWDER 2	BURLINGTON TWP	400535	744941	22	105 - 135	1946	MRPAM	W	N
5-124	NJ WC-DEL VALLEY WC-STPHEN	CINNAMINSON TWP	395906	750006	30	221 - 267	1970	MRPAL	W	P
5-125	NJ WC-DEL VALLEY WC 11	CINNAMINSON TWP	395929	745922	79	239 - 281	1959	MRPAM	W	P
5-167	EVESHAM MUA 5	EVESHAM TWP	395247	745157	50	458 - 548	1973	MRPAU	W	P
5-187	FLORENCE TWP WD 4	FLORENCE TWP	400703	744832	30	119 - 134	1948	MRPAM	W	P
5-261	USGS-MEDFORD 5 OBS	MEDFORD TWP	395525	745025	72	740 - 750	1967	MRPAM	O	U
5-284	MOORESTOWN TWP WD 4	MOORESTOWN TWP	395936	745452	59	298 - 338	1959	MRPAM	W	P
5-393	RIVERSIDE INDUSTRY 39	RIVERSIDE TWP	400212	745748	15	54 - 67	1952	MRPAM	W	N
5-658	WILLINGBORO MUA 7	WILLINGBORO TWP	400201	745308	19	179 - 255*	1958	MRPAM	W	P
5-667	WILLINGBORO MUA 5	WILLINGBORO TWP	400250	745321	39	230 - 256	1958	MRPAM	W	P
5-758	TENNECO CHEM 10	BURLINGTON TWP	400418	745255	10	114**		MRPAM	W	N
5-780	WASTE RESOURCE OBS 6	CINNAMINSON TWP	400106	745915	40	30 - 50	1978	MRPAM	O	U
5-822	MT LAURAL MUA 3	MOUNT LAUREL TWP	395620	745529	35	592 - 642	1974	MRPAL	W	P
5-823	MT LAURAL MUA 4	MOUNT LAUREL TWP	395615	745512	35	590 - 640	1974	MRPAL	W	P
7- 8	BELMAWR BORO WD 1	BELLMAWR BORO	395146	750542	75	380 - 557*	1966	MRPAL	W	P
7- 12	BELMAWR BORO WD 3	BELLMAWR BORO	395221	750637	35	331 - 359	1956	MRPAL	W	P
7- 18	BERLIN BORO WD 9	BERLIN BORO	394738	7456141	45	650 - 713	1955	MRPAU	W	P
7- 30	SJ PORT COMM NY SHIP 5A	CAMDEN CITY	395447	750711	11	87 - 104	1940	MRPAU	O	U
7- 46	CAMDEN CITY WD-CITY 11	CAMDEN CITY	395512	750640	13	124 - 154	1942	MRPAM	W	P
7- 64	CAMDEN CITY WD-CITY 17	CAMDEN CITY	395546	750533	34	230 - 265	1954	MRPAL	W	P
7- 98	NEW JERSEY WC-CAMDEN 52	CAMDEN CITY	395715	750519	18	147 - 198	1965	MRPAL	W	P
7-122	NEW JERSEY WC-BROWN 44	CHERRY HILL TWP	395252	745943	80	684 - 741*	1974	MRPAL	W	P
7-124	NEW JERSEY WC-BROWN 45	CHERRY HILL TWP	395252	745943	77	483 - 626*	1973	MRPAM	W	P
7-134	NEW JERSEY WC-OLD ORCH 37	CHERRY HILL TWP	395353	745708	68	454 - 488	1968	MRPAM	W	P
7-143	NEW JERSEY WC-ELLISBG 16	CHERRY HILL TWP	395441	750104	40	187 - 220	1957	MRPAU	W	P
7-147	NEW JERSEY WC-KINGSTN 25	CHERRY HILL TWP	395455	745929	44	309 - 367	1961	MRPAM	W	P
7-183	NEW JERSEY WC-GIBBSBO 43	GIBBSBORO BORO	394945	745855	70	923 -1011	1972	MRPAL	W	P
7-189	NEW JERSEY WC-GIBBSBO 41	GIBBSBORO BORO	395003	745851	65	1022 -1097	1972	MRPAL	W	P
7-221	USGS-GLOUC CTY CG BASE 1	GLOUCESTER CITY	395356	750738	11	162 - 170	1966	MRPAL	O	U
7-249	GARDEN ST WC-BLACKWOOD 3	GLOUCESTER TWP	394754	750343	81	426 - 447	1956	MRPAU	W	P
7-273	NEW JERSEY WC-OTTERBK 29	GLOUCESTER TWP	395030	750347	60	612 - 712	1965	MRPAL	W	P
7-274	NEW JERSEY WC-OTTERBK 39	GLOUCESTER TWP	395030	750347	60	269 - 349	1968	MRPAU	W	P
7-278	NEW JERSEY WC-HADDON 15	HADDON HGTS BORO	395238	750316	65	452 - 594	1956	MRPAL	W	P
7-283	NEW JERSEY WC-EGBERT OBS	HADDON HGTS BORO	395246	750434	23	445 - 455	1962	MRPAL	O	U
7-302	HADDONFLD BORO WD-RULON	HADDONFIELD BORO	395319	750140	25	523 - 572	1956	MRPAL	W	P
7-304	HADDONFLD BORO WD-LAKE ST	HADDONFIELD BORO	395404	750202	50	307 - 372*	1967	MRPAL	W	P
7-315	NEW JERSEY WC-MAGNOLIA 16	MAGNOLIA BORO	395134	750229	78	428 - 510	1964	MRPAM	W	P
7-329	MERCH-PENN WCOM-BROWN 2A	PENNSAUKEN TWP	395628	750406	16	110 - 140	1965	MRPAM	W	P
7-341	MERCH-PENN WCOM-DEL GN 2	PENNSAUKEN TWP	395800	750417	39	115 - 145	1954	MRPAM	W	P
7-345	MERCH-PENN WCOM-PARK 5	PENNSAUKEN TWP	395758	750120	20	248 - 288	1948	MRPAL	W	P
7-350	MERCH-PENN WCOM-PARK 2	PENNSAUKEN TWP	395802	750118	12	232 - 257	1943	MRPAL	W	P
7-354	PETTY ISLAND OBS	PENNSAUKEN TWP	395811	750556	11	78**	1949	MRPAL	O	U
7-367	CAMDEN CITY WD-PUCHACK	PENNSAUKEN TWP	395840	750307	10	127 - 175	1924	MRPAL	W	P
7-369	CAMDEN CITY WD-DELAIR 2	PENNSAUKEN TWP	395851	750355	5	109 - 144	1930	MRPAL	W	P
7-372	MERCH-PENN WCOM-NAT HWY 1	PENNSAUKEN TWP	395902	750153	40	195 - 230*	1967	MRPAL	W	P
7-379	CAMDEN CITY WD-MORRIS 10	PENNSAUKEN TWP	395919	750302	16	75 - 115	1960	MRPAL	W	P
7-386	CAMDEN CITY WD-MORRIS 3A	PENNSAUKEN TWP	395933	750229	10	73 - 103	1953	MRPAL	W	P
7-412	NEW JERSEY WC-ELM TREE 2	VOORHEES TWP	394922	7456301	48	1082 -1092	1963	MRPAL	O	U
7-477	USGS-NEW BROOKLYN PK 2 OBS	WINSLOW TWP	394215	7456171	11	829 - 839	1961	MRPAU	O	U
7-527	CAMDEN CITY WD-CITY 18	CAMDEN CITY	395550	750537	40	258 - 288	1976	MRPAL	W	P
7-528	CAMDEN CITY WD-PUCHACK 7	PENNSAUKEN TWP	395835	750302	20	140 - 180	1975	MRPAL	W	P
7-545	CAMDEN CITY WD-MORRIS 11	PENNSAUKEN TWP	395900	750325	10	102 - 144	1979	MRPAL	W	P
7-555	PENLER ANODIZING CO 1	CAMDEN CITY	395850	750230	50	75 - 80	1968	MRPAU	W	N
7-566	NJDEP-HARRISON AVE 6	CAMDEN CITY	395718	750605	15	20 - 40	1980	MRPAM	O	U
7-567	NJDEP-HARRISON AVE 7	CAMDEN CITY	395718	750605	15	102 - 122	1980	MRPAL	O	U
7-571	PENNSAUKN LANDFILL MON 4	PENNSAUKEN TWP	395912	750248	21	47 - 48	1979	MRPAM	O	U
7-586	CAMDEN CITY WD-MORRIS 12	PENNSAUKEN TWP	395914	750324	10	86 - 117*	1981	MRPAL	W	P
7-602	MERCH-PENN WCOM HWY 2	PENNSAUKEN TWP	395917	750125	25	182 - 206	1982	MRPAL	W	P

Table 2.--Records of wells sampled, Potomac-Raritan-Magothy aquifer system, 1985-86--Continued

Well number	Local well identifier	Municipality	Latitude	Longitude	Altitude of land surface (feet)	Screened interval[1] (feet)	Year drilled	Aquifer[2] unit	Use of[3] site	Use of[4] water
15- 1	CLAYTON BORO WD 3	CLAYTON BORO	393913	750517	133	746 - 800*	1956	MRPAU	W	P
15- 24	DEPTFORD TWP MUA 4	DEPTFORD TWP	395115	750706	40	282 - 345	1971	MRPAM	W	P
15- 28	E GREENWICH TWP WD 2	E GREENWICH TWP	394755	751327	70	191 - 216	1956	MRPAU	W	P
15- 63	GLASSBORO BORO WD 4	GLASSBORO BORO	394308	750702	150	549 - 599	1961	MRPAU	W	P
15- 69	GREENWICH TWP WD 3	GREENWICH TWP	394920	751619	10	108 - 168	1959	MRPAM	W	P
15- 79	EI DUPONT REPAUNO 6	GREENWICH TWP	394944	751734	10	84 - 109	1967	MRPAM	W	N
15- 97	HERCULES CHEM GIBB 8 OBS	GREENWICH TWP	395000	751636	5	102 - 107	1954	MRPAM	O	U
15-109	MOBIL OIL-GREENWICH 40	GREENWICH TWP	395027	751503	20	226 - 259	1946	MRPAL	W	N
15-118	MOBIL OIL-GREENWICH 47	GREENWICH TWP	395036	751501	20	220 - 240	1953	MRPAL	W	N
15-130	SO JERSEY WC 3	HARRISON TWP	394408	751330	35	234 - 265	1953	MRPAU	W	P
15-192	MANTUA MUA 5	MANTUA TWP	394641	751109	88	315 - 337	1957	MRPAU	W	P
15-210	PAULSBORO WD 6-1973	PAULSBORO BORO	394921	751417	15	185 - 227*	1973	MRPAM	W	P
15-253	WASHINGTON TWP MUA 6-64	WASHINGTON TWP	394437	750249	152	584 - 652	1964	MRPAU	W	P
15-276	W DEPTFORD TWP WD 4	WEST DEPTFORD TWP	394821	751026	60	242 - 288	1963	MRPAU	W	P
15-282	W DEPTFORD TWP 5	WEST DEPTFORD TWP	394913	751105	55	388 - 450	1973	MRPAL	W	P
15-283	SHELL CHEM CO 3	WEST DEPTFORD TWP	394919	751256	30	358 - 383	1962	MRPAL	W	N
15-308	PENWALT CORP TW 8	WEST DEPTFORD TWP	395044	751242	10	231 - 271	1969	MRPAL	T	U
15-312	W DEPTFORD TWP WD 6	WEST DEPTFORD TWP	395107	750946	20	322 - 372	1973	MRPAL	W	P
15-314	TEXACO EAGLE PT 6-PROD	WEST DEPTFORD TWP	395153	750946	15	280 - 318	1949	MRPAL	W	N
15-323	TEXACO EAGLE PT 3-OBS	WEST DEPTFORD TWP	395235	750950	20	255 - 275	1948	MRPAL	O	U
15-331	WOODBURY WD RAILROAD 5	WOODBURY CITY	394955	750908	35	405 - 457	1960	MRPAL	W	P
15-342	DEL MONTE CORP 10	WOOLWICH TWP	394438	751914	60	192 - 279	1967	MRPAU	W	F
15-347	GREENWICH TWP WD 5	GREENWICH TWP	394932	751722	20	82 - 117	1977	MRPAM	W	P
15-348	GREENWICH TWP WD 6	E GREENWICH TWP	394910	751541	20	105 - 135	1978	MRPAU	W	P
15-374	DEPTFORD TWP MUA 6	DEPTFORD TWP	394843	750728	50	430 - 486	1979	MRPAM	W	P
15-385	PITMAN WD 4	PITMAN BORO	394345	750804	125	520**	1980	MRPAU	W	P
15-390	GLOUCESTER CO SEW AUTH 1	WEST DEPTFORD TWP	395020	751340	10	91 - 106	1971	MRPAU	W	N
15-417	S&S AUCTION HOUSE 1 1978	LOGAN TWP	394820	751833	10	61 - 71	1978	MRPAM	W	N
15-431	WOODBURY CITY WD 6-81	WOODBURY CITY	395034	750842	30	211 - 305	1980	MRPAM	W	P
15-439	ESSEX CHEM-OLIN 2-1970	PAULSBORO BORO	395048	751401	10	215 - 235	1970	MRPAL	W	N
33-187	USGS-POINT AIRY OBS	PILESGROVE TWP	394037	751914	72	664 - 672	1958	MRPAL	W	R
PH- 6	US NAVY 6	PHILADELPHIA	395348	751059	10	138 - 163	1942	MRPAL	U	U
PH -12	US NAVY 12	PHILADELPHIA	395342	751021	8	101	1944	MRPAM	O	U
PH -15	US NAVY 15	PHILADELPHIA	395326	751015	10	59 - 69	1945	MRPAU	T	U
PH -19	US NAVY 19	PHILADELPHIA	395314	751010	8	242 - 247	1946	MRPAL	T	U
PH- 86	US NAVAL HOSPITAL	PHILADELPHIA	395429	751050	8	117 - 142	1942	MRPAL	U	U
H -820	DEL VAL FISH CO INC	PHILADELPHIA	395633	750949	35	35 - 55	1979	MRPAL	W	Q

1 Screened interval
* Multiple screens in well.
** Well depth, screened interval unknown.

2 Aquifer unit
MRPAU, Potomac-Raritan-Magothy aquifer system--upper aquifer.
MRPAM, Potomac-Raritan-Magothy aquifer system--middle aquifer.
MRPAL, Potomac-Raritan-Magothy aquifer system--lower aquifer.

