GROUND WATER

SELECTED HYDROGEOLOGIC AND CHLORIDE-CONCENTRATION DATA FOR THE NORTHERN AND CENTRAL COASTAL AREA OF NEW CASTLE COUNTY, DELAWARE

U.S. GEOLOGICAL SURVEY

Open File Report 95-766

Prepared in cooperation with the

U.S. ARMY CORPS OF ENGINEERS

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Baltimore, Maryland

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U.S. DEPARTMENT OF THE INTERIOR

BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY

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Multiply	By	To obtain
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
million gallons (Mgal)	3,785	cubic meter
million gallons per day (Mgal/d)	0.04381	cubic meter per second

Abbreviated water-quality units: Chemical concentrations are reported in milligrams per liter (mg/L).

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.

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ABSTRACT

This report summarizes and presents existing hydrogeologic and chloride-concentration data from the northern and central coastal area of New Castle County, Delaware. The report was prepared as an initial stage to evaluate the effects that the proposed deepening of the main navigational channel of the Delaware River would have on ground-water resources in Delaware. The study area was defined on the basis of current and projected ground-water usage from aquifers known or thought to be in hydraulic contact with the Delaware River. The report includes maps that show the location of the study area and associated geologic and hydrologic characteristics. Tables listing hydrologic characteristics, water use, annual ground-water withdrawals, and chloride-concentration data for the study area also are included.

INTRODUCTION

The U.S. Army Corps of Engineers (COE), Philadelphia District, is evaluating the possibility of making improvements to the main navigational channel of the Delaware River. These improvements could include deepening the channel from the existing depth of about 40 ft below mean-low water (MLW) to about 45 ft below MLW, thereby extending navigable deep water from Delaware Bay to Philadelphia, Pa., and Camden, N.J. Many public and private ground-water supplies have been developed adjacent to the Delaware River in the reach where channel improvements are being considered. There are concerns that deepening the channel may adversely affect ground-water supplies developed in the adjacent Coastal Plain aquifers of Delaware. The Potomac aquifer system is of particular interest because it is the sole-source ground-water supply for northern New Castle County. A previous study (Phillips, 1987) has documented brackish-water intrusion from the Delaware River into aquifers of the Potomac Formation in northern New Castle County. The Magothy and Englishtown-Mount Laurel aquifers are sources of water in the southern part of the county below the Chesapeake and Delaware Canal (C&D Canal). Water quality in these aquifers and the Potomac aquifers could be affected if channel deepening causes salinity in the river and the C&D Canal to increase. Some of that water could infiltrate into adjacent aquifers, causing an increase in chloride and sodium concentrations.

The amount of water infiltrating from the Delaware River into the Potomac and other aquifers and the water's subsequent effect on ground-water quality is dependent on four factors: (1) the depth and distribution of the aquifers relative to the river channel, (2) the nature of the sediments overlying the aquifers where they extend under the river, (3) the direction and magnitude of the hydraulic gradient between the aquifers and the river, and (4) the salinity of the river water. Deepening the channel could affect factors 2 and 4 above. Dredging could breach confining layers of fine-grained relatively impermeable sediments under the river, which would provide a conduit for river water to flow into underlying aquifers. Removing 5 ft of bottom material from the river could cause higher salinity water to encroach farther upstream in the river and the C&D Canal. If this water migrates into the aquifers, it could eventually cause increased salinity in areas currently experiencing brackish-water intrusion. Even without deepening the channel, the hydraulic gradient between the river and aquifer (factor 3), which now is from the river into the aquifer in many places, is likely to increase because of higher rates of ground-water pumpage in New Castle County. Water-level data for the aquifers that are needed to evaluate the hydraulic gradient are presented in this report. Existing data related to factors 1 and 2 also have been compiled in this report and are presented along with chloride-concentration data (an indication of salinity) for the study area. This study was done in cooperation with the U.S. Army Corps of Engineers.

Purpose and Scope

This report presents available hydrogeologic and chloride-concentration data for the coastal area of northern and central New Castle County, Del. Data for the depth and distribution of aquifers and confining units, the aquifer and confining-unit sediments, water-level data within aquifers, and existing salinity distributions in ground water and river water are presented. Maps are provided to show the location of the study area and its associated geologic and hydrologic characteristics. Tables list information about the hydrogeologic characteristics, water use, annual ground-water withdrawals, and chloride-concentration data for the study area.

Description of Study Area

The study area was defined on the basis of current and projected ground-water usage from aquifers known or thought to be the uppermost aquifer underlying the Delaware River. The study area lies in northern and central New Castle County, Del., and is bounded approximately on the west by U.S. Route 13, on the east by the Delaware River, on the north by the Christina River, and on the south by the Appoquinimink River (fig. 1). These boundaries were chosen to include the parts of aquifers where most of the pumpage in this area of the State occurs. Topography is relatively flat to gently rolling, with land-surface elevations ranging from sea level to about 80 ft above sea level. The area is underlain by unconsolidated sediments of the Atlantic Coastal Plain Physiographic Province that form a wedge-shaped deposit of highly variable permeability (Cushing and others, 1973). The Coastal Plain sediments range in thickness from a few feet at the Christina River to approximately 1,600 ft at the Appoquinimink River (Sundstrom and Pickett, 1971).

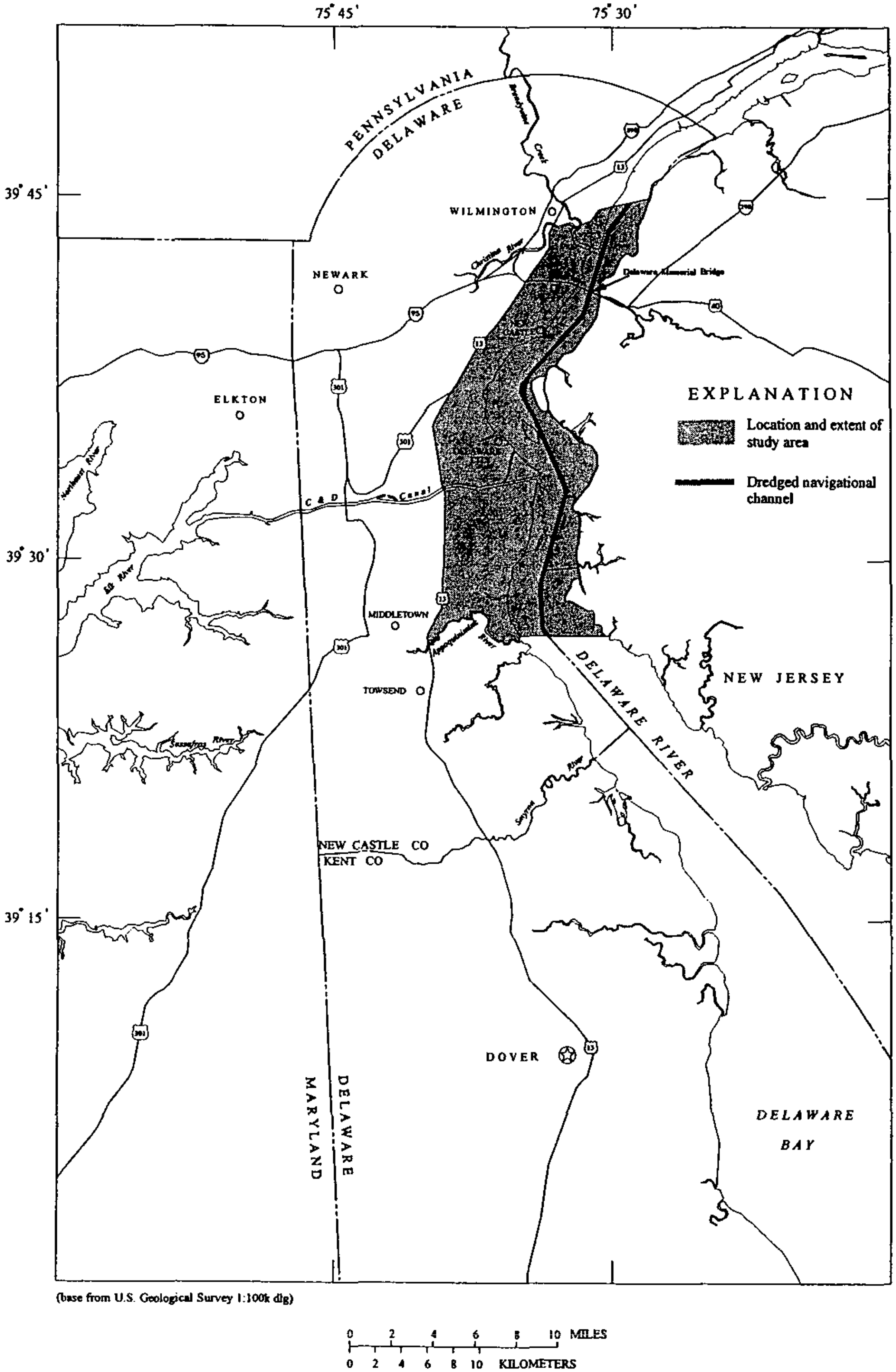


Figure 1. Location of study area.

Conceptual Models of Saltwater Intrusion

Brackish water, which is water with salinity and corresponding chloride concentrations between that of normal seawater and that of normal freshwater (Bates and Jackson, 1987), is found in the aquifers adjacent to the Delaware River under three conditions: Infiltration from the river (Phillips, 1987); leakage from landfills; and at depth, as naturally occuring brines in the southernmost part of the study area (Sundstrom and Pickett, 1971; Groot, 1983). The focus of this report is on conditions related to potential brackish-water infiltration from the Delaware River. Elevated chloride concentrations caused by landfills and the formation of brines at depth are not related to conditions in the Delaware River and are not presented in this report.

Ground-water-flow directions under steady-state (prepumping) and pumping conditions are shown in figures 2a and 2b, respectively. These simplified flow models show the primary hydrogeologic factors that influence the movement of brackish water from the Delaware River into the underlying aquifers. These factors include (1) water levels in the aquifers relative to sea level, (2) the distribution of aquifer outcrop and subcrop areas and overlying confining units, (3) the nature of bottom sediments in the bay, and (4) the distribution of and sedimentary sequence in paleochannels and dredged channels.

Water levels in the aquifers exert the major control on river-water intrusion and are strongly related to pumping. A typical flow regime under steady-state (prepumping) conditions is shown in figure 2a. As fresh ground water is withdrawn from the aquifers, water levels decline, often to below sea level. As this happens, directions of flow change until a new equilibrium between hydraulic heads in the aquifers and the bay is established. A typical flow regime under pumping conditions is shown in figure 2b.

The distribution of aquifer outcrop and subcrop areas and overlying confining units plays an important role in determining the degree to which brackish-water intrusion is likely to occur. Where aquifers crop out or subcrop in Delaware Bay and chloride concentrations in the river are higher than in the ambient ground water, brackish water (which is denser than freshwater) can flow downward into the aquifer. If the hydraulic head in the aquifer is sufficiently high, or low permeable silt and clay confining units crop out or subcrop in the bay above the aquifer, brackish-water intrusion is retarded.

Sediments are deposited in the bottom of the bay by fluvial and tidal action. The nature of these sediments affects the ease with which brackish water is able to intrude into the aquifers. If the bottom sediments consist of silt, clay, or organic ooze, hydraulic conductivity is apt to be low, and brackish-water intrusion is inhibited. Conversely, if the bottom sediments consist of sand and gravel or are relatively thin, brackish-water intrusion is apt to be facilitated.

The distribution of paleo- or dredged channels affects the brackish-water intrusion because the creation of channels can remove confining units.

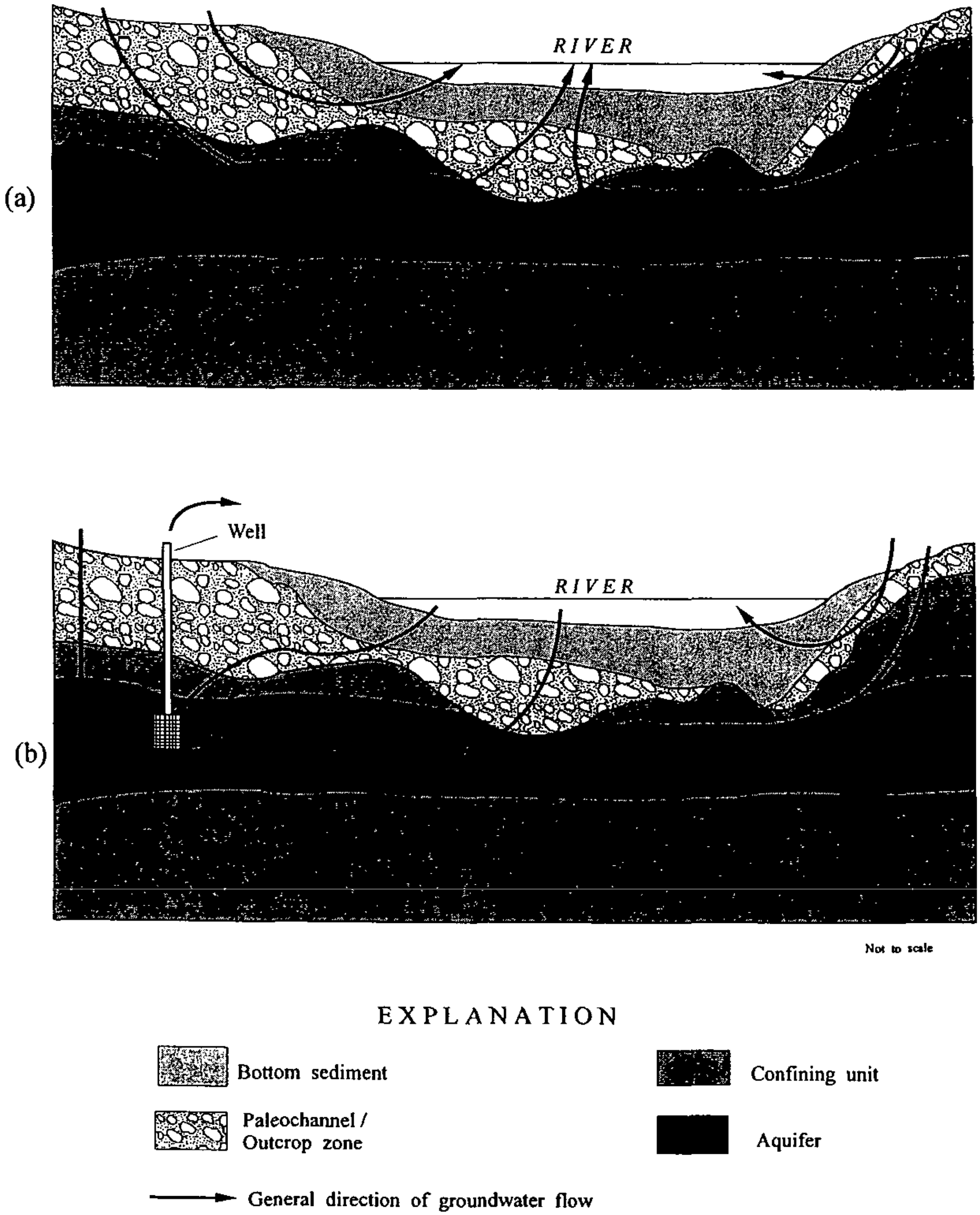


Figure 2. Schematic diagrams showing ground-water-flow directions under (a) steady-state and (b) pumping conditions. (from Phillips and Ryan, 1989)

This changes the distribution of aquifer outcrop at these locations and can expose areas of high permeability and relatively low hydraulic head to the river and facilitate the flow of brackish water into the aquifer.

Rates of change in flow direction are determined by the relative elevations of the water level in the river and the aquifer, the orientation and physical characteristics of the aquifer, the distance to a pumped well from the zone of hydraulic contact, and the rate of recharge to and discharge from the aquifer. Ground water generally moves very slowly. Years, decades, or centuries may pass before brackish water reaches a well.

Previous Investigations

Numerous investigations related to ground water have been conducted in the study area. The investigations can be organized into five categories: (1) General geology and hydrology; (2) ground-water resource information; (3) investigations and compilations of ground-water quality; (4) investigations and compilations of water quality in the river; and (5) quantitative investigations of ground-water flow, including intrusion of river water into the Potomac aquifer.

(1) Results of studies of the general geology and hydrology of the study area have been reported by Jordan and Groot (1962), Bonini (1967), Spoljaric (1967), Spoljaric and Woodruff (1970), Owens and others (1970), Pickett (1970), Pickett and Spoljaric (1971), Cushing and others (1973), Woodruff (1981 and 1986), Duran (1986), Trapp (1992), and Vroblesky and Fleck (1991).

(2) General ground-water resource information has been reported by Marine and Rasmussen (1955), Rasmussen and others (1957), Rima and others (1964), Sundstrom and others (1967), Sundstrom and Pickett (1971), Groot and others (1983), Knobel (1985), Talley (1978 and 1988), Frick and Shaffer (1977), and Metcalf & Eddy (1991a and 1991b).

(3) Investigations and compilations of ground-water quality have been reported by Groot and Beamer (1958), Woodruff (1969 and 1970), Apgar (1979), Groot (1983), Talley (1985), Avery and others (1993), and Bachman and Ferrari (1995).

(4) Investigations and compilations of water quality in the river have been reported by Cohen (1957), Martin and Denver (1982), Hull and Titus (1986), Phillips (1987), Delaware River Basin Commission (1989), DiLorenzo and others (1993), and White (1993).

(5) Quantitative investigations of ground-water flow have been reported by Ambrose and others (1980), Apgar and Panigrahi (1982), Martin and Denver (1982), Martin (1984), Phillips (1987), and Avery and others (1994), who evaluated the area along the reach of the Chesapeake and Delaware Canal.

The results of these investigations as they relate to the current project are presented in this report.

Acknowledgments

Data for this report were provided by Gerald Kauffman (Regional Planning and Management, New Castle County) and by officials of the Delaware Department of Public Health, the Delaware Department of Natural Resources and Environmental Control (DNREC), and the U.S. Army Corps of Engineers, Philadelphia District (COE). Publications and other information were provided by Scott Andres of the Delaware Geological Survey (DGS), Blair Venables and Stuart Lovell of DNREC, John Sharpe of the Delaware Estuarine Program, Richard Tortoriello of the Delaware River Basin Commission, and the COE.

HYDROGEOLOGIC DATA

Relatively impermeable crystalline basement rocks in the study area slope seaward and are overlain by a wedge-shaped deposit of unconsolidated sediments of highly variable permeability (Cushing and others, 1973). This deposit ranges in thickness from a few feet at the Christina River to approximately 1,600 ft at the Appoquinimink River (Sundstrom and Pickett, 1971). The sediments consist of a system of unconsolidated sand and silty clay that represent cycles of marine transgression and regression interrupted by erosional and depositional unconformities. In the study area, a series of aquifers and confining units can be defined in these sediments on the basis of their mineralogic, structural, physical, and chemical properties. Many of these properties were determined by the depositional environments of the aquifers. These depositional environments ranged from fluvial (Potomac Formation) through marginal-marine (Magothy Formation), to marine (Matawan, Monmouth, and Rancocas Groups) (Spoljaric and Jordan, 1966). These sediments are overlain unconformably by the fluvial deposits of the Columbia Formation.

Surficial deposits of the Columbia Formation blanket most of the study area. The thickness of these deposits is highly variable, reflecting the occurrence of the sediments as fillings of former stream valleys (paleochannels) (Jordan, 1964). Several paleochannels were exposed by the construction of the C&D Canal (fig. 1). The channels range up to more than half a mile in apparent width and cut into the underlying formations from elevations of 40 to 70 ft above sea level down to tens of feet below sea level. Paleochannels are found in many locations all over the study area and form a locally productive water-table (unconfined) aquifer that provides recharge to underlying confined aquifers where they subcrop.

Ground water in the study area flows in water-table and confined aquifers. Several confined aquifers crop out or subcrop beneath the Columbia Formation in the study area. The geologic units that contain these aquifers include the Potomac Formation, Magothy Formation, Matawan Group (Englishtown Formation), Monmouth Group (Mount Laurel Formation) and Rancocas Group (Vincentown Formation). The distribution of these units (with the Columbia Formation removed) is shown in figure 3. The relation between the stratigraphy and the water-bearing properties of the aquifers in New Castle County is summarized in table 1. Each of the aquifers in the study area is

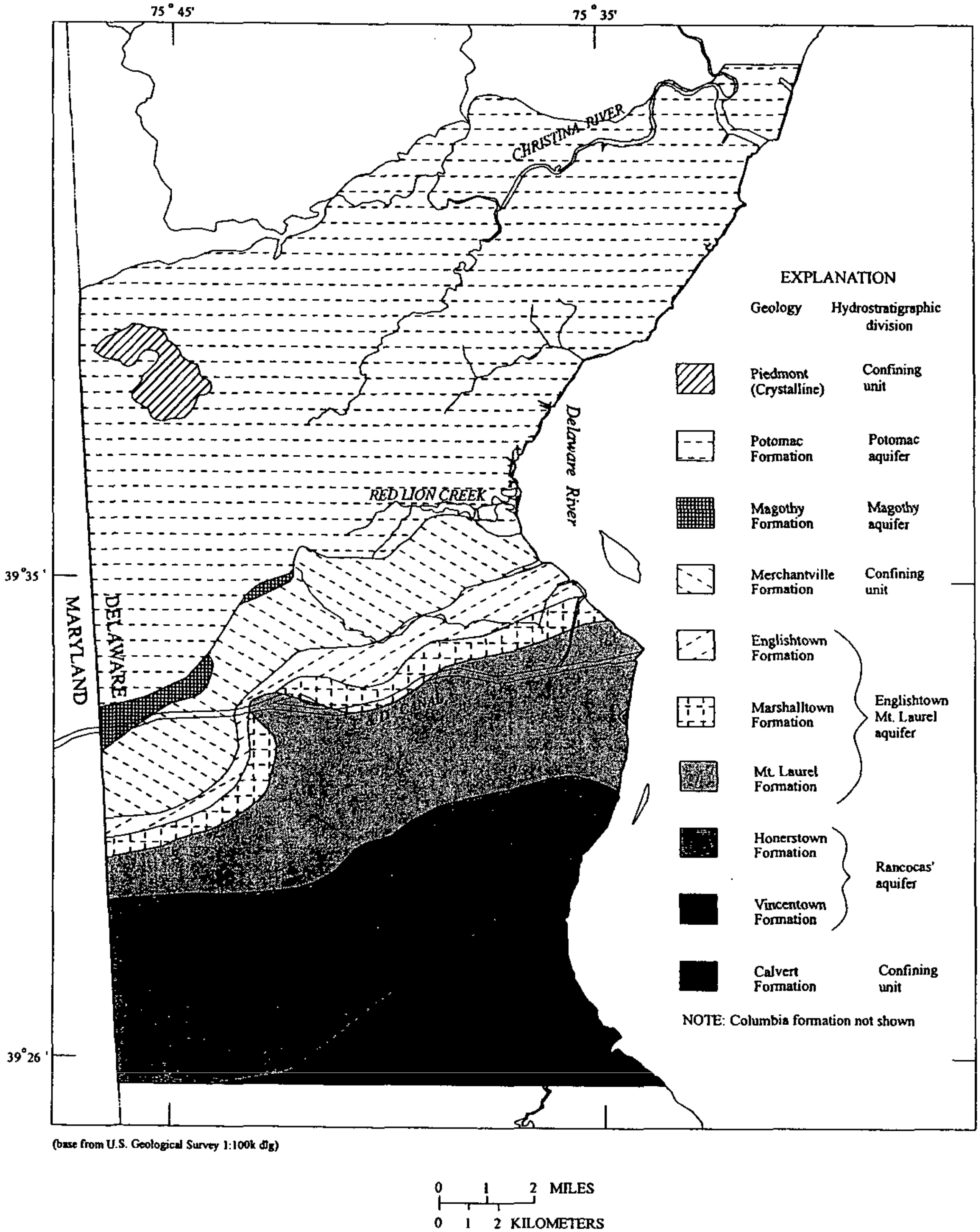


Figure 3. Geology of Delaware within the northern and southern boundaries of the study area. (modified from Sundstrom and Pickett, 1971; and Bachman and Ferrari, 1995).

Table 1. Hydrostratigraphy of central New Castle County, Delaware

System	Series	Stratigraphic unit	Hydrostratigraphic division Delaware (New Jersey)	Lithology	Water-bearing properties
Quaternary	Holocene and Pleistocene	Holocene sediments		Silt, sandy silt, silty sand, some gravel, abundant organics, some peat	Leaky confining unit
		Columbia Group	Columbia aquifer (Holly Beach aquifer)	Sand, gravel, some clay, dominantly quartz; fluvial	Water table aquifer, usually surficial, often in hydraulic connection with an underlying unit, large quantity of water where thickness is greater than 40 ft
Tertiary	Miocene	Calvert Formation	Confining unit south of Appoquinimink River	Silty clay; marine	Confining unit
	Paleocene	Rancocas Group	Rancocas aquifer (Vincentown aquifer)	Quartz; silty, glauconitic sand; marine	Sandy zones function as aquifers
Cretaceous	Upper	Monmouth Group and Matawan Group	Englishtown-Mt. Laurel aquifer system (Wenone-Mt.Laurel aquifer and Englishtown aquifer system)	Medium-coarse sand with glauconite, fossils, some silt; marine Fine sand and silt, micaceous and glauconitic; marine	Sandy zones function as aquifers interbedded with leaky confining units
	Lower	Magothy Formation	Magothy aquifer (Upper Potomac-Raritan-Magothy [PRM] aquifer system)	Silty clay with interbedded sand, predominantly quartz and kaolinite; marginal marine	Hydraulically connected to upper Potomac aquifer
		Potomac Formation	Upper, middle, and lower Potomac aquifers (Middle and lower PRM aquifer system)	Quartz sand with some gravel, variegated silt and clay, some beds of gray clay; fluvial	Sandy zones function as aquifers in lower, middle, and upper parts of Potomac Formation
Paleozoic and Precambrian		Crystalline rocks (basement)	Confining unit (basement)	Complex assemblage of igneous and metamorphic rocks	Not an important aquifer in the Coastal Plain

described in more detail in the following sections, from north to south in order of subcropping. Particular emphasis is placed on the uppermost aquifer directly underlying the Delaware River and its river-channel deposits.

The geology of the study area (fig. 3) and the available cross sections of the river indicate that the Delaware River might cross outcrops of the Potomac, Englishtown-Mt. Laurel, and Rancocas aquifers (Sundstrom and Pickett, 1971; Frick and Shaffer, 1977; Phillips, 1987; Bachman and Ferrari, 1995). As shown in table 1, Holocene sediments of various thickness overlie most of these geologic formations. The Potomac aquifers underlie the river from about 3 mi northeast of Wilmington to about 4 mi southwest of New Castle (fig. 1). The Englishtown-Mount Laurel aquifers underlie the river from about 3 mi upstream of the C&D Canal to about 3 mi downstream of the canal. The Rancocas aquifer underlies the river between the C&D Canal and the Appoquinimink River. The Piney Point Formation consists of the Piney Point aquifer (Cushing and others, 1973). The Piney Point aquifer is not a significant source of water in the study area (Leahy, 1982). The Piney Point aquifer is not in hydraulic connection with Delaware Bay (Cushing and others, 1973) and is not thought to be recharged by bay water.

Aquifers in the Potomac Formation

The predominantly fine-grained sediments of the Potomac Formation were deposited by a stream system of coalescing alluvial fans and exhibit considerable vertical and horizontal variability (Sundstrom and others, 1967). Several aquifers of highly variable transmissivity separated by generally continuous confining units have been identified (Martin and Denver, 1982). Martin (1984) found that most of the recharge for the Potomac aquifers occurred at or near the land surface where the aquifers crop out or subcrop below the unconfined aquifer or a confining unit. Water in these aquifers that is not affected by pumpage flows southeast and eventually discharges into overlying sediments and the Delaware River (Phillips, 1987).

Previous workers have divided the Potomac Formation into a hydrologic system with either two or three aquifers. Rasmussen and others (1957) divided the Potomac Formation into lower, middle, and upper Potomac aquifers. Sundstrom and others (1967) divided the Potomac Formation in the C&D Canal area into upper and lower aquifers. Woodruff (1985) agreed that most of the Potomac Formation is characterized by two aquifers, but found evidence to support the three-aquifer interpretation in some areas in New Castle County. Martin (1984) and Phillips (1987) also identified three aquifers in the formation and used them as a basis for a digital flow model of the Potomac Formation in New Castle County. The three-aquifer interpretation is used in this report (fig. 4).

Delineation of the lower Potomac aquifer north of the Delaware Memorial Bridge is difficult because of the lack of data. Data from Duran (1986) that were collected by use of marine seismic-reflection and electromagnetic-conductivity techniques indicate that, north of the Delaware Memorial Bridge, the Potomac Formation is mostly fine grained and consists of relatively thin and discontinuous sand bodies. Analysis of these data indicate that the lower Potomac aquifer underlies the river directly in some

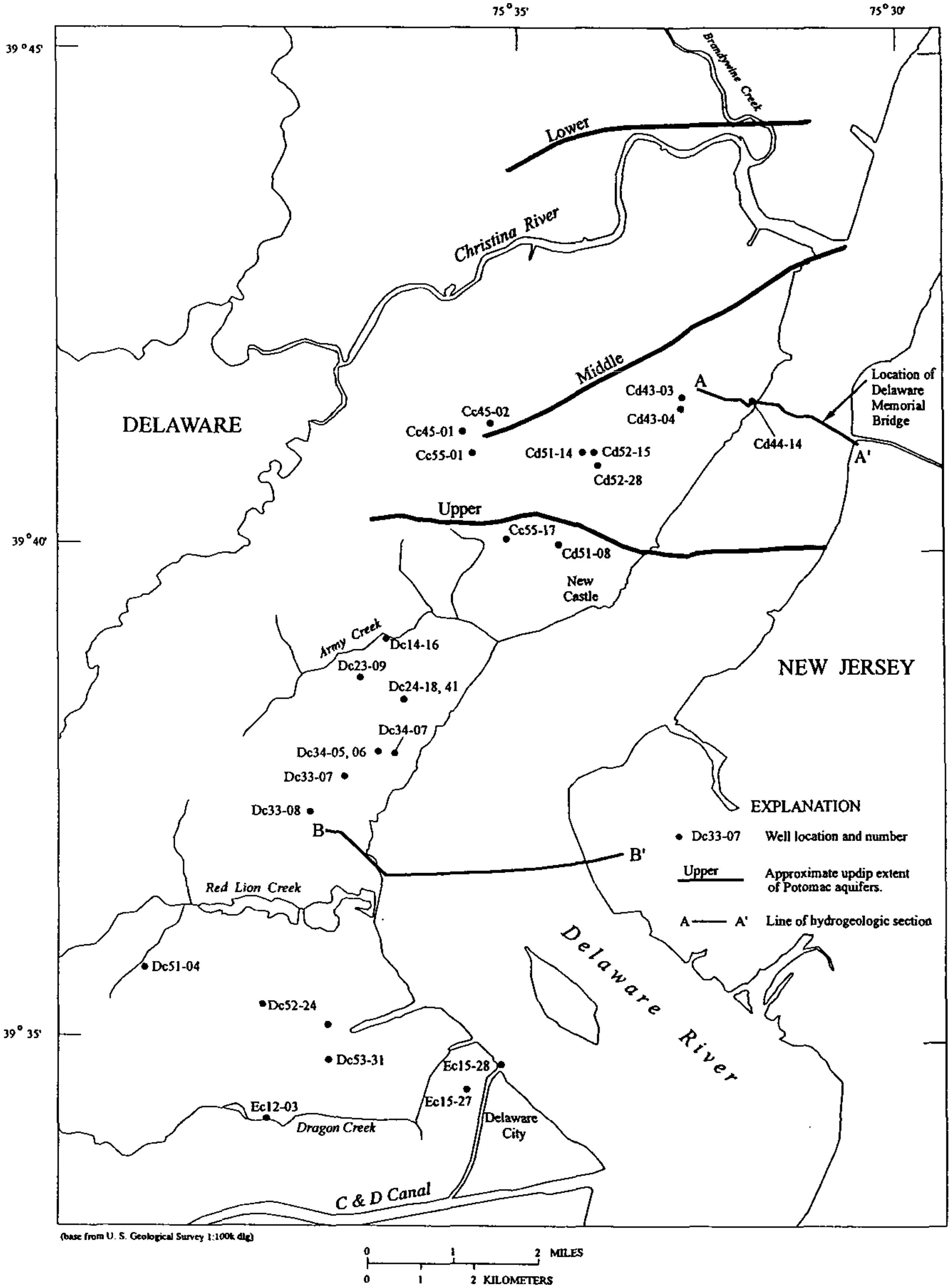


Figure 4. Location of lower, middle, and upper Potomac aquifers; hydrogeologic sections (A - A' and B - B'); and wells measured for dissolved chloride concentration.

reaches from north of the Christina River south to the Delaware Memorial Bridge (Phillips, 1987). In general, however, the lower Potomac is not a productive aquifer in this part of Delaware. As a result, this aquifer is not used for major ground-water withdrawals, and very little data exist. For this reason, this aquifer is not discussed in this report.

The middle Potomac aquifer is the most important water-producing aquifer in the area between the city of New Castle and the Delaware Memorial Bridge and is also the uppermost aquifer underlying the Delaware River in this area (fig. 4). The structure contours for the top of the middle Potomac aquifer for the entire study area are shown in figure 5. North of New Castle, in the subcrop zone where recharge occurs, depth to the top of the aquifer ranges from about sea level to about 120 ft below sea level. In this area, the aquifer is overlain only by Columbia Group sediments and by thin lenses of younger Potomac sediments. The middle Potomac aquifer underlies the river at a depth of 100 to 152 ft below sea level at the Delaware Memorial Bridge (fig. 6). The aquifer is continuous to the west, underlying the ICI and Collins Park well fields. The sand unit labeled "Kp" in figure 6 underlies the ICI well field between 60 and 76 ft below sea level, and is either part of the Potomac Formation or a paleochannel in the Columbia Group (Phillips, 1987). Since the unit is in hydraulic contact with the Potomac sand at the Collins Park well field, it funcions hydraulically as part of the middle Potomac aquifer.

The upper Potomac aquifer is the most important water-producing aquifer between the city of New Castle and Red Lion Creek (fig. 4). The structure contours of the top surface of the aquifer in the study area are shown in figure 7. A hydrogeologic section (B--B') extending between the area just north of Red Lion Creek eastward to New Jersey is shown in figure 8. The top of the upper Potomac aquifer at the west end of the section is 88 to 112 ft below sea level, with a thickness of approximately 20 ft. The aquifer is not continuous beneath the river, but could be in hydraulic connection with the river through the Columbia sand and gravel. The confining unit over the Columbia is locally thin, especially near the New Jersey coast.

Magothy Aquifer

The hydrology of the Magothy aquifer in and near its subcrop area (fig. 9) is closely associated with the upper aquifer zone of the Potomac Formation (Sundstrom and Pickett, 1971). According to Cushing and others (1973), water in this aquifer is recharged south of the C&D Canal. Locally, ground water flows north toward the canal; regional flow is south to downdip parts of the aquifer system outside the study area. The marginal-marine sediments that compose the Magothy aquifer rest directly on the fluvial sediments of the upper Potomac Formation. In the northern end of the distribution of the Magothy aquifer, where the aquifer's sands lie on the upper sands of the Potomac aquifer, the two aquifers are hydraulically connected and are considered a single aquifer in hydrologic treatment near the C&D Canal (Sundstrom and Pickett, 1971). Farther to the south, where the aquifers are more deeply buried, the Magothy Formation marine clay thickens and the Magothy aquifer is more confined. The contours showing depth to the top surface of the Magothy Formation are shown in figure 9.

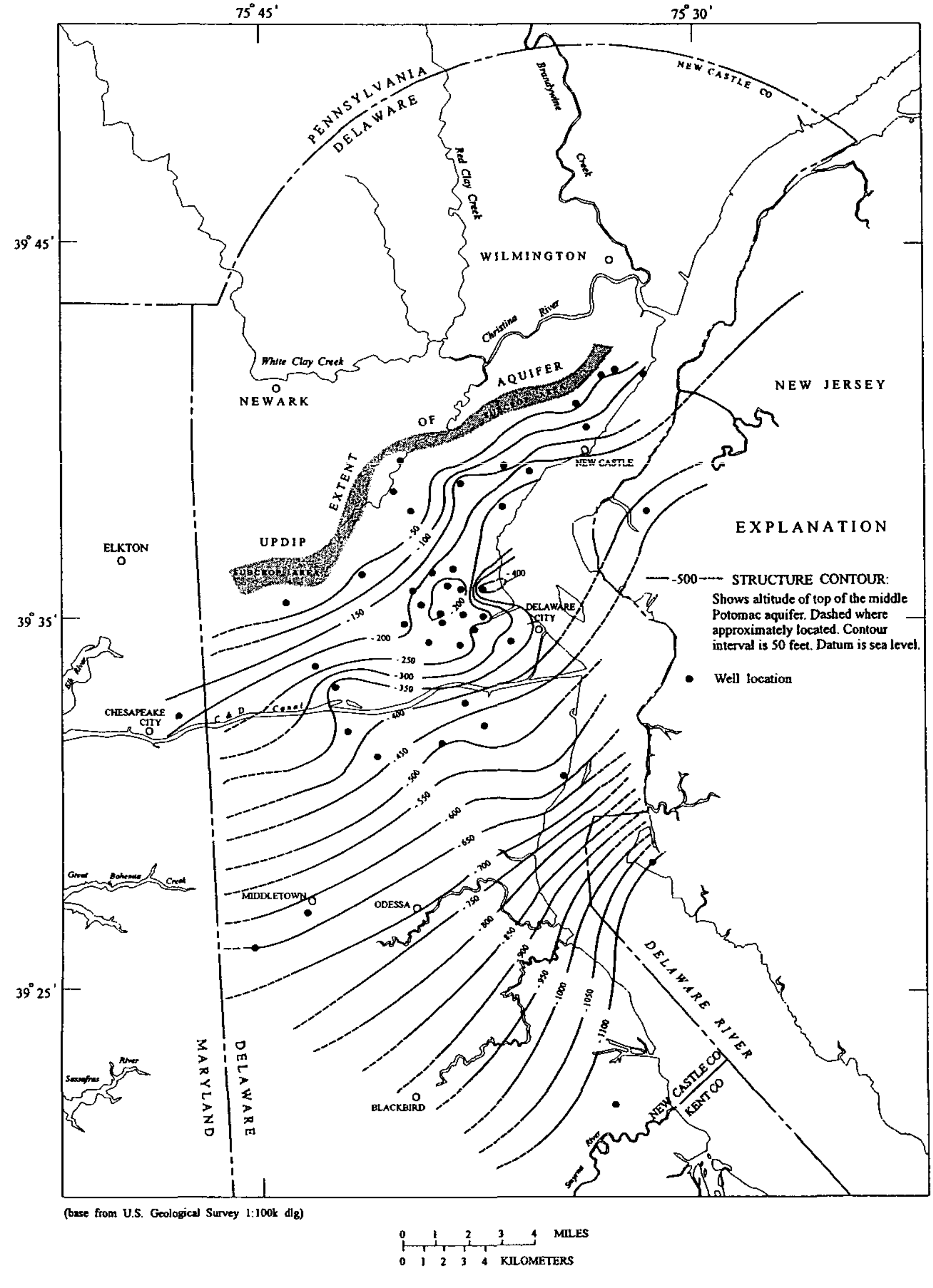
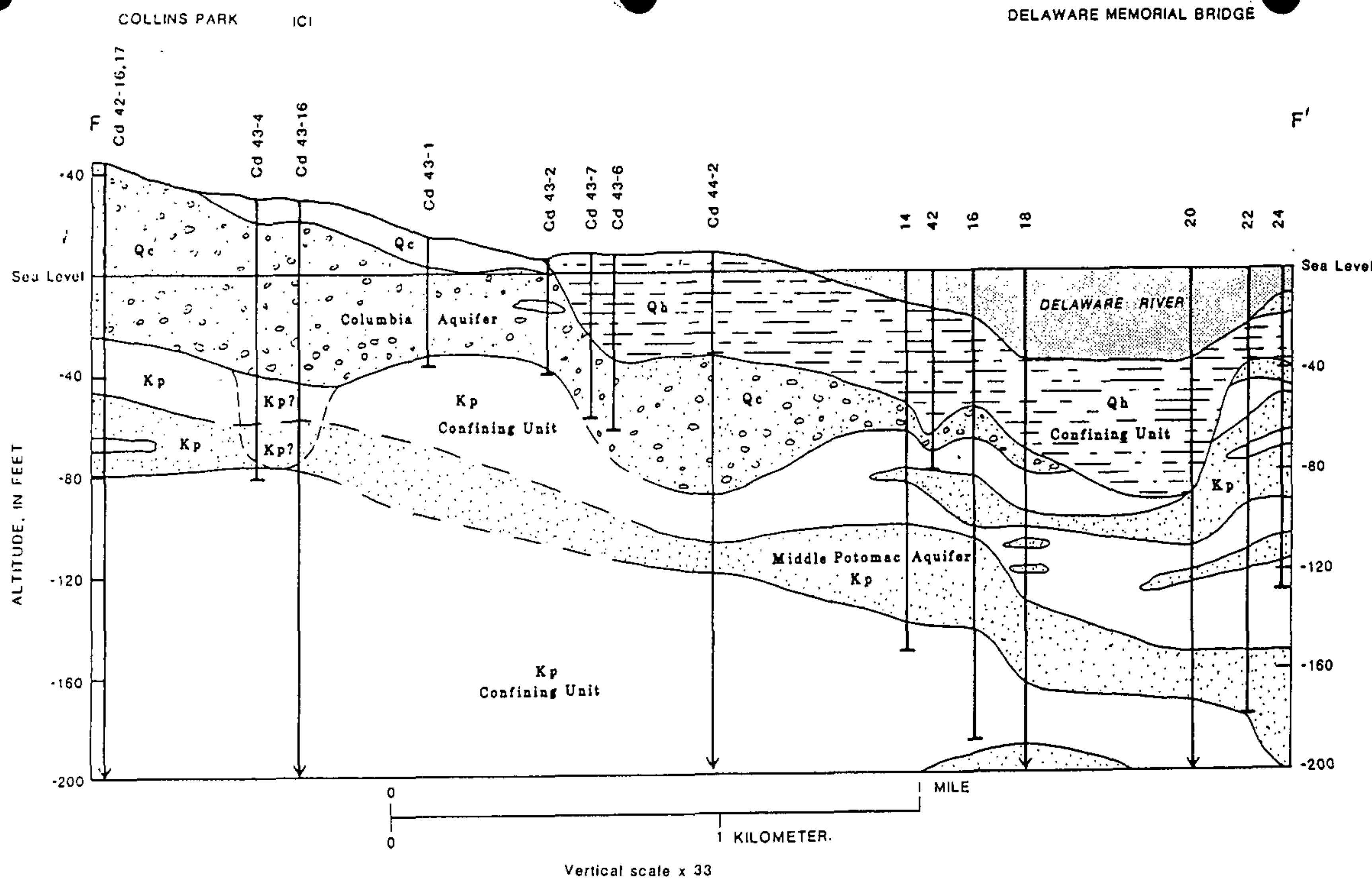


Figure 5. Altitude and configuration of the top of the middle Potomac aquifer (from Martin, 1984, fig.6).