3 Use of site
W, withdrawal
O, observation
T, test
U, unused

4 Use of water
P, public supply
I, irrigation
N, industrial
U, unused
F, fire Protection
R, recreation
Q, aquaculture

Table 3.--Changes in Potomac-Raritan-Magothy aquifer codes since 1984 for selected wells

Well number	Local well identifier	Municipality	Latitude	Longitude	Altitude of land surface (feet)	Screened interval[1] (feet)	Year drilled	Old aquifer[2] unit	Updated aquifer[2] unit
5-130	NJ WC-DEL VALLEY WC 13	CINNAMINSON TWP	400002	750044	70	167- 198	1963	MRPA-M	MRPA-L
5-139	HOLIDAY LAKE WORTHINGTON	DELANCO TWP	400204	745541	25	188- 198	1958	MRPA-M	MRPA-L
5-143	NJ WC-DEL VALLEY WC 23	DELRAN TWP	400105	745734	36	118- 168	1964	MRPA-M	MRPA-L
5-274	CAMPBELL SOUP 1 OBS	MOORESTOWN TWP	395841	745905	40	241- 262	1958	MRPA-M	MRPA-L
5-330	US ARMY-FT DIX 4	NEW HANOVER TWP	395949	743655	140	1056- 1086	1943	MRPA-L	MRPA
5-332	US ARMY-FT DIX 5	NEW HANOVER TWP	400106	743720	150	1064- 1104	1969	MRPA-L	MRPA
5-333	US ARMY-FT DIX 2	NEW HANOVER TWP	400129	743656	131	1030- 1051	1941	MRPA-L	MRPA
5-335	US AIR FORCE-MCGUIRE D	NEW HANOVER TWP	400141	743525	110	1012- 1075	1953	MRPA-L	MRPA
5-336	US AIR FORCE-MCGUIRE C	NEW HANOVER TWP	400150	743428	102	1036- 1089	1953	MRPA-L	MRPA
5-337	US AIR FORCE-MCGUIRE A	NEW HANOVER TWP	400216	743607	122	992- 1055	1953	MRPA-L	MRPA
5-344	HOFFMAN-LA ROCHE CO 1974	NORTH HANOVER TWP	400546	743446	136	783- 814*	1974	MRPA-M	MRPA
5-388	US ARMY-FT DIX 6	PEMBERTON TWP	395939	743742	160	1090- 1140	1970	MRPA-L	MRPA-U
5-392	RIVERSIDE PUB SCHOOL 1	RIVERSIDE TWP	400158	745710	20	90- 100	1965	MRPA-M	MRPA-2
5-651	WILLINGBORO MUA 3	WILLINGBORO TWP	400139	745325	28	203- 304*	1959	MRPA	MRPA-M
5-653	WILLINGBORO MUA 4	WILLINGBORO TWP	400152	745435	28	177- 280	1958	MRPA	MRPA-M
5-777	HOLIDAY LK ICE CREAM STD	EDGEWATER PK TWP	400203	745532	40	40- 50	1978	MRPA	MRPA-M
5-780	WASTE RESOURCE OBS 6	CINNAMINSON TWP	400106	745915	40	30- 50	1978	MRPA	MRPA-M
5-781	WASTE RESOURCE OBS 5	CINNAMINSON TWP	400059	745924	37	30- 50	1978	MRPA	MRPA-M
5-788	C R ENGLAND CO	BURLINGTON TWP	400540	744847	45	45- 53	1972	MRPA	MRPA-U
7- 8	BELLMAWR BORO WD 4	BELLMAWR BORO	395146	750542	75	380- 557*	1966	MRPA	MRPA-L
7-211	GLOUCESTER CITY WD 2	GLOUCESTER CITY	395345	750653	11	141- 171	1929	MRPA-U	MRPA-M
7-304	HADDONFLD BORO WD-LAKE ST	HADDONFIELD BORO	395404	750202	50	307- 372*	1967	MRPA-M	MRPA-L
7-323	STEVENS AND STEVENS 1	PENNSAUKEN TWP	395608	750438	18	74- 84	1956	MRPA-U	MRPA-2
7-326	MERCH-PENN WCOM-BROWN 1	PENNSAUKEN TWP	395627	750404	25	107- 137	1959	MRPA-L	MRPA-M
7-339	PREDCO PREC PANELS	PENNSAUKEN TWP	395743	750448	32	108**	1962	MRPA-M	MRPA-L
7-340	MERCH-PENN WCOM-DEL GN 1	PENNSAUKEN TWP	395752	750411	50	97- 123	1955	MRPA-M	MRPA-L
7-520	BROOKLAWN BORO WD 3-61	BROOKLAWN BORO	395251	750732	10	307- 327	1961	MRPA-U	MRPA-L
7-559	MEADOWBROOK SWIM CLUB	PENNSAUKEN TWP	395815	750150	50	97- 107	1963	MRPA-U	MRPA-M
7-560	MERCH-PENN WCOM-WDBINE 2	MRCHNTVILLE BORO	395652	750307	50	196- 226	1979	MRPA-M	MRPA-L
7-562	NJDEP-HARRISON AVE 2	CAMDEN CITY	395709	750615	15	26- 46	1980	MRPA	MRPA-M
7-566	NJDEP-HARRISON AVE 6	CAMDEN CITY	395718	750605	15	20- 40	1980	MRPA	MRPA-M
7-568	PENNSAUKEN LANDFILL MON 1	PENNSAUKEN TWP	395921	750210	26	59- 60	1979	MRPA	MRPA-M
7-571	PENNSAUKEN LANDFILL MON 4	PENNSAUKEN TWP	395912	750248	21	47- 48	1979	MRPA	MRPA-M
15-102	EI DUPONT REPAUNO 20	GREENWICH TWP	395016	751738	3	73- 103	1940	MRPA-M	MRPA-L
15-103	EI DUPONT REPAUNO H	GREENWICH TWP	395021	751730	2	83- 103	1945	MRPA-M	MRPA-L
15-107	EI DUPONT REPAUNO C	GREENWICH TWP	395025	751757	2	75- 105	1945	MRPA-M	MRPA-L
15-357	EI DUPONT REPAUNO 7 OBS	GREENWICH TWP	394957	751737	4	105**	1945	MRPA-M	MRPA-L
15-395	REPAUPO FIRE CO 30-1972	GREENWICH TWP	394801	751759	20	93- 113	1979	MRPA-U	MRPA-M
15-417	S&S AUCTION HOUSE 1 1978	LOGAN TWP	394820	751833	10	61- 71	1978	MRPA-U	MRPA-M
15-439	ESSEX CHEM-OLIN 2-1970	PAULSBORO BORO	395048	751401	10	215- 235	1970	MRPA	MRPA-L
21- 92	CHAMPALE INC-YARDSIDE	TRENTON CITY	401152	744528	27	70- 80	1961	MRPA	MRPA-M
21- 93	ROEBLING & SONS	TRENTON CITY	401156	744506	30	125- 147	1940	MRPA	MRPA-M
21-147	PUB SERV E-G-DUCK ISL 1	HAMILTON TWP	401026	744344	10	43- 63	1977	MRPA	MRPA-M
21-202	HAMILTON SQUARE WC 6	HAMILTON TWP	401353	743953	100	228**	1950	MRPA	MRPA-M
21-203	CHAMPALE INC-OLD WELL	TRENTON CITY	401153	744527	27	90**	1950	MRPA	MRPA-M
21-207	HAND WILLIAM 1-1930	WEST WINDSOR TWP	401607	743553	100	90- 95	1930	MRPA	MRPA-M

[1] Screened interval
* Multiple screens in well.
** Well depth, screened interval unknown.

[2] Aquifer units
MRPA, Potomac-Raritan-Magothy aquifer system--undifferentiated.
MRPA-U, Potomac-Raritan-Magothy aquifer system--upper aquifer.
MRPA-M, Potomac-Raritan-Magothy aquifer system--middle aquifer.
MRPA-L, Potomac-Raritan-Magothy aquifer system--lower aquifer.
MRPA-2, Indicates well screened in more than one unit of the Potomac-Raritan-Magothy aquifer system.

Table 5.--Results of analyses of ground-water samples for common constituents and physical characteristics, 1985-86

[°C, degrees Celsius; dashes indicate missing data; µS/cm, microsiemens per centimeter at 25 degrees Celsius; concentrations in milligrams per liter, except as noted; <, less than; µg/L, micrograms per liter]

Well number	Local well identifier	Date of sample collection (yr-mo-dy)	Temper-ature (°C)	Specific conductance (µS/cm) Field	Specific conductance (µS/cm) Lab	pH (units) Field	pH (units) Lab	Alkalinity (as $CaCO_3$) Field	Alkalinity (as $CaCO_3$) Lab	Dis-solved oxygen	Hardness (as $CaCO_3$) Total	Hardness (as $CaCO_3$) Non-carbonate
5- 39	NJ WC-DEL VALLEY WC 15	19850814	14.5	212	210	5.60	5.90	16	14	3.6	66	50
5- 40	NJ WC-DEL VALLEY WC 16	19850814	16.5	242	246	6.30	6.50	53	52	2.2	89	36
5- 60	BURLINGTON CITY WC 2	19850909	13.0	192	205	6.90	6.80	70	63	--	76	6
5- 76	HEAL, CHARLES	19850904	13.0	252	219	6.40	5.50	37	<1.0	.6	31	<1
5- 76	HEAL, CHARLES	19850904	13.0	252	214	6.40	5.10	37	<1.0	.6	31	<1
5- 89	TENNECO CHEM 7	19850910	14.5	170	170	4.50	4.50	0	<1.0	0	47	47
5- 91	TENNECO CHEM 4	19850910	14.0	340	380	6.00	6.00	62	61	2.2	120	58
5- 97	HERCULES POWDER 1	19850702	14.0	211	174	6.50	5.30	27	6.0	.2	50	24
5-100	HERCULES POWDER 2	19850702	14.0	135	168	6.10	6.00	7	8.0	2.8	49	42
5-124	NJ WC-DEL VALLEY WC-STPHEN	19850802	14.0	96	95	4.90	5.00	3	2.0	--	25	22
5-125	NJ WC-DEL VALLEY WC 10	19850814	14.0	84	79	5.00	5.10	2	2.0	8.5	19	17
5-167	EVESHAM MUA 5	19850815	19.0	222	223	7.80	7.50	91	85	.2	90	<1
5-167	EVESHAM MUA 5	19850815	19.0	222	225	7.80	7.50	91	86	.2	90	<1
5-167	EVESHAM MUA 5	19850815	18.0	200	225	7.50	7.30	91	86	.2	90	<1
5-187	FLORENCE TWP WD 4	19850702	14.5	244	292	6.50	6.60	88	70	1.2	110	19
5-261	USGS-MEDFORD 5 OBS	19851002	16.0	174	162	7.80	7.30	71	64	0	63	<1
5-261	USGS-MEDFORD 5 OBS	19851002	16.0	174	163	7.80	7.40	71	64	0	63	<1
5-284	MOORESTOWN TWP WD 4	19850816	14.5	172	153	6.60	6.50	85	59	.2	64	<1
5-284	MOORESTOWN TWP WD 4	19850816	14.5	172	153	6.60	6.60	85	59	.2	64	<1
5-284	MOORESTOWN TWP WD 4	19850816	15.0	172	151	6.60	6.50	85	59	.2	64	<1
5-393	RIVERSIDE INDUSTRY 39	19850816	16.5	278	295	5.20	5.50	6	9.0	3.9	73	67
5-658	WILLINGBORO MUA 7	19850703	14.0	96	58	6.70	6.20	40	16	.4	18	<1
5-667	WILLINGBORO MUA 5	19850703	14.0	142	138	5.70	5.20	2	2.0	3.9	37	35
5-758	TENNECO CHEM 10	19850910	13.0	--	232	5.20	5.40	3	5.0	8.7	85	82
5-780	WASTE RESOURCE OBS 6	19851008	15.5	1,100	1,080	6.90	6.60	145	111	3.5	190	42
5-822	MT LAURAL MUA 3	19850903	17.5	--	175	6.70	6.70	59	56	.3	65	6
5-823	MT LAURAL MUA 4	19850903	16.5	--	174	6.80	6.70	67	57	.3	66	<1
7- 8	BELMAWR BORO WD 4	19850715	16.5	204	184	7.90	7.70	64	68	.2	56	<1
7- 12	BELMAWR BORO WD 3	19850715	16.5	370	355	7.70	7.20	148	128	.4	130	<1
7- 18	BERLIN BORO WD 9	19850815	20.0	212	212	7.70	7.70	93	87	.3	56	<1
7- 30	SJ PORT COMM NY SHIP 5A	19851015	16.0	--	347	7.30	7.60	215	133	.2	95	<1
7- 46	CAMDEN CITY WD-CITY 11	19850829	15.5	--	533	6.20	6.30	125	124	.4	190	60
7- 46	CAMDEN CITY WD-CITY 11	19850829	15.5	--	525	6.20	6.20	125	102	.4	190	60
7- 46	CAMDEN CITY WD-CITY 11	19850829	15.5	--	535	6.20	6.20	125	124	.4	190	60
7- 64	CAMDEN CITY WD-CITY 17	19850829	15.0	--	500	5.80	6.00	60	58	--	140	75
7- 98	NEW JERSEY WC-CAMDEN 52	19850807	14.5	520	529	6.20	6.30	121	94	.3	140	24
7-122	NEW JERSEY WC-BROWN 44	19850808	17.0	178	224	7.60	7.10	85	79	.2	86	1
7-124	NEW JERSEY WC-BROWN 45	19850808	16.5	234	190	7.20	7.40	82	70	.2	65	<1
7-134	NEW JERSEY WC-OLD ORCH 37	19850808	17.0	237	236	6.90	7.30	86	85	.3	99	13
7-143	NEW JERSEY WC-ELLISBG 16	19850813	15.0	212	203	7.10	6.60	81	76	.3	85	4
7-147	NEW JERSEY WC-KINGSTN 25	19850813	16.0	212	211	6.90	6.50	66	70	.4	88	22
7-183	NEW JERSEY WC-GIBBSBO 43	19850711	22.0	174	163	7.50	7.10	67	67	.2	42	<1
7-189	NEW JERSEY WC-GIBBSBO 41	19850711	22.0	211	201	7.50	7.40	73	70	.3	42	<1
7-221	USGS-GLOUC CTY CG BASE 1	19850918	15.5	575	490	7.20	6.80	229	215	.1	160	<1
7-249	GARDEN ST WC-BLACKWOOD 3	19850815	16.5	194	198	8.10	7.70	91	83	.3	44	<1
7-273	NEW JERSEY WC-OTTERBK 29	19850809	17.5	178	189	7.80	7.50	65	69	.2	39	<1
7-274	NEW JERSEY WC-OTTERBK 39	19850809	16.0	176	177	7.90	7.40	75	69	.2	56	<1
7-278	NEW JERSEY WC-HADDON 15	19850807	16.0	185	191	7.50	7.20	65	67	.2	62	<1
7-283	NEW JERSEY WC-EGBERT OBS	19851001	15.0	198	185	8.00	7.20	--	65	.1	50	<1
7-302	HADDONFLD BORO WD-RULON	19850716	17.0	225	210	7.60	7.10	94	75	.2	75	<1
7-304	HADDONFLD BORO WD-LAKE ST	19850716	16.0	223	200	7.20	6.70	--	64	.4	82	18
7-315	NEW JERSEY WC-MAGNOLIA 16	19850809	16.0	186	190	7.60	7.30	65	67	.3	63	<1
7-329	MERCH-PENN WCOM-BROWN 2A	19850709	14.5	120	117	5.00	5.40	1	2.0	4.6	26	25
7-341	MERCH-PENN WCOM-DEL GN 2	19850710	15.5	310	304	7.20	6.90	117	113	3.2	110	<1
7-345	MERCH-PENN WCOM-PARK 5	19850731	16.0	104	104	5.40	5.30	3	4.0	3.8	27	24
7-350	MERCH-PENN WCOM-PARK 2	19850731	15.0	118	110	5.00	5.10	3	3.0	1.8	28	25
7-354	PETTY ISLAND OBS	19851112	14.5	560	518	6.60	6.80	259	238	.1	130	<1
7-367	CAMDEN CITY WD-PUCHACK	19850806	14.5	295	186	5.60	5.80	22	21	1.7	50	28
7-369	CAMDEN CITY WD-DELAIR 2	19850717	16.0	322	268	7.10	6.70	80	66	.2	70	<1
7-372	MERCH-PENN WCOM-NAT HWY 1	19850801	15.0	135	134	4.80	4.90	--	3.0	3.5	33	30
7-379	CAMDEN CITY WD-MORRIS 10	19850717	15.0	398	289	7.00	6.50	176	114	.5	84	<1
7-386	CAMDEN CITY WD-MORRIS 3A	19850806	14.5	775	639	6.40	6.30	296	220	.4	210	<1
7-412	NEW JERSEY WC-ELM TREE 2	19850919	19.5	162	151	8.10	7.50	63	63	.1	44	<1
7-477	USGS-NEW BROOKLYN PK 2 OBS	19850923	20.0	432	434	9.30	9.00	--	231	.1	15	<1
7-527	CAMDEN CITY WD-CITY 18	19850829	14.5	--	427	5.70	5.80	54	54	.5	120	66

Table 5.--Results of analyses of ground-water samples for common constituents and physical characteristics, 1985-86--Continued

Well number	Local well identifier	Date of sample collection (yr-mo-dy)	Dis-solved sodium	Dis-solved potas-sium	Dis-solved calcium	Dis-solved magne-sium	Dis-solved silica	Dis-solved chloride	Dis-solved sulfate	Dis-solved fluoride
5- 39	NJ WC-DEL VALLEY WC 15	19850814	11	4.2	10	10	12	14	42	<0.1
5- 40	NJ WC-DEL VALLEY WC 16	19850814	12	3.9	20	9.5	8.3	12	50	<.1
5- 60	BURLINGTON CITY WC 2	19850909	8.3	2.0	20	6.2	6.2	7.9	22	.1
5- 76	HEAL, CHARLES	19850904	6.4	1.4	7.1	3.1	13	13	67	1.3
5- 76	HEAL, CHARLES	19850904	6.4	1.4	7.2	3.2	13	14	67	<.1
5- 89	TENNECO CHEM 7	19850910	7.0	2.2	9.9	5.3	9.0	15	38	<.1
5- 91	TENNECO CHEM 4	19850910	21	3.9	25	14	7.1	32	81	<.1
5- 97	HERCULES POWDER 1	19850702	8.8	1.9	12	4.9	11	11	76	<.1
5-100	HERCULES POWDER 2	19850702	8.2	1.9	10	5.9	11	15	37	<.1
5-124	NJ WC-DEL VALLEY WC-STPHEN	19850802	4.8	2.0	5.5	2.6	8.0	11	11	<.1
5-125	NJ WC-DEL VALLEY WC 10	19850814	4.4	1.8	4.6	1.8	7.4	8.6	1.8	<.1
5-167	EVESHAM MUA 5	19850815	5.7	9.2	25	6.5	8.2	2.2	24	<.1
5-167	EVESHAM MUA 5	19850815	5.8	9.1	25	6.5	8.2	2.0	23	.2
5-167	EVESHAM MUA 5	19850815	5.9	9.2	25	6.5	8.2	1.9	23	.2
5-187	FLORENCE TWP WD 4	19850702	11	2.7	23	12	8.2	20	27	<.1
5-261	USGS-MEDFORD 5 OBS	19851002	3.9	6.6	19	3.5	7.8	2.4	12	.2
5-261	USGS-MEDFORD 5 OBS	19851002	3.9	6.7	19	3.5	7.9	2.3	12	.2
5-284	MOORESTOWN TWP WD 4	19850816	2.9	4.0	18	4.5	11	2.9	30	<.1
5-284	MOORESTOWN TWP WD 4	19850816	2.8	3.8	18	4.6	11	3.1	29	.2
5-284	MOORESTOWN TWP WD 4	19850816	2.8	3.9	18	4.5	11	2.9	30	.2
5-393	RIVERSIDE INDUSTRY 39	19850816	23	4.3	14	9.3	7.1	32	47	<.1
5-658	WILLINGBORO MUA 7	19850703	2.5	1.3	4.6	1.6	10	5.7	28	<.1
5-667	WILLINGBORO MUA 5	19850703	7.2	1.7	8.5	3.7	9.7	15	15	.1
5-758	TENNECO CHEM 10	19850910	5.1	3.1	14	12	8.4	12	58	<.1
5-780	WASTE RESOURCE OBS 6	19851008	96	29	37	23	7.3	95	160	<.1
5-822	MT LAURAL MUA 3	19850903	5.9	5.6	20	3.4	9.3	3.6	21	<.1
5-823	MT LAURAL MUA 4	19850903	5.6	5.6	20	3.5	9.5	3.1	23	<.1
7- 8	BELMAWR BORO WD 4	19850715	13	7.8	16	3.6	7.5	3.0	20	.2
7- 12	BELMAWR BORO WD 3	19850715	17	9.7	36	8.6	9.3	12	32	.3
7- 18	BERLIN BORO WD 9	19850815	19	8.9	14	5.1	8.8	1.3	19	.3
7- 30	SJ PORT COMM NY SHIP 5A	19851015	18	4.2	24	8.5	7.3	29	81	.3
7- 46	CAMDEN CITY WD-CITY 11	19850829	22	6.1	46	17	1.5	26	96	<.1
7- 46	CAMDEN CITY WD-CITY 11	19850829	21	6.1	46	17	1.5	27	96	<.1
7- 46	CAMDEN CITY WD-CITY 11	19850829	21	6.1	46	17	1.5	26	96	<.1
7- 64	CAMDEN CITY WD-CITY 17	19850829	40	6.0	34	12	11	45	99	<.1
7- 98	NEW JERSEY WC-CAMDEN 52	19850807	27	5.4	33	15	7.6	43	58	.3
7-122	NEW JERSEY WC-BROWN 44	19850808	5.0	9.9	25	5.3	7.9	2.0	27	.2
7-124	NEW JERSEY WC-BROWN 45	19850808	7.9	8.3	19	4.0	8.8	3.8	18	.1
7-134	NEW JERSEY WC-OLD ORCH 37	19850808	3.7	9.1	29	6.1	8.7	2.0	30	<.1
7-143	NEW JERSEY WC-ELLISBG 16	19850813	4.9	5.9	25	5.2	9.1	3.1	25	.1
7-147	NEW JERSEY WC-KINGSTN 25	19850813	3.4	7.1	26	5.2	8.7	2.2	30	.1
7-183	NEW JERSEY WC-GIBBSBO 43	19850711	15	6.7	12	2.6	9.3	6.1	9.6	.3
7-189	NEW JERSEY WC-GIBBSBO 41	19850711	23	6.6	12	2.8	9.3	8.4	19	.2
7-221	USGS-GLOUC CTY CG BASE 1	19850918	16	8.3	43	12	6.8	24	37	.4
7-249	GARDEN ST WC-BLACKWOOD 3	19850815	23	6.6	12	3.3	8.4	2.0	14	.5
7-273	NEW JERSEY WC-OTTERBK 29	19850809	21	6.4	11	2.7	9.0	8.8	10	.3
7-274	NEW JERSEY WC-OTTERBK 39	19850809	11	6.3	16	3.6	8.5	1.7	15	.4
7-278	NEW JERSEY WC-HADDON 15	19850807	9.8	8.0	18	3.9	8.6	4.2	20	.3
7-283	NEW JERSEY WC-EGBERT OBS	19851001	14	6.6	14	3.3	8.2	5.4	19	.2
7-302	HADDONFLD BORO WD-RULON	19850716	8.6	7.9	22	4.6	9.0	4.6	27	.2
7-304	HADDONFLD BORO WD-LAKE ST	19850716	2.7	6.6	24	5.1	8.4	1.9	36	.1
7-315	NEW JERSEY WC-MAGNOLIA 16	19850809	9.1	8.3	18	4.1	8.3	3.2	20	.3
7-329	MERCH-PENN WCOM-BROWN 2A	19850709	9.3	2.2	5.8	2.7	15	14	26	<.1
7-341	MERCH-PENN WCOM-DEL GN 2	19850710	13	2.8	27	10	5.4	19	8.3	.2
7-345	MERCH-PENN WCOM-PARK 5	19850731	5.9	2.1	6.4	2.6	12	13	5.5	<.1
7-350	MERCH-PENN WCOM-PARK 2	19850731	5.9	2.4	6.7	2.6	14	15	6.0	<.1
7-354	PETTY ISLAND OBS	19851112	14	5.4	32	12	24	12	13	.3
7-367	CAMDEN CITY WD-PUCHACK	19850806	12	2.8	11	5.5	6.6	21	22	<.1
7-369	CAMDEN CITY WD-DELAIR 2	19850717	18	3.5	18	6.0	7.9	34	32	.1
7-372	MERCH-PENN WCOM-NAT HWY 1	19850801	8.7	2.0	7.2	3.5	9.2	15	16	<.1
7-379	CAMDEN CITY WD-MORRIS 10	19850717	12	5.6	20	8.2	9.4	22	2.3	.6
7-386	CAMDEN CITY WD-MORRIS 3A	19850806	25	12	42	25	5.9	35	80	.6
7-412	NEW JERSEY WC-ELM TREE 2	19850919	9.8	6.1	13	2.7	9.2	3.7	7.7	.2
7-477	USGS-NEW BROOKLYN PK 2 OBS	19850923	100	4.9	5.0	.44	13	4.0	5.6	.5
7-527	CAMDEN CITY WD-CITY 18	19850829	30	5.9	31	10	11	35	80	.1

Table 5.--Results of analyses of ground-water samples for common constituents and physical characteristics, 1985-86--Continued

Well number	Local well identifier	Date of sample collection (yr-mo-dy)	Total iron (µg/L)	Dis-solved iron (µg/L)	Total manga-nese (µg/L)	Dis-solved manga-nese (µg/L)	Dis-solved organic carbon	Phenol	Dissolved solids: Residue at 180°C	Dissolved solids: Sum of constituents
5- 39	NJ WC-DEL VALLEY WC 15	19850814	340	<3	20	3	1.2	1	115	130
5- 40	NJ WC-DEL VALLEY WC 16	19850814	--	<3	--	30	1.7	1	144	6,150
5- 60	BURLINGTON CITY WC 2	19850909	2,200	140	2,500	2,100	--	3	120	120
5- 76	HEAL, CHARLES	19850904	43,000	42,000	500	460	1.6	1	144	170
5- 76	HEAL, CHARLES	19850904	42,000	42,000	480	460	--	--	141	170
5- 89	TENNECO CHEM 7	19850910	1,400	1,300	200	190	.4	4	99	88
5- 91	TENNECO CHEM 4	19850910	270	99	1,600	1,700	1.3	5	225	230
5- 97	HERCULES POWDER 1	19850702	11,000	11,000	100	90	1.0	5	148	140
5-100	HERCULES POWDER 2	19850702	360	290	20	30	1.1	2	109	95
5-124	NJ WC-DEL VALLEY WC-STPHEN	19850802	100	8	30	27	.6	1	75	49
5-125	NJ WC-DEL VALLEY WC 10	19850814	290	7	30	19	1.0	3	58	51
5-167	EVESHAM MUA 5	19850815	100	27	20	10	1.1	2	130	140
5-167	EVESHAM MUA 5	19850815	110	24	20	10	.8	4	135	140
5-167	EVESHAM MUA 5	19850815	120	34	20	10	1.4	1	131	140
5-187	FLORENCE TWP WD 4	19850702	50	21	20	22	1.3	2	182	170
5-261	USGS-MEDFORD 5 OBS	19851002	1,000	760	30	47	--	--	97	100
5-261	USGS-MEDFORD 5 OBS	19851002	1,100	760	30	47	.7	5	99	100
5-284	MOORESTOWN TWP WD 4	19850816	9,200	9,200	100	87	.7	10	105	130
5-284	MOORESTOWN TWP WD 4	19850816	--	9,400	40	87	1.5	4	116	130
5-284	MOORESTOWN TWP WD 4	19850816	9,200	9,100	110	88	.5	3	116	130
5-393	RIVERSIDE INDUSTRY 39	19850816	60	13	70	46	.7	1	187	170
5-658	WILLINGBORO MUA 7	19850703	12,000	12,000	80	78	5.8	5	55	87
5-667	WILLINGBORO MUA 5	19850703	190	120	50	46	1.2	1	94	84
5-758	TENNECO CHEM 10	19850910	480	55	<10	27	.5	3	137	140
5-780	WASTE RESOURCE OBS 6	19851008	780	10	5,300	4,800	11	11	634	660
5-822	MT LAURAL MUA 3	19850903	1,800	1,400	130	130	.5	1	108	110
5-823	MT LAURAL MUA 4	19850903	5,400	5,300	70	87	.8	1	108	110
7- 8	BELMAWR BORO WD 4	19850715	650	330	20	18	--	<1	115	110
7- 12	BELMAWR BORO WD 3	19850715	200	110	40	42	--	<1	208	220
7- 18	BERLIN BORO WD 9	19850815	80	5	20	6	1.4	4	128	130
7- 30	SJ PORT COMM NY SHIP 5A	19851015	54,000	58,000	640	650	4.3	3	200	370
7- 46	CAMDEN CITY WD-CITY 11	19850829	20	32	660	670	2.2	2	296	300
7- 46	CAMDEN CITY WD-CITY 11	19850829	20	31	650	690	2.4	4	298	300
7- 46	CAMDEN CITY WD-CITY 11	19850829	30	28	670	680	2.3	4	302	300
7- 64	CAMDEN CITY WD-CITY 17	19850829	290	12	290	290	1.6	3	330	290
7- 98	NEW JERSEY WC-CAMDEN 52	19850807	820	760	3,500	3,400	2.4	5	303	290
7-122	NEW JERSEY WC-BROWN 44	19850808	770	640	40	39	--	5	127	130
7-124	NEW JERSEY WC-BROWN 45	19850808	740	680	50	45	3.1	<1	113	120
7-134	NEW JERSEY WC-OLD ORCH 37	19850808	1,000	990	50	52	2.4	1	134	140
7-143	NEW JERSEY WC-ELLISBG 16	19850813	4,000	3,500	70	61	.7	2	127	130
7-147	NEW JERSEY WC-KINGSTN 25	19850813	850	690	60	55	.9	2	126	120
7-183	NEW JERSEY WC-GIBBSBO 43	19850711	440	--	40	36	.9	<1	106	120
7-189	NEW JERSEY WC-GIBBSBO 41	19850711	380	340	30	30	1.3	<1	--	130
7-221	USGS-GLOUC CTY CG BASE 1	19850918	--	23,000	--	430	4.0	8	262	330
7-249	GARDEN ST WC-BLACKWOOD 3	19850815	200	130	20	7	1.1	4	135	130
7-273	NEW JERSEY WC-OTTERBK 29	19850809	300	300	30	30	1.1	1	106	110
7-274	NEW JERSEY WC-OTTERBK 39	19850809	210	180	30	12	2.8	1	110	110
7-278	NEW JERSEY WC-HADDON 15	19850807	880	770	40	39	.7	2	119	110
7-283	NEW JERSEY WC-EGBERT OBS	19851001	1,000	870	60	44	.4	4	116	110
7-302	HADDONFLD BORO WD-RULON	19850716	1,600	1,500	50	44	1.1	<1	122	140
7-304	HADDONFLD BORO WD-LAKE ST	19850716	4,000	4,100	70	63	1.0	2	122	130
7-315	NEW JERSEY WC-MAGNOLIA 16	19850809	240	230	40	27	--	5	112	110
7-329	MERCH-PENN WCOM-BROWN 2A	19850709	60	56	120	120	1.4	2	83	76
7-341	MERCH-PENN WCOM-DEL GN 2	19850710	260	130	1,300	1,300	1.5	3	156	160
7-345	MERCH-PENN WCOM-PARK 5	19850731	30	10	80	83	.4	1	81	64
7-350	MERCH-PENN WCOM-PARK 2	19850731	180	95	100	100	.5	1	78	69
7-354	PETTY ISLAND OBS	19851112	22,000	23,000	610	600	6.2	1	222	350
7-367	CAMDEN CITY WD-PUCHACK	19850806	<10	6	170	170	1.9	<1	110	100
7-369	CAMDEN CITY WD-DELAIR 2	19850717	10,000	11,000	2,000	1,900	3.1	3	165	180
7-372	MERCH-PENN WCOM-NAT HWY 1	19850801	40	8	50	62	.7	2	80	79
7-379	CAMDEN CITY WD-MORRIS 10	19850717	30,000	29,000	7,500	7,400	3.6	4	180	220
7-386	CAMDEN CITY WD-MORRIS 3A	19850806	49,000	49,000	7,100	6,100	11	13	386	470
7-412	NEW JERSEY WC-ELM TREE 2	19850919	960	510	--	50	.8	13	88	91
7-477	USGS-NEW BROOKLYN PK 2 OBS	19850923	620	17	10	1	1.4	20	270	270
7-527	CAMDEN CITY WD-CITY 18	19850829	170	94	180	170	1.3	2	256	250