EXPLANATION

Dc 44-4 WELL NUMBER

— — — DASHED WHERE CONTACT IS INFERRED

DATUM IS MEAN SEA LEVEL

Qh HOLOCENE SEDIMENTS

Qc COLUMBIA GROUP UNDIFFERENTIATED

Kp POTOMAC FORMATION

Km MERCHANTVILLE FORMATION

SAND

CLAY

SAND and GRAVEL

SILT

SILT, SAND and GRAVEL

Figure 6. Hydrogeologic section A-A' of the shallow hydrologic system under the Delaware River (from Phillips, 1987). (location of section shown in fig. 4.)

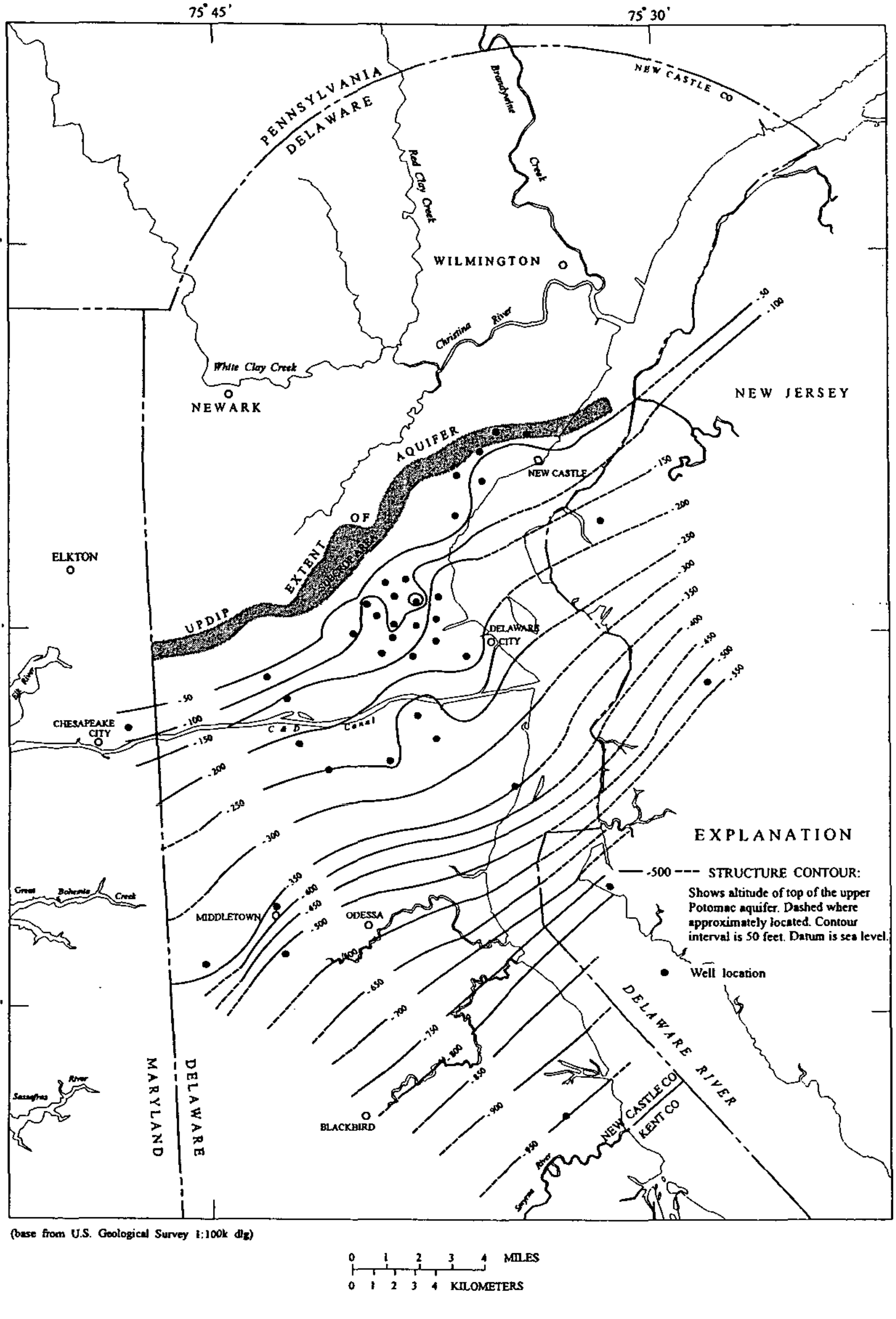


Figure 7. Altitude and configuration of the top of the upper Potomac aquifer (from Martin, 1984, fig.4).

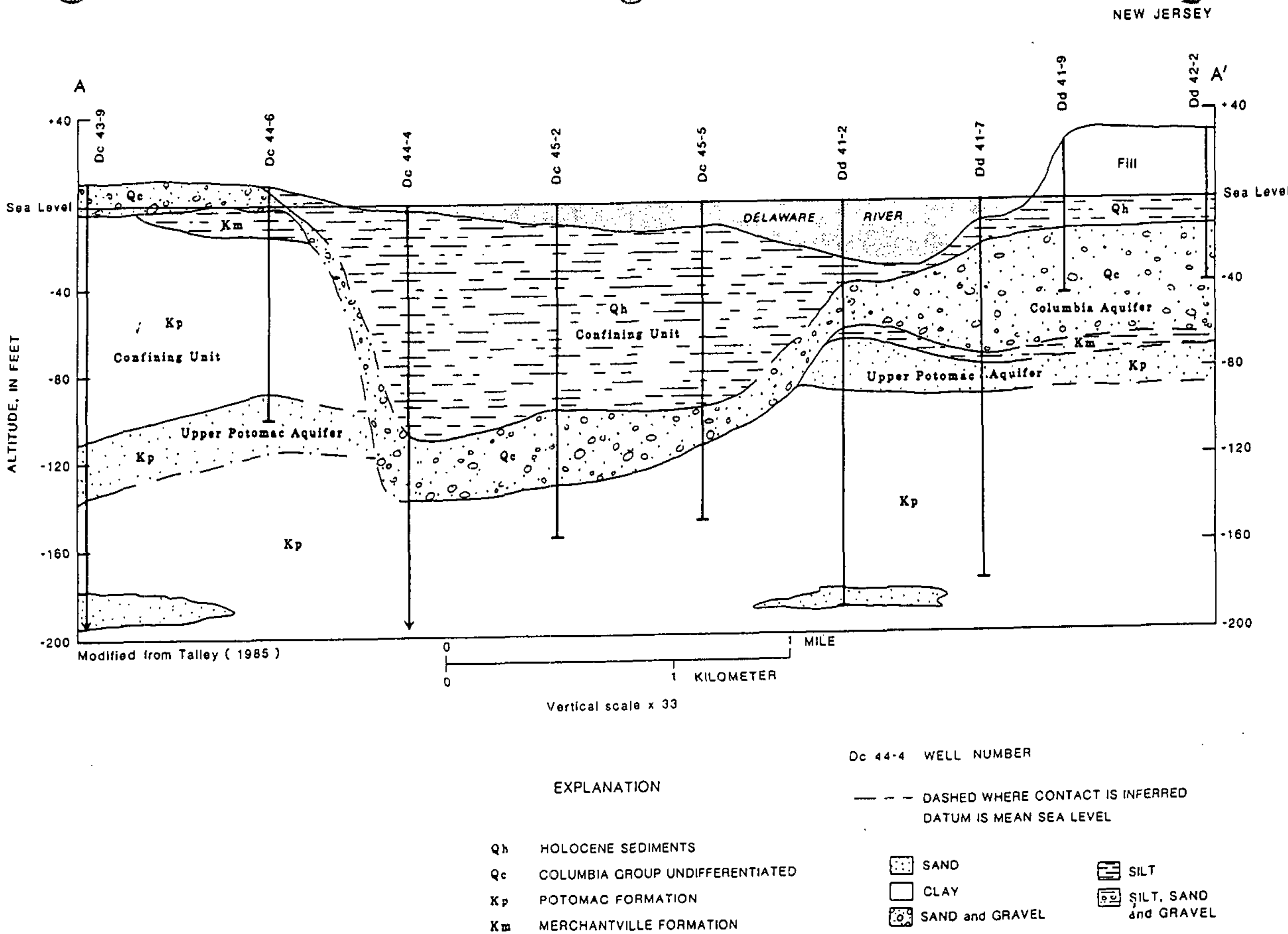


Figure 8. Hydrogeologic section B-B' of the shallow hydrologic system under the Delaware River (from Phillips, 1987). (Location of section shown in fig. 4.)

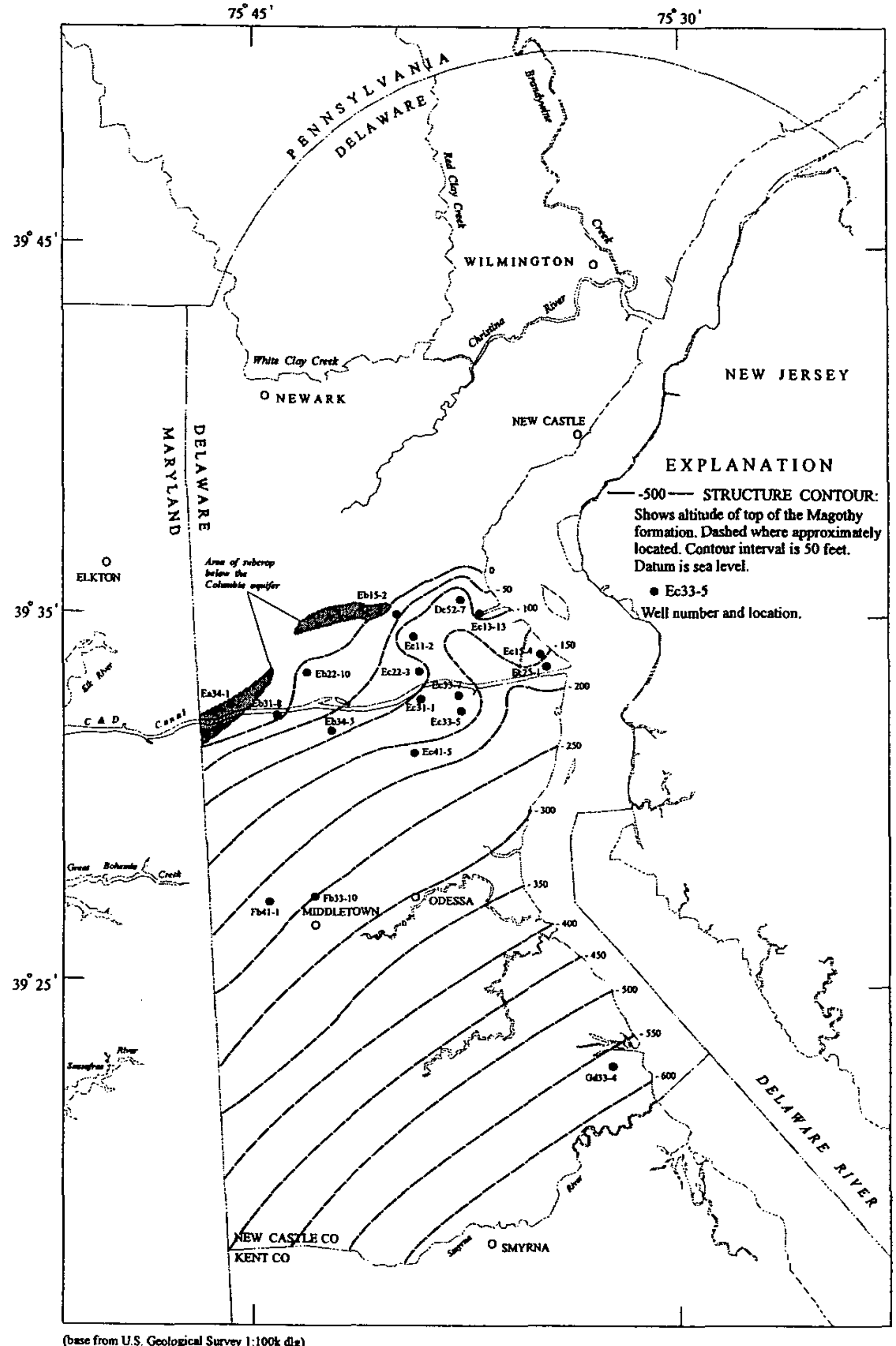


Figure 9. Altitude and configuration of the top of the Magothy Formation.
(from Sundstrom and Picket, 1971, fig. 10))

Englishtown-Mt. Laurel Aquifer System

The Englishtown-Mt. Laurel aquifer system is located within the Matawan and Monmouth Groups (Sundstrom and Pickett, 1971; Groot and others, 1983). Only the Englishtown (Matawn Group) and Mt. Laurel (Monmouth Group) Formations are sufficiently permeable to be used as aquifers (table 1; Bachman and Ferrari, 1995) and are in hydraulic contact with one another. Over much of their extent in the study area, sediments of the Englishtown-Mt. Laurel aquifer system are in hydraulic connection with the Columbia Formation and Rancocas Group. Even the combined aquifer sediments are relatively thin, and have not, historically, been a heavily exploited source of water.

Rancocas Aquifer

The Rancocas aquifer is comprised of the Rancocas Group sediments, which include the Hornerstown and Vincentown Formations (Groot and others, 1983; Bachman and Ferrari, 1995). This aquifer reaches a thickness of approximately 50 ft at the Appoquinimink River (Cushing and others, 1973). In the study area, the Columbia Formation and Rancocas Group form a water-table aquifer that is recharged in uplands and discharged to perennial streams, including Drawyer Creek and the Appoquinimink River (Bachman and Ferrari, 1995). Like the Englishtown-Mt. Laurel system, the Rancocas aquifer has not been heavily exploited as a source of water, although, according to historical records of water use (Sundstrom and Pickett, 1971), it provides up to 25 percent of ground-water withdrawals in New Castle County south of the C&D Canal.

Confining Units Underlying the Delaware River

Information about the stratigraphy of the sediments under the Delaware River is limited to seismic reflection records (Duran, 1986), drillers' logs, and geophysical logs taken during the construction of the Delaware Memorial Bridge and the installation of powerlines across the Delaware Bay (Phillips, 1987), and a set of vibracores taken in the dredged channel by the COE in 1991. Cross sections and a map of the thickness of Holocene sediments in the river were constructed by Phillips (1987, figs. 6, 8, and 10).

In the area investigated by Phillips (1987), geologic events during the Pleistocene resulted in the erosion of Potomac Formation sediments in the river channel and the deposition of the sand, gravel, and clay of the Columbia Formation, which constitute the Columbia aquifer (table 1). Overlying sediments, deposited during Holocene time, are primarily silt and silty sand that act as confining units, separating river water from the aquifers. The thickness of the Holocene sediments underlying the Delaware River ranges from less that 20 ft close to the current shoreline to more than 100 ft in the Pleistocene paleochannel (fig. 10). Only generalized cross sections can be constructed from available drilling and geophysical logs because of the wide spacing between core holes and the highly variable nature of the Holocene and Pleistocene sediments. Based on the cross sections shown in figures 6 and 8, the confining unit underlying the river consists of Holocene sediments and fine-grained clays of the Potomac Formation. In some places, the Columbia Formation, which consists mostly of sand and gravel, is present. The permeability of the Columbia Formation reduces the effectiveness of the confining unit in preventing flow from the river into the underlying aquifers.

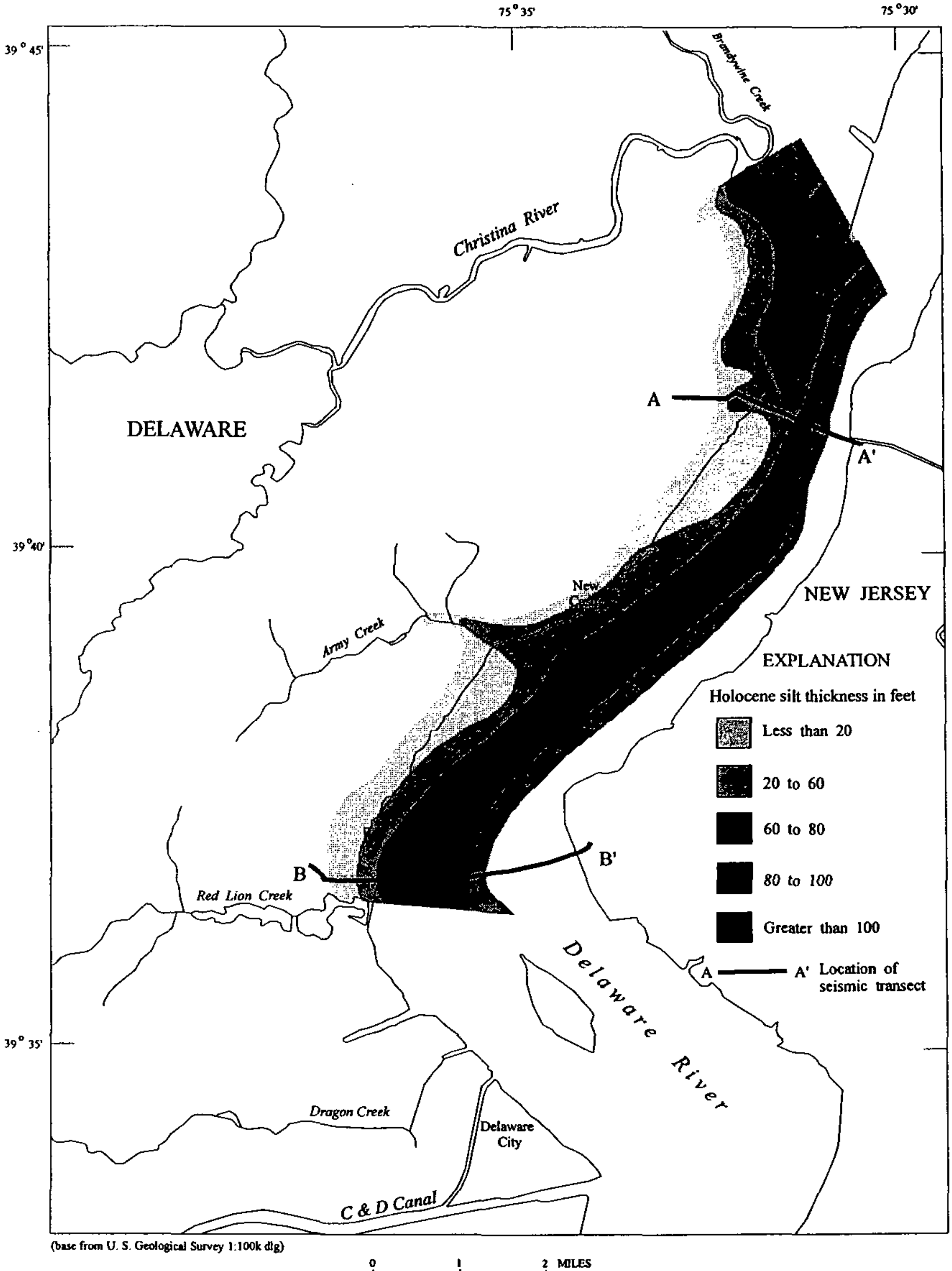


Figure 10. Thickness of the Holocene silt between the Christina River and the Red Lion Creek. (Modified from Phillips, 1987, fig.10)

Water Levels and Water Use in the Aquifers

Ground-water discharge by pumping began in the study area in the early 1900's and became significant after 1955 (Martin and Denver, 1982). Most ground-water withdrawals are made to supply public water systems and industry.

Water-Level Data

In 1971, Sundstrom and Pickett reported that "...under most conditions, the water-table aquifer is protected from the saltwater of the Delaware Estuary...by the impermeable sediments of the bed of the Estuary...from Memorial Bridge southward past the New Castle County line," and also reported that the hydraulic gradient in the water-table aquifer was "toward the estuary." However, by 1979, Apgar reported declines in the potentiometric surface in the middle Potomac aquifer below sea level adjacent to the estuary (fig. 11). By 1982, pumpage had become the major source of discharge from the Potomac aquifers and local cones of depression had formed (Martin, 1984). Declines in aquifer water levels up to 1985 were documented and the resulting cones of depression in the upper and middle Potomac aquifers were mapped by Phillips (1987; fig. 12). The cones of depression at that time had spread locally under the Delaware River, and the hydraulic gradient was from the Delaware River to the Potomac aquifers (Phillips, 1987). Ground-water-flow models prepared by Martin (1984) and Phillips (1987) simulated this reversal of gradient for various pumping conditions.

Although companies that supply public water and major industrial users in New Castle County are required to report volumes pumped by well, reporting of records of measurements of water levels has not always been required and water levels measured at pumped wells are often not at equilibrium conditions. Most water-supply wells north of the C&D Canal in the study area were screened in the middle and upper Potomac aquifers and the Columbia aquifer. No uniform system of data collection and maintenance has been employed. The location of wells can be difficult to identify because of multiple naming conventions instituted by companies, the county, DNREC, and DGS. The U.S. Geological Survey data base contains well-construction information for most wells registered with DGS, including water level at time of construction. However, long-term records of water levels within the study area are available at only two wells--Dc 34-05 and Dc 34-06 (fig. 4). Water levels for these wells during 1978-93 are shown in figure 13. No long-term changes in water levels are evident from these graphs.

Water-Use Data

Ground water is used for many purposes in the study area, including public supply, domestic (self-supplied), commercial, industrial, livestock watering, and irrigation. A comparison of ground-water withdrawals in 1985 and 1990 by category of use and percentage of change is shown in table 2. Total combined use rose 11 percent between 1985 and 1990. Ground-water sources provided about 28 percent of total freshwater withdrawals in the study area in 1985 compared to 30 percent of withdrawals in 1990. Public suppliers withdrew the most ground water (approximately 64 percent) in both 1985 and 1990. During 1985, public-supply withdrawals were 14.45 Mgal/d and increased 10 percent to 15.93 Mgal/d during 1990. Domestic (self-supplied) and commercial ground-water withdrawals increased significantly over the

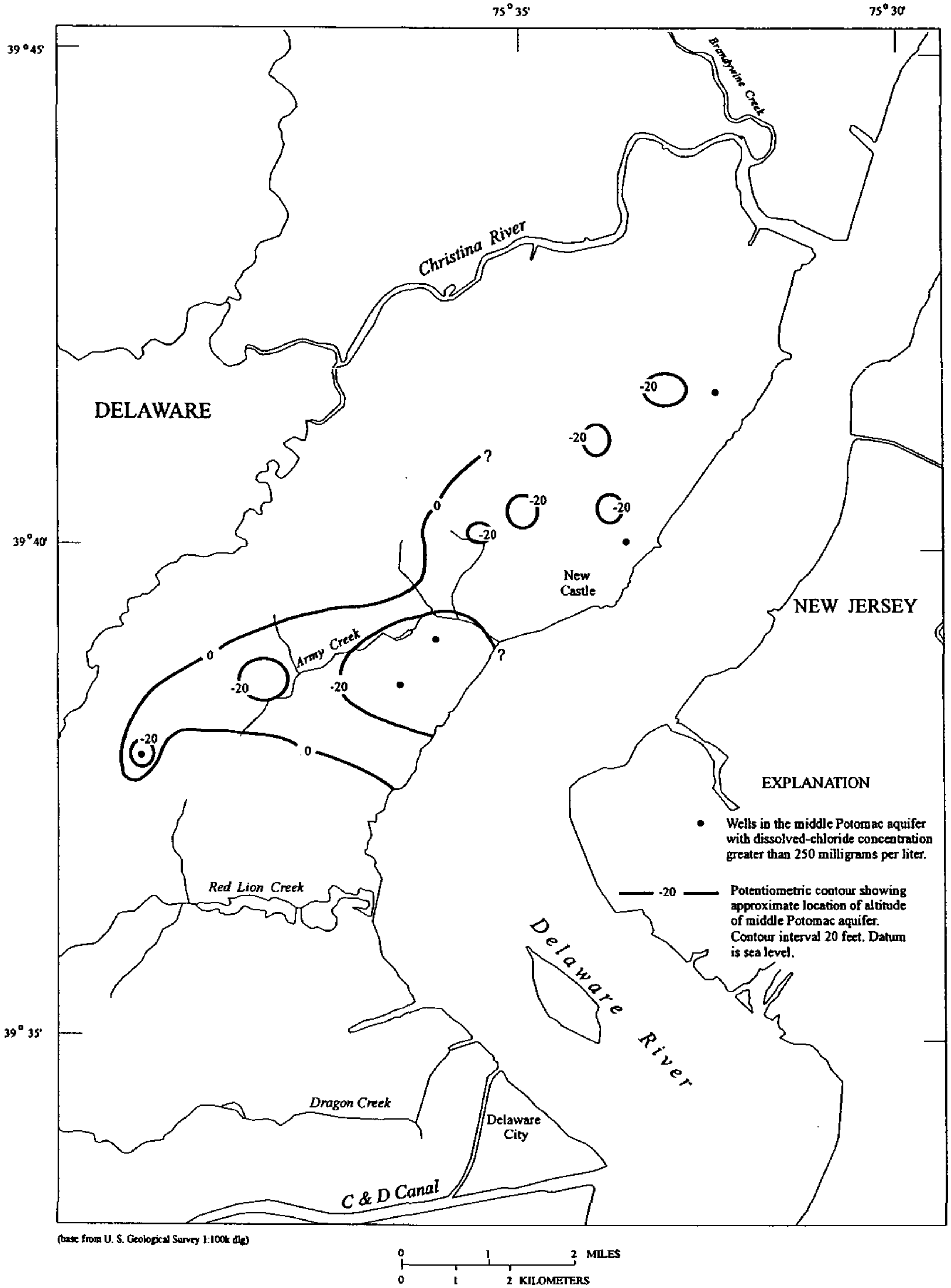


Figure 11. Potentiometric surface in the middle Potomac aquifer in spring 1979 and location of wells measured for dissolved chloride concentration. (Apgar, 1979)

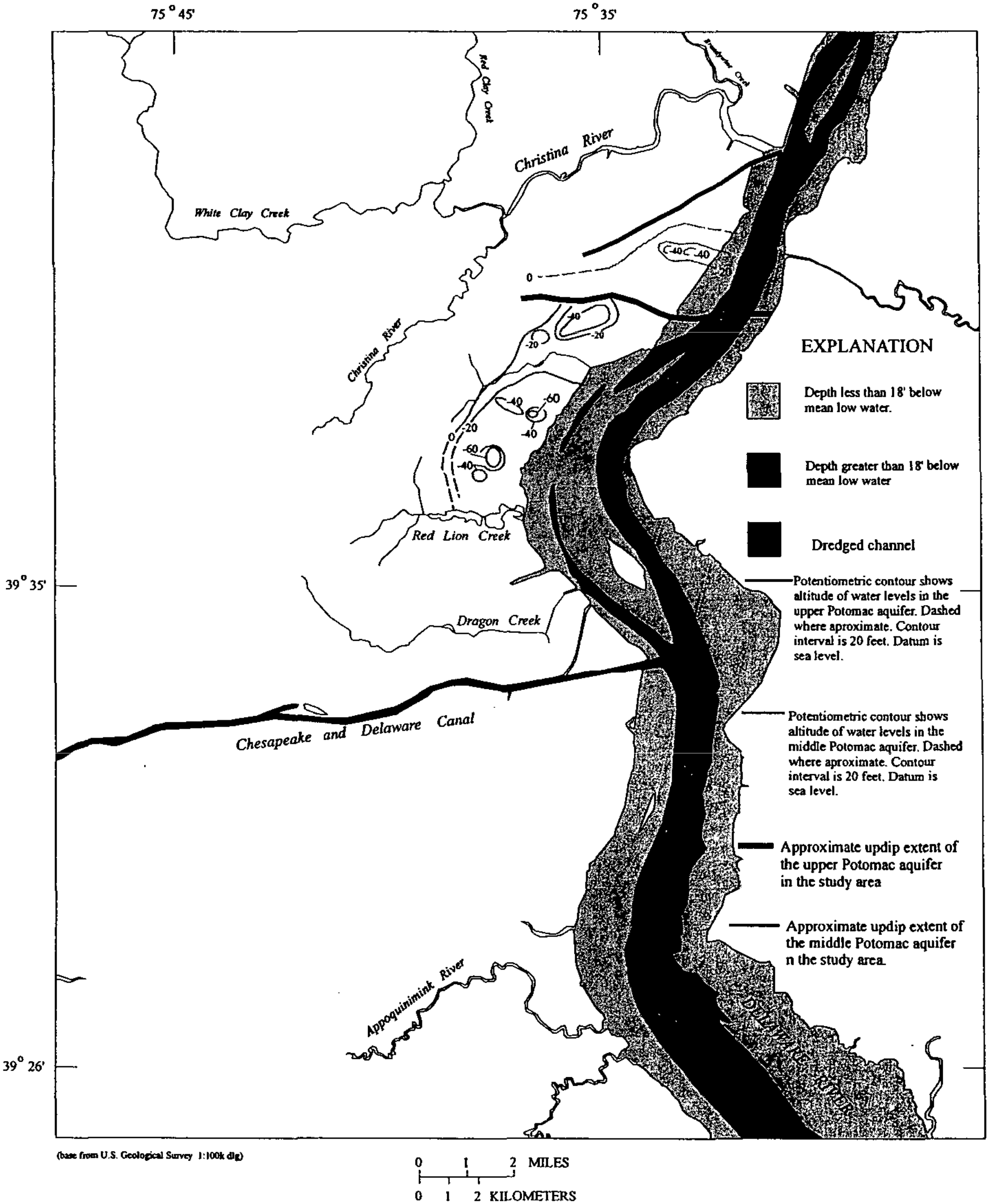
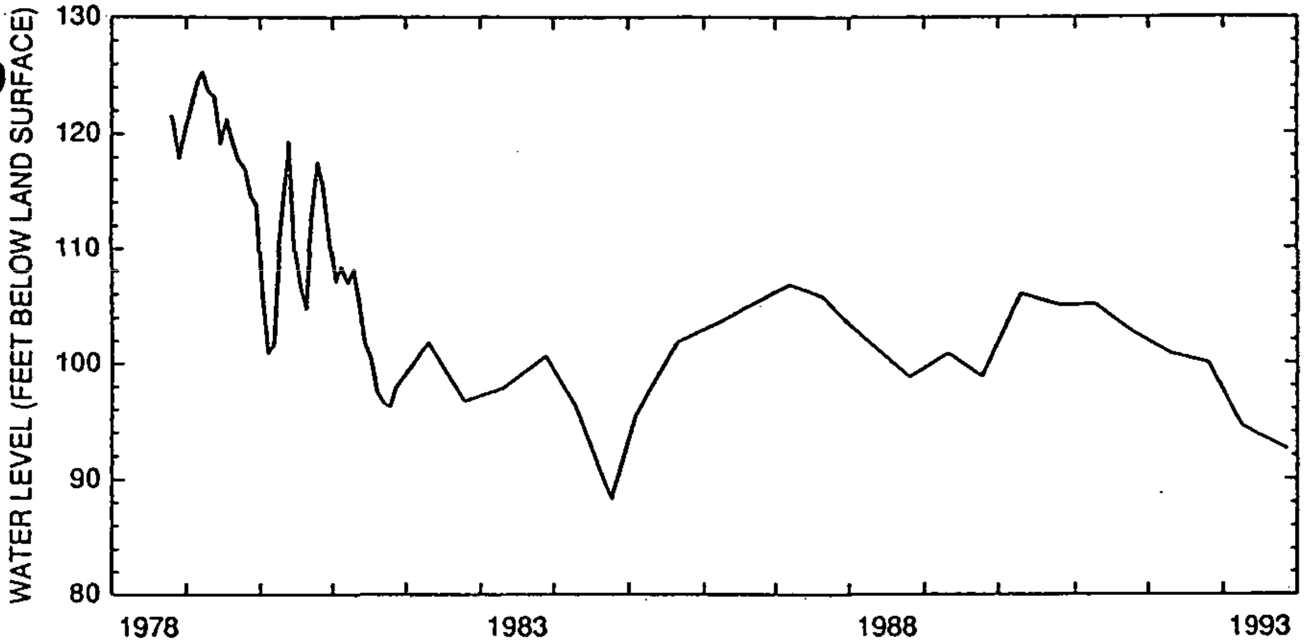


Figure 12. Bathymetry of the Delaware River and potentiometric surfaces of the upper and middle Potomac aquifers during May 1985. (Modified from National Oceanic Atmospheric Administration, 1983; and Phillips, 1987)

a. Well Dc34-05.



b. Well Dc34-06.

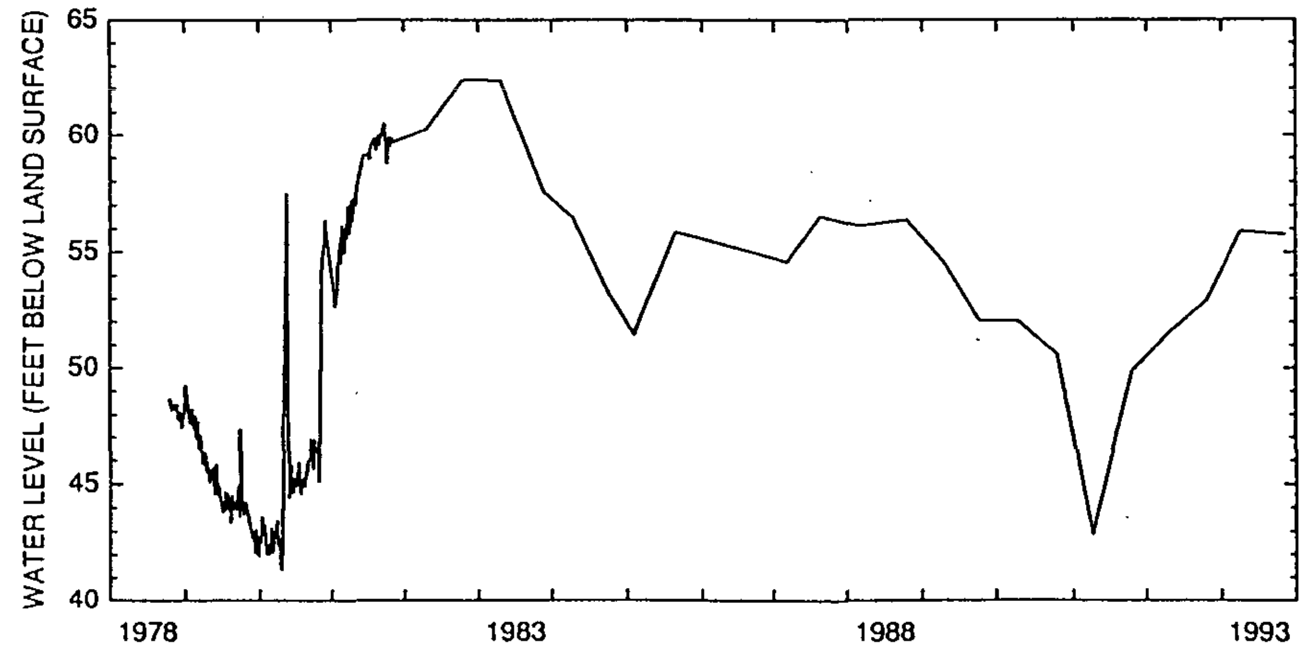


Figure 13. Hydrographs showing water levels for wells (a) Dc34-05 and (b) Dc34-06 screened in the Potomac aquifer, 1978-93.

Table 2. Ground-water withdrawals, by water-use category, in northern and central New Castle County, Delaware, 1985 and 1990

[Source: U.S. Geological Survey Aggregated Water-Use Database System (AWUDS)]

Water-use category	Ground-water withdrawals (million gallons)		Percent change
	1985	1990	
Public supply[1]	14.45	15.93	10
Domestic (self-supplied)[2]	.70	1.96	180
Commercial[1]	.15	.30	100
Industrial[1]	6.71	6.30	-6
Livestock watering[2]	.06	.08	33
Irrigation[2]	.38	.42	11
Total	22.45	24.99	11
Total ground-water and fresh surface-water withdrawals	74.26	88.00	
Percentage of total withdrawals from ground water	30	28	

[1] Reported withdrawals.
[2] Estimated withdrawals.

period--180 percent and 100 percent, respectively--whereas industrial ground-water withdrawals decreased 6 percent from 1985 to 1990.

The principal aquifers that are used for water supply include the Columbia Group, Rancocas, Magothy, Mt. Laurel, and Potomac Group. Withdrawals by aquifer for selected water users in the study area from 1988 to 1993 are shown in table 3. The Potomac Group aquifer supplied the most water (over 17 Mgal/d) for the period of record. The least amount of water (0.05 Mgal/d or less) was withdrawn from the Rancocas aquifer.

Continued population growth and commercial and industrial development in the study area are expected to result in increased water demand (Metcalf & Eddy, 1991b). Increased demand could result in lower aquifer water levels, and that could increase the potential for river-water intrusion into the aquifers. Projected ground-water demand for selected water users in the study area for the period 1995 to 2040 is shown in table 4. The data presented are from a water-supply plan report series prepared for the Water Resources Agency of New Castle County and are based on projected growth and present water-use trends. Estimates of potential reduction in future water demand with the implementation of additional water conservation measures are also shown in the table.

The largest ground-water public-water supplier in the study area is the Artesian Water Company (AWC) (table 3), which has installed water-supply wells in numerous locations. In 1993, total ground-water withdrawals by AWC were about 16.77 Mgal/d. By the year 2040, AWC is expected to withdraw nearly 26 Mgal/d, an increase of about 55 percent (table 4; Metcalf & Eddy, 1991b). It is estimated that implementation of water conservation measures could reduce this increase to 25 percent. Ground-water withdrawals for public supply by Delaware City are projected to increase 24 percent from 0.17 Mgal/d in 1993 to 0.21 Mgal/d by 2040. Most of this water demand will be for residential use and will come from the Potomac aquifer system.

The town of Middletown supplied 0.41 Mgal/d of ground water to users during 1993 (table 3)--83 percent from the upper Potomac aquifer and 17 percent from the Magothy and Mt. Laurel aquifers. By the year 2040, ground-water demand for Middletown is expected to increase to 0.95 Mgal/d (table 4), about 132 percent of current demand. With the implementation of conservation measures, however, the percentage of water-demand increase could be reduced to 75 percent (Metcalf & Eddy, 1991b). Water demand for the Townsend service area was the smallest in the study area during 1993 (0.04 Mgal/d; table 3). Projected water demand for 2040 is 0.06 Mgal/d (table 4)--a 5-percent increase over the period.

For self-supplied systems north of the C&D Canal, the majority of water demand is for industrial and irrigation uses. Total water demand (ground and surface water) was about 12.68 Mgal/d during 1993 (table 4). By 2040, water demand is projected to be 14.28 Mgal/d without conservation measures (Metcalf & Eddy, 1991b). With conservation, the demand could be reduced to 13.79 Mgal/d. For self-supplied systems south of the C&D Canal, total water demand for 2040 is projected to be 13.32 Mgal/d without conservation measures. Conservation measures could reduce demand to 10.86 Mgal/d.

Table 3. Annual ground-water withdrawals, by aquifer, by selected water users in northern and central New Castle County, Delaware, 1988-93

[Source: Delaware Department of Natural Resources and Environmental Control; -- = data not available]

Aquifer Water user	Ground-water withdrawals (million gallons per day)					
	1988	1989	1990	1991	1992	1993
Columbia Group						
Artesian Water Company	0.30	0.32	0.14	0.28	0.39	0.36
DuPont Glasgow	.23	.20	.21	.16	--	.19
Getty Refining	--	--	--	.04	.04	--
ICI	--	--	--	--	.55	.54
Julian	--	--	--	--	--	.24
Newark, City of	1.74	1.52	.83	.60	.65	[1].24
Standard Chlorine	.02	.03	.18	.13	.15	.15
Aquifer total	2.29	2.07	1.36	1.21	1.78	1.72
Rancocas						
Townsend	.04	.04	.04	.05	.05	.04
Aquifer total	.04	.04	.04	.05	.05	.04
Magothy-Mt. Laurel						
Middletown	.10	.14	.16	.13	.10	.07
Van Wingerden Nurseries	.02	.04	.02	.04	.04	.03
Aquifer total	.12	.18	.18	.17	.14	.10
Potomac Group						
Artesian Water Company	14.56	14.90	15.43	15.69	15.98	[2]16.41
Delaware City	.19	.18	.09	.10	.18	.17
Middletown	.33	.25	.26	.31	.35	.34
Board of Water & Light	.77	1.06	.89	.78	1.02	.81
Newark, City of	.45	.48	.47	.52	.52	[1].07
Star Enterprise	.88	4.40	.60	4.00	4.00	3.57
Aquifer total	17.18	21.27	17.74	21.40	22.05	21.37

[1] Surface-water supply (White Clay Creek) was activated December 1992.

[2] Amounts for 1988-93 estimated from Metcalf and Eddy (1991b, table 3.4, p. 3-9).

Table 4. Projected ground-water demand, with and without conservation measures, for selected water users in northern and central New Castle County, Delaware, 1995-2040

[Source: Water-supply plan for New Castle County, Delaware--Future water demands, v. IV. W/O CONS, without conservation measures; CONS, with conservation measures]

Water user	Projected ground-water demand (million gallons per day)												
	1993	1995		2000		2010		2020		2030		2040	
		W/O CONS	CONS	W/O CONS	CONS	W/O CONS	CONS	W/O CONS	CONS	W/O CONS	CONS	W/O CONS	CONS
Artesian Water Company	16.77	17.55	16.20	19.19	16.77	21.74	17.95	23.41	18.86	24.76	19.95	25.98	20.96
Delaware City	.17	.20	.19	.20	.19	.20	.18	.21	.18	.21	.18	.21	.18
Middletown	.41	.48	.46	.53	.48	.68	.56	.76	.60	.85	.66	.95	.72
Board of Water & Light	.81	.49	.47	.51	.47	.53	.48	.55	.50	.60	.53	.63	.55
City of Newark [1]	.31	.32	.32	.33	.33	.35	.35	.36	.36	.37	.37	.38	.38
Townsend	.04	.05	.05	.05	.05	.06	.05	.06	.05	.06	.05	.06	.05
Self-supplied systems [2]													
North of C&D Canal	12.68	12.68	12.63	12.86	12.74	13.13	12.92	13.51	13.20	13.90	13.46	14.28	13.79
South of C&D Canal	6.28	6.28	6.14	6.74	6.39	8.33	7.38	9.96	8.39	11.74	9.68	13.32	10.86
Total	37.47	38.05	36.46	40.41	37.42	45.02	39.87	48.82	42.14	52.49	44.88	55.81	47.49

1 Projected ground-water demands based on 1993 data using 4-percent increase for each 5-year increment.
2 Includes projected ground- and surface-water demand.

CHLORIDE-CONCENTRATION DATA

Chloride concentrations are used as an indication of salinity levels (Cohen, 1957). Chloride-concentration data are available from studies of water quality in the Delaware River and of ground-water withdrawals in the study area.

Dissolved Chloride Concentrations in the Delaware River

The term "salinity" refers to the total concentration of dissolved salts in seawater (Bates and Jackson, 1987). Salinity is usually computed from some other factor, such as chloride concentration or electrical conductivity relative to normal seawater. In this report, chloride concentrations are used to indicate salinity.