Table 5.--Results of analyses of ground-water samples for common constituents and physical characteristics, 1985-86--Continued

Well number	Local well identifier	Date of sample collection (yr-mo-dy)	Temperature (°C)	Specific conductance (µS/cm) Field	Specific conductance (µS/cm) Lab	pH (units) Field	pH (units) Lab	Alkalinity (as $CaCO_3$) Field	Alkalinity (as $CaCO_3$) Lab	Dissolved oxygen	Hardness (as $CaCO_3$) Total	Hardness (as $CaCO_3$) Noncarbonate
7-528	CAMDEN CITY WD-PUCHACK 7	19850806	13.5	85	82	5.10	5.30	3	2.0	7.8	22	19
7-528	CAMDEN CITY WD-PUCHACK 7	19850806	13.5	85	80	5.10	5.20	3	3.0	7.8	22	19
7-528	CAMDEN CITY WD-PUCHACK 7	19850806	13.5	85	83	5.10	5.60	3	2.0	7.8	21	18
7-545	CAMDEN CITY WD-MORRIS 11	19850806	14.5	282	256	6.60	6.60	73	68	.2	79	6
7-555	PENLER ANODIZING CO 1	19850828	13.5	430	471	5.40	5.50	62	63	.2	99	37
7-566	NJDEP-HARRISON AVE 6	19851016	16.0	720	900	6.30	6.20	230	227	7.7	380	150
7-567	NJDEP-HARRISON AVE 7	19851016	17.0	500	552	7.10	6.80	285	241	.2	150	<1
7-571	PENNSAUKN LANDFILL MON 4	19851010	16.0	166	154	4.80	4.90	3	2.0	5.7	36	33
7-586	CAMDEN CITY WD-MORRIS 12	19850717	15.5	235	206	7.10	6.80	60	45	.3	60	<1
7-602	MERCH-PENN WCOM HWY 2	19850801	15.0	138	124	5.00	5.10	2	3.0	3.6	29	27
15- 1	CLAYTON BORO WD 3	19850917	20.5	950	1,020	8.60	8.10	301	309	.3	13	<1
15- 1	CLAYTON BORO WD 3	19850917	20.5	950	1,020	8.60	8.20	301	309	.3	13	<1
15- 24	DEPTFORD TWP MUA 4	19850712	15.5	242	230	8.20	7.50	93	95	.3	49	<1
15- 28	E GREENWICH TWP WD 2	19850723	14.5	465	456	7.90	7.70	141	157	.4	35	<1
15- 63	GLASSBORO BORO WD 4	19850724	18.5	570	548	8.50	8.20	228	232	.3	12	<1
15- 69	GREENWICH TWP WD 3	19850725	14.0	167	179	5.10	3.90	2	<1.0	.3	31	29
15- 79	EI DUPONT REPAUNO 6	19850917	15.0	680	650	5.80	5.40	18	17	.5	74	56
15- 79	EI DUPONT REPAUNO 6	19850917	15.0	680	651	5.60	5.50	18	17	.5	79	61
15- 97	HERCULES CHEM GIBB 8 OBS	19851011	16.0	480	435	6.00	4.90	16	1.0	.1	49	33
15-109	MOBIL OIL-GREENWICH 41	19851018	17.5	810	792	5.80	5.60	106	4.0	.2	130	28
15-118	MOBIL OIL-GREENWICH 47	19851018	15.0	455	455	6.20	5.90	50	42	.3	33	<1
15-118	MOBIL OIL-GREENWICH 47	19851018	15.0	450	455	6.20	5.90	50	42	.3	33	<1
15-130	SO JERSEY WC 3	19850723	16.0	1,000	996	8.30	8.00	251	255	.3	39	<1
15-192	MANTUA MUA 5	19850723	16.0	510	509	8.30	8.00	189	189	.4	30	<1
15-210	PAULSBORO WD 6-1973	19850925	14.5	243	238	5.60	5.10	14	<1.0	.4	34	20
15-253	WASHINGTON TWP MUA 6-64	19850724	19.0	305	311	7.40	7.10	133	133	.1	16	<1
15-276	W DEPTFORD TWP WD 4	19850718	14.0	420	390	8.10	7.70	137	145	.3	35	<1
15-282	W DEPTFORD TWP 5	19850718	16.0	400	496	7.80	7.60	89	115	.3	20	<1
15-283	SHELL CHEM CO 3	19850924	16.5	770	739	8.00	7.40	145	142	.1	28	<1
15-283	SHELL CHEM CO 3	19850924	16.5	770	738	8.00	7.30	145	142	.1	28	<1
15-308	PENWALT CORP TW 8	19850926	15.0	480	506	7.50	7.50	112	106	.2	26	<1
15-312	W DEPTFORD TWP WD 6	19850718	15.0	550	375	8.00	7.50	119	106	.3	24	<1
15-314	TEXACO EAGLE PT 6-PROD	19850924	16.5	292	275	6.70	6.30	47	56	.1	43	<1
15-323	TEXACO EAGLE PT 3-OBS	19851004	16.0	675	718	6.50	6.40	252	236	.1	250	<1
15-331	WOODBURY WD RAILROAD 5	19850722	14.5	368	362	7.80	7.70	95	104	.6	19	<1
15-342	DEL MONTE CORP 10	19850926	15.5	293	304	7.20	7.40	104	100	.2	62	<1
15-347	GREENWICH TWP WD 5	19850725	17.0	225	231	5.80	6.20	17	17	3.1	51	34
15-348	GREENWICH TWP WD 6	19850725	14.0	157	153	4.20	4.10	0	<1.0	1.8	31	31
15-374	DEPTFORD TWP MUA 6	19850712	17.0	280	262	8.10	7.60	104	104	.3	18	<1
15-385	PITMAN WD 4	19850724	17.5	575	568	8.40	8.10	221	226	.3	14	<1
15-390	GLOUCESTER CO SEW AUTH 1	19850926	14.0	--	956	6.60	6.80	197	172	.1	130	<1
15-417	S&S AUCTION HOUSE 1 1978	19851003	15.5	251	277	5.10	5.10	5	3.0	1.3	93	88
15-431	WOODBURY CITY WD 6-81	19850722	14.5	350	345	7.50	8.20	--	113	.2	92	<1
15-439	ESSEX CHEM-OLIN 2-1970	19850925	14.5	730	913	6.30	6.40	82	56	.4	87	5
33-187	USGS-POINT AIRY OBS	19851007	16.0	980	916	8.90	8.20	201	196	.1	11	<1
PH- 6	US NAVY 6	19851114	14.5	755	722	6.40	6.40	243	228	.1	301	58
PH- 12	US NAVY 12	19860123	15.5	605	541	6.70	6.70	145	224	.3	164	19
PH- 15	US NAVY 15	19860124	16.5	560	455	6.60	6.50	260	175	.3	134	<1
PH- 19	US NAVY 19	19851114	16.0	945	843	6.40	6.40	335	238	.2	296	<1
PH- 86	US NAVAL HOSPITAL	19850912	16.0	1,060	954	6.60	6.50	450	438	.2	448	<1
PH- 86	US NAVAL HOSPITAL	19851009	16.5	1,000	--	6.80	--	456	--	.1	--	--
PH-820	DEL VAL FISH CO INC	19850910	17.0	1,210	1,070	6.40	6.30	138	133	--	374	240

Table 5.--Results of analyses of ground-water samples for common constituents and physical characteristics, 1985-86--Continued

Well number	Local well identifier	Date of sample collection (yr-mo-dy)	Dis-solved sodium	Dis-solved potas-sium	Dis-solved calcium	Dis-solved magne-sium	Dis-solved silica	Dis-solved chloride	Dis-solved sulfate	Dis-solved fluoride
7-528	CAMDEN CITY WD-PUCHACK 7	19850806	4.1	1.6	5.1	2.2	9.0	7.4	7.7	<0.1
7-528	CAMDEN CITY WD-PUCHACK 7	19850806	4.0	1.7	5.1	2.2	8.9	7.5	7.6	<.1
7-528	CAMDEN CITY WD-PUCHACK 7	19850806	3.8	1.7	4.9	2.1	8.7	7.7	7.7	<.1
7-545	CAMDEN CITY WD-MORRIS 11	19850806	12	2.9	19	7.6	6.5	19	35	.2
7-555	PENLER ANODIZING CO 1	19850828	49	4.2	18	13	3.6	88	20	<.1
7-566	NJDEP-HARRISON AVE 6	19851016	40	5.2	96	33	10	61	150	<.1
7-567	NJDEP-HARRISON AVE 7	19851016	10	3.8	35	16	5.4	16	.4	1.4
7-571	PENNSAUKN LANDFILL MON 4	19851010	8.3	5.9	6.0	5.0	6.3	17	31	<.1
7-586	CAMDEN CITY WD-MORRIS 12	19850717	12	2.1	15	5.4	6.3	19	25	.2
7-602	MERCH-PENN WCOM HWY 2	19850801	8.8	1.8	6.3	3.2	9.2	14	14	<.1
15- 1	CLAYTON BORO WD 3	19850917	230	8.3	2.8	1.3	9.6	140	<.2	1.7
15- 1	CLAYTON BORO WD 3	19850917	230	9.1	2.8	1.4	9.4	140	<.2	1.6
15- 24	DEPTFORD TWP MUA 4	19850712	31	5.7	14	3.1	7.8	6.0	17	.8
15- 28	E GREENWICH TWP WD 2	19850723	83	5.5	9.3	2.7	9.5	45	8.6	1.1
15- 63	GLASSBORO BORO WD 4	19850724	120	5.4	2.8	1.1	8.7	36	1.7	1.8
15- 69	GREENWICH TWP WD 3	19850725	10	2.2	5.7	3.9	14	14	42	<.1
15- 79	EI DUPONT REPAUNO 6	19850917	78	4.3	16	8.2	8.7	94	100	<.1
15- 79	EI DUPONT REPAUNO 6	19850917	81	4.6	17	8.8	8.7	95	100	<.1
15- 97	HERCULES CHEM GIBB 8 OBS	19851011	53	3.9	12	4.5	18	120	17	<.1
15-109	MOBIL OIL-GREENWICH 41	19851018	83	4.5	30	14	9.4	92	200	.6
15-118	MOBIL OIL-GREENWICH 47	19851018	73	2.2	8.5	2.7	8.6	110	15	.2
15-118	MOBIL OIL-GREENWICH 47	19851018	73	2.2	8.4	2.7	8.6	110	12	.1
15-130	SO JERSEY WC 3	19850723	190	8.8	10	3.3	8.4	160	5.1	1.4
15-192	MANTUA MUA 5	19850723	95	6.2	8.0	2.3	8.4	44	4.1	1.5
15-210	PAULSBORO WD 6-1973	19850925	25	3.1	7.0	3.9	9.3	31	47	.2
15-253	WASHINGTON TWP MUA 6-64	19850724	64	5.7	3.9	1.5	8.8	22	5.0	1.0
15-276	W DEPTFORD TWP WD 4	19850718	71	5.6	9.7	2.5	8.3	33	5.4	1.1
15-282	W DEPTFORD TWP 5	19850718	97	3.1	5.8	1.3	8.4	81	7.7	1.6
15-283	SHELL CHEM CO 3	19850924	140	3.4	7.7	1.9	8.8	140	9.3	2.1
15-283	SHELL CHEM CO 3	19850924	150	3.5	7.7	1.9	8.8	140	9.2	1.7
15-308	PENWALT CORP TW 8	19850926	94	3.5	7.3	1.7	8.6	79	10	1.6
15-312	W DEPTFORD TWP WD 6	19850718	68	3.8	6.9	1.5	8.3	46	9.0	1.2
15-314	TEXACO EAGLE PT 6-PROD	19850924	35	4.2	12	2.9	12	24	42	.3
15-323	TEXACO EAGLE PT 3-OBS	19851004	41	9.8	67	19	15	38	85	.1
15-331	WOODBURY WD RAILROAD 5	19850722	67	3.3	5.5	1.2	8.6	44	7.3	1.0
15-342	DEL MONTE CORP 10	19850926	39	5.4	17	4.6	10	13	24	.3
15-347	GREENWICH TWP WD 5	19850725	17	5.5	11	5.6	6.8	22	33	<.1
15-348	GREENWICH TWP WD 6	19850725	7.3	2.6	4.7	4.7	12	10	35	.1
15-374	DEPTFORD TWP MUA 6	19850712	53	3.8	5.1	1.3	7.8	15	6.8	1.1
15-385	PITMAN WD 4	19850724	120	5.8	3.4	1.3	8.7	44	1.8	2.0
15-390	GLOUCESTER CO SEW AUTH 1	19850926	140	7.8	36	9.7	13	90	160	1.0
15-417	S&S AUCTION HOUSE 1 1978	19851003	4.6	7.2	24	8.0	6.3	28	41	<.1
15-431	WOODBURY CITY WD 6-81	19850722	29	6.4	27	5.7	8.9	22	16	.9
15-439	ESSEX CHEM-OLIN 2-1970	19850925	150	5.1	24	6.2	11	130	170	1.5
33-187	USGS-POINT AIRY OBS	19851007	200	4.7	3.0	.84	7.6	170	4.3	2.1
PH- 6	US NAVY 6	19851114	27	4.4	56	39	17	23	100	.1
PH- 12	US NAVY 12	19860123	27	5.1	39	16	13	49	66	.7
PH- 15	US NAVY 15	19860124	23	43	32	13	15	32	3.4	.3
PH- 19	US NAVY 19	19851114	48	5.5	62	34	14	38	130	.2
PH- 86	US NAVAL HOSPITAL	19850912	38	4.4	72	65	18	55	17	.3
PH- 86	US NAVAL HOSPITAL	19851009	--	--	--	--	--	--	--	--
PH-820	DEL VAL FISH CO INC	19850910	66	12	77	44	14	98	210	<.1

Table 5.--Results of analyses of ground-water samples for common constituents and physical characteristics, 1985-86--Continued

Well number	Local well identifier	Date of sample collection (yr-mo-dy)	Total iron (µg/L)	Dis-solved iron (µg/L)	Total manga-nese (µg/L)	Dis-solved manga-nese (µg/L)	Dis-solved organic carbon	Phenol	Dissolved solids: Residue at 180°C	Dissolved solids: Sum of constituents
7-528	CAMDEN CITY WD-PUCHACK 7	19850806	40	10	20	26	--	--	63	53
7-528	CAMDEN CITY WD-PUCHACK 7	19850806	50	6	20	25	--	--	66	53
7-528	CAMDEN CITY WD-PUCHACK 7	19850806	50	10	30	25	.5	<1	64	53
7-545	CAMDEN CITY WD-MORRIS 11	19850806	7,100	7,100	3,800	3,800	2.2	3	148	160
7-555	PENLER ANODIZING CO 1	19850828	450	230	210	200	5.4	54	270	230
7-566	NJDEP-HARRISON AVE 6	19851016	410	10	1,500	1,500	7.3	4	610	550
7-567	NJDEP-HARRISON AVE 7	19851016	22,000	22,000	7,200	6,800	7.4	<1	224	310
7-571	PENNSAUKN LANDFILL MON 4	19851010	70	11	540	500	1.2	2	90	87
7-586	CAMDEN CITY WD-MORRIS 12	19850717	5,800	6,200	1,200	1,200	1.9	3	115	130
7-602	MERCH-PENN WCOM HWY 2	19850801	30	9	40	39	.5	<1	78	72
15- 1	CLAYTON BORO WD 3	19850917	140	40	<10	2	2.4	8	588	--
15- 1	CLAYTON BORO WD 3	19850917	110	52	<10	2	2.2	6	592	--
15- 24	DEPTFORD TWP MUA 4	19850712	240	260	10	13	2.4	2	147	140
15- 28	E GREENWICH TWP WD 2	19850723	530	170	20	5	2.3	<1	274	250
15- 63	GLASSBORO BORO WD 4	19850724	70	29	10	<1	9.3	2	346	320
15- 69	GREENWICH TWP WD 3	19850725	6,200	5,900	340	320	--	3	102	100
15- 79	EI DUPONT REPAUNO 6	19850917	390	400	740	720	1.9	6	377	360
15- 79	EI DUPONT REPAUNO 6	19850917	370	390	710	760	2.0	6	383	360
15- 97	HERCULES CHEM GIBB 8 OBS	19851011	14,000	11,000	350	330	.6	6	248	250
15-109	MOBIL OIL-GREENWICH 41	19851018	42,000	46,000	1,200	1,200	15	68	495	550
15-118	MOBIL OIL-GREENWICH 47	19851018	3,900	3,800	80	66	1.8	5	243	250
15-118	MOBIL OIL-GREENWICH 47	19851018	3,700	3,800	70	--	1.8	7	243	250
15-130	SO JERSEY WC 3	19850723	100	78	10	3	2.1	2	555	540
15-192	MANTUA MUA 5	19850723	40	4	10	3	1.8	1	288	280
15-210	PAULSBORO WD 6-1973	19850925	7,900	7,800	130	110	1.2	4	140	140
15-253	WASHINGTON TWP MUA 6-64	19850724	60	11	<10	<1	6.4	<1	210	190
15-276	W DEPTFORD TWP WD 4	19850718	90	110	<10	4	1.7	6	241	220
15-282	W DEPTFORD TWP 5	19850718	40	35	10	11	1.3	2	276	260
15-283	SHELL CHEM CO 3	19850924	340	310	20	12	--	--	407	400
15-283	SHELL CHEM CO 3	19850924	360	300	20	13	.9	2	410	410
15-308	PENWALT CORP TW 8	19850926	4,800	1,100	60	39	1.3	4	271	280
15-312	W DEPTFORD TWP WD 6	19850718	70	38	10	9	1.7	2	208	220
15-314	TEXACO EAGLE PT 6-PROD	19850924	2,300	2,200	--	57	.9	1	162	160
15-323	TEXACO EAGLE PT 3-OBS	19851004	16,000	16,000	240	230	3.6	8	437	450
15-331	WOODBURY WD RAILROAD 5	19850722	10	4	<10	<1	4.2	4	210	190
15-342	DEL MONTE CORP 10	19850926	260	100	30	15	1.0	7	167	180
15-347	GREENWICH TWP WD 5	19850725	510	510	100	84	2.4	5	136	130
15-348	GREENWICH TWP WD 6	19850725	110	110	90	99	1.7	2	98	--
15-374	DEPTFORD TWP MUA 6	19850712	40	14	<10	8	1.4	2	165	150
15-385	PITMAN WD 4	19850724	70	30	10	<1	5.8	3	347	320
15-390	GLOUCESTER CO SEW AUTH 1	19850926	9,800	10,000	160	130	6.9	5	570	590
15-417	S&S AUCTION HOUSE 1 1978	19851003	800	340	370	380	1.4	3	162	160
15-431	WOODBURY CITY WD 6-81	19850722	--	540	--	20	1.5	--	195	190
15-439	ESSEX CHEM-OLIN 2-1970	19850925	11,000	10,000	150	100	2.7	22	532	560
33-187	USGS-POINT AIRY OBS	19851007	6,600	250	110	39	2.7	9	527	520
PH- 6	US NAVY 6	19851114	19,000	21,000	5,900	6,200	6.0	--	435	440
PH- 12	US NAVY 12	19860123	47,000	49,000	930	890	5.0	3	294	430
PH- 15	US NAVY 15	19860124	50,000	54,000	640	580	7.5	7	255	390
PH- 19	US NAVY 19	19851114	47,000	48,000	3,500	3,500	8.0	1	551	590
PH- 86	US NAVAL HOSPITAL	19850912	15,000	2,000	3,000	2,900	8.4	17	545	538
PH- 86	US NAVAL HOSPITAL	19851009	--	--	--	--	9.2	11	--	--
PH-820	DEL VAL FISH CO INC	19850910	180	<3	20	22	1.4	5	691	622

Table 6.--Results of analyses of ground-water samples for dissolved trace elements, 1985-86

[Concentrations in micrograms per liter; Dashes indicate missing data; <, less than]

Well number	Local well identifier	Date of sample (yr-mo-dy)	Aluminum	Arsenic	Barium	Beryllium	Cadmium	Chromium	Hexa-valent chromium
5- 39	NJ WC-DEL VALLEY WC 15	19850814	30	<1	100	0.7	2	<10	<1
5- 40	NJ WC-DEL VALLEY WC 16	19850814	10	<1	67	<.5	<1	<10	<1
5- 60	BURLINGTON CITY WC 2	19850909	<10	<1	16	1	<1	<10	<1
5- 76	HEAL, CHARLES	19850904	<10	2	53	<.5	4	10	<1
5- 76	HEAL, CHARLES	19850904	<10	2	54	.5	5	<10	<1
5- 89	TENNECO CHEM 7	19850910	10	<1	64	1	<1	<10	<1
5- 91	TENNECO CHEM 4	19850910	<10	<1	52	1	<1	<10	<1
5- 97	HERCULES POWDER 1	19850702	100	1	83	<.5	<1	20	<1
5-100	HERCULES POWDER 2	19850702	100	<1	64	.6	<1	10	<1
5-124	NJ WC-DEL VALLEY WC-STPHEN	19850802	<10	<1	61	<.5	<1	<10	<1
5-125	NJ WC-DEL VALLEY WC 10	19850814	20	<1	49	1	<1	<10	<1
5-167	EVESHAM MUA 5	19850815	30	<1	140	<.5	<1	<10	<1
5-167	EVESHAM MUA 5	19850815	40	<1	140	<.5	<1	<10	1
5-167	EVESHAM MUA 5	19850815	10	<1	140	.8	<1	<10	<1
5-187	FLORENCE TWP WD 4	19850702	100	<1	57	<.5	<1	<10	<1
5-261	USGS-MEDFORD 5 OBS	19851002	<10	<1	85	<.5	<1	<10	<1
5-261	USGS-MEDFORD 5 OBS	19851002	20	<1	86	<.5	<1	<10	<1
5-284	MOORESTOWN TWP WD 4	19850816	<10	<1	89	<.5	<1	<10	<1
5-284	MOORESTOWN TWP WD 4	19850816	<10	<1	89	.5	1	<10	<1
5-284	MOORESTOWN TWP WD 4	19850816	<10	<1	89	<.5	1	<10	<1
5-393	RIVERSIDE INDUSTRY 39	19850816	<10	<1	91	.5	<1	<10	<1
5-658	WILLINGBORO MUA 7	19850703	100	<1	58	<.5	2	<10	2
5-667	WILLINGBORO MUA 5	19850703	<100	<1	110	<.5	<1	<10	1
5-758	TENNECO CHEM 10	19850910	<10	<1	60	2	<1	<10	<1
5-780	WASTE RESOURCE OBS 6	19851008	50	<1	100	.5	3	10	<1
5-822	MT LAURAL MUA 3	19850903	<10	<1	77	<.5	<1	<10	<1
5-823	MT LAURAL MUA 4	19850903	<10	<1	83	<.5	1	10	<1
7- 8	BELMAWR BORO WD 4	19850715	10	<1	53	<.5	<1	<10	<1
7- 12	BELMAWR BORO WD 3	19850715	10	<1	79	<.5	<1	<10	<1
7- 18	BERLIN BORO WD 9	19850815	20	<1	84	2	<1	<10	<1
7- 30	SJ PORT COMM NY SHIP 5A	19851015	<10	6	25	<.5	6	<10	<1
7- 46	CAMDEN CITY WD-CITY 11	19850829	<10	<1	23	.9	1	<10	<1
7- 46	CAMDEN CITY WD-CITY 11	19850829	<10	<1	23	<.5	1	<10	<1
7- 46	CAMDEN CITY WD-CITY 11	19850829	<10	<1	23	<.5	1	<10	<1
7- 64	CAMDEN CITY WD-CITY 17	19850829	<10	<1	64	.7	<1	<10	<1
7- 98	NEW JERSEY WC-CAMDEN 52	19850807	30	<1	120	<.5	<1	<10	1
7-122	NEW JERSEY WC-BROWN 44	19850808	20	<1	79	<.5	<1	<10	1
7-124	NEW JERSEY WC-BROWN 45	19850808	20	<1	43	.6	<1	10	2
7-134	NEW JERSEY WC-OLD ORCH 37	19850808	<10	<1	120	1	<1	<10	1
7-143	NEW JERSEY WC-ELLISBG 16	19850813	10	<1	78	.8	<1	<10	<1
7-147	NEW JERSEY WC-KINGSTN 25	19850813	30	<1	95	<.5	1	<10	1
7-183	NEW JERSEY WC-GIBBSBO 43	19850711	30	<1	30	.5	<1	<10	<1
7-189	NEW JERSEY WC-GIBBSBO 41	19850711	20	<1	34	.6	<1	10	1
7-221	USGS-GLOUC CTY CG BASE 1	19850918	<10	<1	180	.5	2	<10	<1
7-249	GARDEN ST WC-BLACKWOOD 3	19850815	40	<1	80	<.5	<1	<10	<1
7-273	NEW JERSEY WC-OTTERBK 29	19850809	<10	<1	28	.8	<1	<10	1
7-274	NEW JERSEY WC-OTTERBK 39	19850809	20	<1	68	1	<1	<10	2
7-278	NEW JERSEY WC-HADDON 15	19850807	20	<1	40	<.5	<1	10	<1
7-283	NEW JERSEY WC-EGBERT OBS	19851001	30	<1	40	.8	<1	10	<1
7-302	HADDONFLD BORO WD-RULON	19850716	20	<1	50	<.5	<1	10	<1
7-304	HADDONFLD BORO WD-LAKE ST	19850716	<10	<1	110	<.5	<1	10	<1
7-315	NEW JERSEY WC-MAGNOLIA 16	19850809	20	<1	52	1	<1	<10	<1
7-329	MERCH-PENN WCOM-BROWN 2A	19850709	80	<1	90	.8	<1	<10	<1
7-341	MERCH-PENN WCOM-DEL GN 2	19850710	<10	<1	61	<.5	<1	<10	<1
7-345	MERCH-PENN WCOM-PARK 5	19850731	30	<1	36	<.5	<1	<10	<1
7-350	MERCH-PENN WCOM-PARK 2	19850731	20	<1	38	.5	<1	<10	<1
7-354	PETTY ISLAND OBS	19851112	10	19	240	<.5	1	<10	<1
7-367	CAMDEN CITY WD-PUCHACK	19850806	20	<1	49	<.5	<1	780	390
7-369	CAMDEN CITY WD-DELAIR 2	19850717	<10	<1	89	.5	2	<10	1
7-372	MERCH-PENN WCOM-NAT HWY 1	19850801	40	<1	60	.8	<1	<10	<1

Table 6.--Results of analyses of ground-water samples for dissolved trace elements, 1985-86--Continued