Seawater has a chloride concentration of approximately 19,000 mg/L (White, 1993). Water with chloride concentrations in excess of 250 mg/L [U.S. Environmental Protection Agency (EPA) drinking water regulation for chlorides] is usually considered undesirable for domestic use. In addition, water with chloride concentrations in excess of 50 mg/L is unsatisfactory for some industrial uses (White, 1993). The zone in an estuary where chloride concentrations equal or exceed 250 mg/L is commonly known as the salt front.

Salinity in the Delaware River at any location is dependent on the distance from the ocean, the freshwater flow of the river, the quantity of salty water moving upstream from the ocean, the stage of the tide, and the range of the tide (Cohen, 1957). In general, salinity increases downstream from very low values near Philadelphia, Pa., and Camden, N.J., to seawater concentration at the mouth of the Delaware Bay.

The Delaware River Basin Commission (DRBC) tracks and controls salinity levels in the Delaware River (Hull and Titus, 1986). Salinity level is controlled by regulating the flow of freshwater in the river by releasing water from various reservoirs and limiting consumption in times of drought (Hull and Titus, 1986). The annual mean chloride concentration at the Delaware Memorial Bridge (river mile 68) for a year with average precipitation could be about 530 mg/L, and a wet year mean could be about 200 mg/L (Apgar, 1979). The most severe drought of record was that of the 1960's. The annual mean chloride concentration at the Delaware Memorial Bridge for 1965 was about 1,230 mg/L. The salt front, located on average at river mile 69 (south of Wilmington, Del.), advanced up the estuary as far as river mile 102, just above the Benjamin Franklin Bridge in Philadelphia (Hull and Titus, 1986). During the 1960's drought, saltwater recharged the Potomac-Raritan-Magothy aquifer system, from which water supplies for Philadelphia and Camden are withdrawn (Hull and Titus, 1986). Elevated chloride levels persisted in the aquifer system for more than 10 years. Since that time, the DRBC has used this drought as the basis for water-supply planning, with the goal that the maximum salinity measured in the river during the drought will not be met or exceeded under current conditions.

Advance and retreat of salinity in the river occurs seasonally and daily as the result of freshwater inflow to the river and the range and stage of the tide. During summer and early fall, freshwater inflow is generally at a minimum and sea level is at a maximum--conditions favorable for the advance upstream of more saline water. The daily tidally-generated variations in salinity are locally and regionally significant (DiLorenzo and others, 1993). For example, salinity measurements taken in 1956 at the Reedy Island jetty, located in the river between the C&D Canal and the Appoquinnimink River, ranged between about 80 and 5,500 mg/L (Cohen, 1957).

Dissolved Chloride Concentrations in Ground Water

Phillips (1987) established a well network based on that of Martin and Denver (1982) to sample chloride concentrations and water levels in the area between the C&D Canal and the Christina River. Phillips found areas of brackish river-water intrusion into the Potomac aquifers in the vicinity of the ICI, New Castle, Crown Zellerbach, and Llangollen Estates well fields.

Part of Phillips' well network has been sampled at intervals for chloride concentrations by DNREC since 1979 (table 5, fig. 4). Chloride levels show no apparent trends and have been well below the 250 mg/L EPA drinking water regulation, except in wells Cd 43-03 and Cd43-04 in the ICI well field (figs. 4 and 14). Phillips' data indicated that pumpage at the ICI well field had caused a cone of depression in the middle Potomac aquifer. Consequently, the hydraulic head in the Columbia aquifer under the Delaware River (just south of section A-A', shown in fig. 4) fell below sea level. As a result, brackish water infiltrated downward from the river and was drawn toward the cone of depression, entering the Potomac aquifer where the confining unit is thin or nonexistent. The increased chloride concentrations in the ICI well field have persisted, although they were somewhat lower by 1989 than they were in the late 1970's. Farther south, in the Llangollen well field (fig. 14), another area of river-water infiltration has occurred (Phillips, 1987). Chloride concentrations in well Dc24-18 averaged about 62 mg/L between 1991 and 1993, slightly higher than the 55 mg/L average chloride concentration for this well between 1978 and 1985.

Water levels in the well network have not generally been measured. No other systematic collection of chloride-concentration data or routine water-level measurements have been conducted in the Potomac aquifer system. Low demand for public ground-water supply in the southern half of the study area, combined with the relative thinness of the aquifers, have resulted in a lack of records of chloride concentration or water levels in this area.

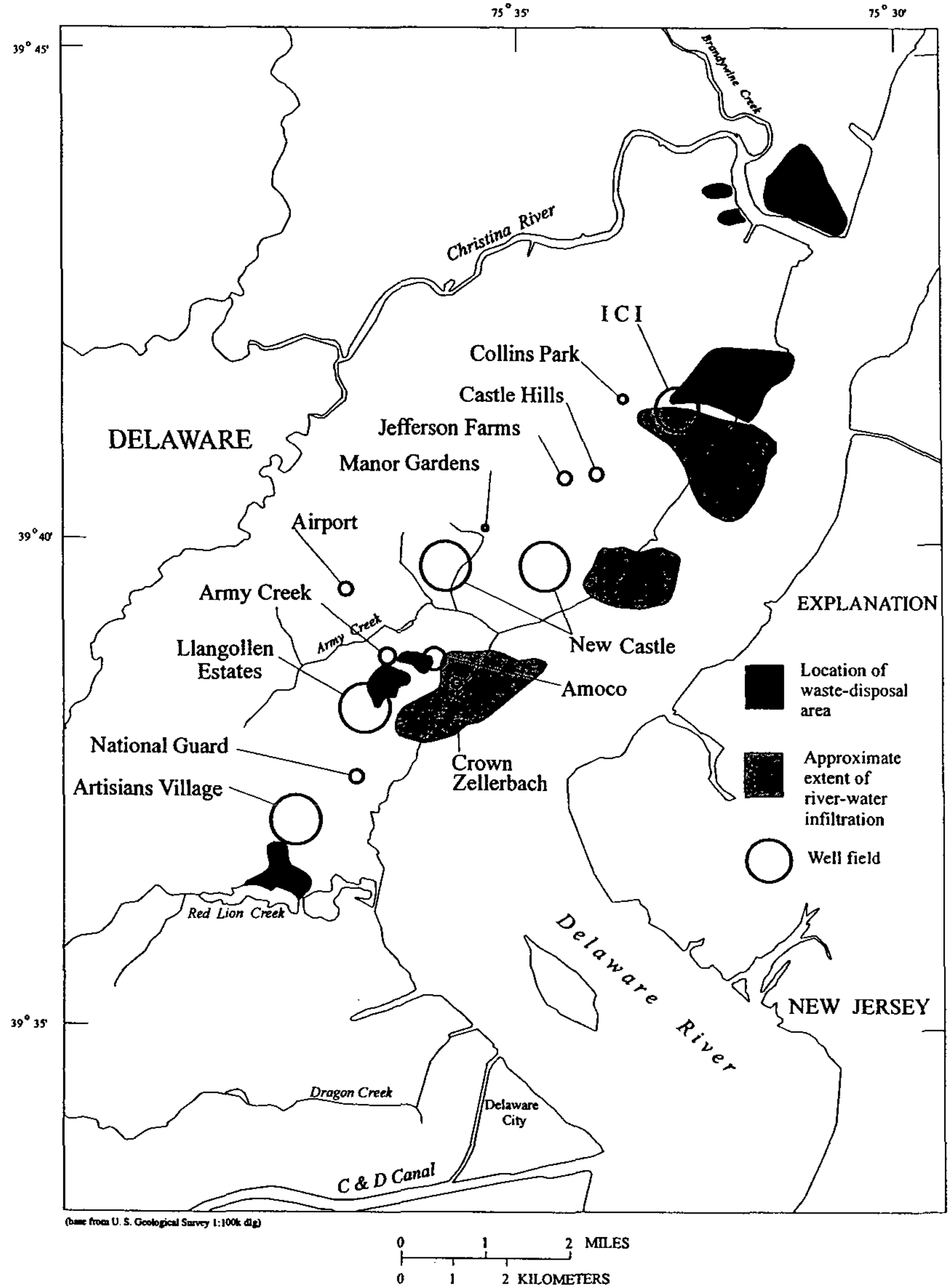


Figure 14. Location of waste-disposal sites and areas of infiltration of river water in the uppermost Potomac aquifer. (Modifidied from Phillips, 1987)

Table 5. Chloride-concentration data for selected wells in northern and central New Castle County, Delaware

[Source: Delaware Department of Natural Resources and Environmental Control and U.S. Geological Survey. < = less than; -- = data not available]

Date	Castle Hills 1 Cd52-15	Jefferson Farm Cd51-14	Castle Hills 3 Cd52-28	New Castle Basin Road Cd51-08	School House Lane Cc55-17	Texaco #10 Dc51-04	Texaco #10a Permit #53065	Delaware Ec15-27	James River Corp*
	Concentrations of chloride, in milligrams per liter — Site name and corresponding State identification number								
1985 Fall	--	--	--	--	--	12.8	--	--	--
1986 Spring	22.5	--	22.5	16.3	--	17.2	--	--	--
1986 Fall	24.6	14.7	24.6	--	--	18.4	--	--	--
1988 Spring	15	17	20	20	12	16	--	--	37
1988 Fall	21	15	31	16	13	17	--	--	61
1989 Spring	20.8	14.5	36.1	19	11.3	10	--	--	59
1989 Fall	11	10	17	13	7	10	--	--	34
1990 Spring	23	2.5	35	25	14	14	--	--	77
1990 Fall	31	2.5	15	14	60	8	--	--	20
1991 Spring	21	20	29	25	13	15	--	--	69
1990 April	23	--	35	--	--	--	--	--	--
1990 October	31	--	19	14	--	--	--	--	--
1991 November	30	19	--	28	12	17	--	--	--
1992 July	18	16	--	--	6	12	--	--	38
1993 January	22	--	--	42	14	15	--	9	74
1993 October	23.1	21.8	--	46.3	14.2	--	5.8	9.5	79.3

* No State identification number available for this site

Date	Llangollen #3 Dc23-09	Llangollen G3 Dc24-18	Llangollen #7 Dc24-41	National Guard 1 Dc34-07	Artisans Village 1 Dc33-07	Texaco #16 Ec13-06
	Concentrations of chloride, in milligrams per liter — Site name and corresponding State identification number					
1979 Fall	65	--	--	--	--	--
1980 Spring	75	--	30.3	--	--	7
1980 Fall	52	--	33	--	--	7
1981 Spring	48	--	54	--	81	5
1981 Fall	48	--	36	--	6	6
1982 Spring	47	--	47	--	10	19
1982 Fall	50	--	--	--	7	7
1983 Spring	--	--	--	--	8	7
1983 Fall	33	--	48	--	8	--
1984 Spring	--	--	--	--	13	--
1984 Fall	--	--	--	--	10	--
1985 Spring	--	--	--	--	--	4.9
1985 Fall	51.6	--	--	--	11	--
1986 Spring	50.9	--	12.1	5.1	10.8	11.7
1986 Fall	--	--	13.4	--	12.8	8
1988 Spring	2.5	--	55	7	15	9
1988 Fall	--	--	14	9	15	2.5
1989 Spring	--	--	12.9	8	15.1	2.5
1989 Fall	10	--	8	2.5	10	2.5
1990 Spring	15.5	--	15.5	10	17	5
1990 Fall	15	--	15	9	63	4.9
1991 Spring	67	--	13	7	13	16.5
1991 November	--	65	16	--	16	--
1992 July	--	57	13	--	11	--
1993 January	--	59	14	--	15	--
1993 October	--	67.2	16	--	15.2	--

Table 5. Chloride-concentration data for selected wells in northern and central New Castle County, Delaware--Continued

Date	Concentrations of chloride, in milligrams per liter Site name and corresponding State identification number ICI #9 Cd43-03	 ICI #10 Cd43-04	 ICI #12 Cd44-14
1967	375.9	241.1	--
1968	302.6	231.4	--
1969	270	215.5	--
1970	230.2	242.4	--
1971	368.1	212.5	--
1972	385.3	145.3	--
1973	695.4	114.2	13.6
1974	596	103	14.2
1975	511.6	416.5	43.7
1976	709.8	672	21.8
1977	670.3	485.5	30.3
1978	413.5	409.4	21.1
1979	218	396.8	11
1980	319	429	--
1981	291	329	25
1982	239.5	277	7
1983	105	175	6
1984	254.5	245	9
1985	207	125	4
1986	184	62	5
1987	179	91	6.5
1988	137	65	23
1989	158.5	104	8
1990	176	325	12
1991 November	--	145	14
1993 January	--	--	5

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United States Department of the Interior

U.S. GEOLOGICAL SURVEY
Water Resources Division
Mountain View Office Park
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West Trenton, New Jersey 08628

January 23, 1996

Mr. Stan Lulewicz
Project Engineer
Corps of Engineers, Philadelphia District
Department of the Army
Wanamaker Building, 100 Penn Square East
Philadelphia, PA 19107-3391

Dear Mr. Lulewicz:

The U.S. Army Corps of Engineers, Philadelphia District, is evaluating the feasibility of improvements to the main navigational channel of the Delaware River, which could include deepening the channel from the existing depth of about 40 ft below mean low water (MLW) to about 45 ft below MLW from deep water in Delaware Bay to Philadelphia, Pa. and Camden, N.J. Concerns have been raised that deepening the channel may adversely affect ground-water supplies developed in the adjacent Coastal-Plain aquifers of New Jersey, particularly in the Potomac-Raritan-Magothy aquifer system where many public and private ground-water supplies have been developed adjacent to the Delaware River in the reach where the channel improvements are being evaluated.

The concerns generally focus on the potential for saltwater from the river to infiltrate into the adjacent aquifers. Hypothetically, this could occur in two ways: (1) the dredging operation might uncover a confining bed at the base of the river channel, improving a pathway for saltwater to infiltrate to a freshwater aquifer; and (2) the deepening of the river channel might allow saltwater to encroach upstream in the river to areas where infiltration of the saltwater into the ground-water system would occurs. An additional concern is (3) that fluids leaching from the dredged-material disposal areas could contain contaminants of sufficient concentration that if they were to infiltrate to the aquifer with recharge water in the outcrop areas, they may adversely effect the potability of nearby water-supply wells.

The USGS has investigated the circumstances relating to these concerns in the course of several projects that have been accomplished in cooperation with the Corps of Engineers and the New Jersey Department of Environmental Protection. The results of the USGS will be discussed further from the perspective of the three concerns outlined above.

Concern (1), dredging breaches confining unit: A geophysical survey of the Delaware River bottom material was conducted by Duran (1986) to determine the configuration of aquifers and confining units beneath the river. The results of this study indicate that there are no places between Wilmington, De. and the Philadelphia, Pa./Camden, N.J. area where a breach of a protective confining unit would occur due to the proposed dredging. Generally, upstream of Little Tinicum Island the sands of the Potomac-Raritan-Magothy aquifer system are exposed in the river bottom. Downstream of Little Tinicum Island, clay, thicker than the proposed depth of dredging, predominates in the river-bottom material.

Concern (2), saltwater in river encroaches onto well-recharge areas: Water-supply wells, to be effected by saltwater in the Delaware River, must be located in proximity to the river or its associated tidal tributaries. Furthermore, the rate of pumpage of these wells must be sufficient to draw a substantial portion of their discharge from the river. Navoy and Voronin (*in review*) tabulated wells that are located within 2 miles of existing saltwater wetlands in Gloucester, Salem, and Cumberland Counties. The reach of the river that extends through Gloucester, Salem, and Cumberland Counties is where the transition between potable and nonpotable water occurs, with respect to dissolved chloride. During annual low-flow conditions, Delaware River water with a dissolved-chloride concentration that exceeds drinking-water standards is in the vicinity of Bridgeport, N.J./Chester, Pa (at about river mile 81). In order to ascertain the likely magnitude of upstream saltwater encroachment in the river that is a result of deepening the shipping channel, the Corps of Engineers, Waterway Experiment Station, constructed a three-dimensional salinity model of the Delaware Estuary. The results of the model indicate that salinity conditions for simulated low-flow and drought conditions will be displaced approximately 1 to 2 kilometers further upstream as a result of channel deepening. The movement of a salinity interface, due to tides, wind, and changes in the freshwater discharge of the Delaware River, is on the order of many miles. Therefore, this magnitude of displacement, as simulated, does not represent a significant change and will not likely have a significant effect on ground-water supply withdrawals in the area, under average conditions. This concern then focuses on whether the 1 to 2 kilometer displacement during extreme low-flow events, such as those related to drought, may effect ground-water supplies upstream of the area where saltwater is normally seen.

Significant drawdown of aquifer water levels to below sea level, which may be indicative of conditions that could favor saltwater intrusion, occurs in the Potomac-Raritan-Magothy aquifer system in the Camden metropolitan area (Navoy and Voronin, *in review*, figs. 23, 24, and 25). The most substantial of the ground-water withdrawals in the area of aquifer drawdown, that receive recharge from the river, are located in Pennsauken Township, Camden County (near river mile 105). These areas are identified in Navoy and Carleton (1995, p. 81, fig. 53) as a "river-influenced zone". Under the most severe drought of record, the river water which exceeded drinking water standards encroached upstream to a location in the vicinity of the Ben Franklin Bridge (river mile 100) for about 21 days. Saltwater in the river, however, does not immediately effect nearby wells. The ground-water travel time from the river to the wells of the Camden Area is slow in human terms, proceeding on the order of years or decades. The rate of flow of ground water is dependent on the distance to travel and the water-level gradient, among other things. Because the distance between the wells and the river is variable, the travel time is also variable. Simulations of 6 transects representative of flowpaths in the vicinity of river-proximal wells and well fields indicated the average travel time for flow from the river ranges from slightly more than one year to 15 years (Navoy, 1991, table 6, p. 112). Travel time to wells located farther from the river could be greater that 15 years. During the time the recharge from the river, that may include salty water, travels in the aquifer, substantial dilution takes place with fresh ground water. Based upon simulations of the ground-water system (Navoy, 1991), an intermittent low flow event, such as that due to drought, with a minimum dissolved chloride concentration in the river of between 2,000 and 4,000 mg/l for a duration of 30 days per year with a return period of 5 years is the type of condition that would result in nonpotability at river-proximal wells or well fields. These simulations compare favorably with observed data from November and December, 1964 where the 21-day encroachment of saltwater with a dissolved chloride concentration of 250 mg/l caused a 10 to 28 mg/l rise in chloride concentration at observed wells (Lennon and others, 1986, figure 15, p. 48), but no loss of potability. The conditions necessary to cause nonpotability at the river-proximal wells are in excess of those which could be attributed to the 1 to 2 kilometer displacement.

Concern (3), disposal area effects nearby wells: Along the river in Gloucester and Salem Counties are a number of sites that are presently used, or could be used for the disposal of dredged-material. The National Park and 17G disposal sites are situated within the outcrop of the Potomac-Raritan-Magothy aquifer system in Gloucester County. Based upon simulation of the ground-water system, wells east of the National Park and 17G sites draw recharge from the sites, but at most, one-quarter of the water originates from the sites and the mean travel time of groundwater from the sites to the wells is more than 25 years (Navoy and Rosman, *in review*, p. 15).

Recharge from the Oldmans #1, Pedricktown North, Pedricktown South, and 15G sites to the nearby Goodrich wells is likely, based upon a potentiometric surface analysis. The proximity of the wells to the sites and the steep head gradient indicate that the travel time to the wells could be relatively short, perhaps on the order of several years (Navoy and Rosman, *in review*, p. 26). Disposal of dredged material at the Raccoon Island, 15D, Penns Neck, Killcohook, and Artificial Island sites are not likely to effect existing ground-water withdrawals in the area because the sites are far from wells or the sites are not in good hydraulic contact with the aquifers (Navoy and Rosman, *in review*, p. 35).

In summary, the concerns about increasing the potential for saltwater from the river to infiltrate into the adjacent aquifers, either as a result of dredging through a confining unit or as a result of the upstream movement of saltwater in the deepened channel can be set aside. No significant confining units will be breached and the saltwater will not significantly move upstream to increase the threat of saltwater intrusion.

The concern that fluids leaching from the dredged-material disposal areas could infiltrate to the aquifer with recharge water can also be set aside. A poor connection exists with the aquifer or the contributing volume of recharge is insignificant at most of the disposal sites. For the several instances where the travel time is short and the contributing volume may be higher than insignificant, the risk of contamination can still be considered low. The Corps of Engineers has investigated the potential for the presence of hazardous substances in the dredged material. Their sampling and analyses indicate that the dredged material is not likely to contain hazardous substances that will exceed regulatory levels. Therefore, even though a recharge pathway may exist and travel time may be short, the risk of contamination will be low.

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Sincerely,

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Supervisory Hydrologist

Evaluation of Ground-Water Flow from Dredged-Material Disposal Sites in Gloucester and Salem Counties, New Jersey

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U.S. GEOLOGICAL SURVEY

Open-File Report 95-XXX

DRAFT

Prepared in cooperation with the
PHILADELPHIA DISTRICT,
U.S. ARMY CORPS OF ENGINEERS,

Evaluation of Ground-Water Flow from Dredged-Material Disposal Sites in Gloucester and Salem Counties, New Jersey

By Anthony S. Navoy and Robert Rosman

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West Trenton, New Jersey
1995

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ABSTRACT

The U.S. Army Corps of Engineers, Philadelphia District, routinely dredges the Delaware River ship channel and is also evaluating the feasibility of deepening the channel from the existing depth of about 40 ft below mean low water to about 45 ft, from deep water in Delaware Bay to Philadelphia, Pa. and Camden, N.J. Many public and private ground-water supplies have been developed adjacent to the Delaware River. The dredged material will be disposed of at 11 possible sites in proximity to the Delaware River in Gloucester and Salem Counties in New Jersey. A concern associated with the dredging operation is that ground-water recharge, originating at the dredged-material disposal sites, may effect nearby water-supply wells. Evaluation of ground-water flow through the use of a numerical ground-water flow model, where possible, and otherwise through the use of potentiometric-surface mapping indicates that recharge from the National Park and 17G sites, and recharge from the Oldmans #1, Pedricktown North, Pedricktown South, and 15G sites is likely to contribute to the flow of nearby wells.

INTRODUCTION

The U.S. Army Corps of Engineers, Philadelphia District, routinely dredges to maintain specified depths in the Delaware River ship channel. The Corps of Engineers is also evaluating the feasibility of improvements to the main navigational channel of the Delaware River, that could include deepening the channel from the existing depth of about 40 ft below mean low water to about 45 ft, from deep water in Delaware Bay to Philadelphia, Pa. and Camden, N.J. The dredged material will be disposed of at 11 possible sites in proximity to the Delaware River in Gloucester and Salem Counties in New Jersey. The disposal of dredged material from these projects onto sites has raised concerns that contaminants contained in the spoil may leach and may adversely affect nearby ground-water supplies derived from the Coastal-Plain aquifers of New Jersey.

Many public and private ground-water supplies have been developed adjacent to the Delaware River. The Potomac-Raritan-Magothy aquifer system is of particular interest as it is the primary source of water supply for Gloucester and Salem Counties, and crops out along the river, where the disposal sites are located. A previous ground-water investigation (Navoy, 1994) has indicated that much of the Potomac-Raritan-Magothy aquifer system outcrop in Gloucester County contributes water as recharge to the many commercial, industrial, and public-supply wells in the area.

The purpose of this report is to evaluate the possible connection between ground-water recharge, originating at the dredged-material disposal sites, and nearby water-supply wells. This was accomplished using ground-water modeling techniques, where available, to delineate the contributing areas of the water-supply wells. For those sites where a ground-water flow model is not available, ground-water level data was collected and the potentiometric surface of the relevant aquifers were evaluated to determine the direction of ground-water flow.

Location of Disposal Sites

Four disposal sites, located near or adjacent to the Delaware River (see figure 1 for locations), are being considered. All of these are adjacent to sites that have been previously used for disposal of dredged material:

Site Name	Location
	PROPOSED DISPOSAL SITES FOR CHANNEL-DEEPENING
15G	South side of Oldmans Creek near Pedricktown, Salem County, N.J., approximately 1 mile inland from the Delaware River
15D	South side of Raccoon Creek near Bridgeport, Gloucester County, N.J., at the Delaware River
Raccoon Island	North side of Raccoon Creek near Bridgeport, Gloucester County, N.J., at the Delaware River
17G	South side of Woodbury Creek near National Park, Gloucester County, N.J., at the Delaware River
	DISPOSAL SITES USED FOR CHANNEL MAINTENANCE
National Park	North side of Woodbury Creek near National Park, Gloucester County, N.J., at the Delaware River
Oldmans #1	Adjacent to the Delaware River, south of Oldmans Creek, near Pedricktown, Salem County,N.J.
Pedricktown North	Adjacent to the Delaware River, south of Oldmans Creek, near Pedricktown, Salem County,N.J.
Pedricktown South	Adjacent to the Delaware River, south of Oldmans Creek, near Pedricktown, Salem County,N.J.
Penns Neck	Adjacent to Salem River, Pennsville, Salem County, N.J.
Killcohook	Adjacent to the Delaware River at Killcohook National Wildlife Refuge, Salem County, N.J.
Artificial Island	Adjacent to Delaware River, at Artificial Island, Salem County, N.J.

Hydrogeology of the Disposal Sites

The dredge-spoil disposal sites are located on the Coastal Plain of New Jersey. The hydrogeology of the Coastal Plain is composed of interbedded sand and gravel aquifers separated by leaky silt and clay confining units. The hydrogeologic units of the Coastal Plain are listed on table 1. Of particular interest is the Potomac-Raritan-Magothy aquifer system, which can be differentiated into three composite members, the upper, middle and lower aquifers. The Potomac-Raritan-Magothy aquifer system crops out in the vicinity of most of the disposal sites and is also used as a substantial source of water supply in the area.

GROUND-WATER FLOW IN THE VICINITY OF THE SITES

The primary aim of this investigation is to determine whether nearby water-supply wells could be hydraulically connected to the dredged-material disposal sites. This was accomplished

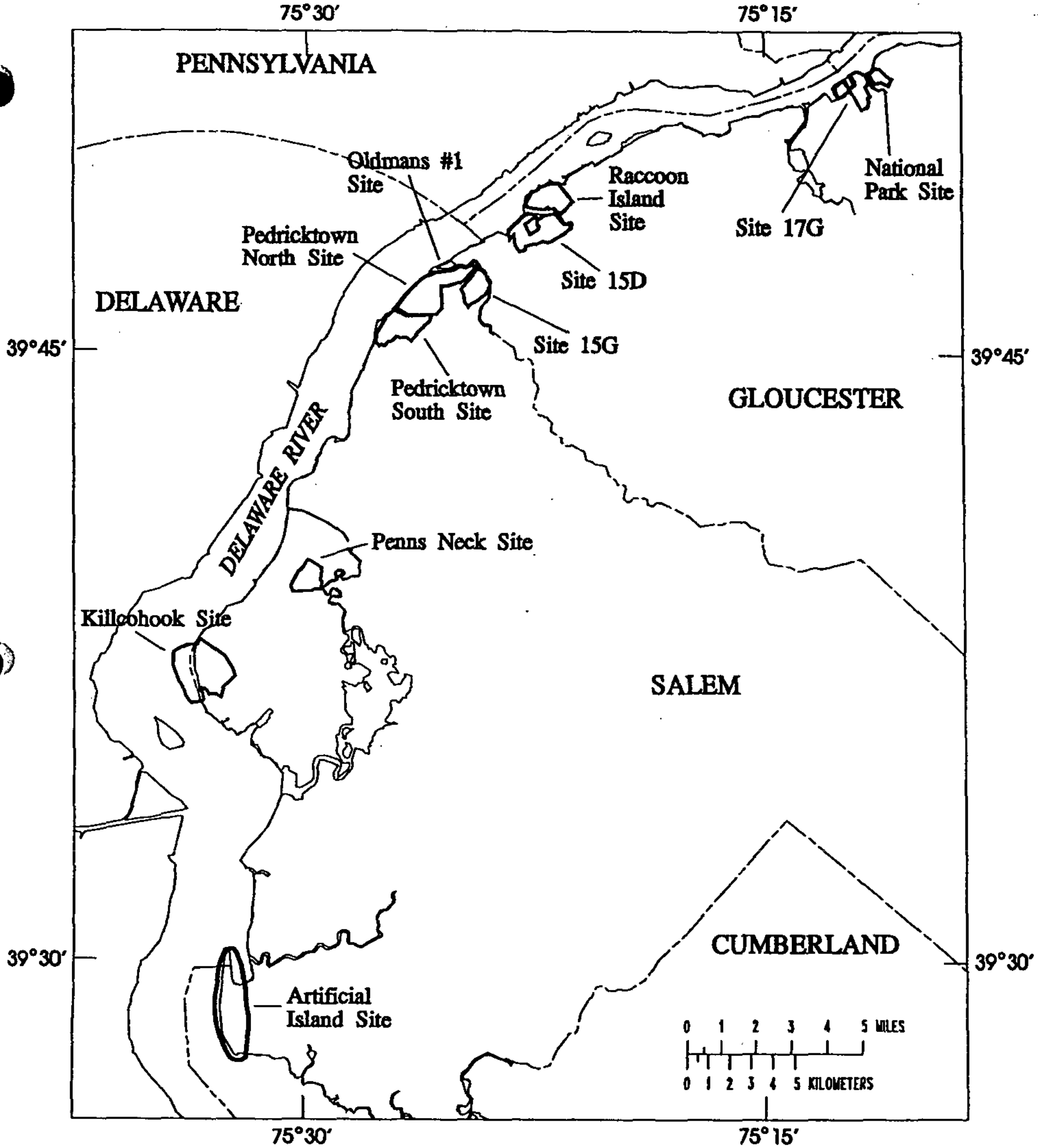


Figure 1.--Location map of dredged-material disposal sites in Salem and Gloucester Counties, New Jersey.

Table 1. --Geologic and hydrogeologic units in the Coastal Plain of New Jersey
[Modified from Zapecza, 1989, table 2.]

SYSTEM	SERIES	GEOLOGIC UNIT	LITHOLOGY	HYDROGEOLOGIC UNIT	HYDROLOGIC CHARACTERISTICS
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	Pennsauken Formation			
		Bridgeton 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.
		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	Sand, quartz and glauconite, fine- to coarse-grained.	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.		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.	Vincentown aquifer	Yields small to moderate quantities of water in and near its outcrop area.
		Hornerstown Sand	Sand, clayey, glauconitic, dark-green, fine- to coarse-grained.		Poorly permeable sediments.
Cretaceous	Upper Cretaceous	Tinton Sand	Sand, quartz, glauconitic, brown and gray, fine- to coarse-grained, clayey, micaceous.		
		Red Bank Sand		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.		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 Formation	Clay, silty, dark-greenish-gray; contains glauconitic quartz sand.	Marshalltown-Wenonah confining unit	A leaky confining unit.
		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, and 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 are present.		
		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.
				Confining unit	
		Raritan Formation	Sand, quartz, light-gray, fine- to coarse-grained, poorly arkosic; contains red, white, and variegated clay. Includes Farrington Sand Member.	Middle aquifer	
				Confining unit	
	Lower Cretaceous	Potomac Group	Alternating clay, silt, sand, and gravel.	Lower aquifer	
Pre-Cretaceous		Bedrock	Precambrian and lower Paleozoic crystalline rocks, 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.

using a ground-water flow model of the Potomac-Raritan-Magothy aquifer system for the sites in Gloucester County. Because a ground-water flow model of the aquifer system in Salem count is not currently available, potentiometric surface measurement were used to determine flow directions and thus the possible destinations for recharge occurring in the disposal sites.

Evaluation of National Park and 17G Sites

The National Park and 17G sites are located on the outcrop area of the upper Potomac-Raritan-Magothy aquifer in Gloucester County adjacent to the Delaware River. This outcrop includes a veneer of post-Cretaceous sands that are hydraulically connected to the upper aquifer. Underlying the site, at depth, are the middle and lower Potomac-Raritan-Magothy aquifers. These underlying units are used for water-supply in the area. The intervening confining units are leaky, allowing recharge to move vertically towards pumpage. The elevations of the aquifers, in the vicinity of the National Park and 17G sites, are listed in table 2.

Table 2. --Top and bottom altitude of Potomac-Raritan-Magothy aquifer system units in the vicinity of the National Park and 17G disposal sites

Aquifer	Altitude (sea level)
top of the upper aquifer	land surface
bottom of the upper aquifer	-45 to -80
top of the middle aquifer	-100 to -120
bottom of the middle aquifer	-130 to -150
top of the lower aquifer	-160 to -180
bottom of the lower aquifer	-180 to -250

The effects of withdrawals from the ground-water system in the vicinity of the National Park and 17G disposal sites were simulated using the ground-water flow model developed by Navoy and Carleton (in press). Seven of the significant production wells in the area (greater than 10,000 gal./year) were found to be drawing recharge water from the disposal sites. The contributing areas of these wells were determined using a particle-tracking model post processor (Pollock, 1989) and are shown on figures 2 through 8. The procedure for particle tracking involved a process where 2,400 simulated particles were started in the pumped wells and the model post processor backed the particles up through the ground-water flow system to delineate the points of origin or recharge. These points of recharge were intersected with the disposal areas using a Geographic Information System. In this manner, the recharge originating from the disposal areas was identified and also can lead to indication of the proportion of the amount of flow from the disposal sites that will be contributed to the wells. The particle-tracking analysis also yields information about the velocity or travel time of the simulated particles. The minimum, mean, and maximum simulated travel times, and percentage of flow originating at a disposal site, for each of the wells found

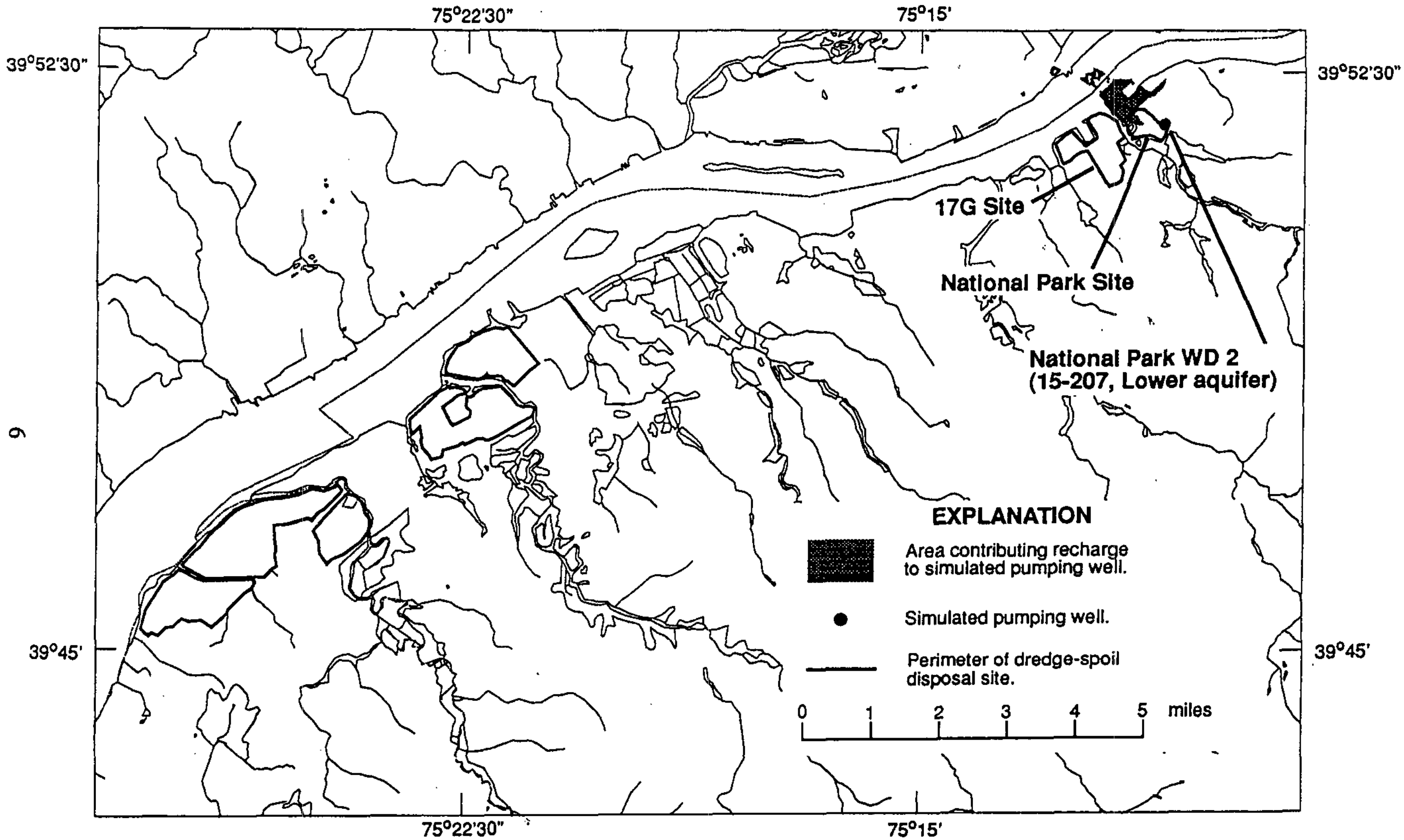


Figure 2.-- Simulated contributing area for National Park Water Department well 2 (15-207, Lower aquifer).

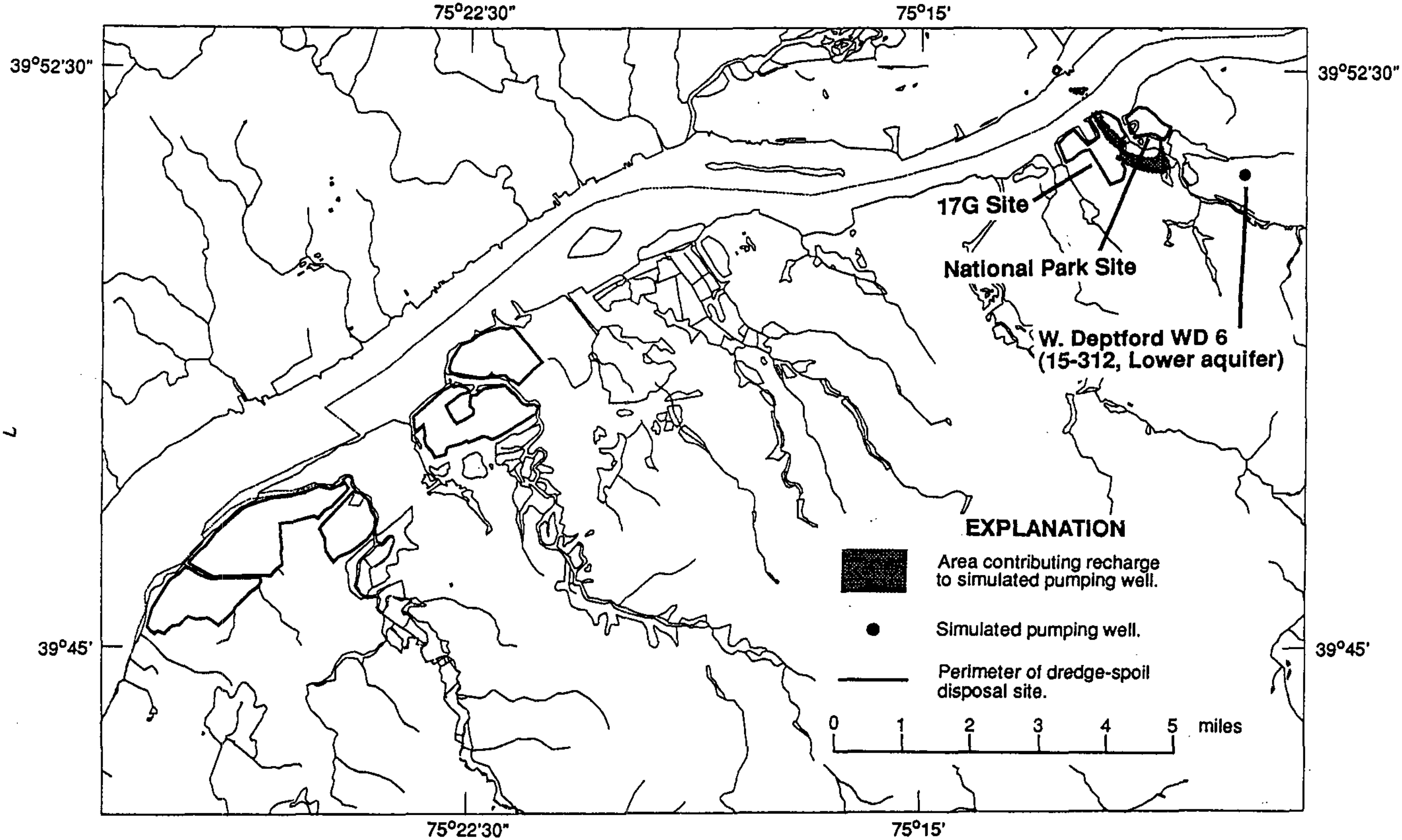


Figure 3.-- Simulated contributing area for West Deptford Water Department well 6 (15-312, Lower aquifer).

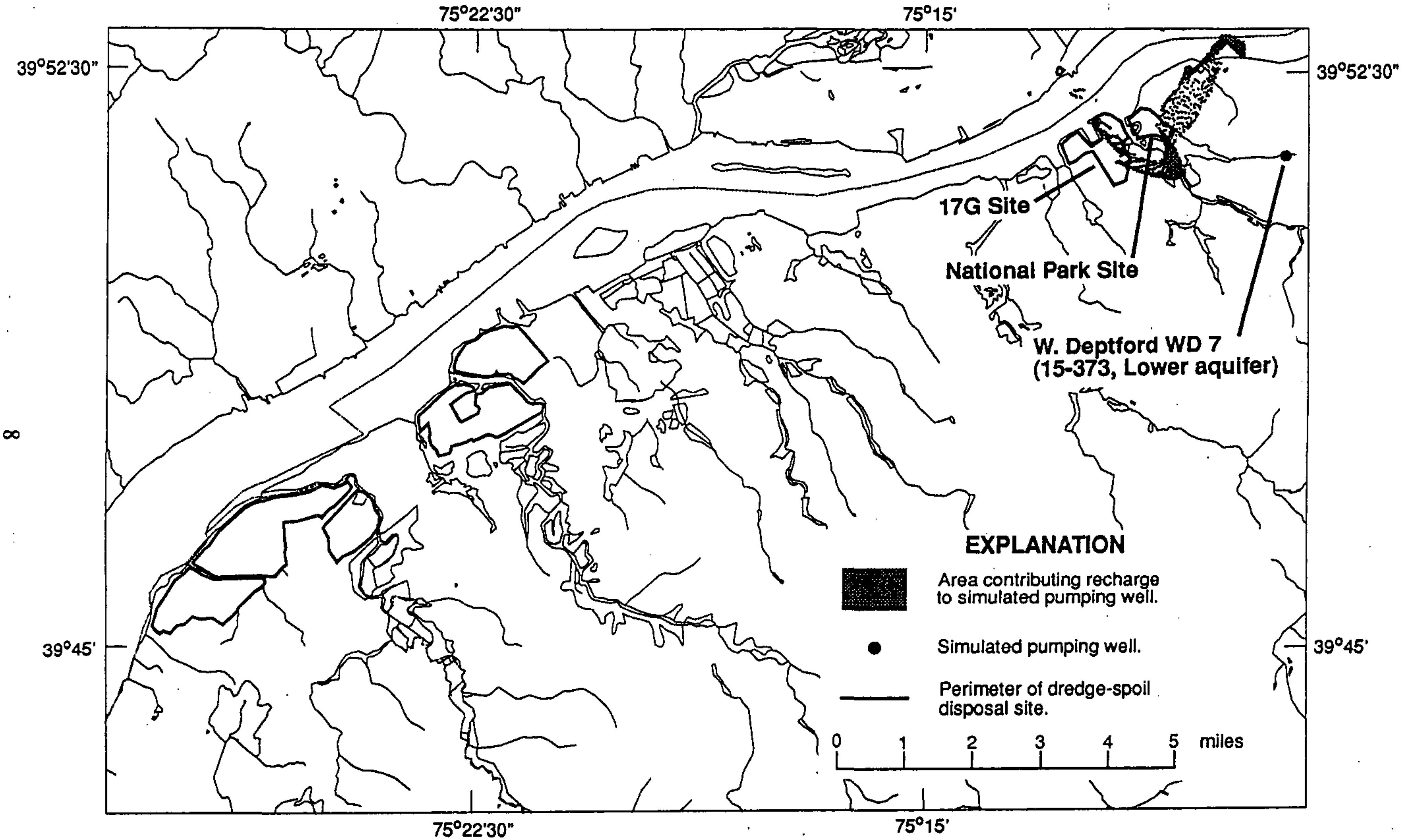


Figure 4.-- Simulated contributing area for West Deptford Water Department well 7 (15-373, Lower aquifer).