Well number	Local well identifier	Date of sample (yr-mo-dy)	Cobalt	Copper	Lead	Lithium	Molyb-denum	Stron-tium	Vana-dium	Zinc
5- 39	NJ WC-DEL VALLEY WC 15	19850814	<3	<10	<10	<4	<10	88	<6	41
5- 40	NJ WC-DEL VALLEY WC 16	19850814	<3	<10	<10	<4	<10	95	<6	10
5- 60	BURLINGTON CITY WC 2	19850909	<3	<10	<10	<4	<10	79	<6	5
5- 76	HEAL, CHARLES	19850904	<3	<10	20	9	<10	36	<6	<3
5- 76	HEAL, CHARLES	19850904	<3	<10	20	7	<10	37	<6	3
5- 89	TENNECO CHEM 7	19850910	3	<10	<10	7	<10	64	<6	35
5- 91	TENNECO CHEM 4	19850910	7	<10	<10	7	<10	140	<6	14
5- 97	HERCULES POWDER 1	19850702	<3	<10	30	24	<10	140	<6	10
5-100	HERCULES POWDER 2	19850702	5	10	<10	14	<10	86	<6	67
5-124	NJ WC-DEL VALLEY WC-STPHEN	19850802	<3	10	<10	8	<10	62	<6	27
5-125	NJ WC-DEL VALLEY WC 10	19850814	<3	40	10	12	<10	63	<6	17
5-167	EVESHAM MUA 5	19850815	<3	<10	<10	8	<10	630	<6	<3
5-167	EVESHAM MUA 5	19850815	<3	<10	<10	7	<10	630	<6	<3
5-167	EVESHAM MUA 5	19850815	<3	<10	<10	8	<10	630	<6	<3
5-187	FLORENCE TWP WD 4	19850702	<3	<10	<10	4	<10	150	<6	4
5-261	USGS-MEDFORD 5 OBS	19851002	<3	<10	<10	10	<10	860	<6	<3
5-261	USGS-MEDFORD 5 OBS	19851002	<3	<10	<10	11	<10	870	<6	<3
5-284	MOORESTOWN TWP WD 4	19850816	<3	<10	<10	19	<10	430	<6	<3
5-284	MOORESTOWN TWP WD 4	19850816	<3	<10	<10	19	<10	430	<6	<3
5-284	MOORESTOWN TWP WD 4	19850816	<3	<10	<10	18	<10	430	<6	<3
5-822	MT LAURAL MUA 3	19850903	<3	<10	<10	7	<10	940	<6	21
5-823	MT LAURAL MUA 4	19850903	<3	<10	<10	<4	<10	970	<6	60
5-393	RIVERSIDE INDUSTRY 39	19850816	<3	<10	<10	10	<10	68	<6	89
5-658	WILLINGBORO MUA 7	19850703	<3	<10	<10	14	<10	85	<6	11
5-667	WILLINGBORO MUA 5	19850703	3	20	<10	26	<10	78	<6	41
5-758	TENNECO CHEM 10	19850910	<3	30	<10	<4	<10	85	<6	19
5-780	WASTE RESOURCE OBS 6	19851008	20	<10	<10	<4	<10	160	<6	38
7- 8	BELMAWR BORO WD 4	19850715	<3	<10	<10	7	<10	930	<6	14
7- 12	BELMAWR BORO WD 3	19850715	8	<10	<10	5	<10	2,300	<6	5
7- 18	BERLIN BORO WD 9	19850815	<3	<10	<10	10	<10	410	<6	<3
7- 30	SJ PORT COMM NY SHIP 5A	19851015	<3	<10	<10	5	<10	160	<6	4
7- 46	CAMDEN CITY WD-CITY 11	19850829	<3	<10	10	5	<10	280	<6	12
7- 46	CAMDEN CITY WD-CITY 11	19850829	5	<10	20	6	<10	280	<6	11
7- 46	CAMDEN CITY WD-CITY 11	19850829	4	<10	20	9	<10	280	<6	11
7- 64	CAMDEN CITY WD-CITY 17	19850829	8	50	10	19	<10	780	<6	37
7- 98	NEW JERSEY WC-CAMDEN 52	19850807	70	<10	<10	19	<10	450	<6	68
7-122	NEW JERSEY WC-BROWN 44	19850808	<3	<10	<10	<4	<10	1,400	<6	13
7-124	NEW JERSEY WC-BROWN 45	19850808	<3	<10	<10	<4	<10	1,100	<6	17
7-134	NEW JERSEY WC-OLD ORCH 37	19850808	<3	<10	<10	5	<10	1,400	<6	6
7-143	NEW JERSEY WC-ELLISBG 16	19850813	<3	<10	<10	9	<10	640	<6	9
7-147	NEW JERSEY WC-KINGSTN 25	19850813	<3	<10	<10	5	<10	1,200	<6	13
7-183	NEW JERSEY WC-GIBBSBO 43	19850711	<3	<10	<10	5	<10	730	<6	9
7-189	NEW JERSEY WC-GIBBSBO 41	19850711	<3	<10	<10	6	<10	760	<6	5
7-221	USGS-GLOUC CTY CG BASE 1	19850918	<3	<10	<10	5	<10	1,800	<6	4
7-249	GARDEN ST WC-BLACKWOOD 3	19850815	<3	<10	<10	7	<10	430	<6	4
7-273	NEW JERSEY WC-OTTERBK 29	19850809	<3	<10	<10	<4	<10	710	<6	16
7-274	NEW JERSEY WC-OTTERBK 39	19850809	<3	<10	<10	<4	<10	640	<6	16
7-278	NEW JERSEY WC-HADDON 15	19850807	<3	<10	10	7	<10	1,100	<6	11
7-283	NEW JERSEY WC-EGBERT OBS	19851001	<3	<10	<10	<4	<10	880	<6	<3
7-302	HADDONFLD BORO WD-RULON	19850716	<3	<10	<10	<4	<10	1,200	<6	4
7-304	HADDONFLD BORO WD-LAKE ST	19850716	<3	<10	<10	4	<10	1,100	<6	16
7-315	NEW JERSEY WC-MAGNOLIA 16	19850809	<3	<10	<10	<4	<10	1,000	<6	10
7-329	MERCH-PENN WCOM-BROWN 2A	19850709	8	10	<10	30	<10	81	<6	62
7-341	MERCH-PENN WCOM-DEL GN 2	19850710	20	<10	<10	<4	<10	300	<6	5
7-345	MERCH-PENN WCOM-PARK 5	19850731	6	10	10	18	<10	110	<6	20
7-350	MERCH-PENN WCOM-PARK 2	19850731	6	110	20	22	<10	130	<6	57
7-354	PETTY ISLAND OBS	19851112	<3	<10	<10	<4	<10	210	<6	100
7-367	CAMDEN CITY WD-PUCHACK	19850806	5	10	<10	8	<10	140	<6	41
7-369	CAMDEN CITY WD-DELAIR 2	19850717	80	<10	<10	5	<10	120	<6	4
7-372	MERCH-PENN WCOM-NAT HWY 1	19850801	4	40	10	11	<10	99	<6	28

Table 6.--Results of analyses of ground-water samples for dissolved trace elements, 1985-86--Continued

Well number	Local well identifier	Date of sample (yr-mo-dy)	Aluminum	Arsenic	Barium	Beryllium	Cadmium	Chromium	Hexa-valent chromium
7-379	CAMDEN CITY WD-MORRIS 10	19850717	<10	1	67	<0.5	2	10	<1
7-386	CAMDEN CITY WD-MORRIS 3A	19850806	<10	<1	110	2	5	<10	<1
7-412	NEW JERSEY WC-ELM TREE 2	19850919	20	<1	33	.6	<1	<10	<1
7-477	USGS-NEW BROOKLYN PK 2 OBS	19850923	90	<1	31	.6	1	<10	<1
7-527	CAMDEN CITY WD-CITY 18	19850829	20	<1	62	.7	<1	<10	<1
7-528	CAMDEN CITY WD-PUCHACK 7	19850806	40	<1	33	<.5	<1	10	<1
7-528	CAMDEN CITY WD-PUCHACK 7	19850806	40	<1	27	.7	<1	10	<1
7-528	CAMDEN CITY WD-PUCHACK 7	19850806	30	<1	27	.5	<1	10	<1
7-545	CAMDEN CITY WD-MORRIS 11	19850806	10	<1	85	1	1	<10	<1
7-555	PENLER ANODIZING CO 1	19850828	40	<1	120	.7	<1	<10	<1
7-566	NJDEP-HARRISON AVE 6	19851016	<10	<1	54	2	<1	10	<1
7-567	NJDEP-HARRISON AVE 7	19851016	<10	1	510	.6	<1	10	<1
7-571	PENNSAUKN LANDFILL MON 4	19851010	90	<1	75	<.5	<1	960	980
7-586	CAMDEN CITY WD-MORRIS 12	19850717	20	4	37	<.5	<1	10	<1
7-602	MERCH-PENN WCOM HWY 2	19850801	<10	<1	58	<.5	1	<10	<1
15- 1	CLAYTON BORO WD 3	19850917	30	<1	42	<.5	<1	<10	<1
15- 1	CLAYTON BORO WD 3	19850917	20	<1	41	.5	<1	<10	<1
15- 24	DEPTFORD TWP MUA 4	19850712	30	<1	56	1	<1	<10	<1
15- 28	E GREENWICH TWP WD 2	19850723	10	<1	67	<.5	<1	<10	<1
15- 63	GLASSBORO BORO WD 4	19850724	30	<1	26	.5	<1	<10	<1
15- 69	GREENWICH TWP WD 3	19850725	90	3	90	2	1	10	<1
15- 79	EI DUPONT REPAUNO 6	19850917	30	<1	86	<.5	<1	<10	<1
15- 79	EI DUPONT REPAUNO 6	19850917	20	<1	86	<.5	<1	<10	<1
15- 97	HERCULES CHEM GIBB 8 OBS	19851011	10	2	420	.6	<1	<10	<1
15-109	MOBIL OIL-GREENWICH 41	19851018	460	1	82	4	4	10	<1
15-118	MOBIL OIL-GREENWICH 47	19851018	<10	<1	76	1	1	10	<1
15-118	MOBIL OIL-GREENWICH 47	19851018	<10	<1	81	1	1	10	<1
15-130	SO JERSEY WC 3	19850723	20	<1	86	<.5	<1	<10	<1
15-192	MANTUA MUA 5	19850723	10	<1	60	<.5	<1	10	<1
15-210	PAULSBORO WD 6-1973	19850925	160	1	72	2	2	<10	<1
15-253	WASHINGTON TWP MUA 6-64	19850724	40	1	33	<.5	<1	<10	<1
15-276	W DEPTFORD TWP WD 4	19850718	50	<1	61	.5	1	<10	<1
15-282	W DEPTFORD TWP 5	19850718	20	<1	25	<.5	<1	<10	<1
15-283	SHELL CHEM CO 3	19850924	<10	<1	25	1	2	<10	<1
15-283	SHELL CHEM CO 3	19850924	<10	<1	25	2	<1	<10	<1
15-308	PENWALT CORP TW 8	19850926	20	<1	27	<.5	<1	<10	<1
15-312	W DEPTFORD TWP WD 6	19850718	<10	<1	30	<.5	<1	<10	<1
15-314	TEXACO EAGLE PT 6-PROD	19850924	<10	<1	64	.8	<1	<10	<1
15-323	TEXACO EAGLE PT 3-OBS	19851004	<10	<1	250	.8	1	<10	<1
15-331	WOODBURY WD RAILROAD 5	19850722	30	<1	23	<.5	<1	<10	<1
15-342	DEL MONTE CORP 10	19850926	10	<1	120	<.5	<1	<10	<1
15-347	GREENWICH TWP WD 5	19850725	40	<1	63	<.5	<1	<10	<1
15-348	GREENWICH TWP WD 6	19850725	750	<1	82	1	<1	10	<1
15-374	DEPTFORD TWP MUA 6	19850712	<10	<1	29	1	<1	<10	1
15-385	PITMAN WD 4	19850724	30	<1	30	<.5	<1	<10	<1
15-390	GLOUCESTER CO SEW AUTH 1	19850926	20	<1	190	<.5	1	<10	<1
15-417	S&S AUCTION HOUSE 1 1978	19851003	90	<1	79	<.5	1	<10	<1
15-431	WOODBURY CITY WD 6-81	19850722	10	<1	110	<.5	<1	<10	<1
15-439	ESSEX CHEM-OLIN 2-1970	19850925	120	<1	65	2	1	<10	<1
33-187	USGS-POINT AIRY OBS	19851007	10	<1	33	<.5	<1	<10	<1
PH- 6	US NAVY 6	19851114	10	2	34	<.5	<1	<10	<1
PH- 12	US NAVY 12	19860123	<10	2	57	<.5	4	<10	<1
PH- 15	US NAVY 15	19860124	<10	49	150	<.5	4	<10	<1
PH- 19	US NAVY 19	19851114	<10	<1	120	<.5	3	<10	<1
PH- 86	US NAVAL HOSPITAL	19850912	<10	1	56	2	<1	<10	<1
PH- 86	US NAVAL HOSPITAL	19851009	--	--	--	--	--	--	--
PH-820	DEL VAL FISH CO INC	19850910	10	--	42	<.5	<1	10	<1

Table 6.--Results of analyses of ground-water samples for dissolved trace elements, 1985-86--Continued

Well number	Local well identifier	Date of sample (yr-mo-dy)	Cobalt	Copper	Lead	Lithium	Molyb-denum	Stron-tium	Vana-dium	Zinc
7-379	CAMDEN CITY WD-MORRIS 10	19850717	30	<10	20	<4	<10	180	<6	63
7-386	CAMDEN CITY WD-MORRIS 3A	19850806	9	<10	<10	5	<10	260	<6	21
7-412	NEW JERSEY WC-ELM TREE 2	19850919	<3	<10	<10	4	<10	730	<6	<3
7-477	USGS-NEW BROOKLYN PK 2 OBS	19850923	<3	<10	<10	12	<10	260	<6	<3
7-527	CAMDEN CITY WD-CITY 18	19850829	9	<10	20	21	<10	820	<6	11
7-528	CAMDEN CITY WD-PUCHACK 7	19850806	6	20	<10	11	<10	75	<6	23
7-528	CAMDEN CITY WD-PUCHACK 7	19850806	7	20	<10	13	<10	74	<6	26
7-528	CAMDEN CITY WD-PUCHACK 7	19850806	6	20	<10	10	<10	71	<6	27
7-545	CAMDEN CITY WD-MORRIS 11	19850806	130	<10	<10	5	<10	120	<6	28
7-555	PENLER ANODIZING CO 1	19850828	30	<10	<10	<4	<10	110	<6	17
7-566	NJDEP-HARRISON AVE 6	19851016	9	<10	<10	5	<10	390	<6	15
7-567	NJDEP-HARRISON AVE 7	19851016	130	<10	<10	<4	<10	410	<6	4
7-571	PENNSAUKN LANDFILL MON 4	19851010	30	10	<10	<4	<10	43	<6	79
7-586	CAMDEN CITY WD-MORRIS 12	19850717	20	<10	<10	<4	<10	84	<6	10
7-602	MERCH-PENN WCOM HWY 2	19850801	<3	20	<10	10	<10	93	<6	37
15- 1	CLAYTON BORO WD 3	19850917	<3	<10	<10	8	<10	150	<6	22
15- 1	CLAYTON BORO WD 3	19850917	<3	<10	<10	<4	<10	150	<6	<3
15- 24	DEPTFORD TWP MUA 4	19850712	<3	<10	<10	<4	<10	730	<6	<3
15- 28	E GREENWICH TWP WD 2	19850723	<3	<10	<10	9	<10	370	<6	68
15- 63	GLASSBORO BORO WD 4	19850724	<3	<10	<10	16	<10	130	<6	8
15- 69	GREENWICH TWP WD 3	19850725	30	20	<10	16	<10	140	<6	160
15- 79	EI DUPONT REPAUNO 6	19850917	7	<10	<10	9	<10	330	<6	36
15- 79	EI DUPONT REPAUNO 6	19850917	7	<10	<10	<4	<10	330	<6	36
15- 97	HERCULES CHEM GIBB 8 OBS	19851011	<3	<10	<10	47	<10	470	<6	46
15-109	MOBIL OIL-GREENWICH 41	19851018	<3	<10	<10	11	<10	950	<6	110
15-118	MOBIL OIL-GREENWICH 47	19851018	<3	<10	<10	5	<10	460	<6	40
15-118	MOBIL OIL-GREENWICH 47	19851018	<3	<10	<10	6	--	460	<6	21
15-130	SO JERSEY WC 3	19850723	<3	<10	<10	6	<10	430	<6	6
15-192	MANTUA MUA 5	19850723	<3	<10	<10	<4	<10	290	<6	10
15-210	PAULSBORO WD 6-1973	19850925	40	<10	<10	16	<10	160	<6	41
15-253	WASHINGTON TWP MUA 6-64	19850724	<3	<10	<10	9	<10	150	<6	21
15-276	W DEPTFORD TWP WD 4	19850718	<3	<10	30	10	<10	350	<6	14
15-282	W DEPTFORD TWP 5	19850718	<3	<10	<10	<4	<10	350	<6	8
15-283	SHELL CHEM CO 3	19850924	<3	<10	<10	5	<10	480	<6	<3
15-283	SHELL CHEM CO 3	19850924	<3	<10	<10	<4	<10	480	<6	4
15-308	PENWALT CORP TW 8	19850926	<3	<10	<10	5	<10	370	<6	16
15-312	W DEPTFORD TWP WD 6	19850718	<3	<10	<10	<4	<10	330	<6	8
15-314	TEXACO EAGLE PT 6-PROD	19850924	<3	<10	<10	7	<10	800	<6	9
15-323	TEXACO EAGLE PT 3-OBS	19851004	<3	<10	<10	6	<10	4,200	<6	25
15-331	WOODBURY WD RAILROAD 5	19850722	<3	<10	<10	6	<10	330	<6	10
15-342	DEL MONTE CORP 10	19850926	<3	<10	<10	11	<10	580	<6	22
15-347	GREENWICH TWP WD 5	19850725	4	<10	10	6	<10	91	<6	97
15-348	GREENWICH TWP WD 6	19850725	30	20	20	13	<10	75	<6	130
15-374	DEPTFORD TWP MUA 6	19850712	<3	<10	<10	7	<10	320	<6	35
15-385	PITMAN WD 4	19850724	<3	<10	<10	15	<10	160	<6	<3
15-390	GLOUCESTER CO SEW AUTH 1	19850926	20	<10	<10	15	<10	1,900	<6	15
15-417	S&S AUCTION HOUSE 1 1978	19851003	10	10	<10	<4	<10	130	<6	67
15-431	WOODBURY CITY WD 6-81	19850722	<3	<10	<10	7	<10	1,100	<6	<3
15-439	ESSEX CHEM-OLIN 2-1970	19850925	30	<10	<10	19	<10	1,100	<6	12
33-187	USGS-POINT AIRY OBS	19851007	<3	<10	<10	<4	<10	190	<6	5
PH- 6	US NAVY 6	19851114	<3	<10	10	6	<10	400	<6	20
PH- 12	US NAVY 12	19860123	7	<10	20	6	<10	350	6	7
PH- 15	US NAVY 15	19860124	10	<10	20	<4	<10	460	7	240
PH- 19	US NAVY 19	19851114	<3	<10	20	13	<10	1,300	8	4
PH- 86	US NAVAL HOSPITAL	19850912	<3	<10	<10	<4	<10	380	<6	11
PH- 86	US NAVAL HOSPITAL	19851009	--	--	--	--	--	--	--	--
PH-820	DEL VAL FISH CO INC	19850910	<3	30	<10	8	<10	290	<6	17

Table 7.--Results of analyses of ground-water samples for dissolved nutrients, 1985-86

[Concentrations in milligrams per liter; Dashes indicate missing data; <, less than]

Well number	Local well identifier	Date of sample (yr-mo-dy)	Nitrate and nitrite nitrogen (as N)	Nitrite nitrogen (as N)	Nitrogen, dissolved (as N)	Ammonia and organic nitrogen (as N)	Ammonia nitrogen (as N)	Ammonia nitrogen (as NH_4)	Ortho-phosphate (as P)
5- 39	NJ WC-DEL VALLEY WC 15	19850814	3.90	<0.01	4.0	<0.01	0.1	--	0.02
5- 40	NJ WC-DEL VALLEY WC 16	19850814	2.20	<.01	2.3	<.01	.1	--	.06
5- 60	BURLINGTON CITY WC 2	19850909	.22	.01	.52	.34	.3	.44	.07
5- 76	HEAL, CHARLES	19850904	<.10	<.01	--	.10	.1	.13	<.01
5- 76	HEAL, CHARLES	19850904	<.10	<.01	--	.10	.1	.13	<.01
5- 89	TENNECO CHEM 7	19850910	2.20	<.01	2.6	.03	.4	.04	<.01
5- 91	TENNECO CHEM 4	19850910	1.40	<.01	2.9	1.60	1.5	2.1	.01
5- 97	HERCULES POWDER 1	19850702	<.10	<.01	--	.20	.8	.26	.06
5-100	HERCULES POWDER 2	19850702	.56	<.01	.86	.06	.3	.08	.14
5-124	NJ WC-DEL VALLEY WC-STPHEN	19850802	.56	<.01	.76	.05	.2	.06	<.01
5-125	NJ WC-DEL VALLEY WC 10	19850814	4.40	<.01	4.5	<.01	.1	--	<.01
5-167	EVESHAM MUA 5	19850815	<.10	<.01	--	.12	.3	.15	.02
5-167	EVESHAM MUA 5	19850815	<.10	<.01	--	.12	.4	.15	.02
5-167	EVESHAM MUA 5	19850815	<.10	<.01	--	.11	.4	.14	.05
5-187	FLORENCE TWP WD 4	19850702	2.10	<.01	4.2	1.30	2.1	1.7	<.01
5-261	USGS-MEDFORD 5 OBS	19851002	<.10	<.01	--	.10	.4	.13	<.01
5-261	USGS-MEDFORD 5 OBS	19851002	<.10	<.01	--	.14	.4	.18	<.01
5-284	MOORESTOWN TWP WD 4	19850816	<.10	<.01	--	.08	.3	.1	<.01
5-284	MOORESTOWN TWP WD 4	19850816	<.10	<.01	--	.09	.4	.12	.20
5-284	MOORESTOWN TWP WD 4	19850816	<.10	<.01	--	.10	.8	.13	.02
5-393	RIVERSIDE INDUSTRY 39	19850816	5.60	<.01	5.9	<.01	.3	--	<.01
5-658	WILLINGBORO MUA 7	19850703	<.10	<.01	--	<.01	.3	--	<.01
5-667	WILLINGBORO MUA 5	19850703	5.00	<.01	5.7	<.01	.7	--	<.01
5-758	TENNECO CHEM 10	19850910	4.90	<.01	5.4	.01	.5	.01	.01
5-780	WASTE RESOURCE OBS 6	19851008	23.0	1.20	43	17.0	20	22	.02
5-822	MT LAURAL MUA 3	19850903	<.10	<.01	--	.03	<.1	.04	<.01
5-823	MT LAURAL MUA 4	19850903	<.10	<.01	--	.05	<.1	.06	<.01
7- 8	BELMAWR BORO WD 4	19850715	<.10	<.01	--	.21	.3	.27	.08
7- 12	BELMAWR BORO WD 3	19850715	<.10	<.01	--	.22	.3	.28	.01
7- 18	BERLIN BORO WD 9	19850815	<.10	<.01	--	.39	.8	.5	.02
7- 30	SJ PORT COMM NY SHIP 5A	19851015	<.10	<.01	--	8.50	9.5	11	.03
7- 46	CAMDEN CITY WD-CITY 11	19850829	.79	<.01	6.6	7.10	5.8	9.1	.08
7- 46	CAMDEN CITY WD-CITY 11	19850829	.81	<.01	6.9	6.70	6.1	8.6	.03
7- 46	CAMDEN CITY WD-CITY 11	19850829	.77	<.01	6.3	7.00	5.5	9.0	.09
7- 64	CAMDEN CITY WD-CITY 17	19850829	1.90	.02	3.2	1.10	1.3	1.4	.05
7- 98	NEW JERSEY WC-CAMDEN 52	19850807	2.40	<.01	12	8.30	9.4	11	<.01
7-122	NEW JERSEY WC-BROWN 44	19850808	<.10	<.01	--	.15	.3	.19	<.01
7-124	NEW JERSEY WC-BROWN 45	19850808	<.10	<.01	--	.24	.4	.31	.02
7-134	NEW JERSEY WC-OLD ORCH 37	19850808	.10	<.01	.5	.17	.4	.22	.03
7-143	NEW JERSEY WC-ELLISBG 16	19850813	<.10	<.01	--	.13	.2	.17	<.01
7-147	NEW JERSEY WC-KINGSTN 25	19850813	.10	<.01	.3	.07	.2	.09	<.01
7-183	NEW JERSEY WC-GIBBSBO 43	19850711	3.50	<.01	3.7	<.01	.2	.01	.01
7-189	NEW JERSEY WC-GIBBSBO 41	19850711	<.10	<.01	--	.68	.6	.88	<.01
7-221	USGS-GLOUC CTY CG BASE 1	19850918	<.10	.02	--	12.0	12	15	<.01
7-249	GARDEN ST WC-BLACKWOOD 3	19850815	<.10	<.01	--	.34	.5	.44	.09
7-273	NEW JERSEY WC-OTTERBK 29	19850809	<.10	<.01	--	.18	.2	.23	.03
7-274	NEW JERSEY WC-OTTERBK 39	19850809	<.10	<.01	--	.24	.4	.31	.07
7-278	NEW JERSEY WC-HADDON 15	19850807	<.10	<.01	--	.21	.6	.27	.02
7-283	NEW JERSEY WC-EGBERT OBS	19851001	<.10	.02	--	.18	.3	.23	.02
7-302	HADDONFLD BORO WD-RULON	19850716	<.10	<.01	--	.29	.4	.37	.18
7-304	HADDONFLD BORO WD-LAKE ST	19850716	<.10	<.01	--	.15	.3	.19	.03
7-315	NEW JERSEY WC-MAGNOLIA 16	19850809	<.10	<.01	--	.23	.2	.3	.04
7-329	MERCH-PENN WCOM-BROWN 2A	19850709	<.10	<.01	--	.17	.1	.22	.03
7-341	MERCH-PENN WCOM-DEL GN 2	19850710	<.10	<.01	--	4.00	3.7	5.2	<.01
7-345	MERCH-PENN WCOM-PARK 5	19850731	3.30	<.01	3.5	.02	.2	.03	<.01

Table 7.--Results of analyses of ground-water samples for dissolved nutrients, 1985-86--Continued

Well number	Local well identifier	Date of sample (yr-mo-dy)	Nitrate and nitrite nitrogen (as N)	Nitrite nitrogen (as N)	Nitrogen, dissolved (as N)	Ammonia and organic nitrogen (as N)	Ammonia nitrogen (as N)	Ammonia nitrogen (as NH_4)	Ortho-phosphate (as P)
7-350	MERCH-PENN WCOM-PARK 2	19850731	3.20	<0.01	3.4	0.07	0.2	0.09	0.01
7-354	PETTY ISLAND OBS	19851112	<.10	.01	--	25.0	28	32	.08
7-367	CAMDEN CITY WD-PUCHACK	19850806	1.50	.01	--	.25	.5	.32	.03
7-369	CAMDEN CITY WD-DELAIR 2	19850717	<.10	<.01	--	.10	2.2	.13	.05
7-372	MERCH-PENN WCOM-NAT HWY 1	19850801	3.50	<.01	3.8	.03	.3	.04	<.01
7-379	CAMDEN CITY WD-MORRIS 10	19850717	<.10	<.01	--	2.10	3.4	2.7	<.01
7-386	CAMDEN CITY WD-MORRIS 3A	19850806	.13	.01	11	10.0	11	13	.10
7-412	NEW JERSEY WC-ELM TREE 2	19850919	<.10	<.01	--	.13	.3	.17	.02
7-477	USGS-NEW BROOKLYN PK 2 OBS	19850923	.42	<.01	--	.05	--	.06	<.01
7-527	CAMDEN CITY WD-CITY 18	19850829	2.90	.01	3.3	.20	.4	.26	.04
7-528	CAMDEN CITY WD-PUCHACK 7	19850806	3.00	<.01	3.5	<.01	.5	.01	<.01
7-528	CAMDEN CITY WD-PUCHACK 7	19850806	3.10	<.01	4.0	<.01	.9	.01	<.01
7-528	CAMDEN CITY WD-PUCHACK 7	19850806	3.30	<.01	3.8	.02	.5	.03	.02
7-545	CAMDEN CITY WD-MORRIS 11	19850806	.17	<.01	1.2	1.30	1.0	1.7	<.01
7-555	PENLER ANODIZING CO 1	19850828	<.10	.01	--	.35	1.3	.45	<.01
7-566	NJDEP-HARRISON AVE 6	19851016	3.60	<.01	5.5	1.60	1.9	2.1	.01
7-567	NJDEP-HARRISON AVE 7	19851016	.18	<.01	24	18.0	24	23	.02
7-571	PENNSAUKN LANDFILL MON 4	19851010	.81	<.01	1.5	.03	.7	.04	<.01
7-586	CAMDEN CITY WD-MORRIS 12	19850717	<.10	<.01	--	.16	.7	.21	<.01
7-602	MERCH-PENN WCOM HWY 2	19850801	3.00	<.01	3.2	.03	.2	.04	<.01
15- 1	CLAYTON BORO WD 3	19850917	<.10	<.01	--	.69	1.9	.89	.27
15- 1	CLAYTON BORO WD 3	19850917	<.10	<.01	--	.68	.9	.88	.27
15- 24	DEPTFORD TWP MUA 4	19850712	<.10	<.01	--	.25	.2	.32	.11
15- 28	E GREENWICH TWP WD 2	19850723	<.10	<.01	--	.35	.3	.45	.25
15- 63	GLASSBORO BORO WD 4	19850724	<.10	.02	--	.36	.3	.46	.23
15- 69	GREENWICH TWP WD 3	19850725	.24	<.01	.54	.10	.3	.13	<.01
15- 79	EI DUPONT REPAUNO 6	19850917	8.40	.02	9.6	.57	1.2	.73	<.01
15- 79	EI DUPONT REPAUNO 6	19850917	7.60	.02	8.2	.57	.6	.73	<.01
15- 97	HERCULES CHEM GIBB 8 OBS	19851011	.95	.01	1.7	.20	.8	.26	<.01
15-109	MOBIL OIL-GREENWICH 41	19851018	<.10	<.01	--	2.10	2.4	2.7	<.01
15-118	MOBIL OIL-GREENWICH 47	19851018	.12	<.01	.52	.11	.4	.14	<.01
15-118	MOBIL OIL-GREENWICH 47	19851018	<.10	<.01	--	.06	.3	.08	<.01
15-130	SO JERSEY WC 3	19850723	<.10	<.01	--	.57	.4	.73	.21
15-192	MANTUA MUA 5	19850723	<.10	<.01	--	.39	.3	.5	.20
15-210	PAULSBORO WD 6-1973	19850925	<.10	<.01	--	.16	.2	.21	.04
15-253	WASHINGTON TWP MUA 6-64	19850724	<.10	<.01	--	<.01	<.1	--	.12
15-276	W DEPTFORD TWP WD 4	19850718	<.10	<.01	--	.29	.3	.37	.18
15-282	W DEPTFORD TWP 5	19850718	<.10	<.01	--	.28	.3	.36	.24
15-283	SHELL CHEM CO 3	19850924	<.10	<.01	--	.27	.5	.35	.22
15-283	SHELL CHEM CO 3	19850924	<.10	<.01	--	.25	.4	.32	.22
15-308	PENWALT CORP TW 8	19850926	<.10	<.01	--	.23	.3	.3	.20
15-312	W DEPTFORD TWP WD 6	19850718	<.10	<.01	--	.13	.3	.17	.17
15-314	TEXACO EAGLE PT 6-PROD	19850924	<.10	<.01	--	.27	.9	.35	.05
15-323	TEXACO EAGLE PT 3-OBS	19851004	<.10	<.01	--	1.30	1.6	1.7	<.01
15-331	WOODBURY WD RAILROAD 5	19850722	<.10	<.01	--	.20	.3	.26	.16
15-342	DEL MONTE CORP 10	19850926	<.10	<.01	--	.22	.3	.28	.02
15-347	GREENWICH TWP WD 5	19850725	3.90	<.01	4.5	.50	.6	.64	.03
15-348	GREENWICH TWP WD 6	19850725	.96	<.01	1.5	<.01	.5	.01	<.01
15-374	DEPTFORD TWP MUA 6	19850712	<.10	<.01	--	.20	.2	.26	.28
15-385	PITMAN WD 4	19850724	<.10	<.01	--	.38	.5	.49	.23
15-390	GLOUCESTER CO SEW AUTH 1	19850926	<.10	.01	--	3.90	4.2	5.0	.01
15-417	S&S AUCTION HOUSE 1 1978	19851003	8.10	.03	8.4	.04	.3	.05	<.01
15-431	WOODBURY CITY WD 6-81	19850722	<.10	<.01	--	.32	.6	.41	.11
15-439	ESSEX CHEM-OLIN 2-1970	19850925	<.10	.01	--	.62	.7	.8	<.01
33-187	USGS-POINT AIRY OBS	19851007	.15	<.01	1.2	.22	1.0	.28	.33
PH- 6	US NAVY 6	19851114	<.10	<.01	--	.9	.73	.94	.01
PH- 12	US NAVY 12	19860123	<.10	.01	--	15.0	14.0	18	--
PH- 15	US NAVY 15	19860124	<.10	.02	--	10	9.3	12	--
PH- 19	US NAVY 19	19851114	<.10	<.01	--	4.80	4.5	5.8	<.01
PH- 86	US NAVAL HOSPITAL	19850912	<.10	.01	--	1.00	1.1	1.4	<.01
PH- 86	US NAVAL HOSPITAL	19851009	--	--	--	--	--	--	--
PH-820	DEL VAL FISH CO INC	19850910	18.0	<.01	18	.20	.09	.09	.03