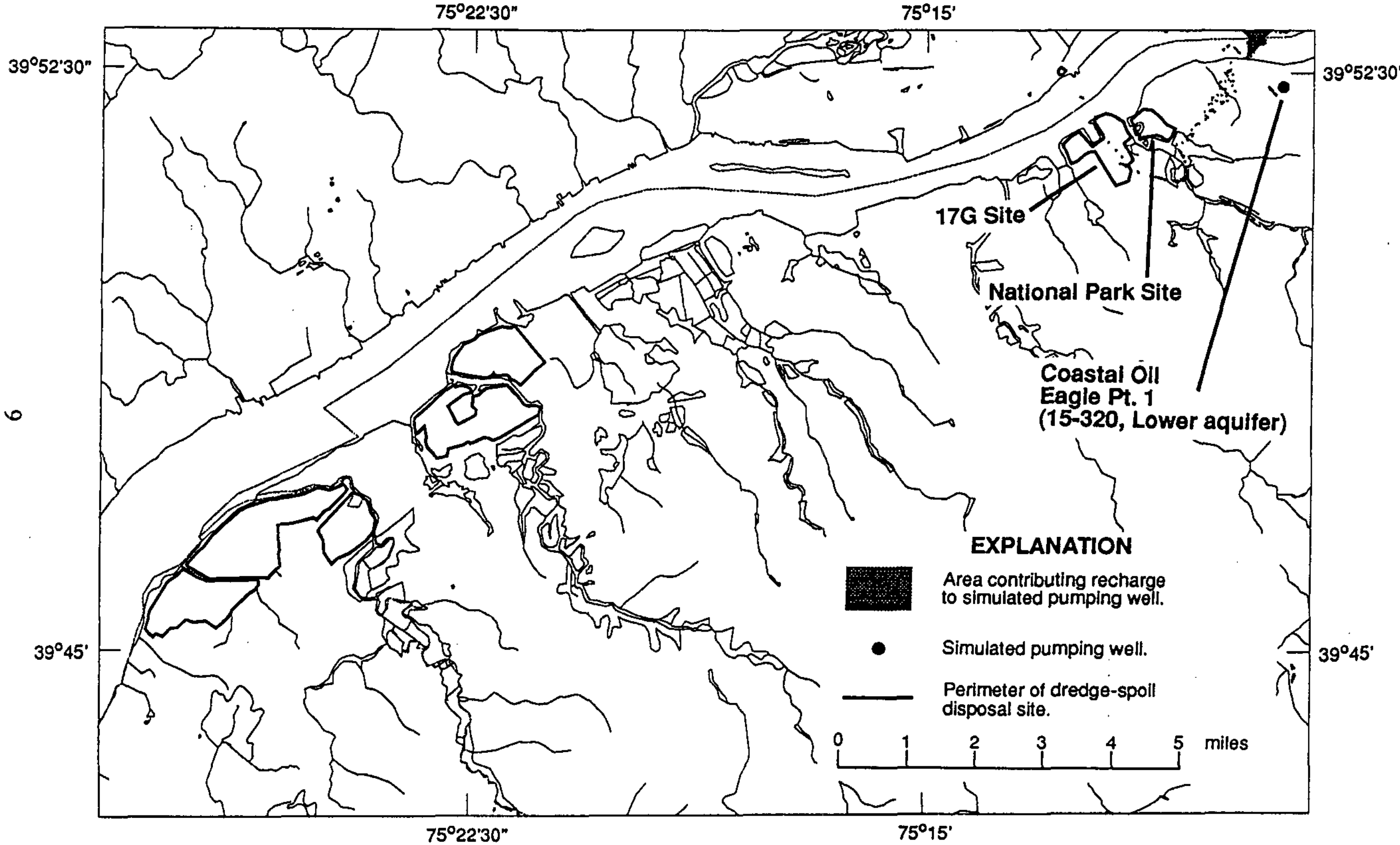


Figure 5.-- Simulated contributing area for Coastal Oil Eagle Point well 1
(15-320, Lower aquifer).

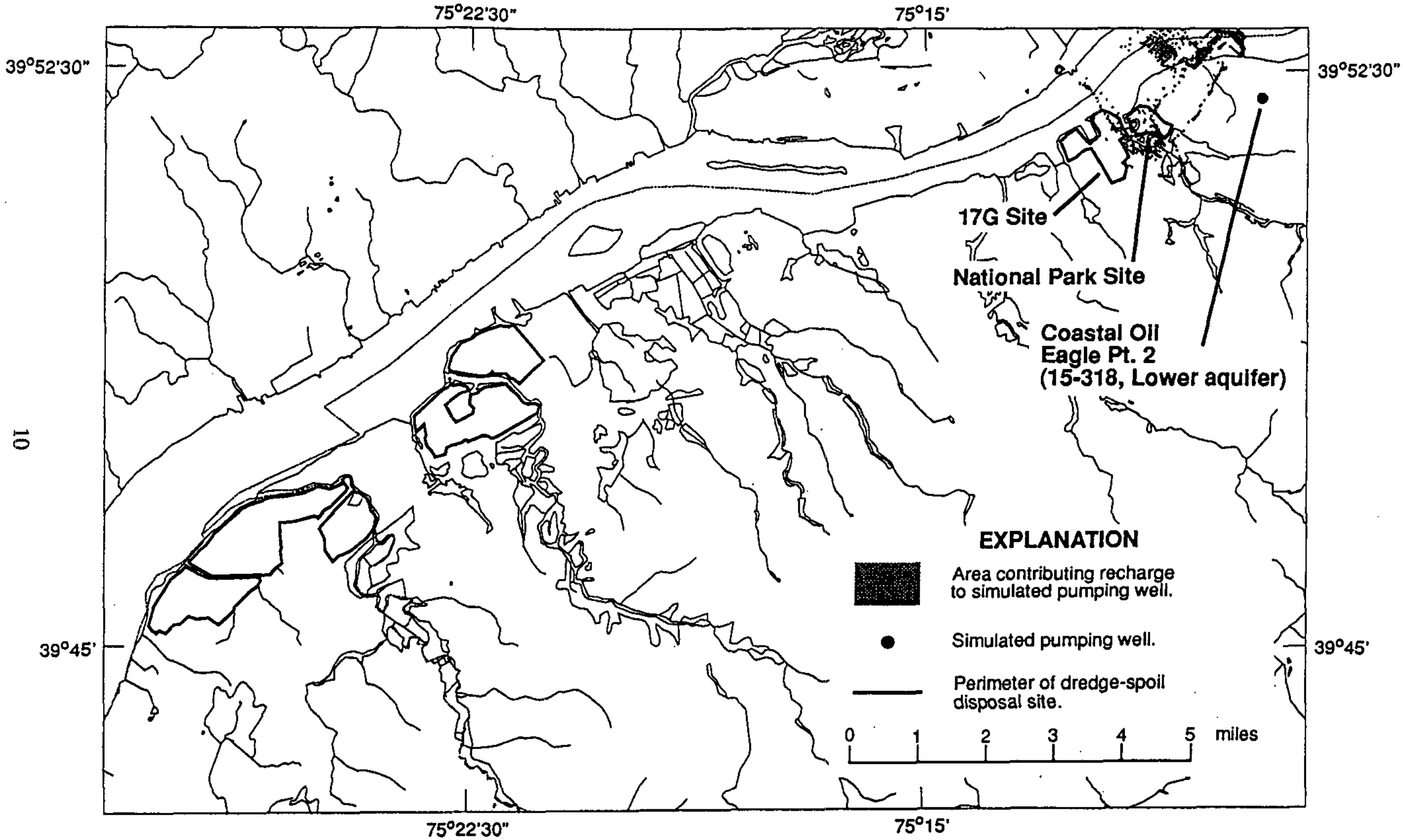


Figure 6.-- Simulated contributing area for Coastal Oil Eagle Point well 2 (15-318, Lower aquifer).

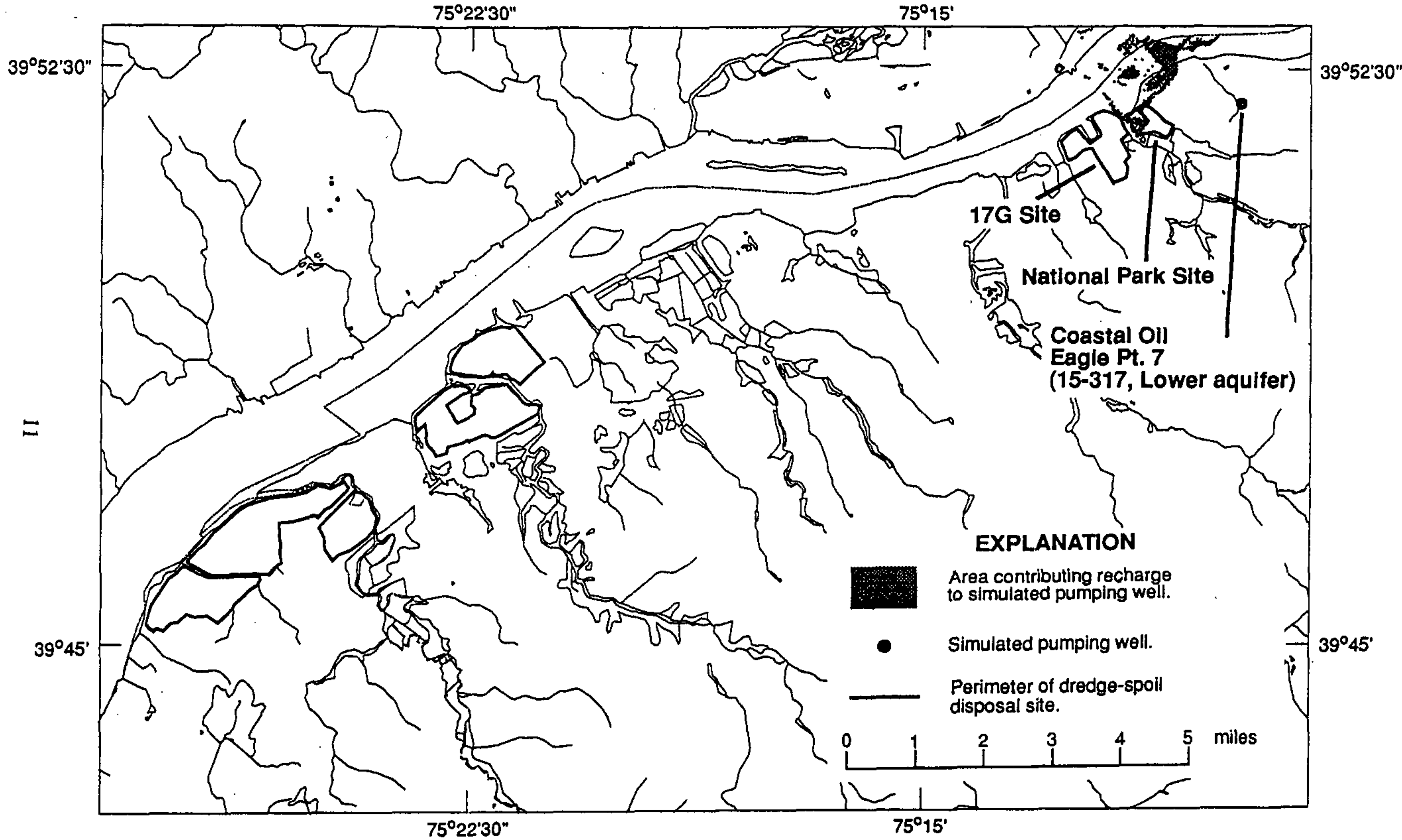


Figure 7.-- Simulated contributing area for Coastal Oil Eagle Point well 7 (15-317, Lower aquifer).

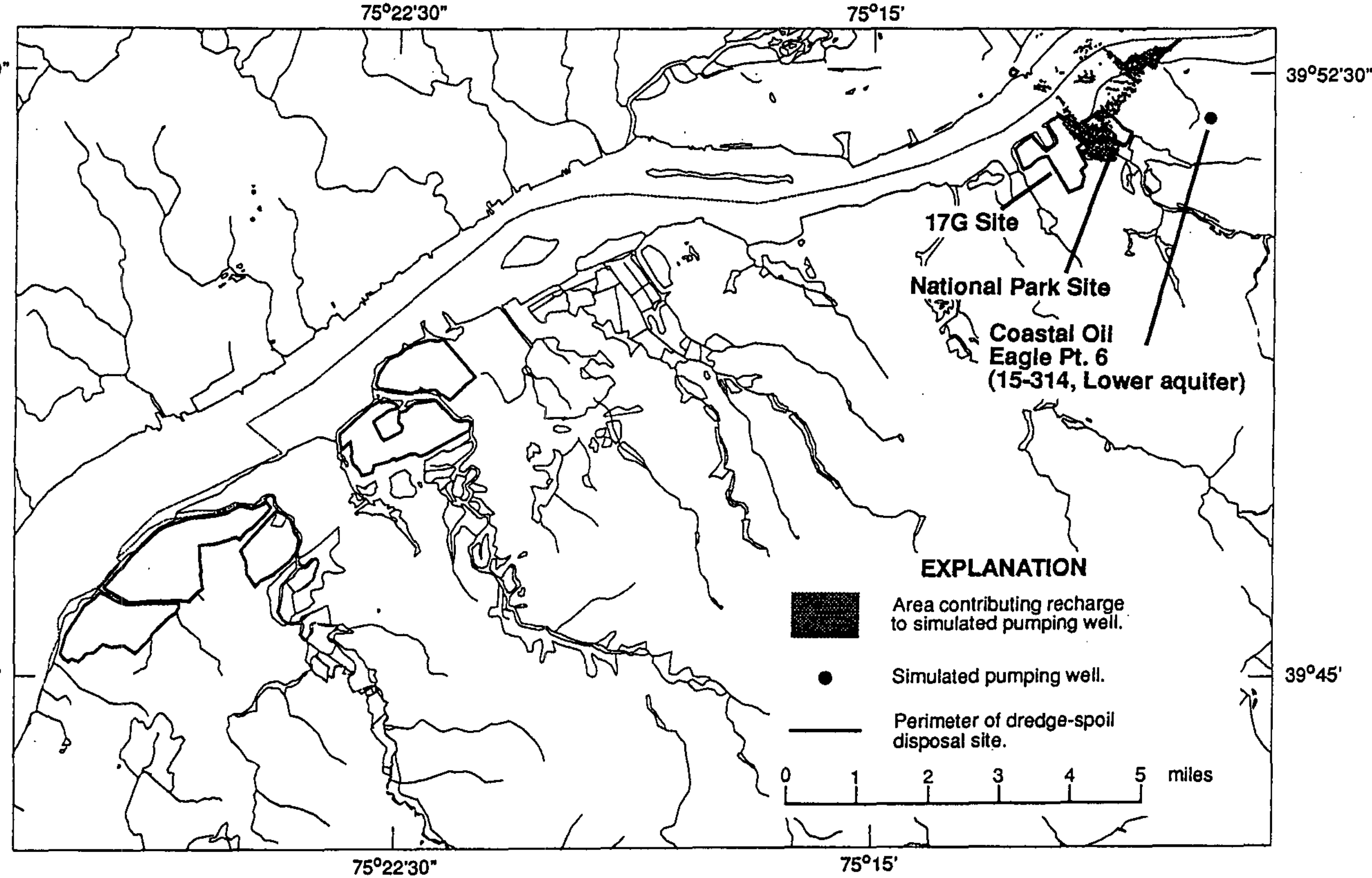


Figure 8.-- Simulated contributing area for Coastal Oil Eagle Point well 6
(15-314, Lower aquifer).

to be receiving water from the disposal sites are listed on table 3.

Table 3. --Simulated ground-water flow contributed from disposal sites near National Park, N.J. to nearby withdrawal wells

Well Name and USGS Well Identifier	Disposal Site	Percentage of Flow from Site to Well	Mean Travel Time (years)	Minimum Travel Time (years)	Maximum Travel Time (years)
National Park WD 2 (15-207)	National Park	14%	23	15	63
W. Deptford WD 6 (15-312)	17G	26%	1,300	48	10,562
W. Deptford WD 7 (15-373)	17G	8%	1,352	58	10,600
W. Deptford WD 7 (15-373)	National Park	2%	122	93	162
Coastal Oil Eagle Pt. 1 (15-320)	17G	1%	6,406	120	10,628
Coastal Oil Eagle Pt. 2 (15-318)	National Park	2%	121	43	170
Coastal Oil Eagle Pt. 2 (15-318)	17G	3%	846	58	10,575
Coastal Oil Eagle Pt. 7 (15-317)	National Park	7%	56	35	88
Coastal Oil Eagle Pt. 6 (15-314)	National Park	9%	76	35	161
Coastal Oil Eagle Pt. 6 (15-314)	17G	4%	67	48	100

As can be seen from table 3, the percentage of flow from the National Park and 17G disposal sites to the nearby wells is low. All have about a quarter or less of their flow originating as recharge from the disposal sites. Also, the mean travel times are generally in excess of 50 years, with the exception of the nearby National Park water-supply well, where the mean travel time is about 20 years. It must be recognized that these figures are the result of a simulation, which is subject to a degree of uncertainty and error. The location and construction characteristics of the significant water-supply wells are listed in table 4 (located at the back of this report).

Evaluation of Raccoon Island, 15D, Oldmans #1, Pedricktown North, Pedricktown South, and 15G Sites

The Raccoon Island, 15D, Oldmans #1, Pedricktown North, Pedricktown South, and 15G sites are located on the outcrop area of the middle Potomac-Raritan-Magothy aquifer, adjacent to the Delaware River in Gloucester and Salem Counties. This outcrop may include a veneer of post-Cretaceous sands that is hydraulically connected to the middle aquifer. Underlying the site, at depth, is the lower Potomac-Raritan-Magothy aquifer. Nearby, to the southeast, the upper Potomac-Raritan-Magothy aquifer crops out and is hydraulically connected through leaky confining units to the middle and lower Potomac-Raritan-Magothy aquifers. These aquifers are used for water-supply in the area. The leaky confining units allow recharge to move vertically towards pumpage. In the vicinity of these sites, the middle Potomac-Raritan-Magothy aquifer can be subdivided into two parts with an intervening confining leaky unit (Lewis and others, 1991, pg. 16), but for the purposes of this report the subdivision will not be considered. The elevations of the aquifers, in the vicinity of the sites, are listed in table 5 (from Lewis and others, 1991, Plates 2a through 5a).

Table 5. --Top and bottom altitude of Potomac-Raritan-Magothy aquifer system units in the vicinity of the Raccoon Island, 15D, Oldmans #1, Pedricktown North, Pedricktown South, and 15G sites

Aquifer	Altitude (sea level) at Raccoon Is./ 15D Sites	Altitude (sea level) at Pedricktown N.&S., Oldmans #1, and 15G Sites
top of the middle aquifer	land surface	land surface
bottom of the middle aquifer	-40 to -80	-40 to -100
top of the lower aquifer	-70 to -100	-90 to -120
bottom of the lower aquifer	-100 to -150	-100 to 200

The effects of withdrawals on ground-water system for the areas, particularly in the vicinity of the Raccoon Island, 15D, Oldmans #1, and 15G sites, were simulated using the ground-water flow model developed by Navoy and Carleton (in press). Two wells, of the significant production wells in the area (greater than 10,000 gal/y), were found, to be drawing recharge water from the disposal sites. Additionally, the contributing area of a third well was found to be close to one of the sites. The contributing areas of these wells were determined using a particle-tracking model post processor (Pollock, 1989) in the same fashion as those described in the analysis of the National Park and 17G sites. The simulated contributing areas are shown on figures 9 through 11. The results of the particle-tracking analysis pertaining to the minimum, mean, and maximum simulated travel times are shown on table 6.

Table 6. --Simulated ground-water flow contributed from the 15D, Oldmans #1, and 15G disposal sites to nearby withdrawal wells

Well Name and USGS Well Identifier	Disposal Site	Percentage of Flow from Site to Well	Mean Travel Time (years)	Minimum Travel Time (years)	Maximum Travel Time (years)
Penns Grove WSC Bridgeport 2 (15-166)	15D	<1%	177	173	180
Monsanto Chem 35D (15-601)	15D	1%	55	44	90
Monsanto Chem 35D (15-601)	Oldmans #1	1%	54	47	64
Monsanto Chem 35D (15-601)	15G	2%	81	51	120
Monsanto Chem 1 (15-167)	15D	contributing area very close	--	--	--

The ground-water flow model developed by Navoy and Carleton ends at about the Gloucester County-Salem County line. Therefore, in order to evaluate the ground-water flow system in

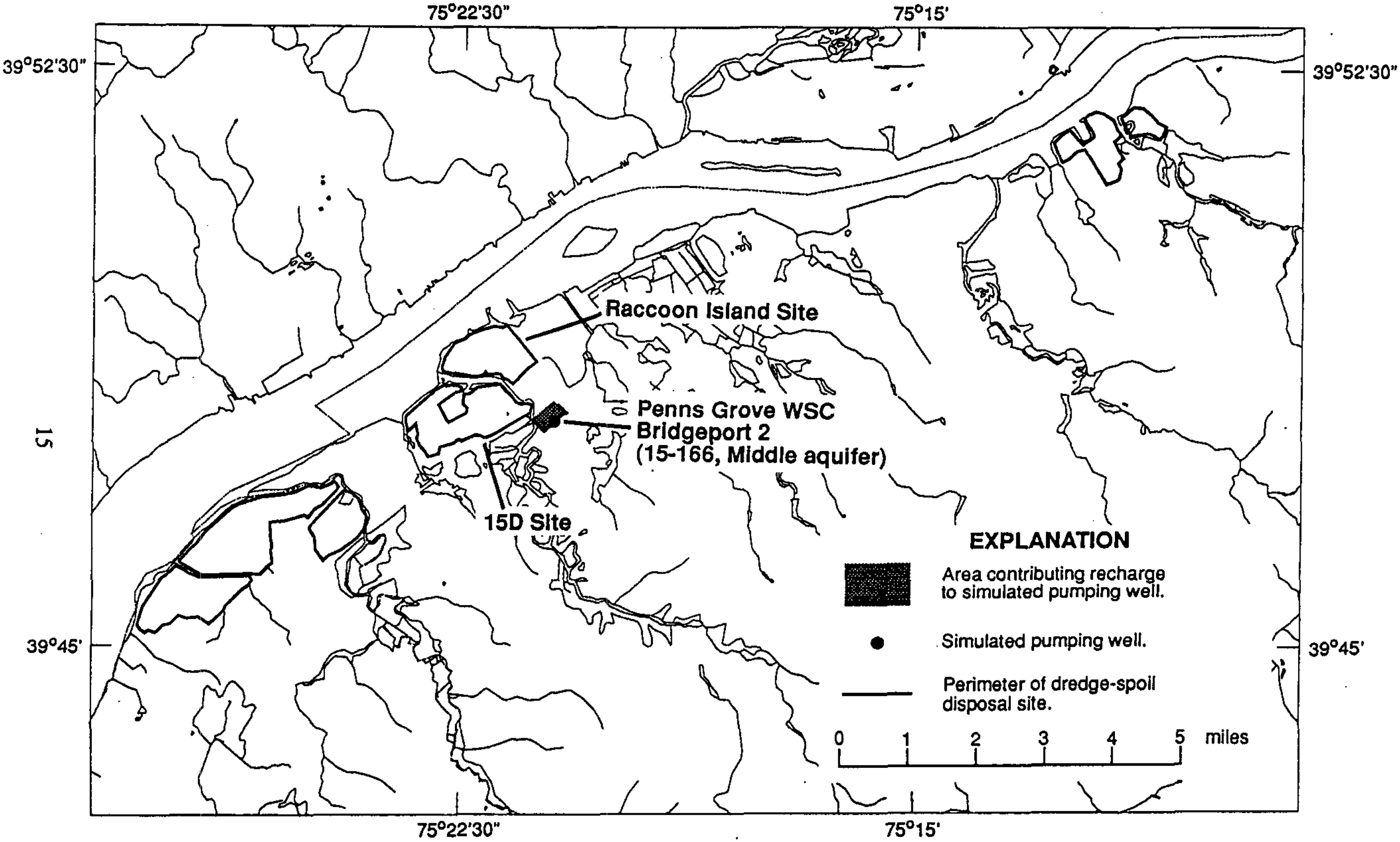


Figure 9.-- Simulated contributing area for Penns Grove Water Supply Company Bridgeport 2 well (15-166, Middle aquifer).

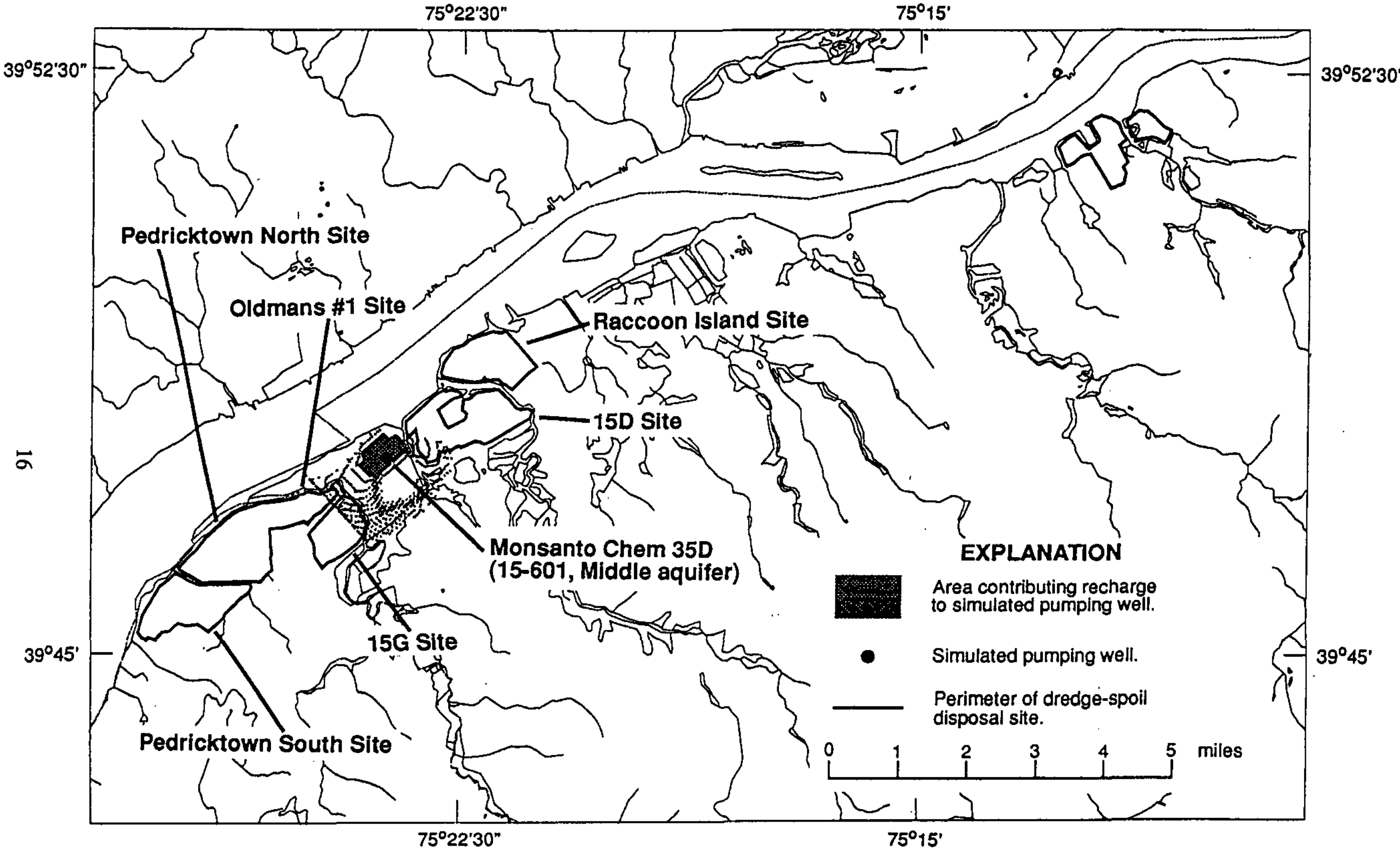


Figure 10.-- Simulated contributing area for Monsanto Chemical well 35D (15-601, Middle aquifer).

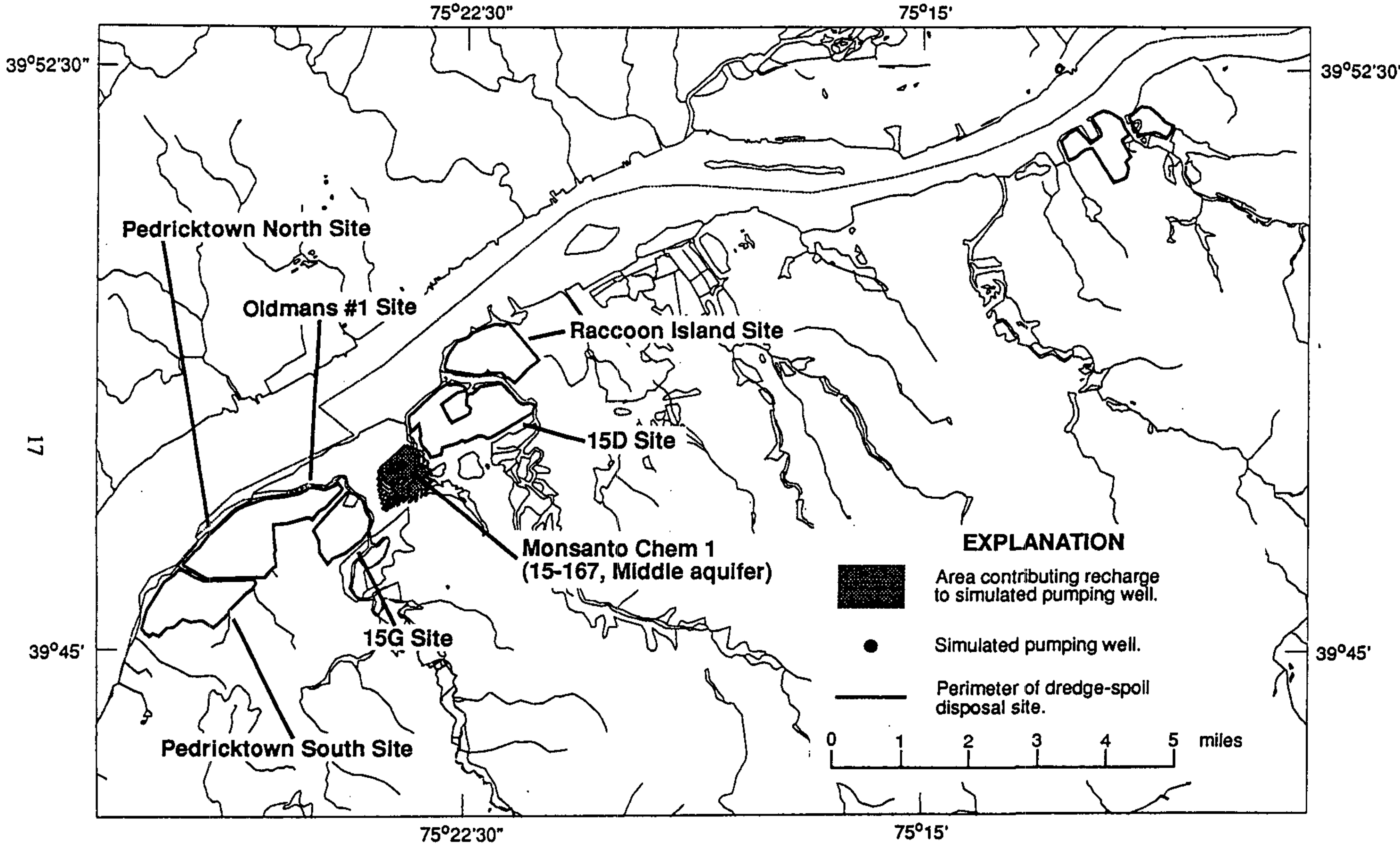


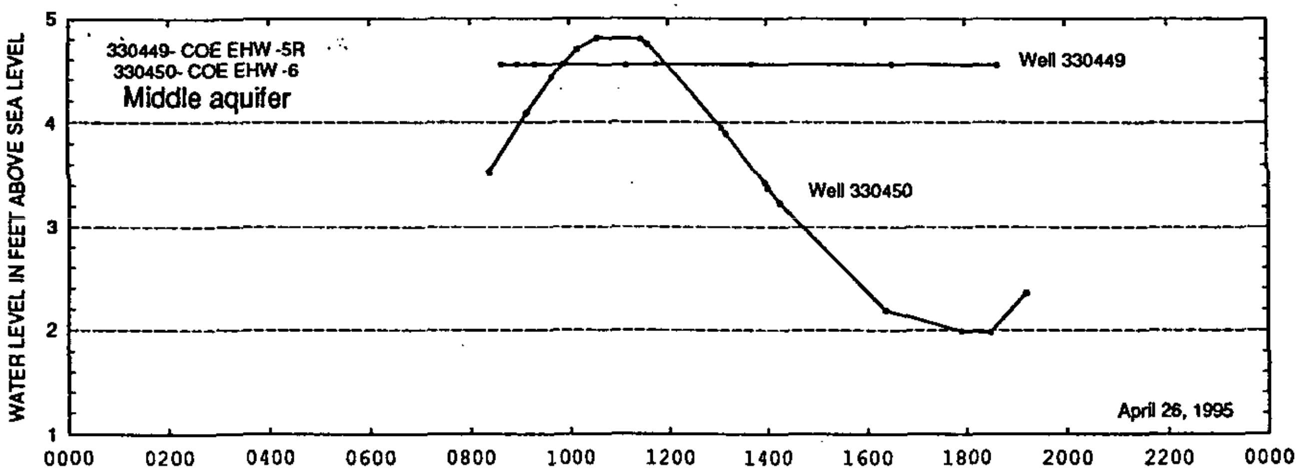
Figure 11.-- Simulated contributing area for Monsanto Chemical well 1 (15-167, Middle aquifer).

the vicinity of the Oldmans #1, Pedricktown North, Pedricktown South, and 15G sites, especially with regard to wells south of the site in Salem County, a different approach was needed. A synoptic ground-water-level data-collection effort was undertaken to map the potentiometric surfaces of the relevant aquifers within three miles of the disposal sites. This technique does not have the precision that is associated with a ground-water flow model but is adequate to suit the purpose of this report, namely indicating the likely wells that could draw recharge from the disposal sites.

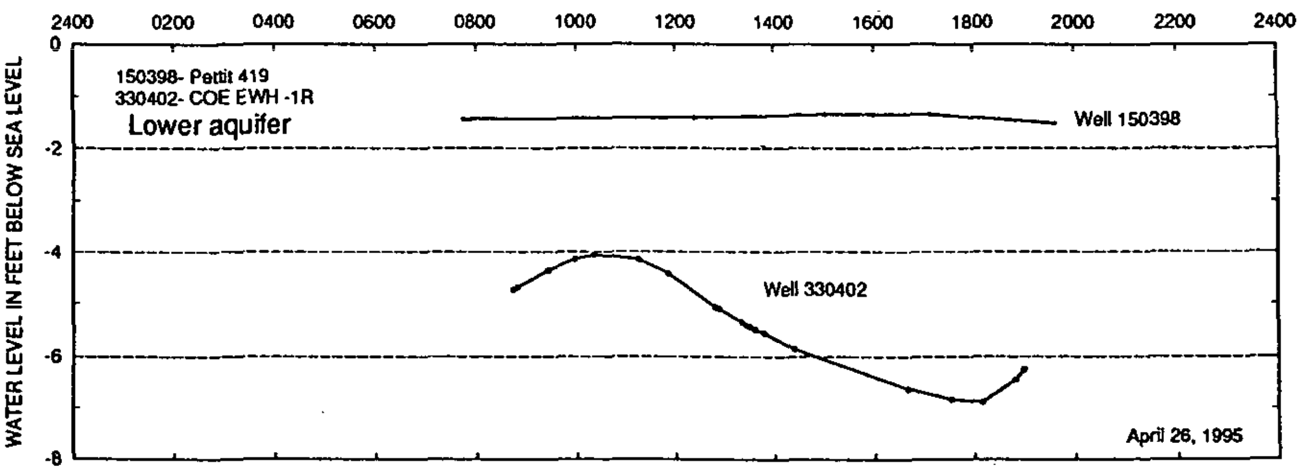
The basic water-level data collected are tabulated in table 7 (located, due to its length, at the back of the report). Because of the proximity of the tidal Delaware River to the sites, an adjustment of the water-level data to consistent tidal conditions was required for some wells. The water levels in four wells were observed during a tidal cycle in order to characterize the magnitude of tidal fluctuations of the confined aquifers. The wells measured were the U.S. Army Corps of Engineers wells EHW-5R (33-449) and EHW-6 (33-450), both screened in the middle Potomac-Raritan-Magothy aquifer, and the Petit well 419 (15-398) and U.S. Army Corps of Engineers well EWH-1R (33-402), both screened in the lower Potomac-Raritan-Magothy aquifer. For each aquifer, one of the wells was located adjacent to the Delaware River and the other well is located about one-half mile away from the river. Figure 12 shows the hydrographs of these wells indicating the tidal fluctuation in ground-water levels during a tidal sequence which changed from high tide to low tide. The maximum tidal fluctuation observed in both the middle and lower Potomac-Raritan-Magothy aquifer wells located adjacent to the river was about 2.8 ft. The tidal fluctuations are barely perceptible in the wells located about one-half mile away from the river. In order to compensate for these fluctuations, the water levels of all measured wells located within one-half mile of the river were adjusted to conform to an estimated mid-tide level. These adjustments are indicated in table 7.

The results of the measurements were compiled into the potentiometric-surface maps of the upper, middle, and lower Potomac-Raritan-Magothy aquifers shown on figures 13 to 15, respectively. Several cones of depression in the potentiometric can be readily seen in the vicinity of the Raccoon Island, 15D, Oldmans #1, Pedricktown North, Pedricktown South, and 15G sites. Of particular interest are the cones of depression in the middle Potomac-Raritan-Magothy aquifer (fig. 14) because they are the closest to the disposal sites. The observed cone of depression, located northeast of Oldmans Creek, in between Oldmans #1 and 15D correspond to the simulated wells and contributing area depicted on figures 10 and 11. As indicated in table 6, those wells draw recharge from the adjacent sites, but the proportion of flow from the sites is low and the travel times are generally more than 50 years. The other significant cone of depression in the middle aquifer is just to the south of the cluster of the Oldmans #1, Pedricktown North, Pedricktown South, and 15G sites. The pumpage associated with the cone of depression is from the B.F. Goodrich Co. wells 4, 6, 9, 10 (33-86, 33-85, 33-83, 33-997). The withdrawals for these wells, listed in table 4, total 427 mgal/y. This withdrawal rate is similar to those of Monsanto wells 1 and 35D (15-167, 15-601) shown on figures 14 and 15. The contributing areas for these wells will be similar in size. It is likely that recharge from the sites will occur to the Goodrich Co. wells because of the proximity to the cluster of sites, especially Pedricktown North and 15G. The proximity of the wells to the sites and the steep head gradient indicate that the travel time to the wells could be relatively short, perhaps on the order of several years.

There were no distinct cones of depression in the lower Potomac-Raritan-Magothy aquifer



HYDROGRAPH OF TIDAL FLUCTUATIONS IN WELL 330449 AND WELL 330450



HYDROGRAPH OF TIDAL FLUCTUATIONS IN WELL 150398 AND WELL 330402

Figure 12.--Hydrographs of wells indicating tidal fluctuations.

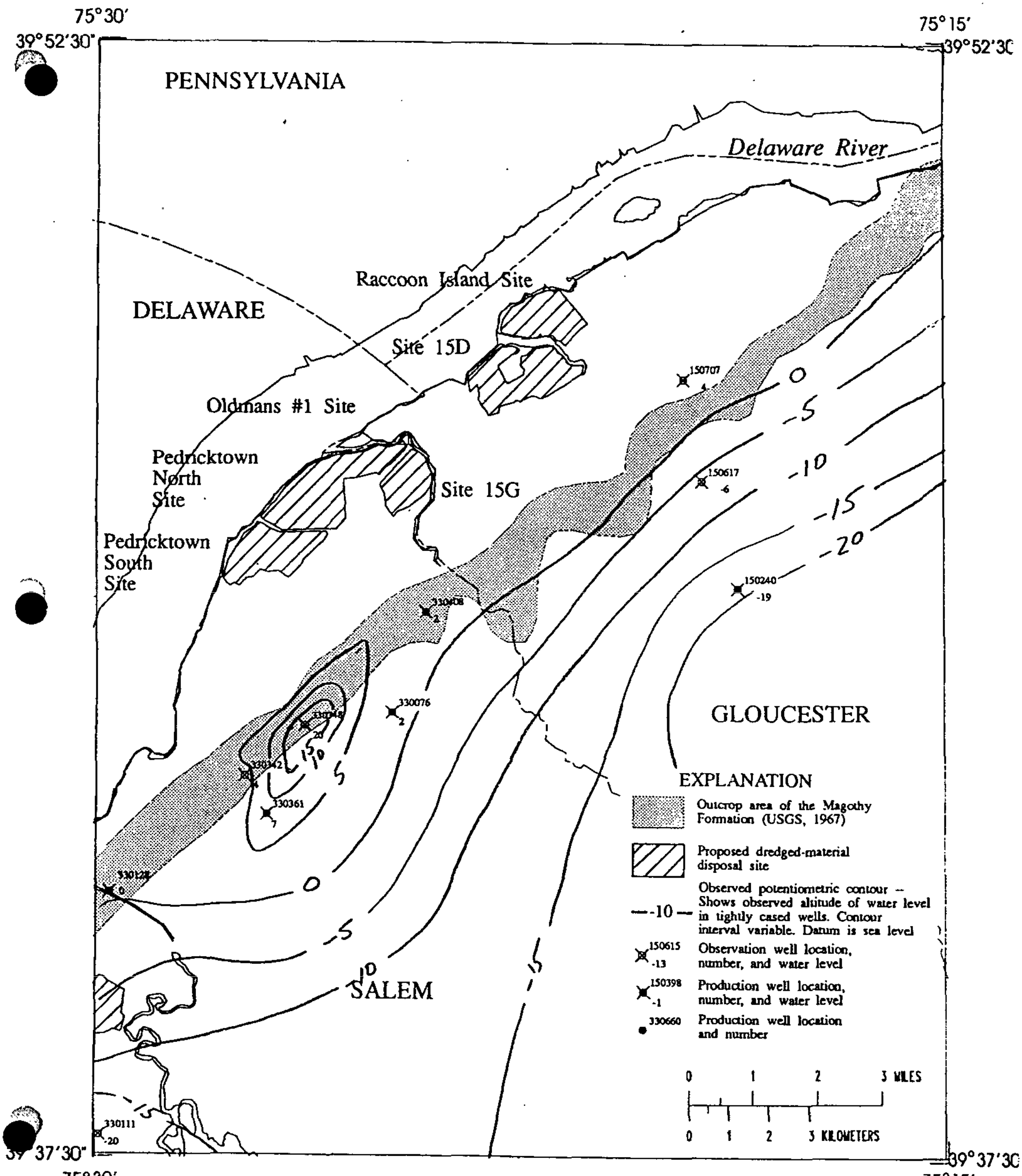


Figure 13.--Potentiometric surface of the Upper Potomac-Raritan-Magothy aquifer in the vicinity of Pedricktown, N.J., March and April 1995.