Table 8.--Results of analyses of ground-water samples for purgeable organic compounds, 1985-86

[Concentrations in micrograms per liter; Dashes indicate missing data; <, less than]

Well number	Local well identifier	Date of sample (yr-mo-dy)	Benzene	Ethyl-benzene	Chloro-benezene	Chloro-ethane	Di-bromo-chloro-methane	Chloro-methane	Chloro-form	Bromo-form
5- 89	TENNECO CHEM 7	19850910	<3.0	<3.0	3.2	<3.0	--	<3.0	<3.0	<3.0
5- 91	TENNECO CHEM 4	19850910	<3.0	<3.0	<3.0	<3.0	--	<3.0	<3.0	<3.0
5-100	HERCULES POWDER 2	19850702	<3.0	<3.0	<3.0	<3.0	--	<3.0	<3.0	<3.0
5-124	NJ WC-DEL VALLEY WC-STPHEN	19850802	<3.0	<3.0	<3.0	<3.0	--	<3.0	<3.0	<3.0
5-393	RIVERSIDE INDUSTRY 39	19850816	<3.0	<3.0	<3.0	<3.0	--	<3.0	<3.0	<3.0
5-780	WASTE RESOURCE OBS 6	19851008	<3.0	<3.0	<3.0	<3.0	--	<3.0	<3.0	<3.0
7- 98	NEW JERSEY WC-CAMDEN 52	19850807	<5.0	<5.0	<5.0	<5.0	--	<5.0	5.2	<5.0
7-329	MERCH-PENN WCOM-BROWN 2A	19850709	<3.0	<3.0	<3.0	<3.0	--	<3.0	<3.0	<3.0
7-345	MERCH-PENN WCOM-PARK 5	19850731	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
7-350	MERCH-PENN WCOM-PARK 2	19850731	<3.0	<3.0	<3.0	<3.0	--	<3.0	<3.0	<3.0
7-367	CAMDEN CITY WD-PUCHACK	19850806	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
7-386	CAMDEN CITY WD-MORRIS 3A	19850806	<3.0	<3.0	16	<3.0	--	<3.0	--	<3.0
7-412	NEW JERSEY WC-ELM TREE 2	19850919	<3.0	<3.0	<3.0	<3.0	--	<3.0	<3.0	<3.0
7-527	CAMDEN CITY WD-CITY 18	19850829	<3.0	<3.0	<3.0	<3.0	--	<3.0	<3.0	<3.0
7-555	PENLER ANODIZING CO 1	19850828	29	<3.0	14	<3.0	--	<3.0	<3.0	<3.0
7-566	NJDEP-HARRISON AVE 6	19851016	3.0	<3.0	<3.0	<3.0	--	<3.0	<3.0	<3.0
15- 79	EI DUPONT REPAUNO 6	19850917	<3.0	<3.0	3.7	<3.0	--	<3.0	3.7	<3.0
15- 97	HERCULES CHEM GIBB 8 OBS	19851011	<3.0	<3.0	<3.0	<3.0	--	<3.0	<3.0	<3.0
15-109	MOBIL OIL-GREENWICH 41	19851018	310	<3.0	<3.0	<3.0	--	<3.0	<3.0	<3.0
15-253	WASHINGTON TWP MUA 6-64	19850724	<3.0	<3.0	<3.0	<3.0	--	<3.0	35	<3.0
15-308	PENWALT CORP TW 8	19850926	<3.0	<3.0	<3.0	<3.0	--	<3.0	<3.0	<3.0
15-342	DEL MONTE CORP 10	19850926	<3.0	<3.0	<3.0	<3.0	--	<3.0	<3.0	<3.0
15-390	GLOUCESTER CO SEW AUTH 1	19850926	<3.0	<3.0	<3.0	<3.0	--	<3.0	<3.0	<3.0
15-439	ESSEX CHEM-OLIN 2-1970	19850925	160	8.5	620	<3.0	--	<3.0	8.4	<3.0
PH- 15	US NAVY 15	19860124	<5.0	<.2	2.3	<.2	<.2	<.2	<.2	<.2
PH- 86	US NAVAL HOSPITAL	19851009	<3.0	<3.0	<3.0	<3.0	--	<3.0	<3.0	<3.0
PH-820	DEL VAL FISH CO INC	19850910	<3.0	<3.0	<3.0	<3.0	--	<3.0	<3.0	<3.0

Well number	Local well identifier	Date of sample (yr-mo-dy)	Methyl-bromide	Methylene chloride	Vinyl chloride	Dichloro-bromo-methane	Dichloro-difluoro-methane	Carbon tetra-chloride	Tetra-chloro-ethylene	Tolu-ene
5- 89	TENNECO CHEM 7	19850910	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
5- 91	TENNECO CHEM 4	19850910	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
5-100	HERCULES POWDER 2	19850702	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
5-124	NJ WC-DEL VALLEY WC-STPHEN	19850802	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
5-393	RIVERSIDE INDUSTRY 39	19850816	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	9.7	<3.0
5-780	WASTE RESOURCE OBS 6	19851008	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
7- 98	NEW JERSEY WC-CAMDEN 52	19850807	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
7-329	MERCH-PENN WCOM-BROWN 2A	19850709	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	7.2	<3.0
7-345	MERCH-PENN WCOM-PARK 5	19850731	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
7-350	MERCH-PENN WCOM-PARK 2	19850731	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
7-367	CAMDEN CITY WD-PUCHACK	19850806	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
7-386	CAMDEN CITY WD-MORRIS 3A	19850806	<3.0	<3.0	4.6	<3.0	<3.0	<3.0	<3.0	<3.0
7-412	NEW JERSEY WC-ELM TREE 2	19850919	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
7-527	CAMDEN CITY WD-CITY 18	19850829	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	15	<3.0
7-555	PENLER ANODIZING CO 1	19850828	<3.0	9.1	3.0	<3.0	<3.0	<3.0	8.5	<3.0
7-566	NJDEP-HARRISON AVE 6	19851016	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
15- 79	EI DUPONT REPAUNO 6	19850917	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	130	<3.0
15- 97	HERCULES CHEM GIBB 8 OBS	19851011	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
15-109	MOBIL OIL-GREENWICH 41	19851018	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
15-253	WASHINGTON TWP MUA 6-64	19850724	<3.0	<3.0	<3.0	4.8	<3.0	<3.0	<3.0	<3.0
15-308	PENWALT CORP TW 8	19850926	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
15-342	DEL MONTE CORP 10	19850926	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
15-390	GLOUCESTER CO SEW AUTH 1	19850926	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
15-439	ESSEX CHEM-OLIN 2-1970	19850925	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	65	5.8
PH- 15	US NAVY 15	19860124	<.2	<1.0	<.2	<.2	<.2	<.2	<.2	3.0
PH- 86	US NAVAL HOSPITAL	19851009	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
PH-820	DEL VAL FISH CO INC	19850910	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	32	<3.0

Table 8.--Results of analyses of ground-water samples for purgeable organic compounds, 1985-86--Continued

Well number	Local well identifier	Date of sample (yr-mo-dy)	Tri-chloro-ethylene	Tri-chloro-fluoro-methane	1,1-Di-chloro-ethylene	1,1-Di-chloro-ethane	1,1,1-Tri-chloro-ethane	1,1,2-Tri-chloro-ethane	1,1,2,2-Tetra-chloro-ethane	1,2-Di chloro-ethane
5- 89	TENNECO CHEM 7	19850910	4.1	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
5- 91	TENNECO CHEM 4	19850910	480	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
5-100	HERCULES POWDER 2	19850702	3.1	<3.0	9.0	4.8	56	<3.0	<3.0	<3.0
5-124	NJ WC-DEL VALLEY WC-STPHEN	19850802	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
5-393	RIVERSIDE INDUSTRY 39	19850816	60.0	<3.0	<3.0	<3.0	<3.9	<3.0	<3.0	<3.0
5-780	WASTE RESOURCE OBS 6	19851008	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
7- 98	NEW JERSEY WC-CAMDEN 52	19850807	160	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	19
7-329	MERCH-PENN WCOM-BROWN 2A	19850709	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
7-345	MERCH-PENN WCOM-PARK 5	19850731	15.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
7-350	MERCH-PENN WCOM-PARK 2	19850731	3.1	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
7-367	CAMDEN CITY WD-PUCHACK	19850806	9.6	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
7-386	CAMDEN CITY WD-MORRIS 3A	19850806	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
7-412	NEW JERSEY WC-ELM TREE 2	19850919	<3.0	<3.0	<3.0	<3.0	8.0	<3.0	<3.0	<3.0
7-527	CAMDEN CITY WD-CITY 18	19850829	10.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<6.7
7-555	PENLER ANODIZING CO 1	19850828	17.0	25	<3.0	9.6	3.9	<3.0	<3.0	<3.0
7-566	NJDEP-HARRISON AVE 6	19851016	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
15- 79	EI DUPONT REPAUNO 6	19850917	8.9	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
15- 97	HERCULES CHEM GIBB 8 OBS	19851011	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
15-109	MOBIL OIL-GREENWICH 41	19851018	5.8	<3.0	3.9	10	<3.0	<3.0	<3.0	<3.0
15-253	WASHINGTON TWP MUA 6-64	19850724	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
15-308	PENWALT CORP TW 8	19850926	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
15-342	DEL MONTE CORP 10	19850926	<3.0	<3.0	<3.0	<3.0	4.2	<3.0	<3.0	<3.0
15-390	GLOUCESTER CO SEW AUTH 1	19850926	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
15-439	ESSEX CHEM-OLIN 2-1970	19850925	27.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	750
PH- 15	US NAVY 15	19860124	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
PH- 86	US NAVAL HOSPITAL	19851009	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
PH-820	DEL VAL FISH CO INC	19850910	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0

Well number	Local well identifier	Date of sample (yr-mo-dy)	1,2-Di chloro-propane	1,3-Di chloro-propene	Trans-1,2-Di-chloro-ethylene	2-Chloro-ethyl-vinyl ether
5- 89	TENNECO CHEM 7	19850910	<3.0	<3.0	<3.0	<3.0
5- 91	TENNECO CHEM 4	19850910	<3.0	<3.0	100	<3.0
5-100	HERCULES POWDER 2	19850702	<3.0	<3.0	<3.0	<3.0
5-124	NJ WC-DEL VALLEY WC-STPHEN	19850802	<3.0	<3.0	<3.0	<3.0
5-393	RIVERSIDE INDUSTRY 39	19850816	<3.0	<3.0	<3.0	<3.0
5-780	WASTE RESOURCE OBS 6	19851008	<3.0	<3.0	<3.0	<3.0
7- 98	NEW JERSEY WC-CAMDEN 52	19850807	<5.0	<5.0	<5.0	<5.0
7-329	MERCH-PENN WCOM-BROWN 2A	19850709	<3.0	<3.0	<3.0	<3.0
7-345	MERCH-PENN WCOM-PARK 5	19850731	<3.0	<3.0	<3.0	<3.0
7-350	MERCH-PENN WCOM-PARK 2	19850731	<3.0	<3.0	<3.0	<3.0
7-367	CAMDEN CITY WD-PUCHACK	19850806	<3.0	<3.0	4.4	<3.0
7-386	CAMDEN CITY WD-MORRIS 3A	19850806	<3.0	<3.0	5.3	<3.0
7-412	NEW JERSEY WC-ELM TREE 2	19850919	<3.0	<3.0	<3.0	<3.0
7-527	CAMDEN CITY WD-CITY 18	19850829	<3.0	<3.0	<3.1	<3.0
7-555	PENLER ANODIZING CO 1	19850828	8.8	<3.0	58	<3.0
7-566	NJDEP-HARRISON AVE 6	19851016	<3.0	<3.0	<3.0	<3.0
15- 79	EI DUPONT REPAUNO 6	19850917	<3.0	<3.0	<3.0	<3.0
15- 97	HERCULES CHEM GIBB 8 OBS	19851011	<3.0	<3.0	<3.0	<3.0
15-109	MOBIL OIL-GREENWICH 41	19851018	<3.0	<3.0	13	<3.0
15-253	WASHINGTON TWP MUA 6-64	19850724	<3.0	<3.0	<3.0	<3.0
15-308	PENWALT CORP TW 8	19850926	<3.0	<3.0	<3.0	<3.0
15-342	DEL MONTE CORP 10	19850926	<3.0	<3.0	<3.0	<3.0
15-390	GLOUCESTER CO SEW AUTH 1	19850926	<3.0	<3.0	<3.0	<3.0
15-439	ESSEX CHEM-OLIN 2-1970	19850925	<3.0	<3.0	46	<3.0
PH- 15	US NAVY 15	19860124	<.2	<.2	<.2	<.2
PH- 86	US NAVAL HOSPITAL	19851009	<3.0	<3.0	<3.0	<3.0
PH-820	DEL VAL FISH CO INC	19850910	<3.0	<3.0	<3.0	<3.0