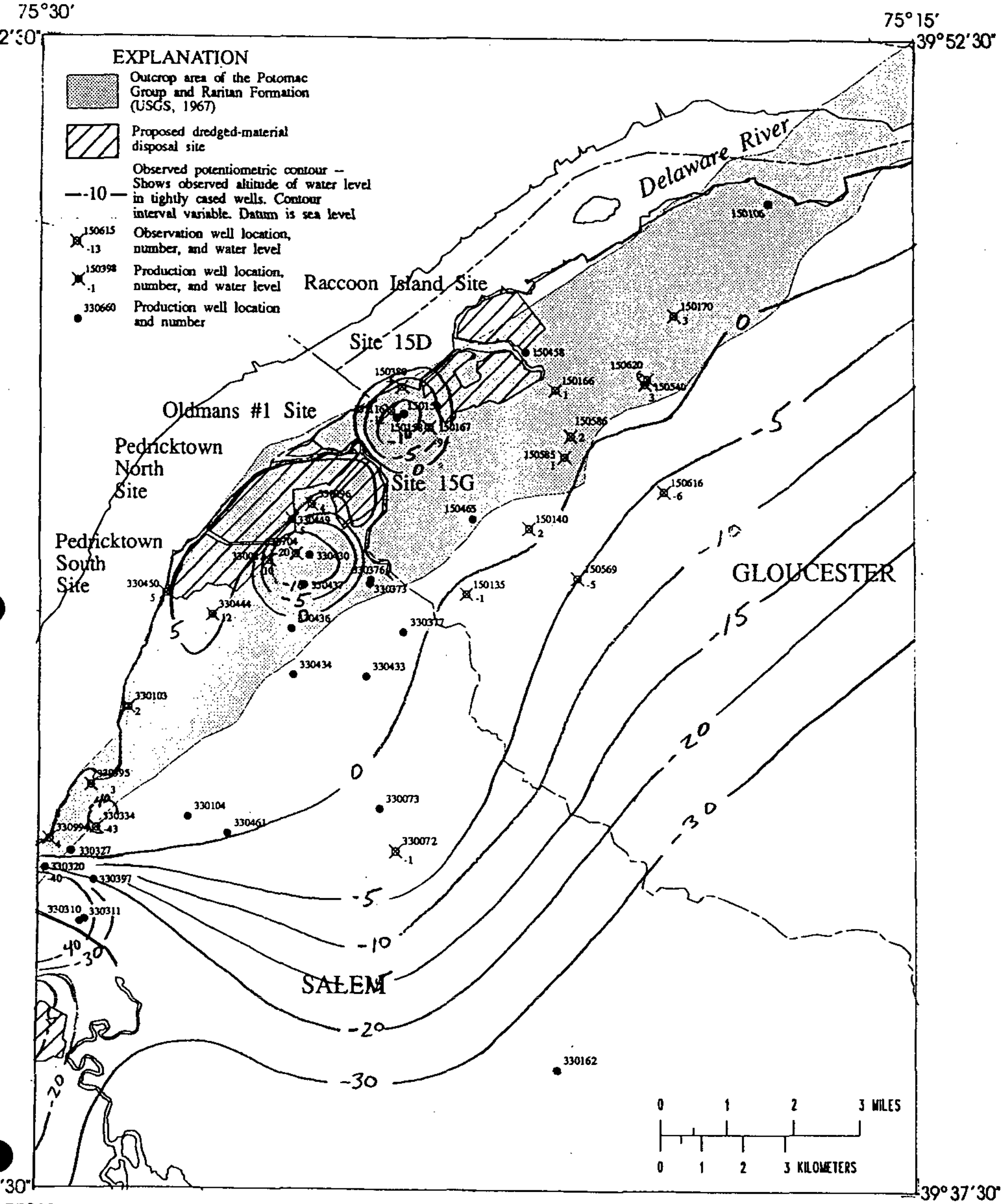


Figure 14.--Potentiometric surface of the Middle Potomac-Raritan-Magothy aquifer in the vicinity of Pedricktown, N.J., March and April 1995.

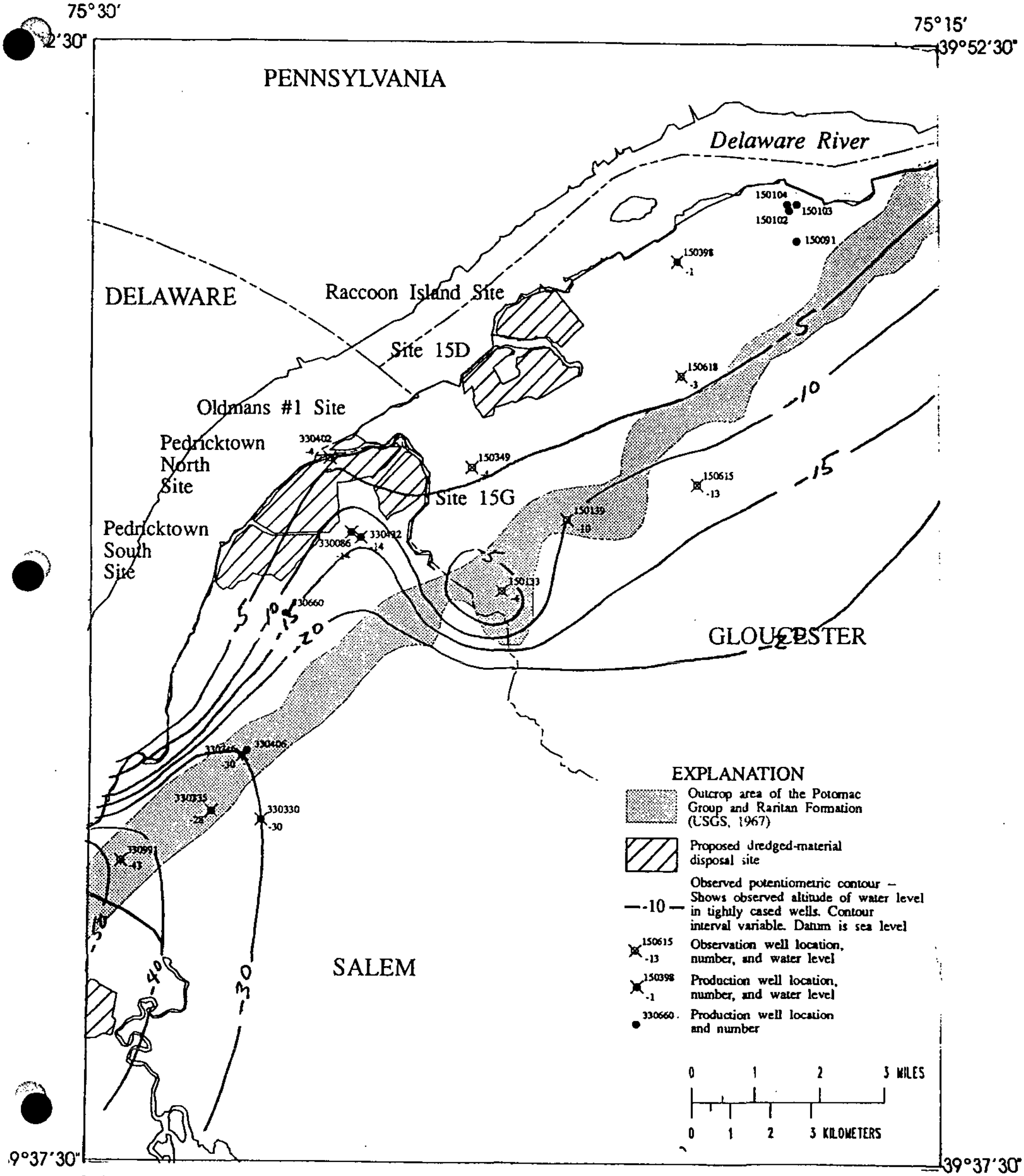


Figure 15.--Potentiometric surface of the Lower Potomac-Raritan-Magothy aquifer in the vicinity of Pedricktown, N.J., March and April 1995.

near the cluster of the Oldmans #1, Pedricktown North, Pedricktown South, and 15G sites. However, as a result of withdrawals on a regional level, water levels in the lower aquifer are lower than in the middle aquifer, especially to the south of the sites. It is possible, therefore, that some recharge from the sites could make its way into the lower aquifer. The water levels in the upper aquifer are generally higher than the middle aquifer, so it would be unlikely that any recharge water from the sites would flow to the upper aquifer.

Evaluation of Penns Neck and Killcohook Sites

The Potomac-Raritan-Magothy aquifer system underlies the Penns Neck and Killcohook sites and is the principle source of water supply for the area. The Penns neck site is situated on top of the confining unit overlying the Upper Potomac-Raritan-Magothy aquifer. This is shown by the existence of the surficial material over the confining units that is above the Upper Potomac-Raritan-Magothy aquifer, indicated in the well log, in table 8, of the nearby Pennsville Township Water Co. well #3A. The Killcohook Site is situated within the outcrop of the Potomac-Raritan-Magothy aquifer system.

Table 8. -- Drillers log of Pennsville Township Water Co. Well # 3A (33-671) (Log of lithology by W.C. Services, Inc. June 21, 1988)

Altitude, ft above mean sea level	Lithology	Hydrogeologic unit
7 to -3	Yellowish & reddish sand	surficial deposits
-3 to -16	Yellow sand and gravel	surficial deposits
-16 to -33	Blue sandy clay	confining unit
-33 to -63	Coarse grey sand	Upper Potomac-Raritan-Magothy aquifer
-63 to -78	Grey clay	confining unit
-78 to -95	Medium to coarse grey sand, large gravel and large stones	Middle Potomac-Raritan-Magothy aquifer
-95 to -97	Grey clay	confining unit
-97 to -99	Reddish clay	confining unit

Potentiometric surface measurements were collected from wells within the Potomac-Raritan-Magothy aquifer system in the vicinity of the Penns Neck and Killcohook sites. The basic water-level data collected are tabulated in table 7 (located, due to its length, at the back of the report). Because of the proximity of the tidal Delaware River to the sites, an adjustment of the water-level data to consistent tidal conditions was done in similar fashion to that discussed earlier. The results of the measurements were compiled into the potentiometric-surface maps of the Upper, Middle, and Lower Potomac-Raritan-Magothy aquifers shown on figures 16 to 18, respectively.

Ground-water flow in the Upper Potomac-Raritan-Magothy aquifer that underlies the Penns

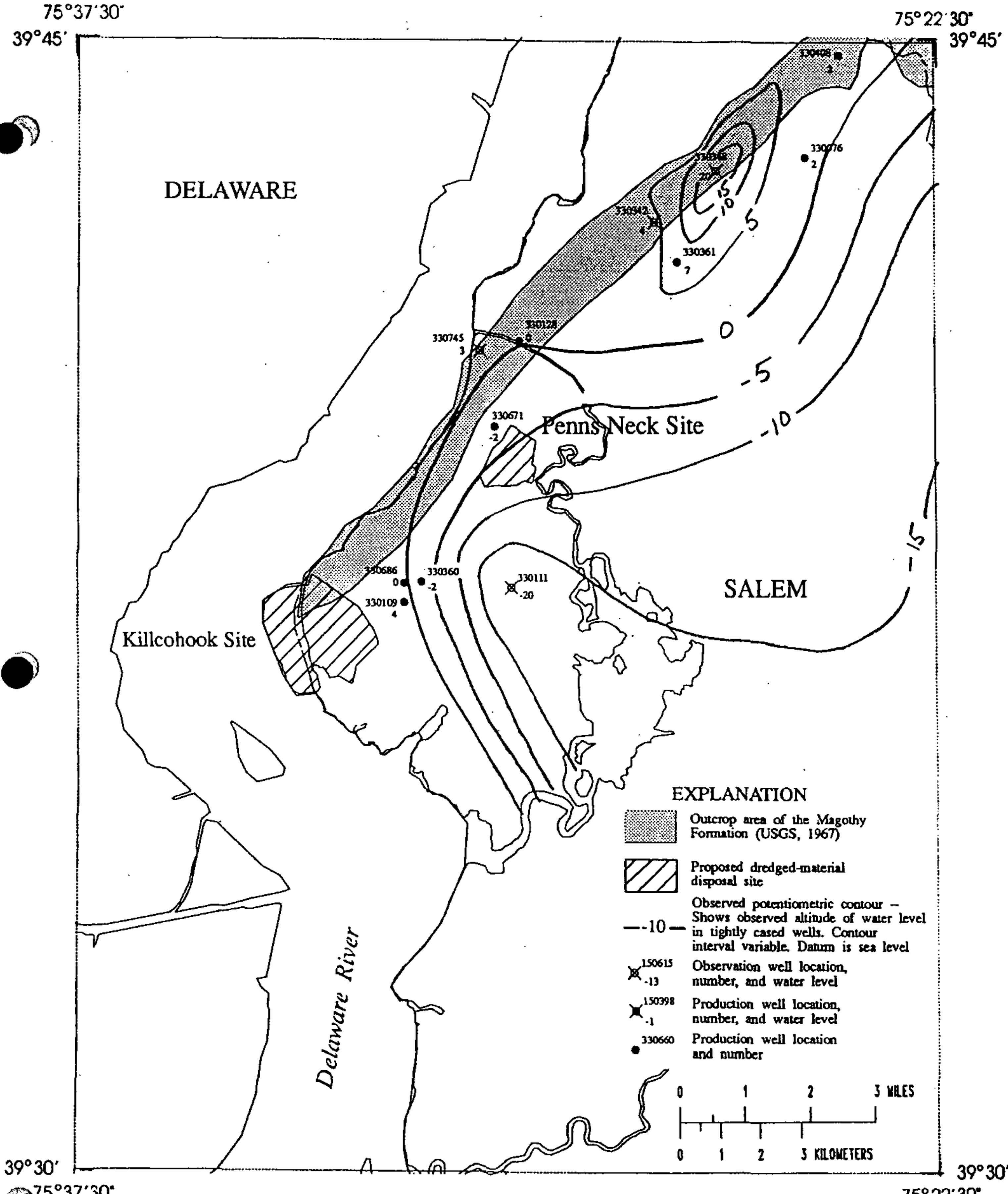


Figure 16.--Potentiometric surface of the Upper Potomac-Raritan-Magothy aquifer in the vicinity of Penns Neck, N.J., March and April 1995

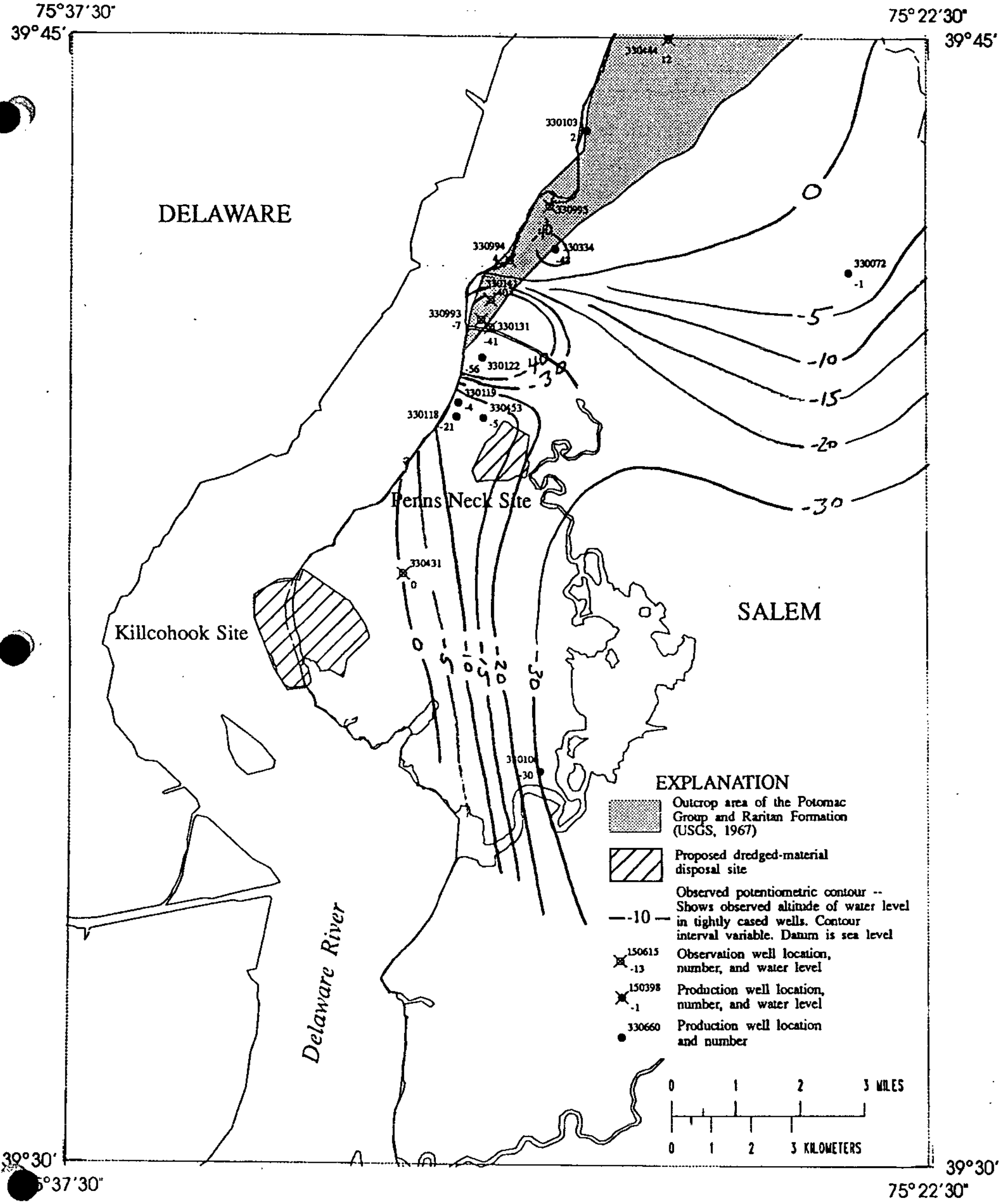


Figure 17.-- Potentiometric surface of the Middle Potomac-Raritan-Magothy aquifer in the vicinity of Penns Neck, N.J., March and April, 1995.

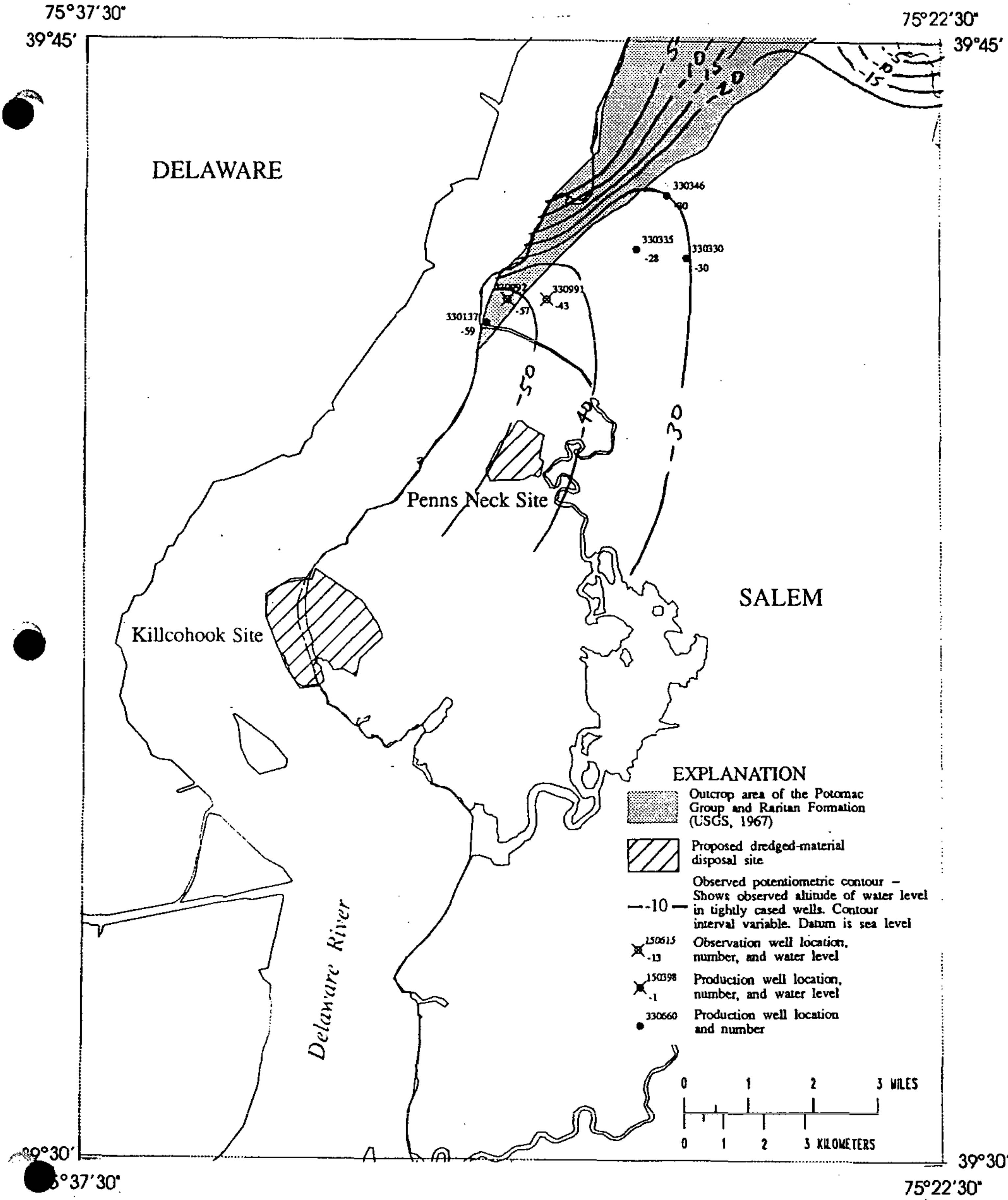


Figure 18.-- Potentiometric surface of the Lower Potomac-Raritan-Magothy aquifer in the vicinity of Penns Neck, N.J., March and April, 1995.

Neck site is generally towards the southeast (fig. 16). Nearby ground-water withdrawals in the Middle Potomac-Raritan-Magothy aquifer, located to the north of the site, have caused a cone of depression and a downward head gradient from the Upper aquifer (fig. 17). Similarly, nearby withdrawals from the Lower Potomac-Raritan-Magothy aquifer located to the north of the site and across the river in Delaware have resulted in a downward head gradient from the Middle aquifer. These downward gradients create the potential for movement of water from the Penns Neck site into the Potomac-Raritan-Magothy aquifer system. The travel time through the confining unit overlying the aquifer system and to any nearby well, however, will probably be more than several decades, as evidenced by the travel times calculated for the National Park site, earlier in this report.

The Killcohook site does not have significant, nearby ground-water withdrawals for public supply, therefore ground-water levels generally remain above sea level (fig. 16). The dominant ground-water flow direction from the disposal area is likely to be towards the Delaware River, because of its position on a point in the river.

Evaluation of Artificial Island Site

The primary source of potable water supply in the vicinity of the Artificial Island site is from the Potomac-Raritan-Magothy aquifer system or the Mount Laurel-Wenonah aquifer. These aquifers occur at depths of 150 feet or more below land surface at the site (Zapecza, 1989, plate 16). Given the thickness of intervening confining units, these aquifers will be isolated from any impact from the surface.

CONCLUSIONS

1.) The National Park and 17G sites are situated within the outcrop of the Potomac-Raritan-Magothy aquifer system. Wells east of the National Park and 17G sites draw recharge from the sites, but at most one-quarter of the water originates from the sites and the mean travel times of ground-water from the sites to the wells are more than 25 years.

2.) The Raccoon Island, 15D, Oldmans #1, Pedricktown North, Pedricktown South, and 15G sites are located within the outcrop of the Potomac-Raritan-Magothy aquifer system. A minimal amount of recharge from the 15D, Oldmans #1, and 15G sites contributes to the withdrawals from the nearby Monsanto wells. The ground-water travel time to these wells could be, on average, 50 years.

3.) Recharge from the Oldmans #1, Pedricktown North, Pedricktown South, and 15G sites to the nearby Goodrich wells is likely. The proximity of the wells to the sites and the steep head gradient indicate that the travel time to the wells could be relatively short, perhaps on the order of several years.

4.) The Penns Neck site is situated above the confining unit overlying the Potomac-Raritan-Magothy aquifer system. Although there is a downward head gradient in the aquifer system, the travel time for the movement of ground water is likely to be more than several decades.

5.) The Killcohook site is located within the outcrop of the Potomac-Raritan-Magothy aquifer system, however, there are no nearby, significant ground-water withdrawals. Ground-water from the site will likely flow to the delaware River.

6.) The ground-water supply withdrawals in the vicinity of the Artificial Island site are from the Potomac-Raritan-Magothy aquifer system or the Mount Laurel-Wenonah aquifer. These aquifers are too deep at the site for any significant impact to occur from the surface.

This evaluation is limited to the determination of likely ground-water flow directions in the vicinity of the disposal sites. Further analysis of the possible geochemistry of the dredged material, and the fate and transport of dissolved dredged-material constituents in the ground-water regime will be necessary to determine the nature of possible effects to the nearby wells.

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Table 4.--Ground-water withdrawals from the Potomac-Raritan-Magothy aquifer system in the vicinity of dredge-spoil disposal sites

[Withdrawal is the greatest daily amount of ground-water withdrawal per year between the years 1988-1993; MRPAU- upper Potomac-Raritan-Magothy aquifer; MRPAM- middle Potomac-Raritan-Magothy aquifer; MRPAL- lower Potomac-Raritan-Magothy aquifer; *- minimal use, backup well]

USGS Well Number	State of New Jersey Permit Number	Owner	Local Identifier	Latitude	Longitude	Township	Aquifer	Screen Interval (ft)	With-drawal (Mgal/y)
150137	30-01371	Pureland Water Co	Pure 2(3-1973)	394535	752054	Logan	MRPAM	158 - 208	116
150144	30-01370	Pureland Water Co	1-1973	394613	752129	Logan	MRPAM	81 - 136	86
150158	30-00873	Monsanto Chemical	Bridgeport W2	394733	752351	Logan	MRPAM	57 - 82	227
150159	30-00872	Monsanto Chemical	Bridgeport E1	394736	752344	Logan	MRPAM	56 - 81	122
150166	30-00410	Penns Grove WSC	Bridgeport 2	394755	752108	Logan	MRPAM	65 - 85	44
150167	30-01170	Monsanto Chemical	1	394726	752319	Logan	MRPAM	64 - 94	146
150569	30-02405	Pureland Water Co	3	394529	752045	Logan	MRPAM	161 - 201	92
150601	30-02123	Monsanto Chemical	35D	394736	752334	Logan	MRPAM	70 - 75	-
330070	30-00229	NJ Turnpike Authrity	1N-2	394141	752343	Oldmans	MRPAM	-	29
330083	30-01139	B F Goodrich Co	9 (PW-1)	394547	752535	Oldmans	MRPAM	93 - 133	134
330085	30-01141	B F Goodrich Co	6 (PW-2)	394556	752530	Oldmans	MRPAM	109 - 129	186
330086	30-01139	B F Goodrich Co	4 (PW-3)	394557	752523	Oldmans	MRPAL	169 - 189	107
330109	30-01322	Ganes Chemical	1973-1	393734	753149	Pennsville	MRPAU	116 - 131	7
330112	30-01033	Pennsville T WD	PTWD 4	393754	753147	Pennsville	MRPAU	117 - 137	74
330118	50-00041	Pennsville T WD	PTWD 1	393958	753045	Pennsville	MRPAM	213 - 238	51
330119	30-00018	Pennsville T WD	PTWD 2	394009	753043	Pennsville	MRPAM	210 - 230	84
330122	30-01234	Atlantic City Electric	Deepwater 3R	394045	753027	Pennsville	MRPAM	154 - 234	20
330125	30-00151	Atlantic City Electric	Deepwater 5	394051	753030	Pennsville	MRPAM	149 - 219	46
330126	30-01080	E I duPont	Ranney 7	394057	752950	Pennsville	MRPAU	52 - 140	.2
330135	30-00987	E I duPont	Ranney 5	394110	752955	Pennsville	MRPAU	47 - 116	175
330137	50-00003	E I duPont	E07-W01F	394112	753028	Pennsville	MRPAL	317 - 347	.5
330316	30-02322	E I duPont	R09-R02C	394121	752921	Carneys Point	MRPAU	-	203
330319	30-01272	E I duPont	Q13-R01CD	394139	752925	Carneys Point	MRPAM	-	.3
330320	--	E I duPont	Layne 3	394140	752953	Carneys Point	MRPAM	-	.2
330321	30-01271	E I duPont	103	394143	752940	Carneys Point	MRPAM	-	228
330322	50-00004	E I duPont	Carney Pt 2	394149	752916	Carneys Point	MRPAM	169 - 219	17
330326	30-00423	E I duPont	Carney Pt 4	394153	752928	Carneys Point	MRPAU	-	.001
330328	30-01109	E I duPont	Carney Pt 1	394157	752918	Carneys Point	MRPAM	175 - 195	21

Table 4.--Ground-water withdrawals from the Potomac-Raritan-Magothy aquifer system in the vicinity of dredge-spoil disposal sites --continued

USGS Well Number	State of New Jersey Permit Number	Owner	Local Identifier	Latitude	Longitude	Township	Aquifer	Screen Interval (ft)	With-drawal (Mgal/y)
330331	30-01099	Penns Grove WSC	Schultes Well	394205	752657	Carneys Point	MRPAM	47 - 62	97
330335	30-01133	E I duPont	Carney Pt 7	394212	752751	Carneys Point	MRPAL	411 - 417	17
330345	50-00102	Penns Grove WSC	PGWSC 2B/RF1A	394241	752711	Carneys Point	MRPAU	45 - 58	72
330346	30-00563	Penns Grove WSC	Ranney 7	394256	752718	Carneys Point	MRPAL	317 - 357	243
330360	28-10466	Pennsville T WD	PTWD 5	393750	753131	Pennsville	MRPAU	101 - 117	117
330361	30-01815	Penns Grove WSC	Layton 4	394205	752700	Carneys Point	MRPAU	44 - 54	77
330364	34-01031	Public Service E-G	PW 5	392743	753158	Lower Alloways Cr	MRPAM	765 - 840	143
330385	--	Public Service E-G	3-74	392754	753215	Lower Alloways Cr	MRPAM	--	13
330452	34-01074	Public Service E-G	Hope Creek	392751	753207	Lower Alloways Cr	MRPAM	746 - 817	61
330453	30-03013	Pennsville T WD	PTWD 6	393957	753017	Pennsville	MRPAM	99 - 114	73
330460	30-03310	Penns Grove WSC	PGWSC 1A/RF2A	394247	752714	Carneys Point	MRPAU	41 - 61	82
330671	30-05148	Pennsville T WD	PTWD 3A	393954	753013	Pennsville	MRPAU	87 - 102	10
330997	30-06023	B F Goodrich Co	10	394547	752535	Oldmans	MRPAM	76 - 105	*

Table 7.-- Water levels measured in wells in the vicinity of the Raccoon Island, 15D, Oldmans #1, Pedricktown North, Pedricktown South, 15G sites, Penns Neck, and Killcohook Sites

[Water altitude adusted to estimated mid-tide level, as necessary; * - water-level data reported by owner, -- - information not available, unknown, or not applicable]

USGS Well Number	State of New Jersey Permit Number	Owner	Local Identifier	Latitude	Longitude	Land Surface Altitude (ft)	Screened Interval (ft)	Date / Time Measured	Water Altitude (ft)	Tide-adjusted Water Altitude (ft)
Upper aquifer of the Potomac-Raritan-Magathy aquifer system.										
150240	30-00973	Del Monte Corp	9	394510	751838	32	190 - 231	3/28/95 1625	-19	--
150617		USGS	Shiveler upper	394637	751916	31	60 - 70	3/23/95 1338	-6	--
150707	50-00077	USGS	Gaventa W TAB	394800	751936	7	6 - 7	3/23/95 1154	4	--
330076	30-00661	Gaehring	Gaehring 1	394328	752446	27	118 - 123	4/17/95 1247	2	--
330109	30-01322	Ganes Chemical	1973-1	393734	753149	5	116 - 131	4/17/95 1451	4	--
330111	30-01253	Pennsville T WD	Hook RD OBS	393746	752955	10	190 - 235	4/04/95 1140	-20	--
330128		E I duPont	N04-M1D	394102	752946	12	108 - 113	4/05/95 1342	0	--
330342		State of NJ	Penns Grove 24	394236	752724	18	46 - 51	4/04/95 1536	4	--
330348		State of NJ	Penns Grove 14 OBS	394317	752619	25	-	4/07/95 1000	20	--
330360	28-10466	Pennsville T WD	PTWD 5	393750	753131	10	101 - 117	4/04/95 1100	-2	--
330361	30-01815	Penns Grove WSC	Layton 4	394205	752700	13	44 - 54	4/06/95 1245	7	--
330408	30-00815	Pedricktown Swim	Swim 1	394450	752410	15	26 - 36	4/11/95 1132	2	--
*330671	30-05148	Pennsville T WD	PTWD 3A	393954	753013	7	87 - 102	3/22/95 --	-2	--
330686	30-08335	Pennsville TWP	PTWD 4A RPL	393749	753149	10	110 - 130	4/04/95 1045	0	--
330745	30-04948-2	Atlantic City Elec Co	Deepwater MW3	394054	753028	9	3 - 18	4/06/95 1750	3	--
Middle aquifer and Undifferentiated part of the Potomac-Raritan-Magathy aquifer system.										
150135	30-01314	Shell Oil Co	Obs Well 8A	394516	752241	7	130 - 180	3/28/95 1455	-1	--
150140	30-01248	Pureland Water Co	Test Well 4	394608	752135	6	132 - 184	3/28/95 1415	2	--

Table 7.-- Water levels measured in wells in the vicinity of the Raccoon Island, 15D, Oldmans #1, Pedricktown North, Pedricktown South, 15G sites, Penns Neck, and Killcohook Sites -- continued

USGS Well Number	State of New Jersey Permit Number	Owner	Local Identifier	Latitude	Longitude	Land Surface Altitude (ft)	Screened Interval (ft)	Date / Time Measured		Water Altitude (ft)	Tide-adjusted Water Altitude (ft)
150166	30-00410	Penns Grove WSC	Bridgeport 2	394755	752108	5	65 - 85	4/06/95	1045	1	--
150167	30-01170	Monsanto Chem	Monsanto 1	394726	752319	10	64 - 94	3/27/95	1541	-9	--
150170	30-01220	Vine Concrete Co	Repaupo 1	394854	751906	11	85 - 106	3/23/95	1013	3	--
150380		Monsanto Chem	Obs 2	394757	752346	18	71 - 76	3/27/95	1444	-7	-6
150540	30-02621	US EPA	EPA 108	394800	751936	7	87 - 97	3/23/95	1149	3	--
150569	30-02405	Pureland Water Co	PWC 3	394529	752045	32	161 - 201	3/28/95	1035	-5	--
150585	30-02522	Rollins Env Services	DP5	394704	752058	8	79 - 89	3/27/95	1021	1	--
150586	30-02539	Rollins Env Services	DP4	394720	752052	12	95 - 125	3/27/95	1013	2	--
150616		USGS	Shiveler middle	394637	751916	31	230 - 240	3/23/95	1333	-6	--
150620	30-03677	USGS	Gaventa middle 1	394804	751933	7	131 - 141	3/23/95	1117	6	--
151116		Monsanto Chem	MW-1D	394738	752357	13	4 - 14	3/27/95	1504	-12	-12
330072	30-00206	NJ Turnpike Auth	1S-1	394154	752351	35	342 - 368	4/03/95	1100	-1	--
330082	30-00660	Bridge, Bruce H	Bridge	394542	752603	6	-	3/23/95	1320	-10	--
330083	30-01139	B F Goodrich CO	10	394547	752535	10	93 - 133	3/27/95	1321	-20	--
330103	30-00467	Penns Grove S A	1	394346	752828	8	50 - 60	3/27/95	1151	2	2
330106		Linski Alex	1	393514	752917	5	359 - 365	4/11/95	1406	-30	--
*330118	50-00041	Pennsville T WD	PTWD 1	393958	753045	8	213 - 238	2/21/95	--	-22	-21
330119	30-00018	Pennsville T WD	PTWD 2	394009	753043	7	210 - 230	4/04/95	1355	-4	-4
330122	30-01234	Atlantic City Elec Co	Deepwater 3R	394045	753018	10	165 - 235	4/06/95	1810	-56	-56
330131	30-01054	E I duPont	H05-M01E	394109	753009	8	237 - 247	4/05/95	1225	-42	-40
330132	30-01055	E I duPont	H05-M02E	394109	753009	9	192 - 200	4/05/95	1226	-43	-41
330141	30-01052	E I duPont	H11-M01E	394131	753009	9	197 - 207	4/05/95	1237	-42	-40
330334	30-00621	E I duPont	Carney Pt 6	394211	752901	5	157 - 182	4/05/95	1311	-43	--

Table 7.-- Water levels measured in wells in the vicinity of the Raccoon Island, 15D, Oldmans #1, Pedricktown North, Pedricktown South, 15G sites, Penns Neck, and Killcohook Sites -- continued

USGS Well Number	State of New Jersey Permit Number	Owner	Local Identifier	Latitude	Longitude	Land Surface Altitude (ft)	Screened Interval (ft)	Date / Time Measured		Water Altitude (ft)	Tide-adjusted Water Altitude (ft)
330431	30-01659	Pennsville T WD	TW 1	393753	753140	10	102 - 117	4/11/95	1330	0	--
330444		Corps of Engineers	DGB 100	394459	752702	23	83 - 88	4/11/95	0907	12	--
330449	30-02228	Corps of Engineers	EHW-5	394614	752539	10	32 - 37	4/11/95	0958	5	--
330450	30-02238	Corps of Engineers	EHW-6	394516	752750	10	28 - 33	4/11/95	0907	5	5
330453	30-03013	Pennsville T WD	PTWD 6	393957	753017	10	99 - 114	4/04/95	1205	-5	--
330704	30-06023	Geon Co	10	394547	752535	10	76 - 105	3/27/95	1321	-20	--
330993	30-03545-7	E I duPont	F07-M01D	394115	753019	10	88 - 93	4/11/95	1233	-9	-7
330994	30-05614-4	E I duPont	L19-M0ID1	394202	752949	12	121 - 126	4/05/95	1258	2	4
330995	30-05495-8	E I duPont	T29-M01C	394245	752907	6	71 - 76	4/05/95	1330	1	3
330996	30-08967	Corps of Engineers	EHW-8	394626	752519	20	-51	4/11/95	1010	4	--
Lower aquifer of the Potomac-Raritan-Magathy aquifer system.											
150133	30-01222	Pureland Water Co	Test Well 1	394510	752244	20	317 - 367	3/28/95	1510	-4	--
150139	30-01223	Pureland Water Co	Test Well 3	394608	752135	7	301 - 345	3/28/95	1355	-10	--
150349		Pureland Water Co	Landtect 2	394650	752316	6	170 - 220	3/28/95	1235	-4	--
150398	30-02016	Pettit, Louis	419	394935	751938	1	50 - 60	3/23/95	0918	-1	--
150615		USGS	Shiveler lower	394637	751916	29	378 - 388	3/23/95	1342	-13	--
150618		USGS	Gaventa deep	394804	751933	7	230 - 240	3/23/95	1105	-3	--
330086	30-01139	B F Goodrich Co	4 (PW-3)	394557	752523	13	169 - 189	3/27/95	1344	-14	--
330137	50-00003	E I duPont	E07-W01F	394112	753028	10	317 - 347	4/05/95	1230	-62	-59
330330	50-00098	Penns Grove WSC	Layton 11	394205	752657	16	--	4/06/95	1230	-30	--
330335	30-01133	E I duPont	Carney PT 7	394212	752751	15	411 - 417	4/05/95	1351	-28	--
330346	30-00563	Penns Grove WSC	Ranney 7	394256	752718	19	317 - 357	4/05/95	1145	-30	--

Table 7.-- Water levels measured in wells in the vicinity of the Raccoon Island, 15D, Oldmans #1, Pedricktown North, Pedricktown South, 15G sites, Penns Neck, and Killcohook Sites -- continued

USGS Well Number	State of New Jersey Permit Number	Owner	Local Identifier	Latitude	Longitude	Land Surface Altitude (ft)	Screened Interval (ft)	Date / Time Measured		Water Altitude (ft)	Tide-adjusted Water Altitude (ft)
330402		Corps of Engineers	EHW-1 TEST	394657	752546	6	109 - 114	4/11/95	1025	-4	-4
330432	30-01141	B F Goodrich CO	3	394553	752513	10	180 - 195	3/27/95	--	-14	--
330991	30-01913-3	E I duPont	P11-M0IF	394131	752926	15	429 - 434	4/05/95	1250	-43	--
330992	30-01049-7	E I duPont	H11-W01F	394131	753007	11	307 - 455	4/05/95	1240	-59	-57

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1996

U.S. DEPARTMENT OF THE INTERIOR

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TABLES

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

Multiply	By	To obtain
foot (ft)	0.3048	meter
foot squared per day (ft^2/d)	0.0929	meter squared per day
mile (mi)	1.609	kilometer
square mile (mi^2)	0.00405	square kilometer
million gallons per day (Mgal/d)	3785.	cubic meters per day
million gallons per year (Mgal/y)	3785.	cubic meters per year

Abbreviated water-quality unit: mg/L (milligram per liter)

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 both the United States and Canada, formerly called Sea Level Datum of 1929.

HYDROGEOLOGIC CONDITIONS ADJACENT TO THE DELAWARE RIVER, GLOUCESTER, SALEM, AND CUMBERLAND COUNTIES, NEW JERSEY

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ABSTRACT

Interest in deepening the shipping channel of the Delaware River from Philadelphia, Pennsylvania, downstream through Delaware Bay to the Atlantic Ocean has raised concerns about the possibility of saltwater intrusion in New Jersey Coastal Plain aquifers adjacent to the Delaware River and Delaware Bay. This report presents a review of relevant previous investigations and hydrogeologic data. The data, based on the work of the previous investigations, include hydrogeologic framework information, transmissivity maps, potentiometric-surface maps, water-use information, and concentrations of dissolved chloride in ground water, which can serve as a baseline for further analysis.

INTRODUCTION

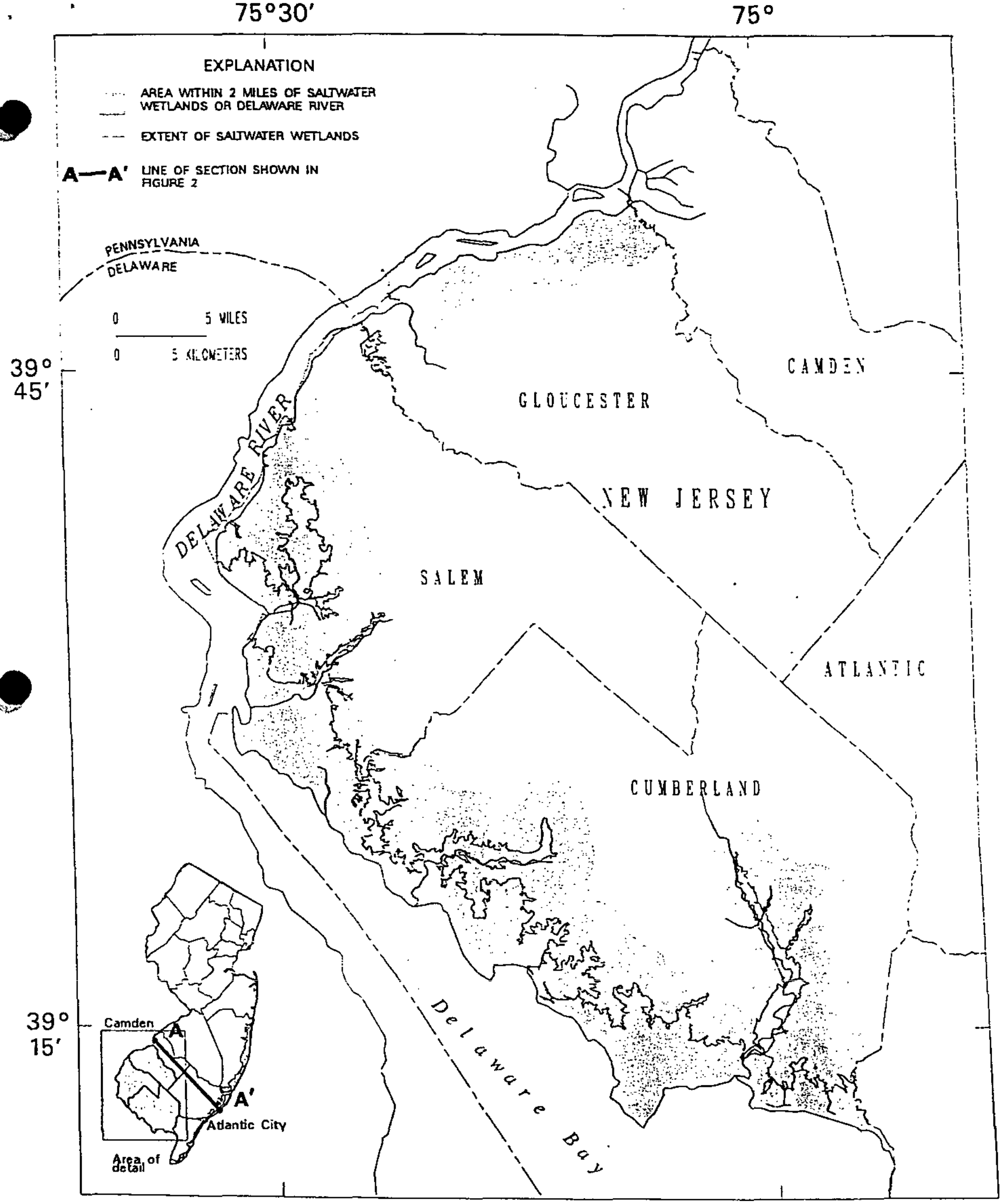
The U.S. Army Corps of Engineers is examining the feasibility of deepening the shipping channel of the Delaware River from Philadelphia, Pa., downstream through Delaware Bay, to the Atlantic Ocean. The proposed project would deepen the channel by 5 ft, from the existing depth of about 40 ft below mean low water (MLW) to about 45 ft below MLW from deep water in Delaware Bay to Philadelphia, Pa. and Camden, N.J. The consequences of deepening the channel could affect the nearby ground-water flow system by allowing saltwater to encroach upriver, which in turn could allow the saltwater to intrude freshwater aquifers used for potable water supply. The potential for saltwater intrusion of this kind, however, is limited. Under natural conditions, a ground-water flow system typically discharges water to rivers and bays; if the flow system is reversed by pumping, saltwater may infiltrate from a river or bay into the ground-water system. Therefore, the primary concern in this instance is whether saltwater will intrude the aquifers of the New Jersey Coastal Plain where ground water is withdrawn are made near the Delaware River and Delaware Bay.

The purpose of this report is to provide hydrogeologic data about the ground-water system adjacent to the Delaware River and Delaware Bay in New Jersey to serve as a baseline for further analysis and to enable the identification of areas that may have some sensitivity to the effects of the channel deepening.

The data tables and maps contained within this report use a well-numbering system consisting of a two-digit county code followed by a four-digit sequence number. The county codes are as follows: Cumberland, 11; Gloucester, 15; and Salem, 33.

Description of Study Area

The proposed channel-deepening project involves the reach of the Delaware River and Delaware Bay from Philadelphia to the Atlantic Ocean. This study focuses on the reach in proximity to Gloucester, Salem, and Cumberland, Counties in New Jersey, as shown in figure 1. The



Base from U.S. Geological Survey digital data, 1:2,000,000, 1993
Universal Transverse Mercator projection, zone 18

Figure 1. Location of the study area.

study area extends from the river or bay shore to a point about 2 miles upstream from the boundary between the freshwater and saltwater wetlands in order to focus on the area of possible saltwater intrusion. This boundary between freshwater and saltwater wetlands, indicated on figure 1, is based on National Wetland Inventory maps (Smith, 1991). Areas further downstream of Cumberland County were not included in the study area because Delaware Bay salinity is near that of seawater (Sharp, 1988, p. 46); therefore the effects of channel deepening on the ground-water system in those areas are likely to be insignificant.

Regional Hydrogeologic Setting

The New Jersey Coastal Plain is a seaward-dipping wedge of unconsolidated sediments that range in age from Cretaceous to Quaternary. These sediments consist mainly of clay, silt, sand, and gravel. Units that are mostly sand and gravel are more permeable and are considered aquifers. Those that are mostly silt or clay are relatively impermeable and are considered confining units. The units that make up the New Jersey Coastal Plain are shown in diagrammatic section in figure 2 and tabulated in table 1, along with their geologic and hydrogeologic names. Hydrostratigraphic nomenclature differs somewhat on either side of the Delaware River. In order to minimize the possibility of confusion, table 2 shows the relation between aquifers in New Jersey and those in Delaware.

Of the New Jersey Coastal Plain aquifers (table 1), only the Kirkwood-Cohansey aquifer system, the Wenonah-Mount Laurel aquifer, and the Potomac-Raritan-Magothy aquifer system are in hydraulic contact with the Delaware River or Bay and are significant source of water supply. The Piney Point aquifer, used for water supply in Delaware and several locations in New Jersey, underlies the Bay in the subsurface, but is not in direct hydraulic contact. These aquifers potentially could be affected by channel deepening.

The Kirkwood-Cohansey aquifer system is primarily an unconfined (water-table) aquifer that underlies much of southern New Jersey. This aquifer system includes part of the Kirkwood Formation, the Cohansey Sand, and the overlying, hydraulically connected sediments of the Beacon Hill Gravel, the Bridgeton Formation, and the Cape May Formation. The aquifer system is primarily sand with interbedded clay. The Cohansey Sand is coarser than the underlying Kirkwood Formation. Outside the study area, in Atlantic County, the sands in the lower part of the Kirkwood Formation become confined as the sedimentary sequence thickens to the southeast. These units, the Rio Grande water-bearing zone and the Atlantic City 800-foot sand aquifer, are not of significance to this study.

The Piney Point aquifer is composed of sand and shell beds. The aquifer does not crop out, but terminates in the subsurface; thus, it does not receive recharge directly from the land surface. Ground water does flow, however, between the Piney Point aquifer and overlying or underlying aquifers.

The Wenonah-Mount Laurel aquifer consists of the coarser grained part of the Wenonah Formation and the Mount Laurel Sand, both of late Cretaceous age (table 1 and Zapecza, 1989). The Wenonah-Mount Laurel aquifer extends beneath much of the Coastal Plain of New Jersey in the subsurface and crops out in a narrow band 1 to 3 miles wide that occurs within the study area in Salem and Gloucester Counties.

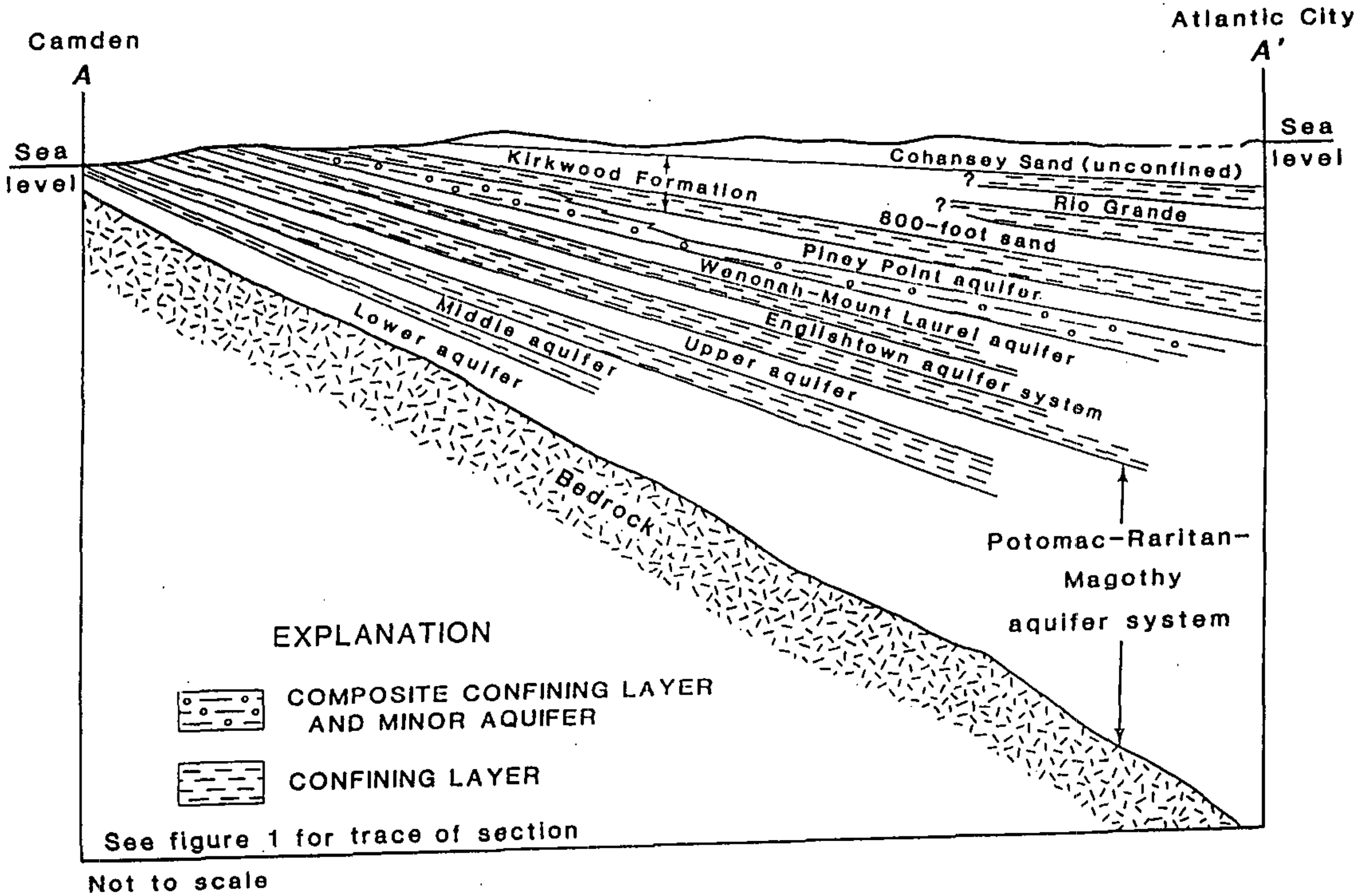


Figure 2. Diagrammatic hydrogeologic section of the New Jersey Coastal Plain (From Eckel and Walker, 1986, fig. 2).

Table 1. Geologic and hydrogeologic units in the Coastal Plain of New Jersey
[Modified from Zapecza, 1989, table 2]

SYSTEM	SERIES	GEOLOGIC UNIT	LITHOLOGY	HYDROGEOLOGIC UNIT	HYDROLOGIC CHARACTERISTICS
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	Pennsauken 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	Sand, quartz and glauconite, fine- to coarse-grained.	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.		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.	Vincentown aquifer	Yields small to moderate quantities of water in and near its outcrop area.
		Hornerstown Sand	Sand, clayey, glauconitic, dark-green, fine- to coarse-grained.		Poorly permeable sediments.
Cretaceous	Upper Cretaceous	Tinton Sand	Sand, quartz, glauconitic, brown and gray, fine- to coarse-grained, clayey, micaceous.		
		Red Bank Sand		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.		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 Formation	Clay, silty, dark greenish-gray; contains glauconitic quartz sand.	Marshalltown-Wenonah confining unit	A leaky confining unit.
		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, and 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 are present.		
		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, poorly arkosic; contains red, white, and variegated clay. Includes Farrington Sand Member.	Confining unit	
				Middle aquifer	
				Confining unit	
	Lower Cretaceous	Potomac Group	Alternating clay, silt, sand, and gravel.	Lower aquifer	
Pre-Cretaceous		Bedrock	Precambrian and lower Paleozoic crystalline rocks, 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.

Table 2. Generalized hydrostratigraphic correlation between Delaware and New Jersey
[Modified from Vroblesky and Fleck, 1991, pl. 1; Zapecza, 1989, table 2; and Martin, 1984, p. 5]

DELAWARE	NEW JERSEY
Columbia aquifer	Holly Beach aquifer
Chesapeake aquifer	Kirkwood-Cohansey aquifer system
	Rio Grande water-bearing zone
	Atlantic City 800-foot sand aquifer
Piney Point aquifer	Piney Point aquifer
Rancocas aquifer	Vincentown aquifer
Englishtown-Mount Laurel aquifer system	Wenonah-Mount Laurel aquifer
	Englishtown aquifer system
Magothy aquifer	Upper Potomac-Raritan-Magothy aquifer
upper Potomac aquifer	Middle Potomac-Raritan-Magothy aquifer
middle Potomac aquifer	
lower Potomac aquifer	Lower Potomac-Raritan-Magothy aquifer
Basement rocks	Basement rocks

The Englishtown aquifer system, an important water-supply source in the central and northeastern parts of the New Jersey Coastal Plain, becomes clayey and silty in the vicinity of Gloucester County and southward to Delaware Bay, and therefore is not of significance to this study.

The Potomac-Raritan-Magothy aquifer system contains upper, middle, and lower aquifers separated by intervening confining units. It is bounded above by the Merchantville-Woodbury confining unit and below by the bedrock surface. The Upper aquifer generally corresponds to the sands of the Magothy Formation, and the Middle and Lower aquifers generally correspond to the sand deposits within the undifferentiated Raritan Formation and Potomac Group, respectively (table 1). Further discussion of these aquifers and the other hydrogeologic units of the New Jersey Coastal Plain is given in Zapecza (1989).

Concepts of Saltwater Intrusion

Saltwater intrusion is a concern when ground water is withdrawn from an aquifer that is hydraulically connected with a salty surface-water body, such as Delaware Bay. A water-level gradient may occur that can induce saltwater to flow toward a well (Freeze and Cherry, 1979, p. 375). The water level in a well can be drawn down to an altitude below sea level by pumping. Seawater enters the aquifer at the point of connection and flows downgradient ("downhill") through the aquifer toward the well. Eventually, the saltwater may arrive at the well, possibly rendering the ground water unpotable. This situation is depicted in figure 3. The length of time necessary for saltwater to move from its source to a nearby well depends on the distance, the rate of pumping, and the hydraulic properties of the aquifers, and may total years, decades, or centuries as a result of the generally slow velocity of ground water. Whether or not the water in the well eventually becomes unpotable depends on the proportion of saltwater in the well's total contributing flow. Intrusion can occur in two ways, lateral intrusion and upconing. These two aspects are shown in figure 3. The horizontal movement of saltwater through an aquifer is called lateral intrusion. The vertical movement of saltwater, perhaps through a confining unit, is called upconing. This process typically occurs directly beneath pumping wells.

Another possible avenue for saltwater intrusion in New Jersey's Coastal Plain aquifers is the movement of pre-existing saltwater. Saltwater is present in the subsurface in certain areas (Meisler, 1980; Meisler and others, 1984) as a result of the operation of natural processes over geologic time. This subsurface saltwater also can be affected and moved by water-supply withdrawals, resulting in the same pathways depicted in figure 3. Given the proper circumstances, saltwater could intrude into New Jersey's Coastal Plain aquifers from salty surface-water bodies or from naturally occurring subsurface saltwater. Further study would be required at any locale to

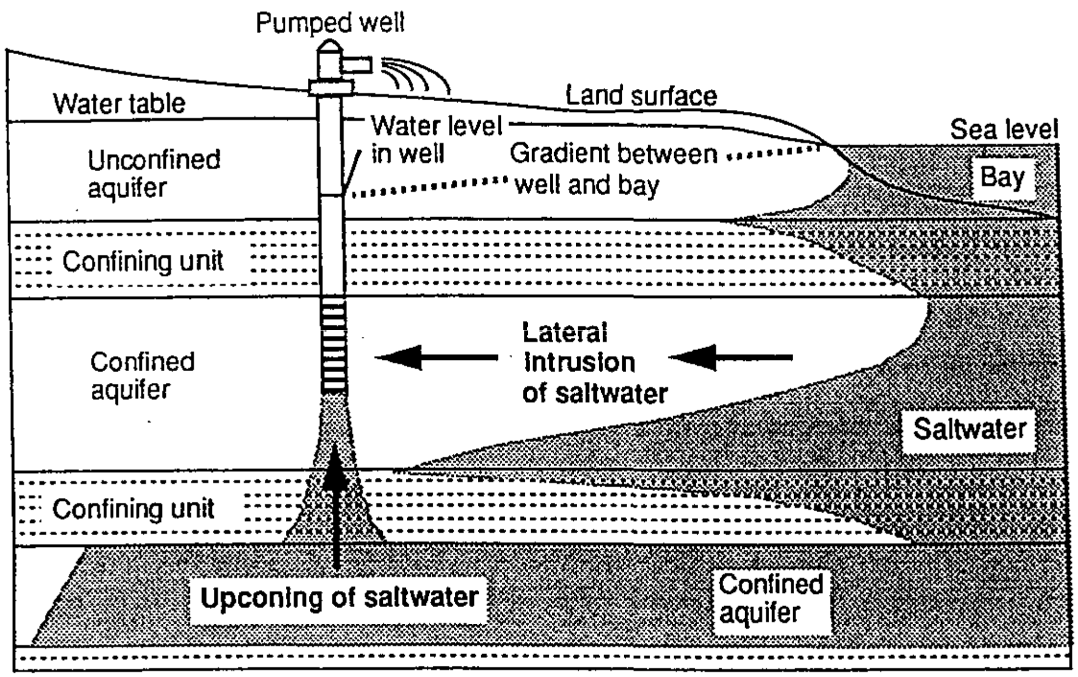


Figure 3. Two aspects of saltwater intrusion (Modified from Heath, 1987, p. 68).

determine the source of observed saltwater in an aquifer and the process(es) responsible for its movement.

Previous Investigations

The relevant previous hydrogeologic investigations of the study area can be organized into three general categories: investigations pertaining to general hydrogeology and ground-water resources, and investigations of ground-water quality, and quantitative investigations of ground-water flow. These investigations are summarized below.

General Hydrogeology and Ground-Water Resources

Barksdale and others (1958) summarized the available ground-water resources of the lower Delaware Valley. They observed the deepening cones of depression in the Potomac-Raritan-Magothy aquifer system in the Camden metropolitan area. Greenman and others (1961) focused on the Coastal Plain deposits in southeastern Pennsylvania. They amassed a significant collection of well logs and developed fence diagrams and stratigraphic correlations across the area. They attempted to relate the hydrostratigraphy in the Philadelphia area to that devised by other workers in the Raritan Bay area of the northern New Jersey Coastal Plain. Their usage of Potomac-Raritan-Magothy aquifer system subdivisional nomenclature from the northeastern New Jersey Coastal Plain has not persisted in the Philadelphia and Camden areas. Hardt and Hilton (1969), Rosenau and others (1969), and Rooney (1971) conducted ground-water investigations in Gloucester, Salem, and Cumberland Counties, respectively. These works represent a significant source of quantitative data on the Coastal Plain aquifers, including hydrostratigraphic, water-level, water-use, and water-quality data. Hardt (1963) summarized information pertaining to existing public water supplies in Gloucester County.

Several studies have focused on specific townships. Barton and Kozinski (1991) investigated the hydrogeology of Greenwich Township, Gloucester County, which is adjacent to the Delaware River. Their report is a source of potentiometric-surface maps of the Potomac-Raritan-Magothy aquifer system and many well logs. Lewis and others (1991) investigated the hydrogeology and ground-water quality of Logan Township, Gloucester County, and adjacent areas in Salem County, which also border on the Delaware River.

Duran (1986) used surface geophysical methods to determine the type and distribution of bottom sediments in the ship channel of the Delaware River between Northeast Philadelphia, Pa. and Wilmington, De. Walker (1983), and Eckel and Walker (1986) compiled water-level of the major aquifers of the New Jersey Coastal Plain, measurements in 1978 and 1983, respectively, and prepared regional potentiometric-surface maps.

Ground-Water Quality

Seaber (1963) compiled 8,957 determinations of dissolved-chloride concentrations in water samples collected during 1923-61 from 884 wells in the New Jersey Coastal Plain, including 78 wells in Gloucester County, 74 wells in Salem County, and 3 wells in Cumberland County. Schaefer (1983) compiled dissolved chloride measurements for selected wells in the New Jersey Coastal Plain sampled during 1977-81. Within the study area, 21 wells were sampled in Gloucester County, 24 wells were sampled in Salem County, and 5 wells were sampled in Cumberland

County. The report identifies several high chloride concentrations measured in the Piney Point aquifer at Gandys Beach in Cumberland County, and indicates that the source of the chloride is either existing dissolved chloride in the aquifer, leakage of high-chloride water from Delaware Bay through the overlying Kirkwood Formation, or the result of a break in the casing of one of the wells (Schaefer, 1983, p. 40). Fusillo and Voronin (1981), and Fusillo and others (1984) compiled existing water-quality data for the Potomac-Raritan-Magothy aquifer system between Trenton and Pennsville, and included information on organic as well as inorganic constituents. Knobel (1985) presents a compilation of ground-water-quality data for the Atlantic Coastal Plain, including the States of New Jersey, Delaware, Maryland, Virginia, and North Carolina. This source provides a broad perspective on the range in water-quality constituents.

Hull and Titus (1986) compiled a study of the possible effects of sea-level rise on the Delaware Estuary. One part of that study, authored by Lennon and others (1986), reviewed the effects of saltwater encroachment in the Delaware River during the drought of the mid-1960's and the subsequent intrusion of saltwater into the Potomac-Raritan-Magothy aquifer system in the Camden area. Although water-supply wells were not rendered unpotable by this episode, the occurrence does validate the concerns about saltwater intrusion.

Ground-Water Flow

Luzier (1980) and Harbaugh and others (1980) used a single-layer ground-water flow model of the Potomac-Raritan-Magothy aquifer system across the New Jersey Coastal Plain to examine flow paths and management strategies. Their analysis was limited by coarse horizontal discretization and the two-dimensional perspective of flow; however, they attempted to quantify the flow between the Potomac-Raritan-Magothy aquifer system and Delaware River, and to test several barrier-well strategies to reduce the updip movement of deep saline water within the Potomac-Raritan-Magothy aquifer system. Sloto (1988) developed a ground-water flow model of the Lower Potomac-Raritan-Magothy aquifer in Philadelphia and nearby New Jersey to test various management strategies. Zapecza and others (1987), Zapecza (1989), and Martin (*in press*), as part of the USGS Regional Aquifer System Analysis (RASA) of the North Atlantic Coastal Plain project, undertook a detailed definition of the hydrostratigraphy of the New Jersey Coastal Plain and an assessment of ground-water flow using a 11-layer flow model. These investigations represent benchmark studies of the hydrogeology of the New Jersey Coastal Plain. They provide a regional perspective that will facilitate further study at a finer resolution. Navoy and Carleton (1995) simulated the flow of ground water between the Potomac-Raritan-Magothy aquifer system and the Delaware River in the Camden, New Jersey, area, including Gloucester County. They found that the cones of depression in the aquifer system are inducing a flow of about 29 Mgal/d into the aquifer system from the river and that the potential exists for saltwater intrusion into the aquifer system during drought or conditions of future sea-level rise.

HYDROGEOLOGIC CONDITIONS

The hydrogeologic conditions that control the movement of ground water, including that of intruding saltwater, are the physical framework of the aquifers and confining units, commonly termed the hydrogeologic framework; the transmissivity of the aquifers; the water-level configuration within and between aquifers that is used to determine the potentiometric gradient; the rate of ground-water withdrawals; and the chloride concentration in the ground water. The available information about these conditions in the study area is presented below.

Hydrogeologic Framework and Transmissivity

The physical framework of hydrogeologic units is commonly described by using two types of contour maps: a map showing the altitude of the top or bottom of the unit and a map showing the thickness of the unit. These types of maps are presented for the Kirkwood-Cohansey aquifer system, the Piney Point aquifer, the Wenonah-Mount Laurel aquifer, and the Potomac-Raritan-Magothy aquifer system in the study area. These maps were derived from the maps of the entire New Jersey Coastal Plain produced by Zapecza (1989). The maps of the transmissivity of the aquifers were derived from the modeling study of the New Jersey Coastal Plain aquifers by Martin (*in press*).

Kirkwood-Cohansey Aquifer System

The Kirkwood-Cohansey aquifer system is generally the unconfined (water-table) aquifer where it exists in the study area. It is in direct contact with the Delaware River and associated tidal tributaries in Salem and Cumberland Counties. The altitude of the base of the Kirkwood-Cohansey aquifer system is shown in figure 4. Because it crops out at land surface, the aquifer's thickness can be determined by calculating the difference between the elevation of the land surface and the altitude of the base of the aquifer (fig. 4). The transmissivity of the Kirkwood-Cohansey aquifer system is shown in figure 5.

Piney Point Aquifer

The Piney Point aquifer is confined throughout the study area. It does not crop out in New Jersey, but exists only in the subsurface. The altitude of the top of the Piney Point aquifer is shown in figure 6, its thickness is shown in figure 7, and its transmissivity is shown in figure 8.

Wenonah-Mount Laurel Aquifer

The Wenonah-Mount Laurel aquifer crops out along the Delaware River in Salem County, where it is in direct contact with the river and associated tidal tributaries. The altitude of the top of the Wenonah-Mount Laurel aquifer and its outcrop area are shown in figure 9, its thickness is shown in figure 10, and its transmissivity is shown in figure 11.

Potomac-Raritan-Magothy Aquifer System

The Potomac-Raritan-Magothy aquifer system crops out along the Delaware River in Gloucester and northern Salem Counties. In places within the study area, one or several of its constituent aquifers are in direct contact with the river and associated tidal tributaries. In Cumberland and southern Salem Counties, the Potomac-Raritan-Magothy aquifer system is confined. The altitude of the top of the Upper Potomac-Raritan-Magothy aquifer and its outcrop area are shown in figure 12, its thickness is shown in figure 13, and its transmissivity is shown in figure 14. The altitude of the top of the Middle Potomac-Raritan-Magothy aquifer and its outcrop area are shown in figure 15, its thickness is shown in figure 16, and its transmissivity is shown in figure 17. The altitude of the top of the Lower Potomac-Raritan-Magothy aquifer and its outcrop area are shown in figure 18, its thickness is shown in figure 19, and its transmissivity is shown in figure 20.

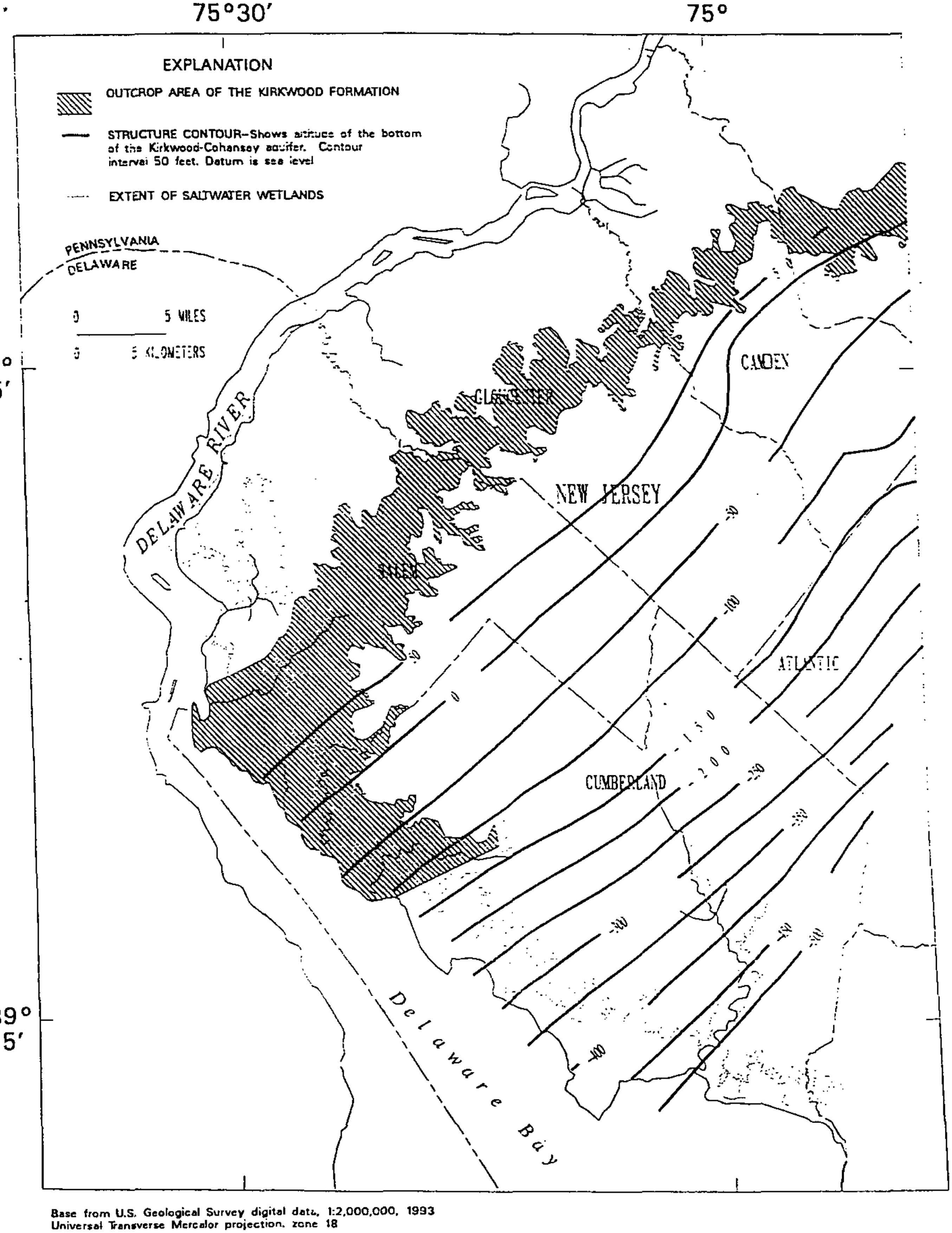


Figure 4. Altitude of the base of the Kirkwood-Cohansey aquifer system (Modified from Zapecza, 1989, pl. 23).

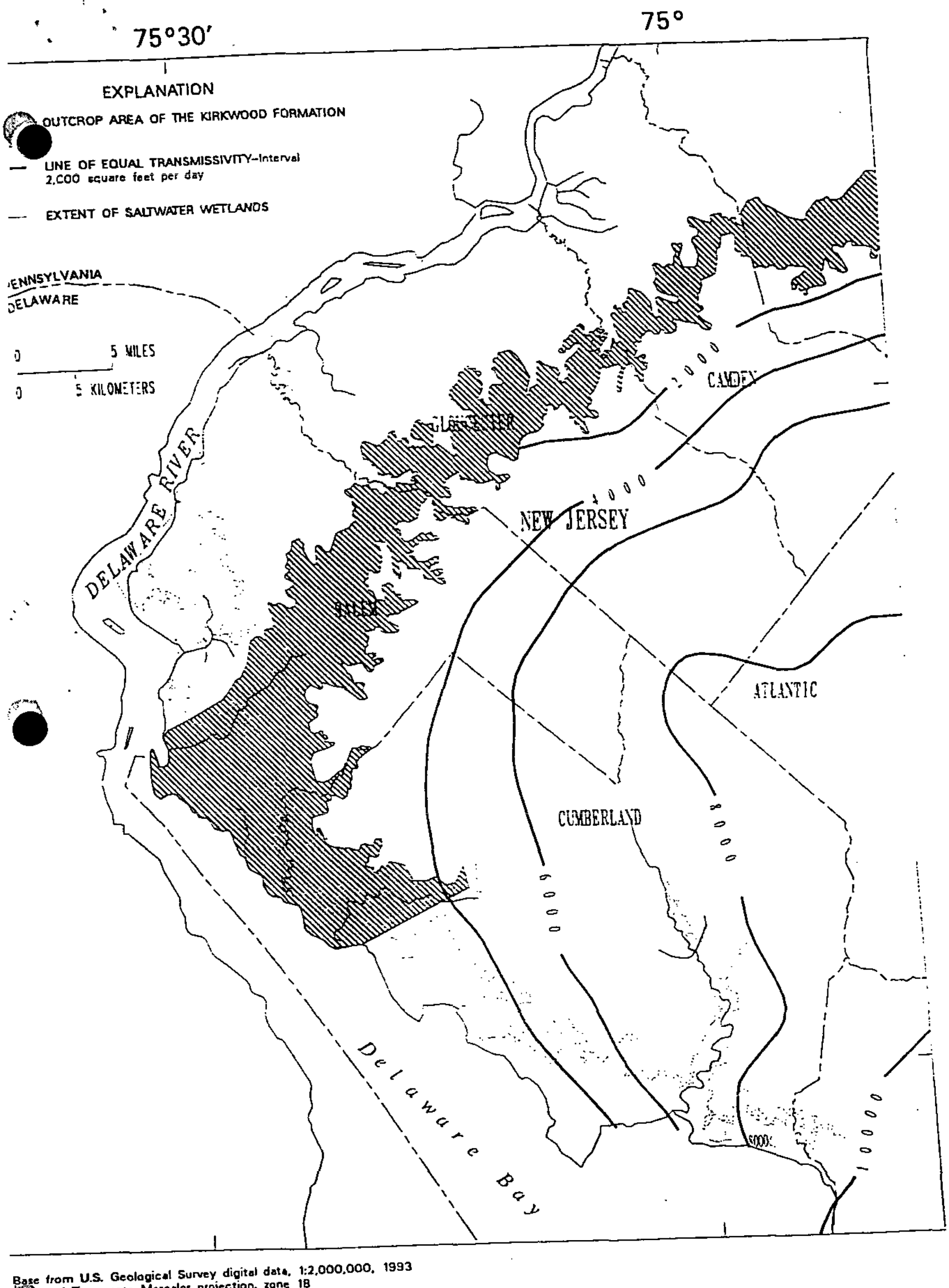


Figure 5. Transmissivity of the Kirkwood-Cohansey aquifer system (Modified from Martin, *in press*, fig. 63).

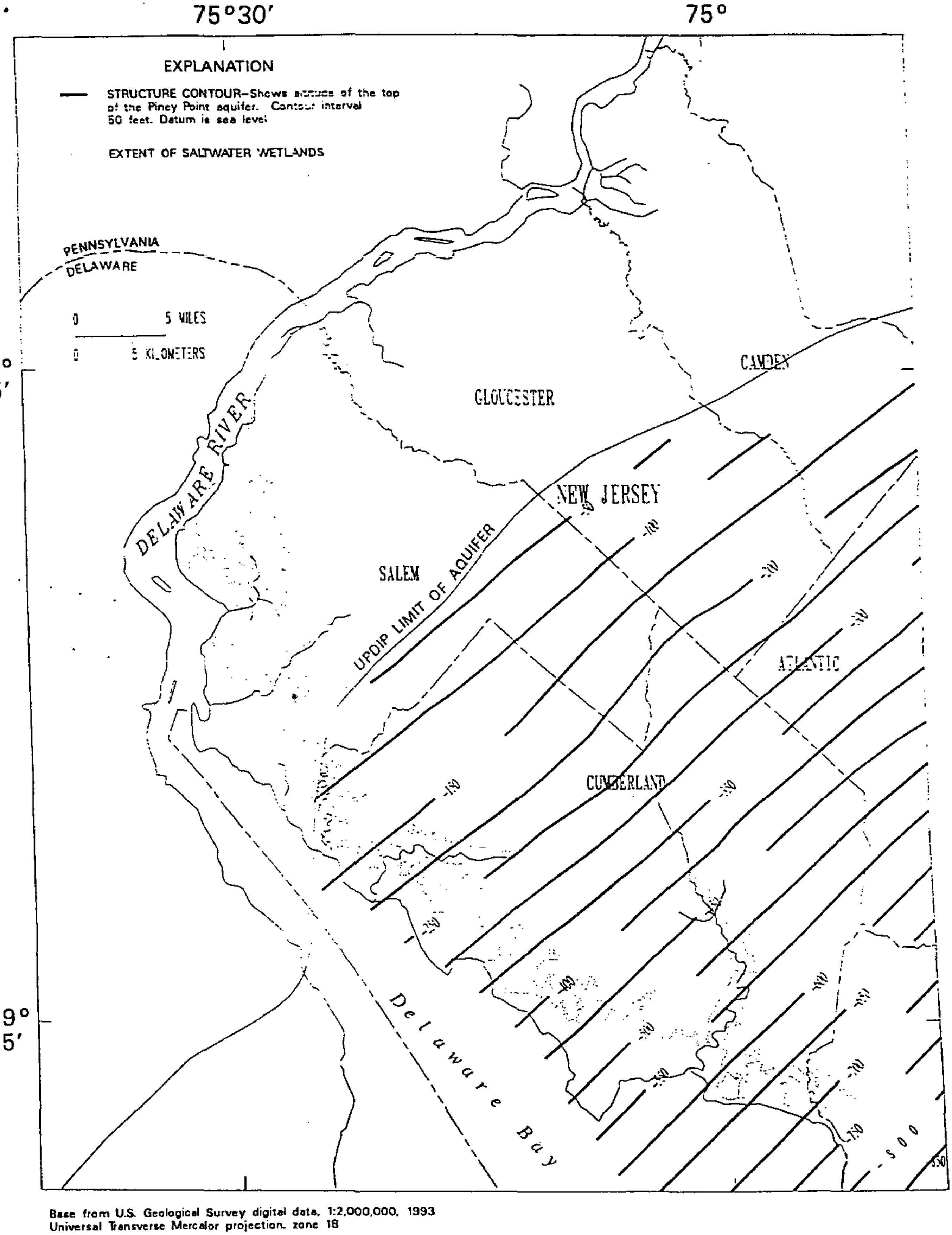
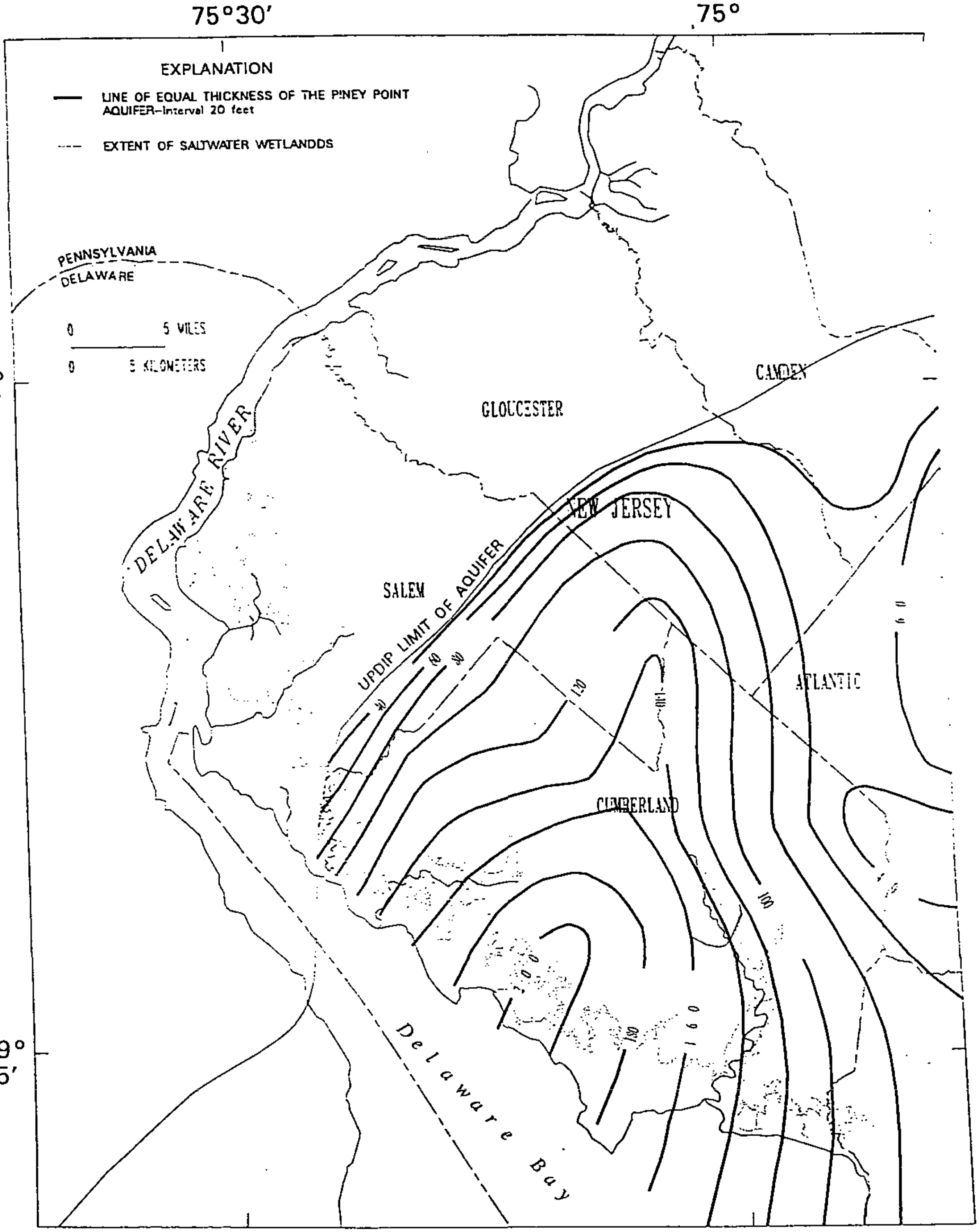


Figure 6. Altitude of the top of the Piney Point aquifer (Modified from Zapecza, 1989, pl. 20).



Base from U.S. Geological Survey digital data, 1:2,000,000, 1993
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Figure 7. Thickness of the Piney Point aquifer (Modified from Zapecza, 1989, pl. 21).

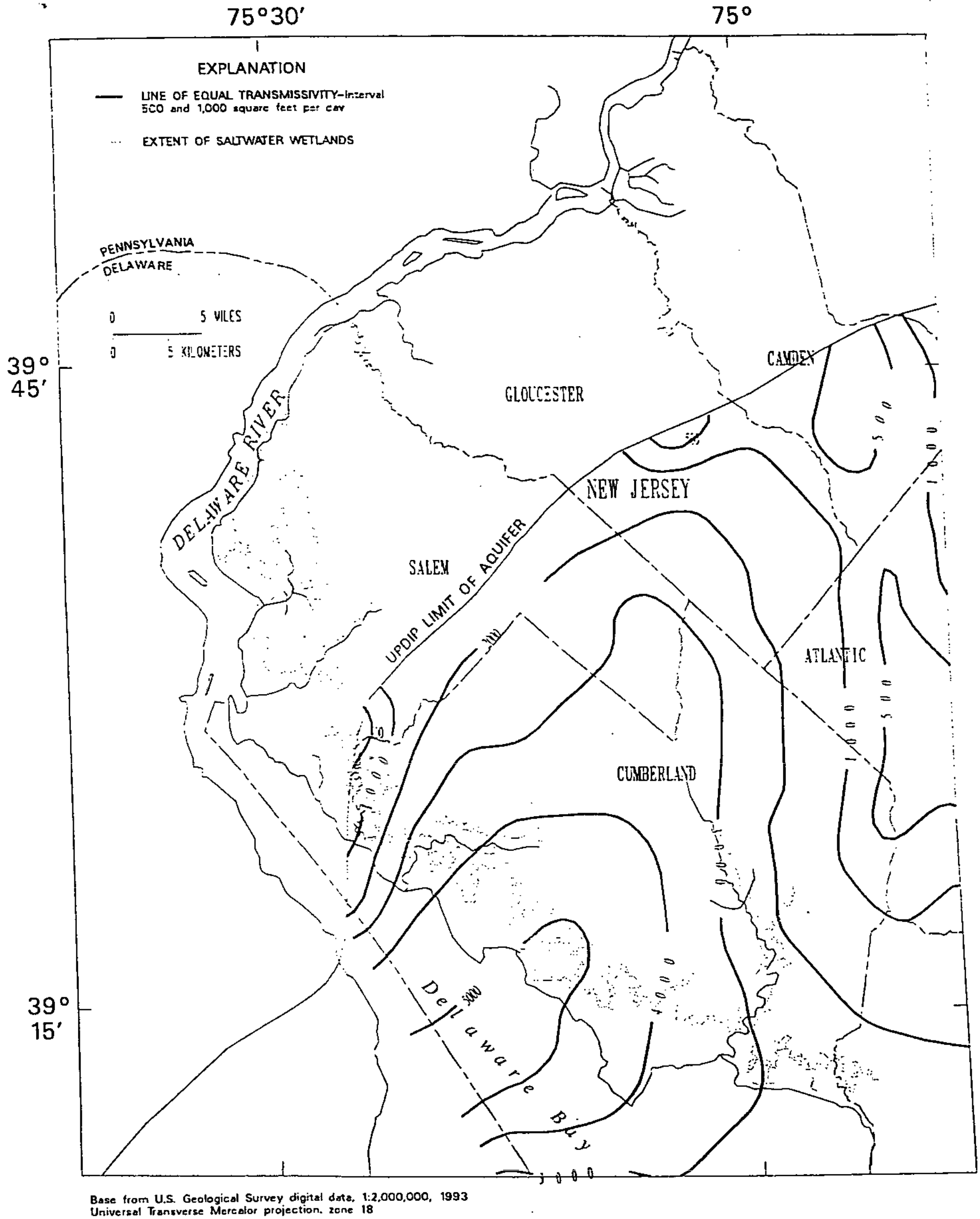

Figure 8. Transmissivity of the Piney Point aquifer (Modified from Martin, *in press*, fig. 61).

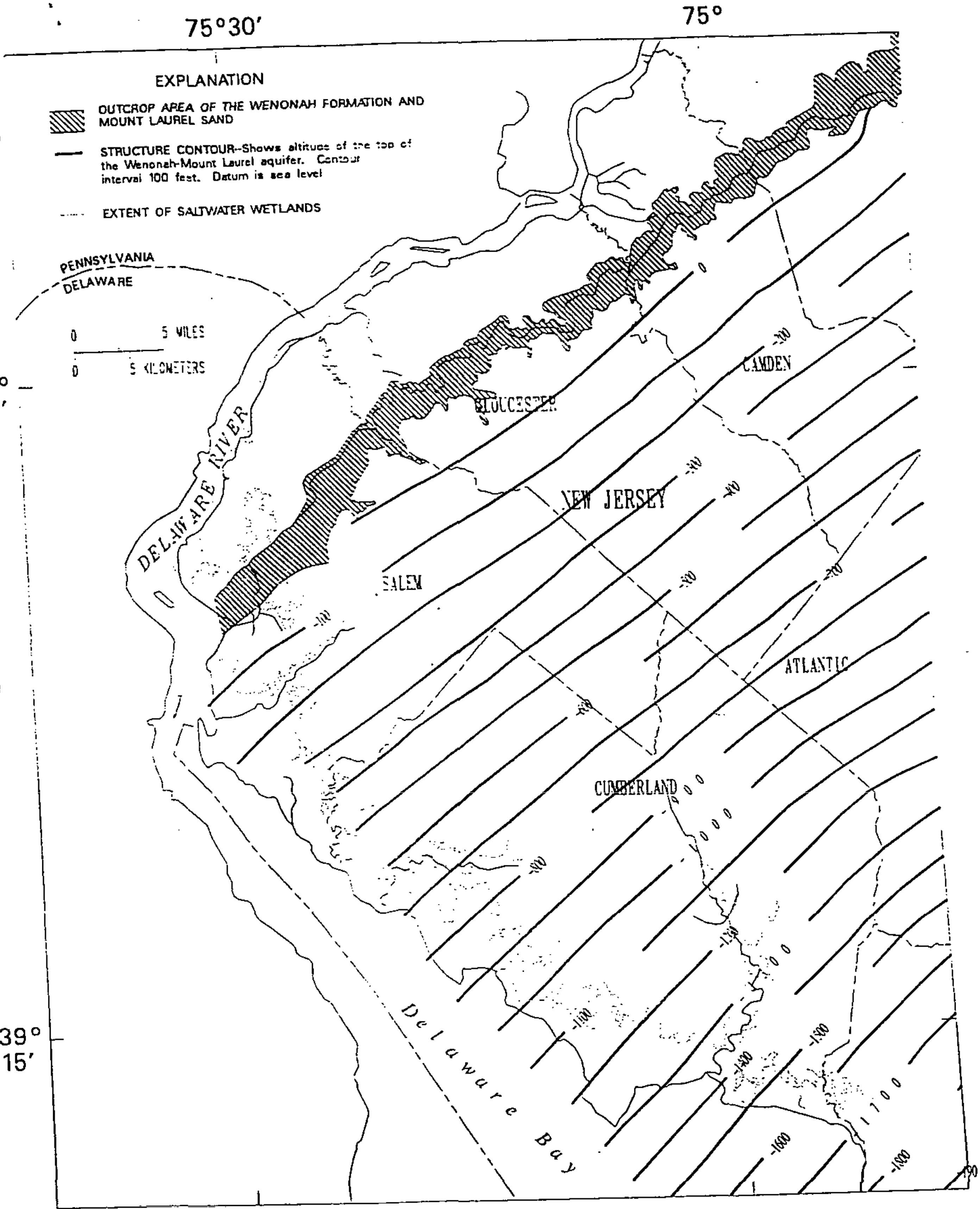

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Figure 9. Altitude of the top of the Wenonah-Mount Laurel aquifer and its outcrop area (Modified from Zapecza, 1989, pl. 16).

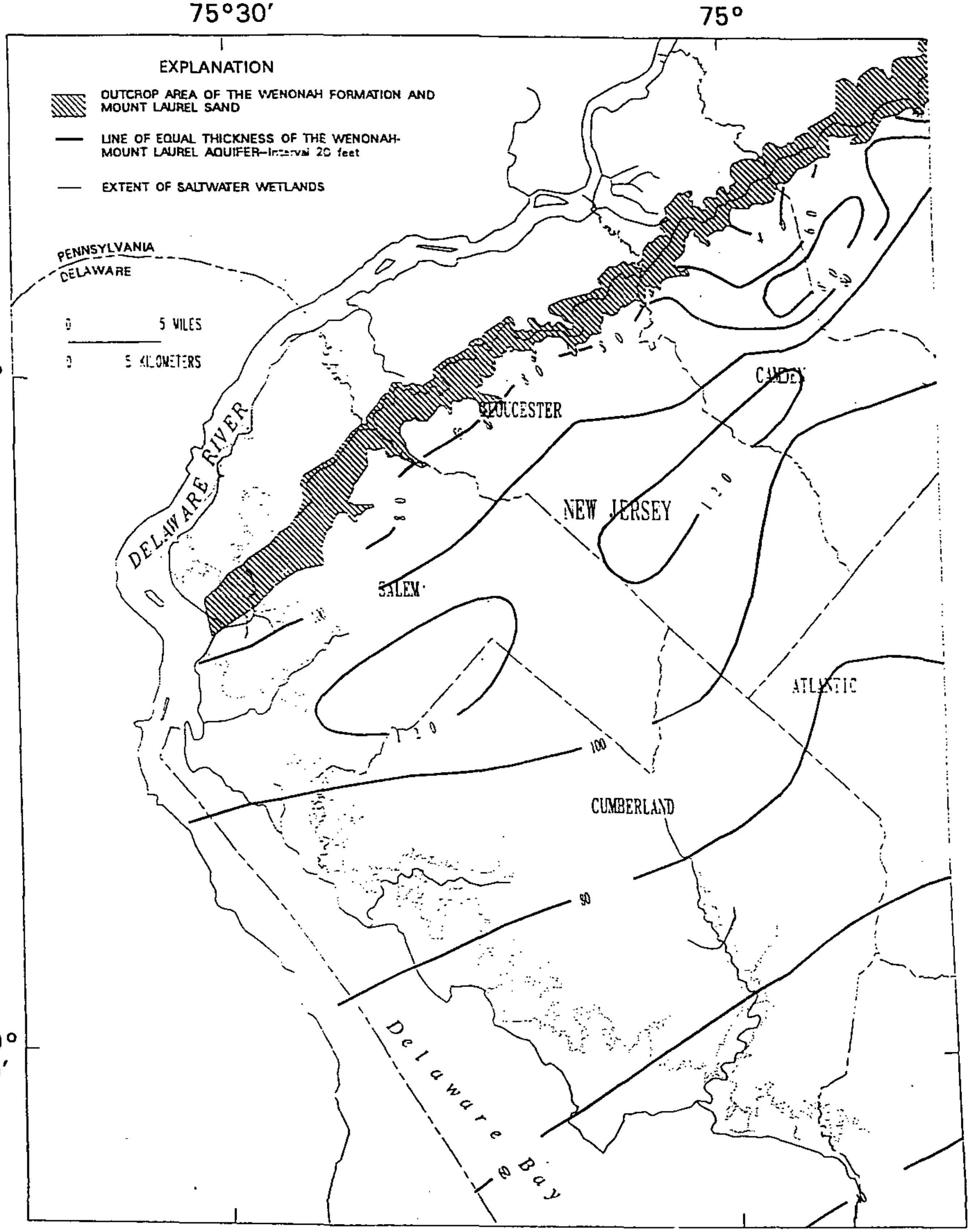

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Figure 10. Thickness of the Wenonah-Mount Laurel aquifer (Modified from Zapecza, 1989, pl. 17).

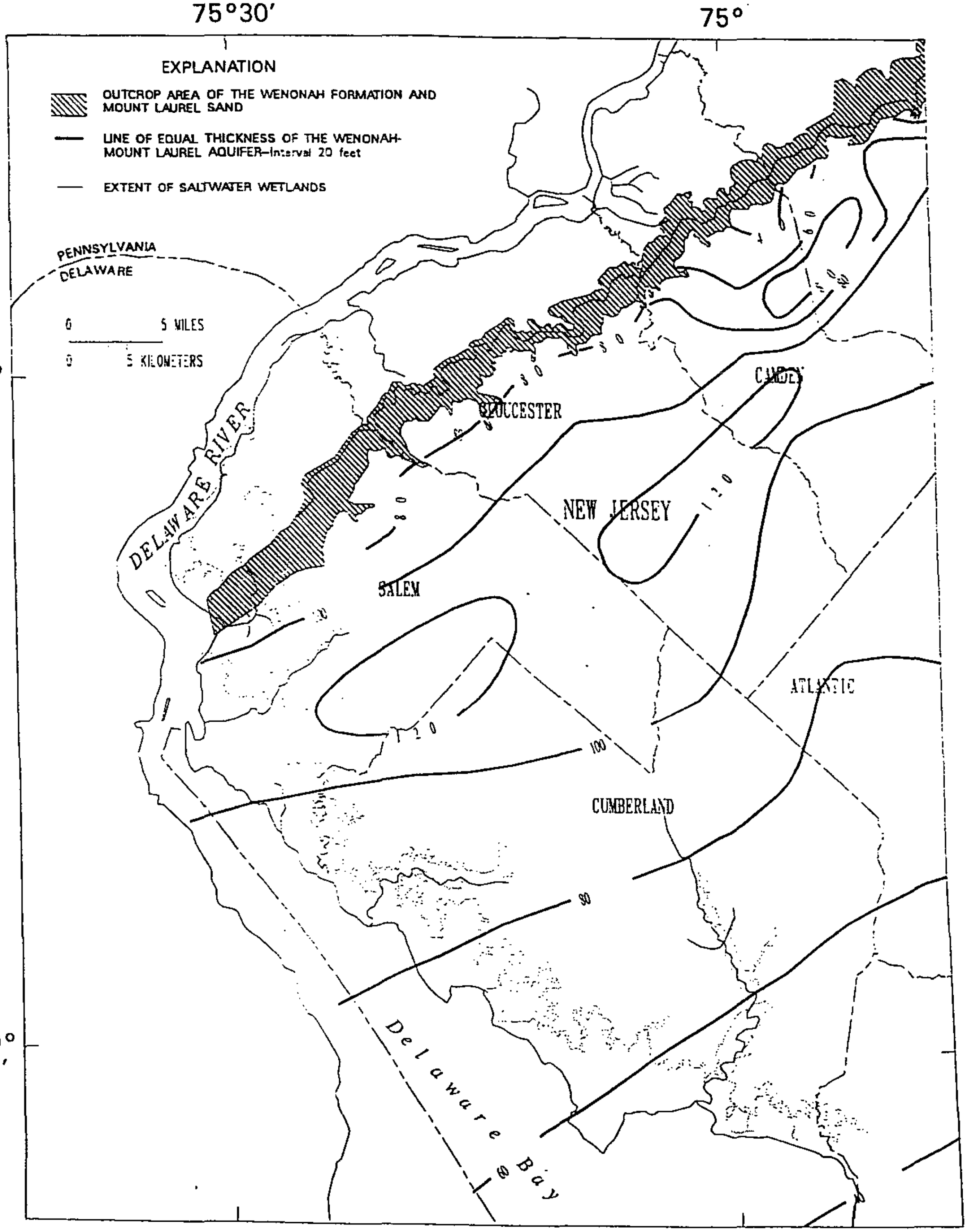

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Figure 10. Thickness of the Wenonah-Mount Laurel aquifer (Modified from Zapecza, 1989, pl. 17).

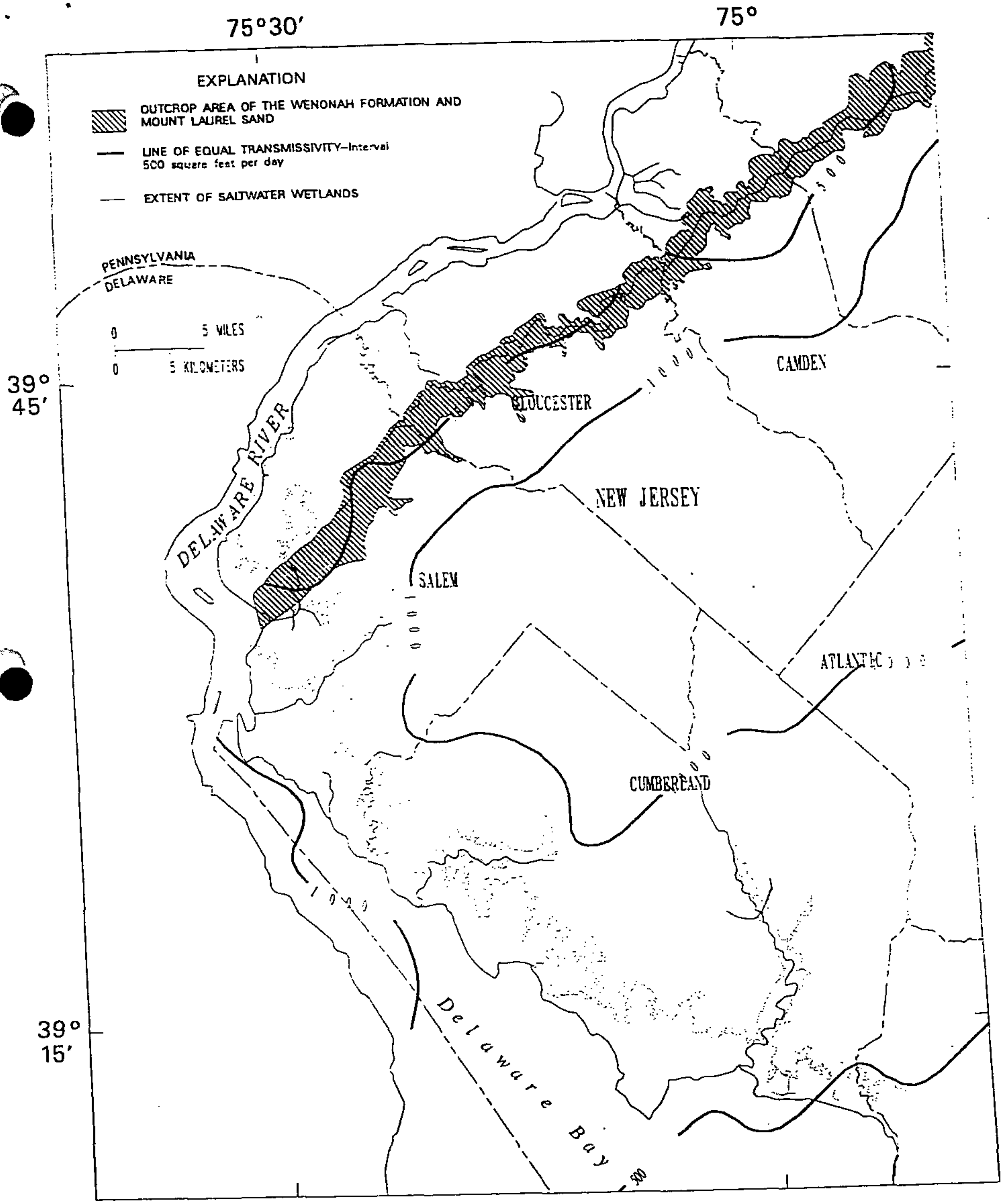

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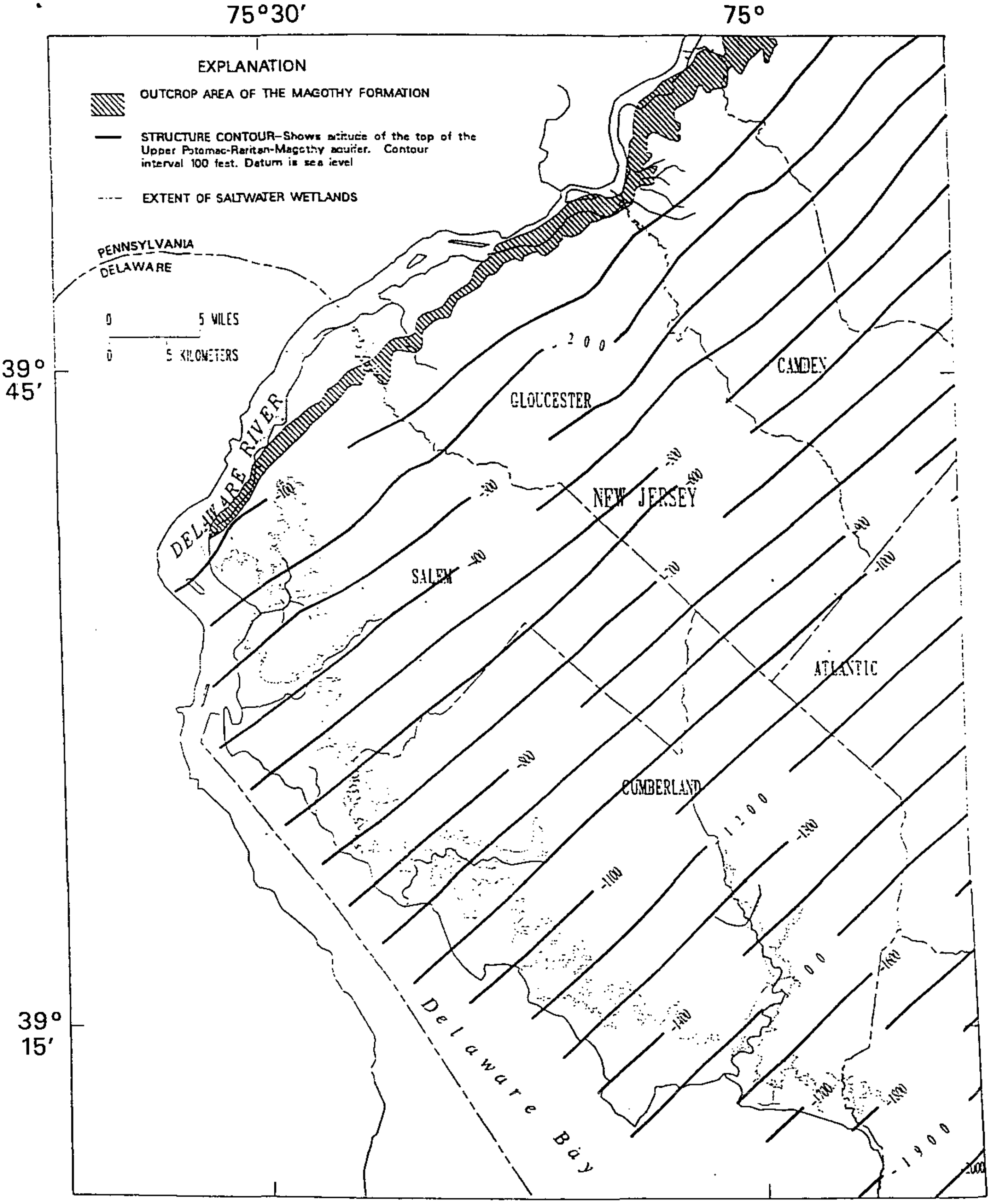
Figure 11. Transmissivity of the Wenonah-Mount Laurel aquifer (Modified from Martin, *in press*, fig. 59).



Base from U.S. Geological Survey digital data, 1:2,000,000, 1993
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Figure 12. Altitude of the top of the Upper Potomac-Raritan-Magothy aquifer and its outcrop area (Modified from Zapecza, 1989, pl. 10).

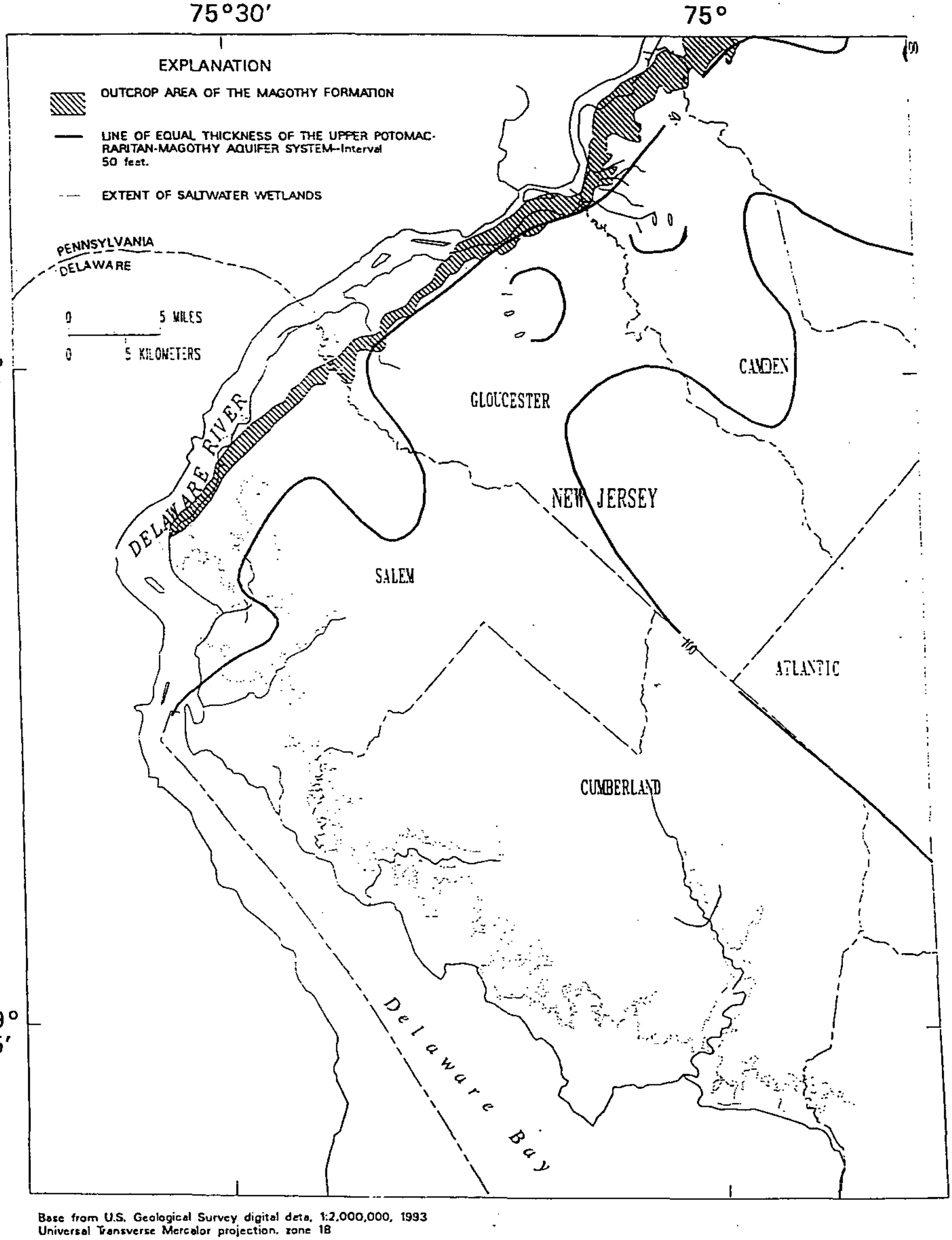
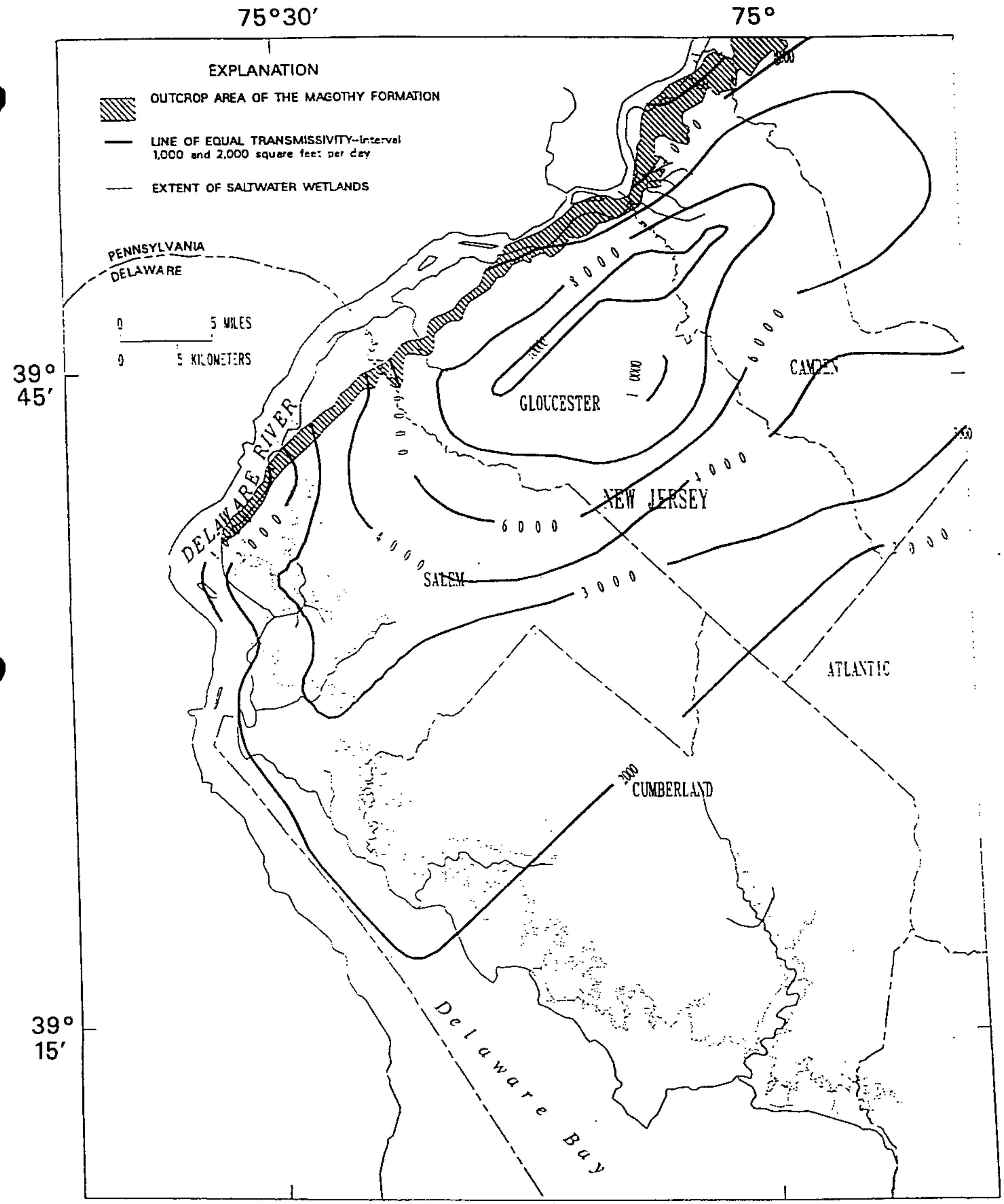


Figure 13. Thickness of the Upper Potomac-Raritan-Magothy aquifer (Modified from Zapecza, 1989, pl. 11).



Base from U.S. Geological Survey digital data, 1:2,000,000, 1993
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Figure 14. Transmissivity of the Upper Potomac-Raritan-Magothy aquifer (Modified from Martin, *in press*, fig. 57).

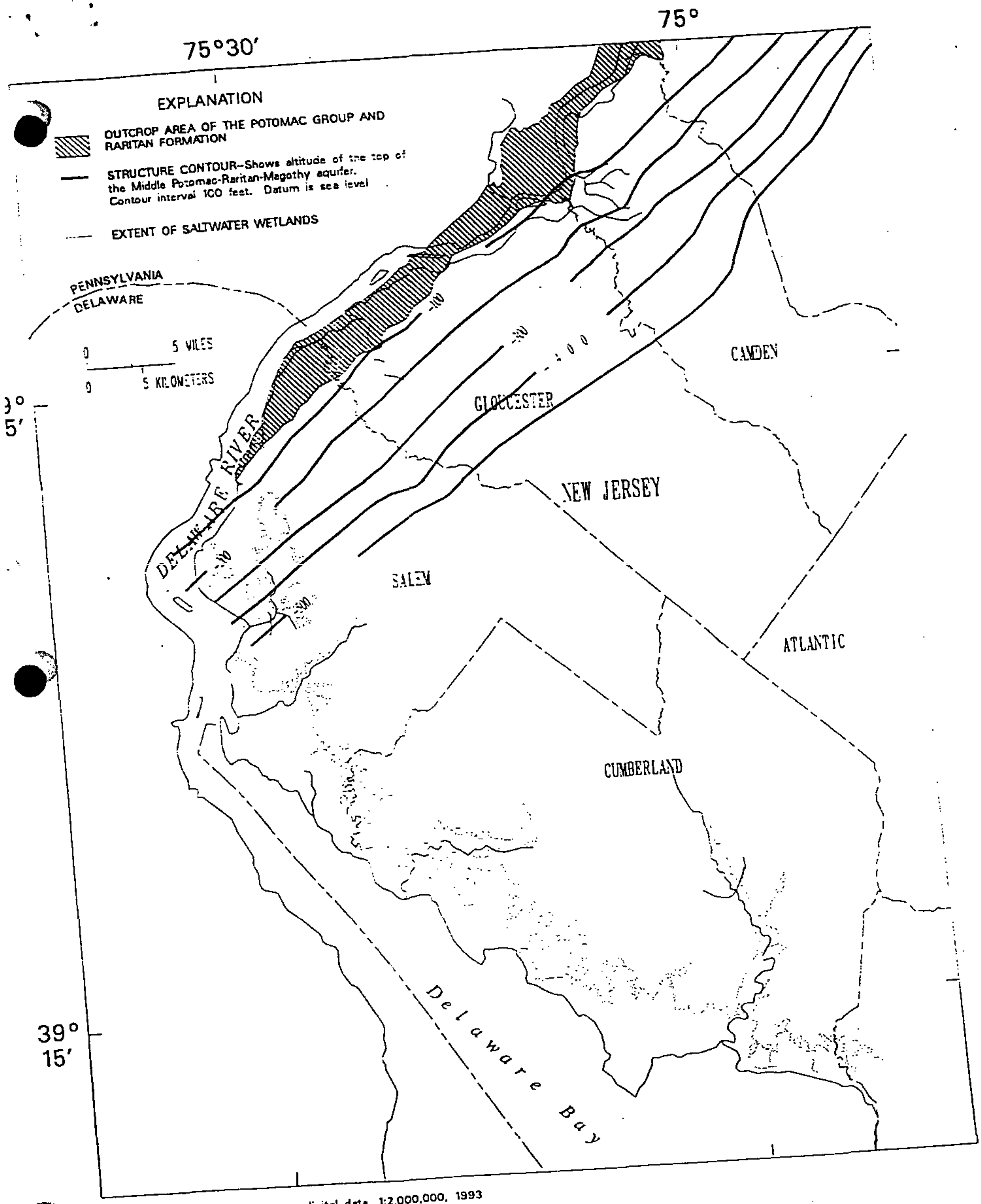

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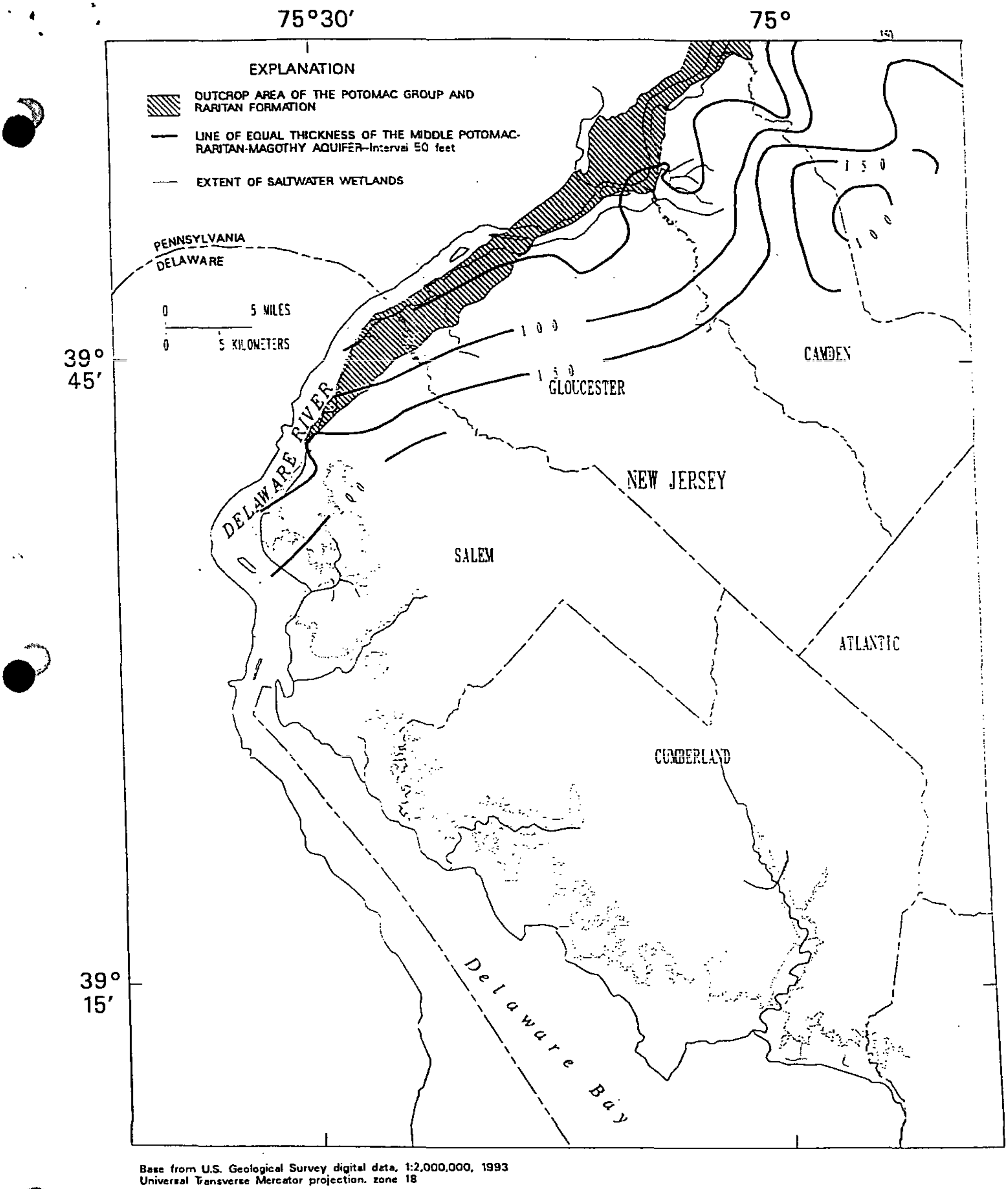
Figure 15. Altitude of the top of the Middle Potomac-Raritan-Magothy aquifer and its outcrop area (Modified from Zapecza, 1989, pl. 7).



Base from U.S. Geological Survey digital data, 1:2,000,000, 1993
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Figure 16. Thickness of the Middle Potomac-Raritan-Magothy aquifer (Modified from Zapecza, 1989, pl. 8).

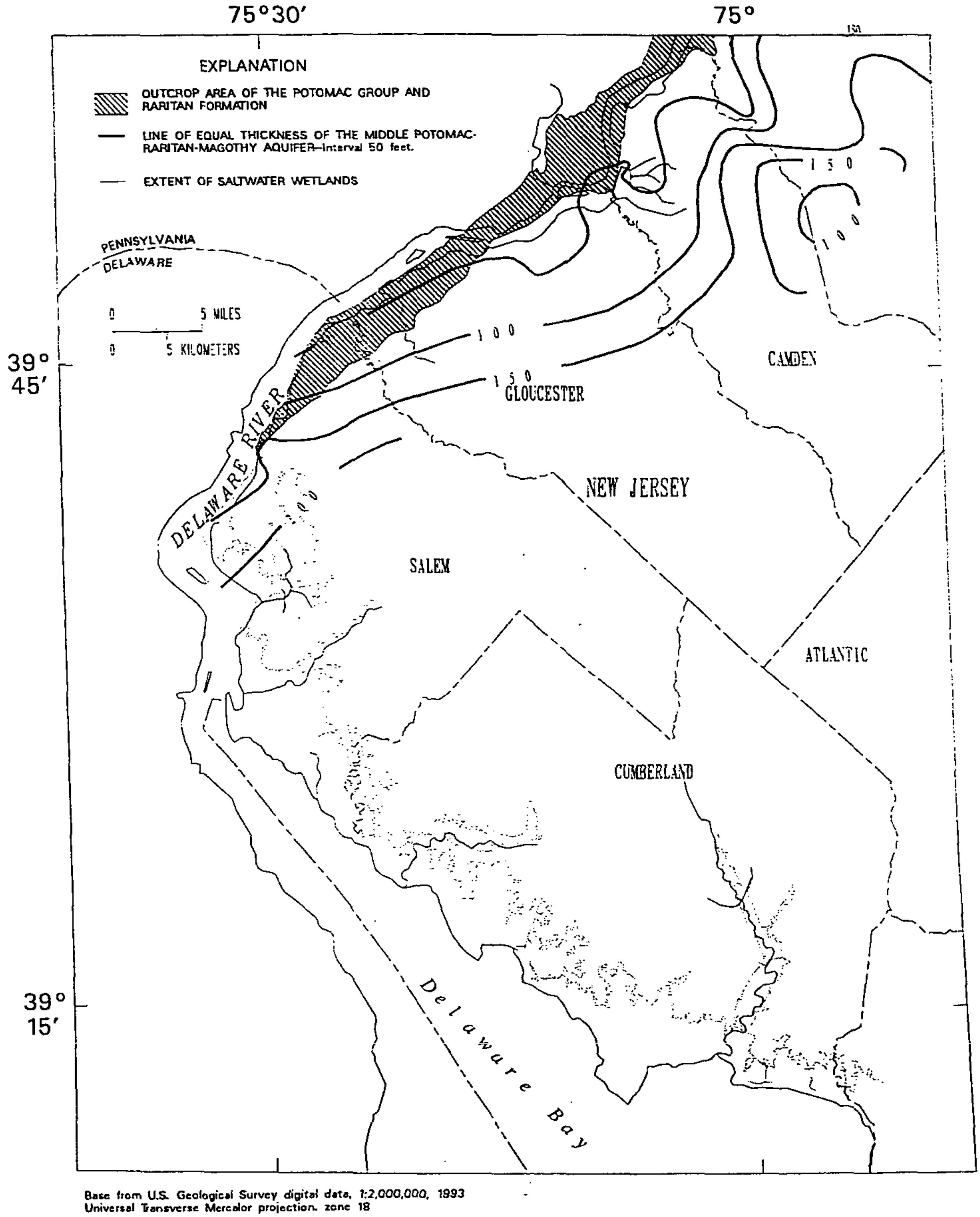

Figure 17. Transmissivity of the Middle Potomac-Raritan-Magothy aquifer (Modified from Martin, *in press*, fig. 56).

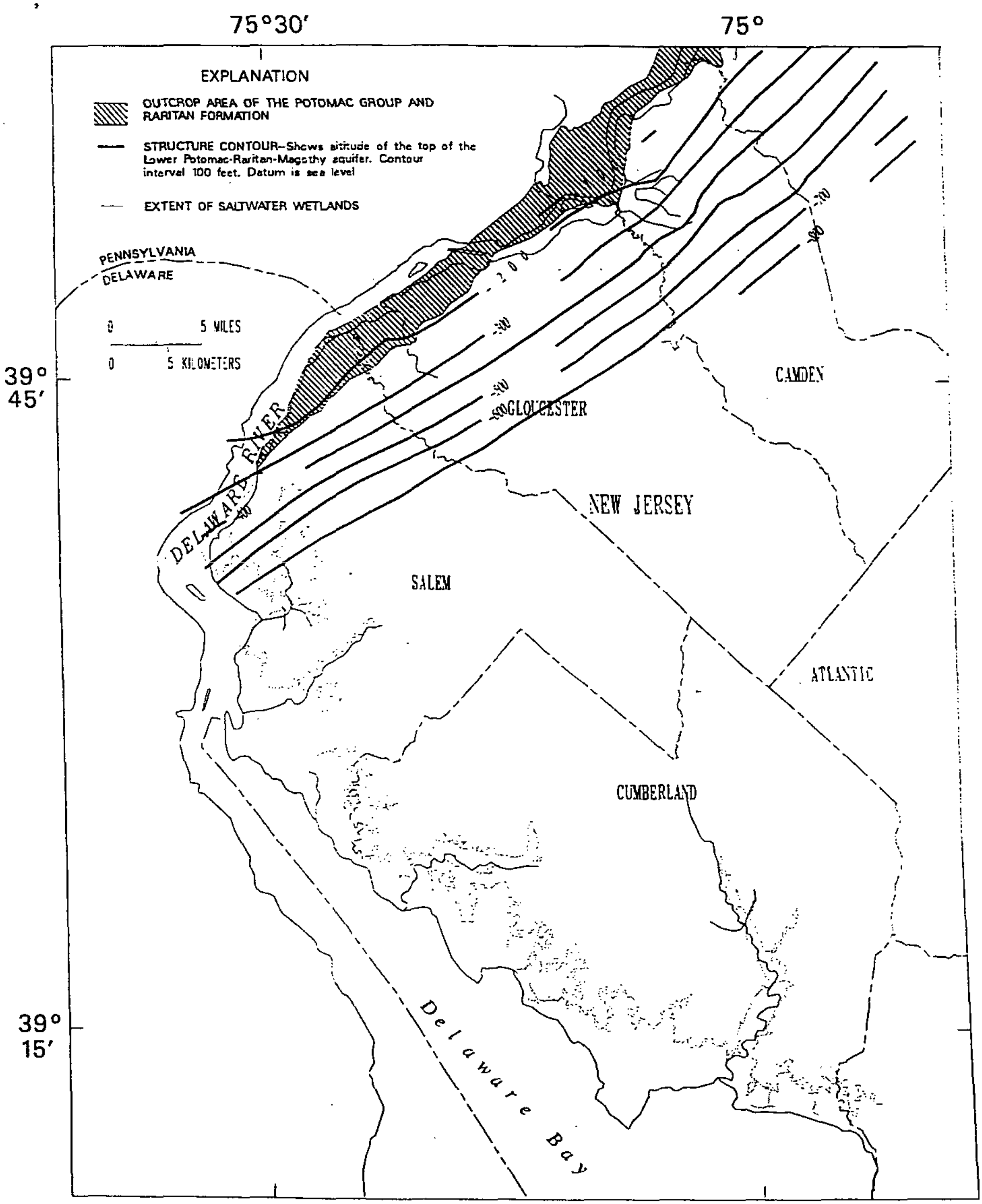

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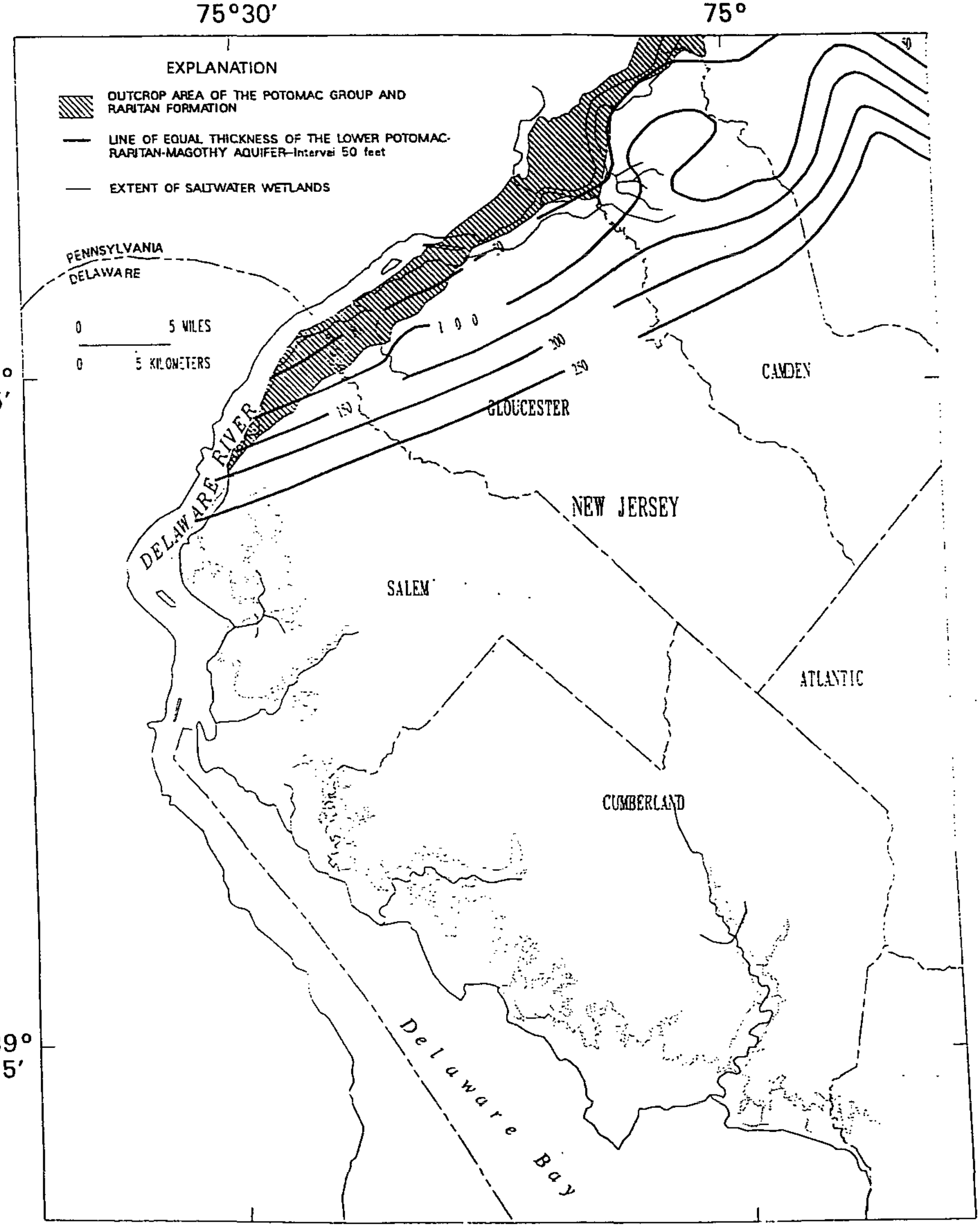
Figure 18. Altitude of the top of the Lower Potomac-Raritan-Magothy aquifer and its outcrop area (Modified from Zapecza, 1989, pl. 6).



Base from U.S. Geological Survey digital data, 1:2,000,000, 1993
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Figure 19. Thickness of the Lower Potomac-Raritan-Magothy aquifer (Modified from Zapecza, 1989, pl. 6).

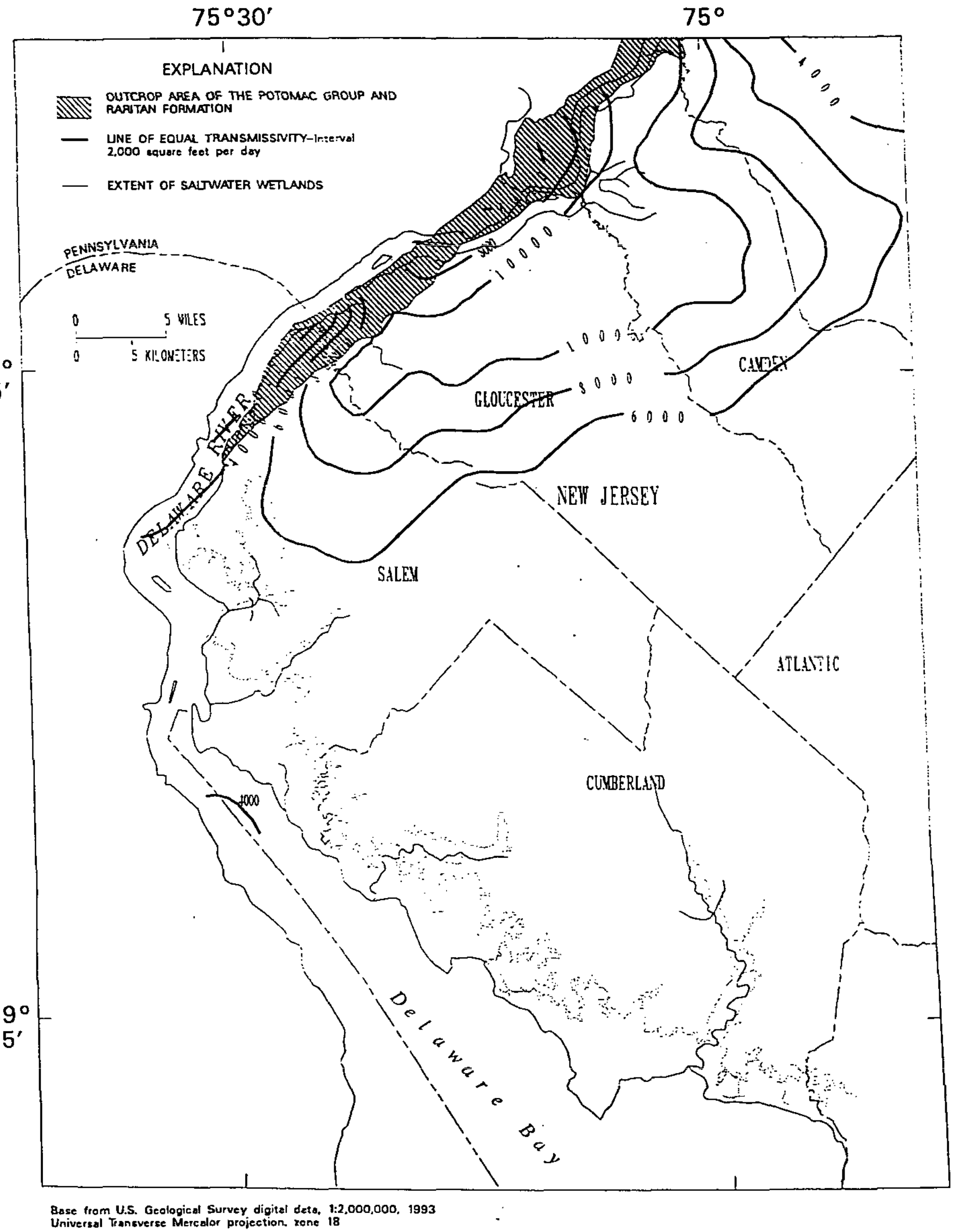


Figure 20. Transmissivity of the Lower Potomac-Raritan-Magothy aquifer (Modified from Martin, *in press*, fig. 55).

Ground-Water Levels

Ground-water levels can provide useful information about the direction of ground-water flow between and within aquifers, as well as between surface-water bodies and the ground-water system. Ground-water levels are typically compiled and presented in the form of potentiometric-surface (or water-level) contour maps. Because the Kirkwood-Cohansey aquifer system is unconfined, and contains the water table over much of the study area, and water-table potentiometric-surface maps are typically complex, a potentiometric-surface map of the aquifer system was not compiled. The potentiometric surfaces of the other aquifers used for water supply in the study area have been mapped by Rosman and others (1995). The potentiometric surface of the Piney Point aquifer is shown in figure 21, the Wenonah-Mount Laurel aquifer in figure 22, the Upper Potomac-Raritan-Magothy aquifer in figure 23, the Middle Potomac-Raritan-Magothy aquifer in figure 24, and the Lower Potomac-Raritan-Magothy aquifer in figure 25. The individual data-point locations and water levels are tabulated in Rosman and others (1995). Earlier data can be found in Zapecza and others (1987).

Ground-Water Withdrawals

The locations of and rates of withdrawal from water-supply wells are important pieces of information in an investigation of saltwater intrusion. As described earlier in this report, ground-water typically discharges to surface-water bodies near estuaries and the ocean. This flow direction can be reversed when ground-water withdrawals rates are sufficient. Wells located more than 2 miles from the Delaware River were found by Navoy and Carleton (1995) not to be affected by the river. For the purposes of this report, wells located more than 2 miles from the present extent of saltwater wetlands are not likely to be affected by the proposed changes in the Delaware River channel, and, thus, need not be considered. Wells in Gloucester County, located within 2 miles of saltwater wetlands or the Delaware River, and for which withdrawals are reported to the New Jersey Department of Environmental Protection (NJDEP) are shown in figure 26 and are tabulated in table 3 (at end of report). These include water-supply wells of public-water purveyors, commercial interests, and industrial concerns, but do not include private domestic wells, for which reporting is not required in New Jersey. Irrigation wells are indicated separately on the map because of their seasonal use; they are not included in table 3 because they are subject to different NJDEP reporting requirements. This information was retrieved from the USGS, New Jersey District, State Water Use Database System (SWUDS). Similarly, withdrawal wells in Salem County located within 2 miles of saltwater wetlands or the Delaware River are shown in figure 27 and are tabulated in table 4 (at end of report). Withdrawal wells in Cumberland County located within 2 miles of saltwater wetlands or the Delaware River are shown in figure 28 and are tabulated in table 5 (at end of report). Information about irrigation wells in Gloucester, Salem, and Cumberland Counties located within 2 miles of saltwater wetlands or the Delaware River is tabulated in table 6 (at end of report), but water use is not reported. For further analysis, irrigation water use could be estimated by crop type by using water-demand estimates outlined in Clawges and Titus (1993).

Chloride Concentrations in Ground Water

Dissolved chloride, a major component of seawater, is commonly used as an indicator of saltwater intrusion into the ground-water system. The dissolved-chloride concentration in seawater is about 19,000 mg/L (Hem, 1970, table 2). The U.S. Environmental Protection

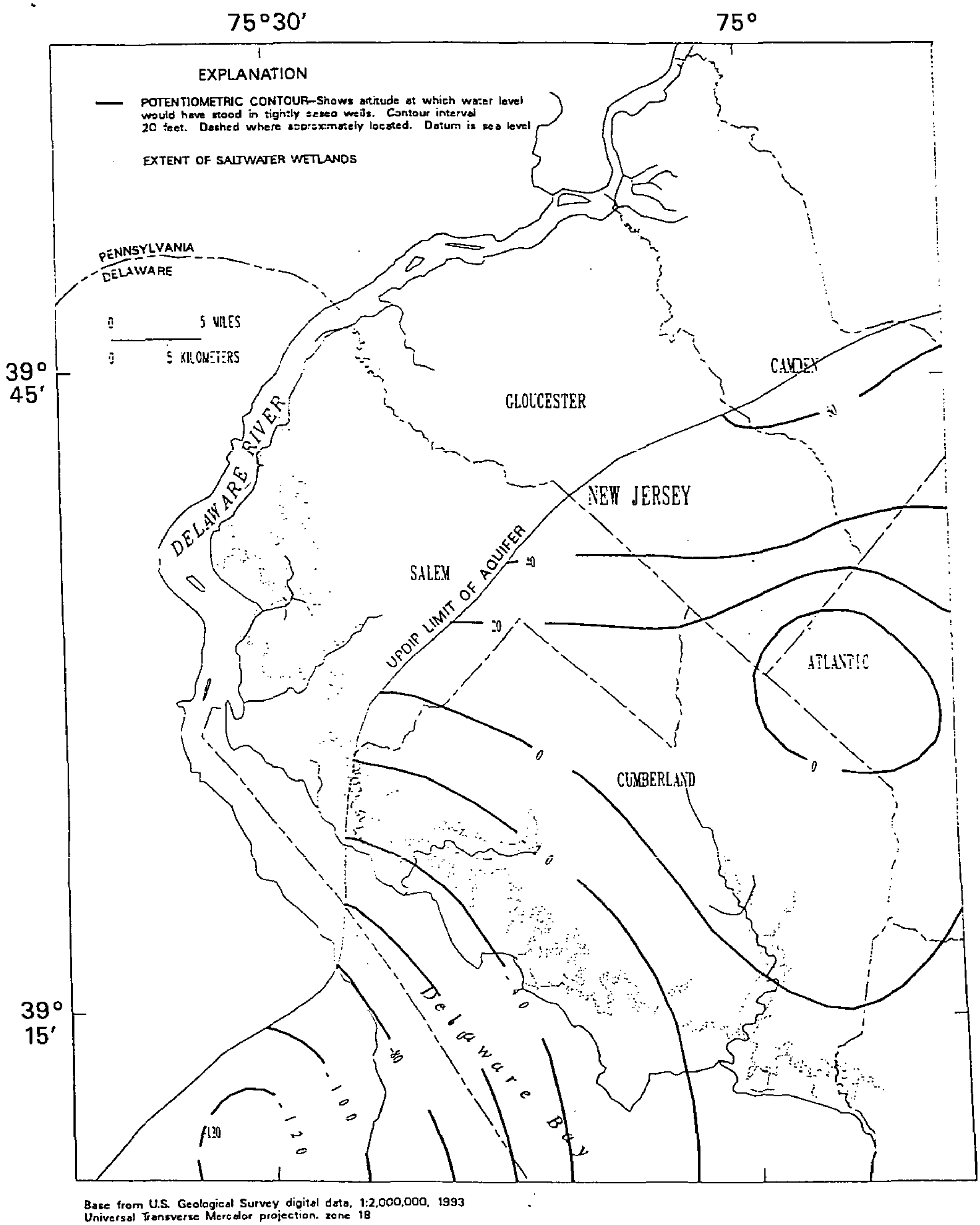
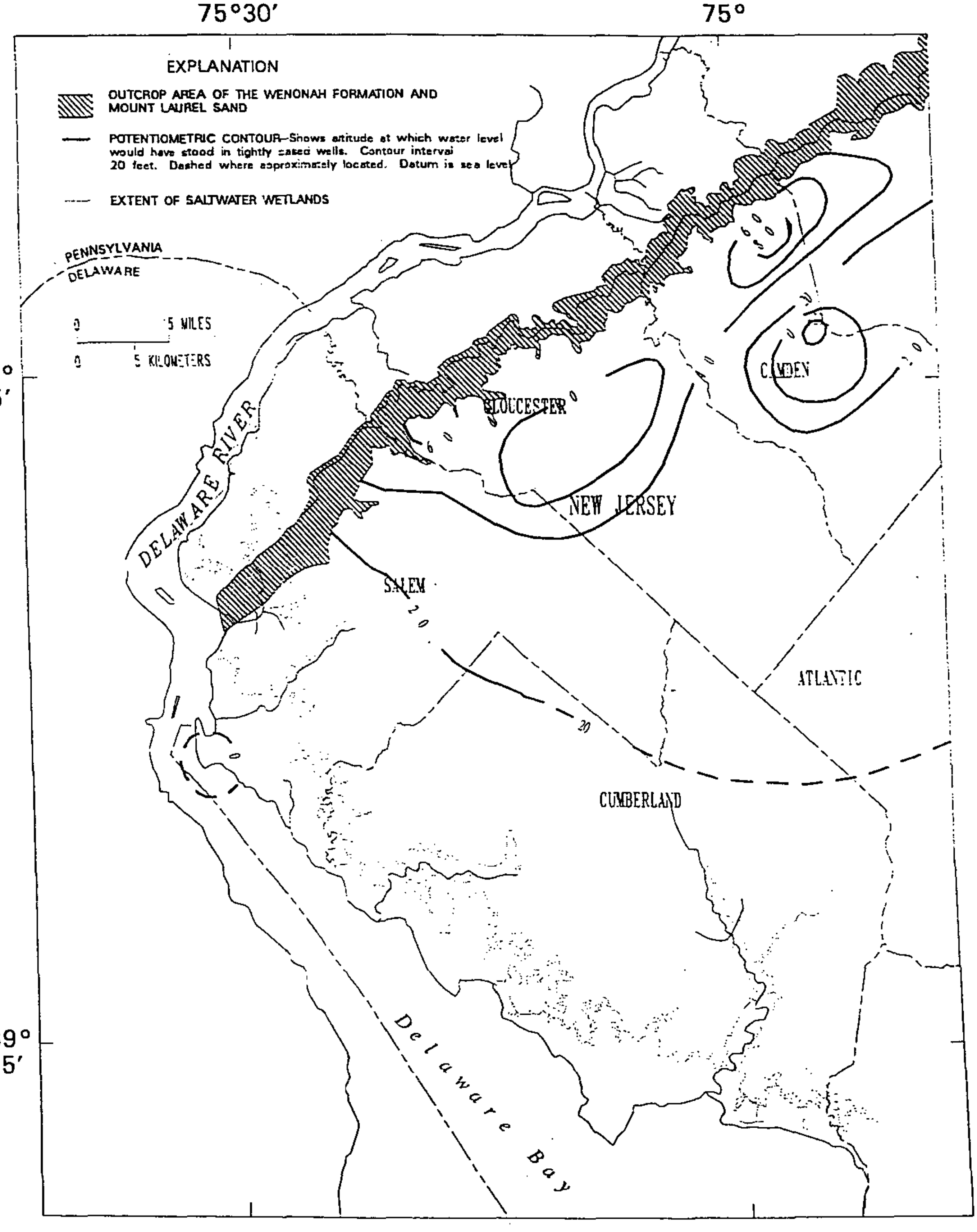


Figure 21. Potentiometric surface of the Piney Point aquifer, 1988 (Modified from Rosman and others, 1995, pl. 2).



Base from U.S. Geological Survey digital data, 1:2,000,000, 1993
Universal Transverse Mercator projection, zone 18

Figure 22. Potentiometric surface of the Wenonah-Mount Laurel aquifer, 1988 (Modified from Rosman and others, 1995, pl. 4).

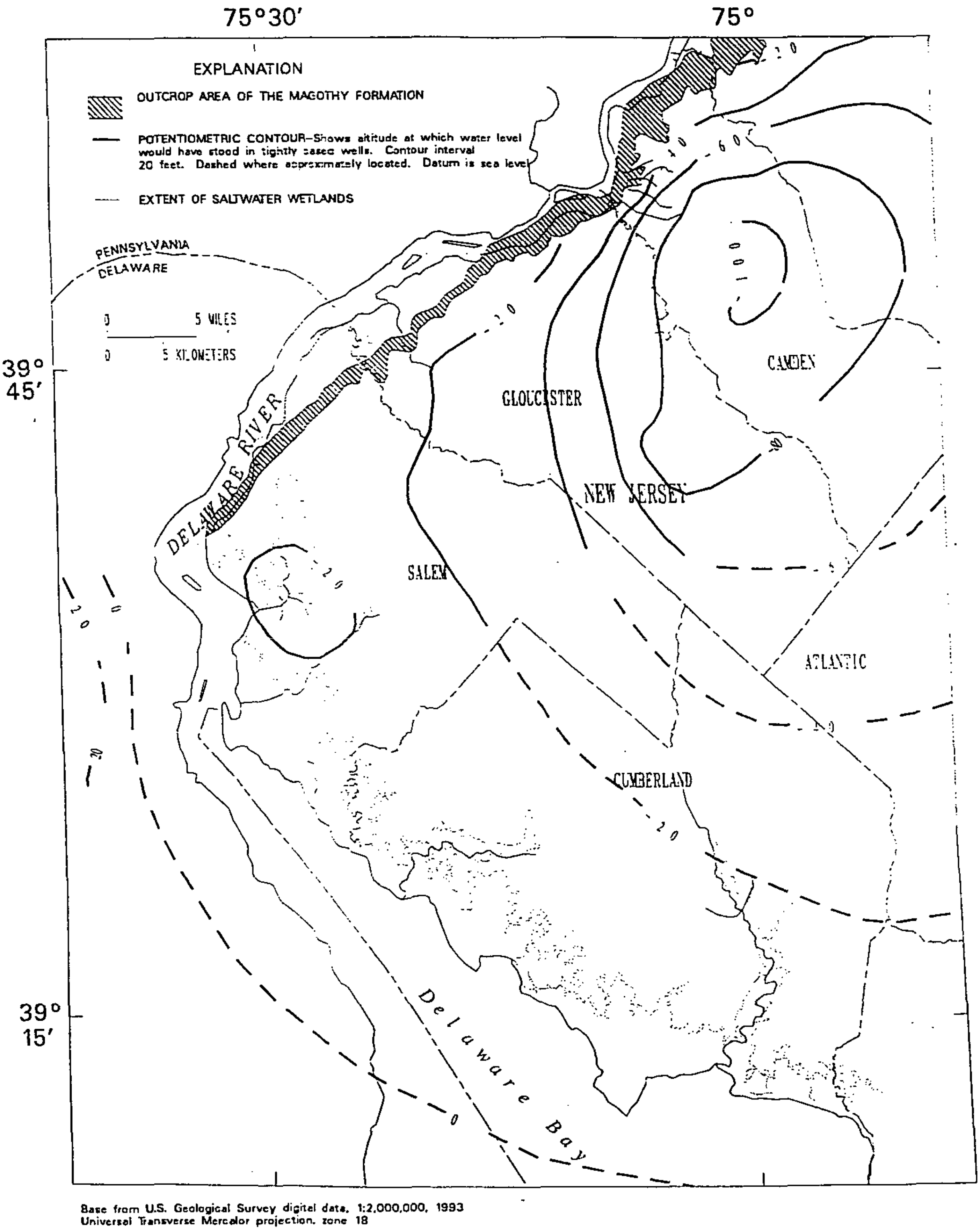
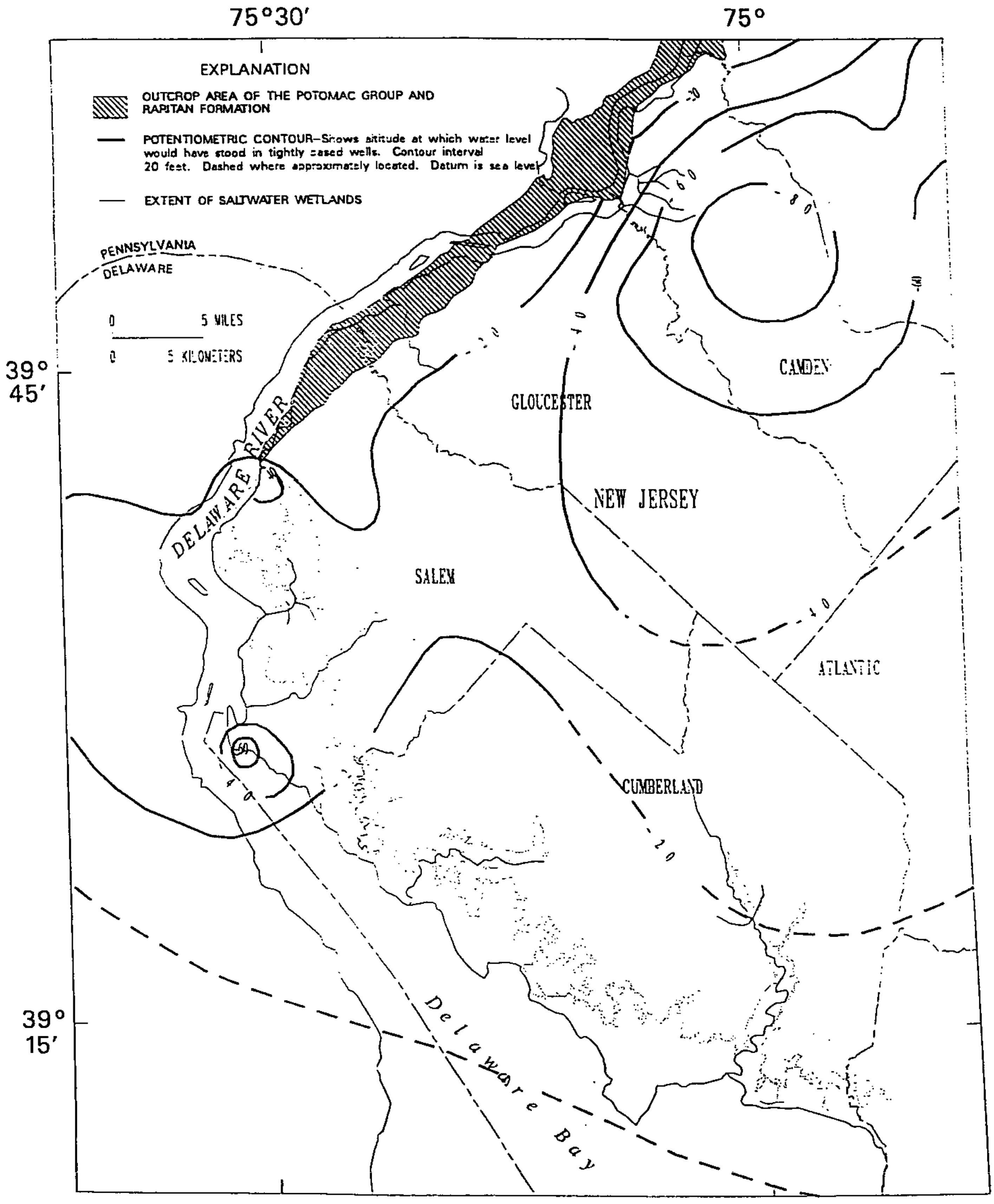


Figure 23. Potentiometric surface of the Upper Potomac-Raritan-Magothy aquifer, 1988 (Modified from Rosman and others, 1995, pl. 6).



Base from U.S. Geological Survey digital data, 1:2,000,000, 1993
Universal Transverse Mercator projection, zone 18

Figure 24. Potentiometric surface of the Middle Potomac-Raritan-Magothy aquifer, 1988 (Modified from Rosman and others, 1995, pl. 7).

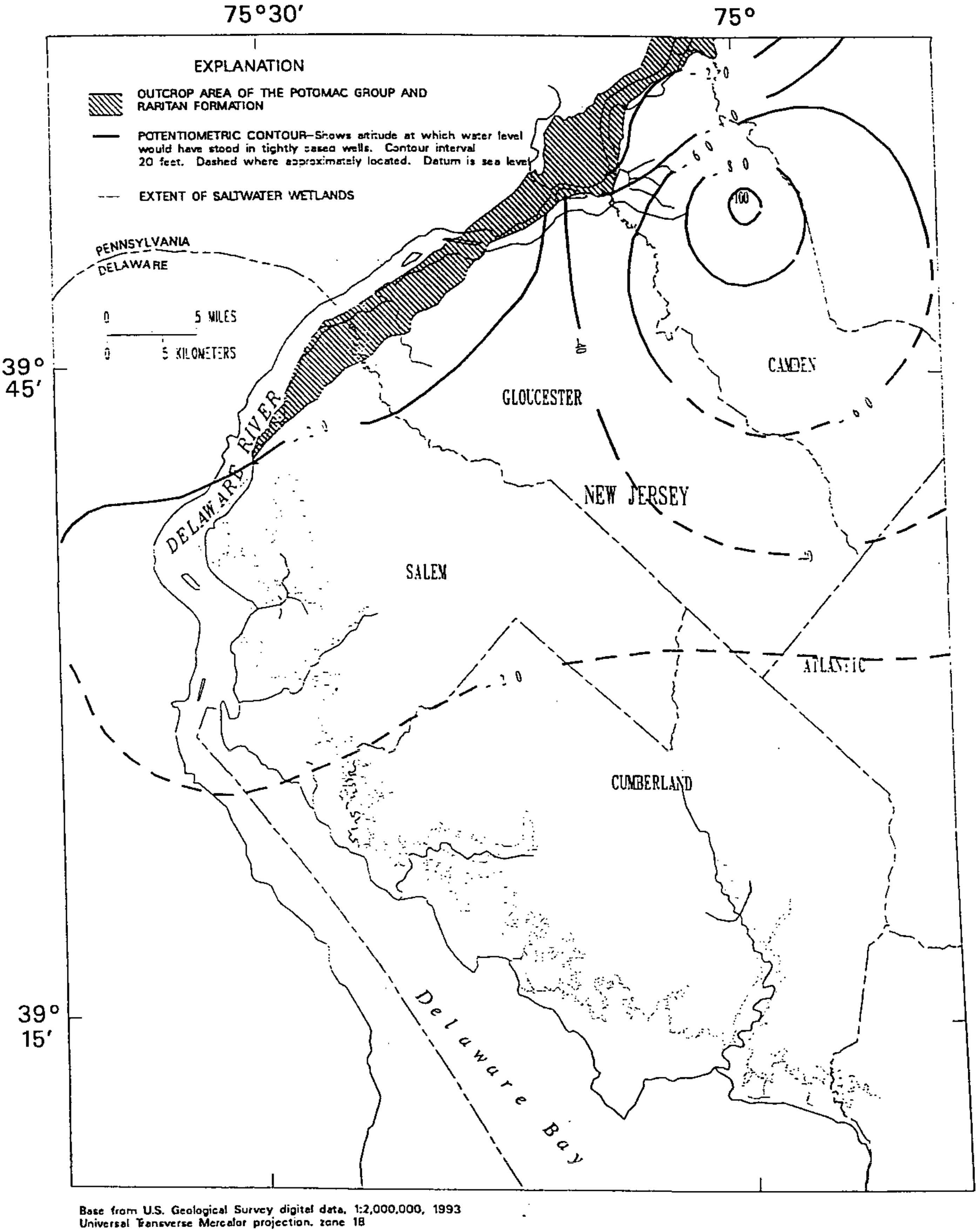
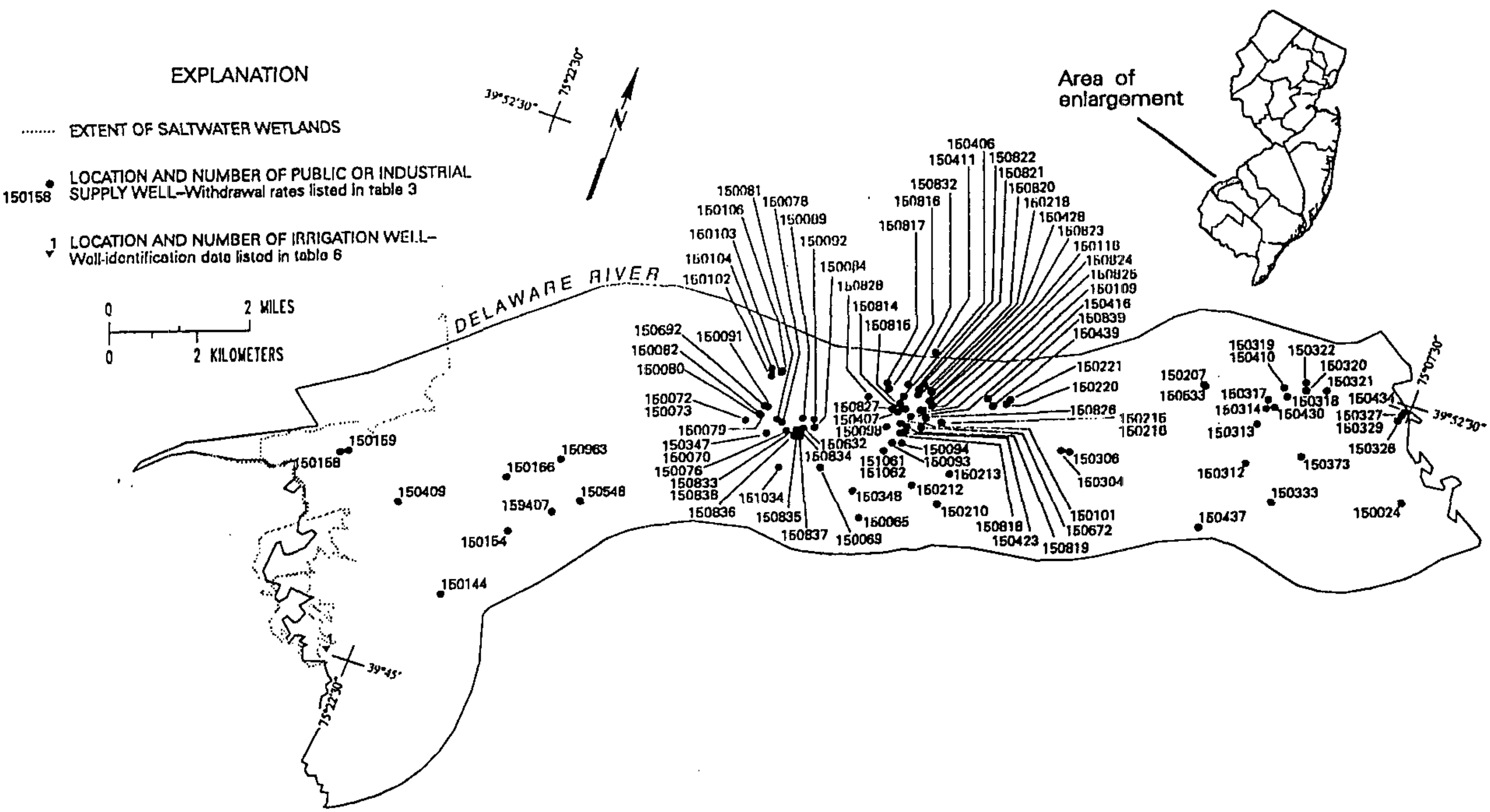


Figure 25. Potentiometric surface of the Lower Potomac-Raritan-Magothy aquifer, 1988 (Modified from Rosman and others, 1995, pl. 8).



Base from U.S. Geological Survey digital data, 1:2,000,000, 1993
Universal Transverse Mercator projection, zone 18

Figure 26. Withdrawal wells in Gloucester County located within 2 miles of saltwater wetlands or the Delaware River.

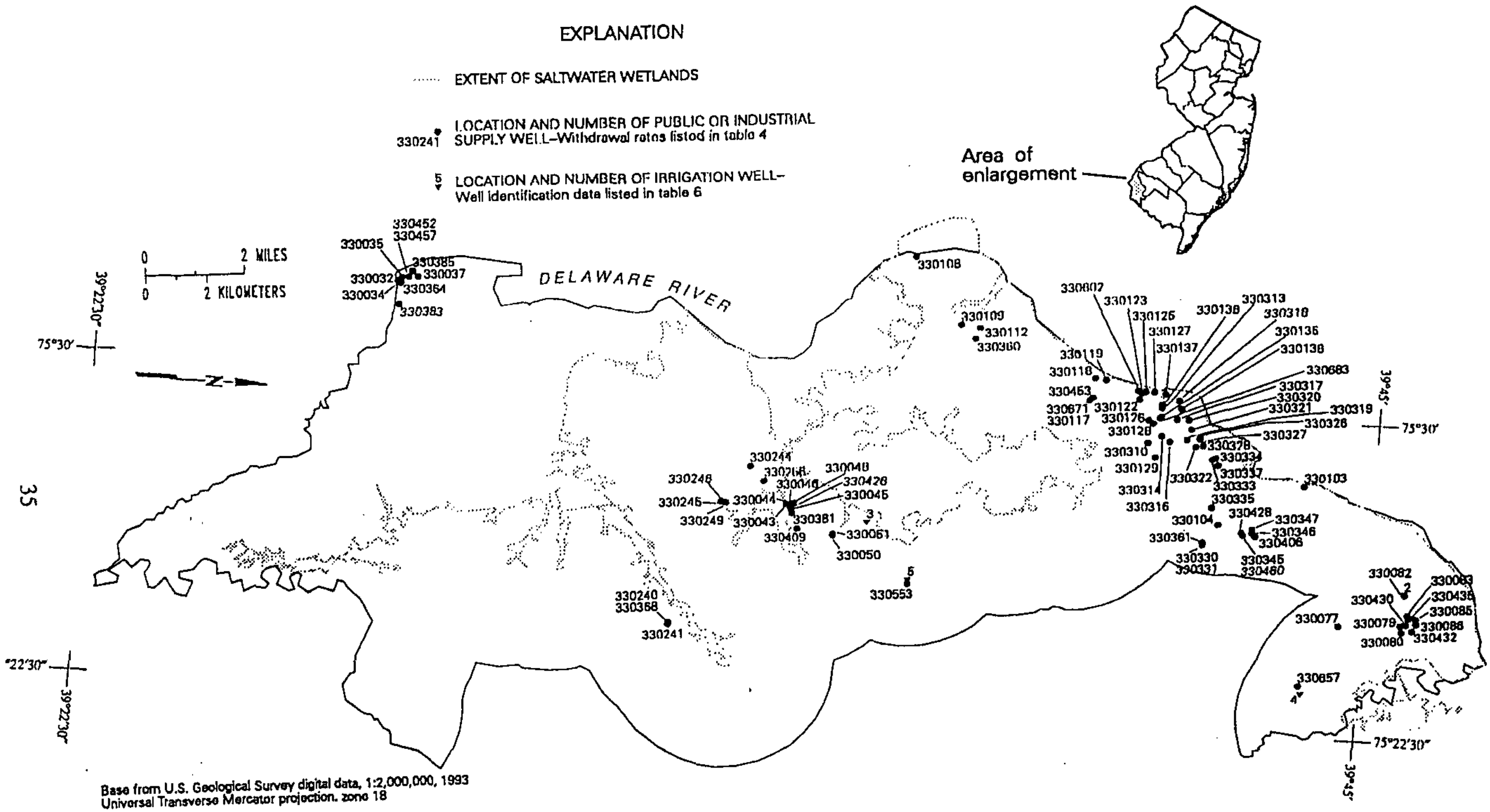


Figure 27. Withdrawal wells in Salem County located within 2 miles of saltwater wetlands or the Delaware River

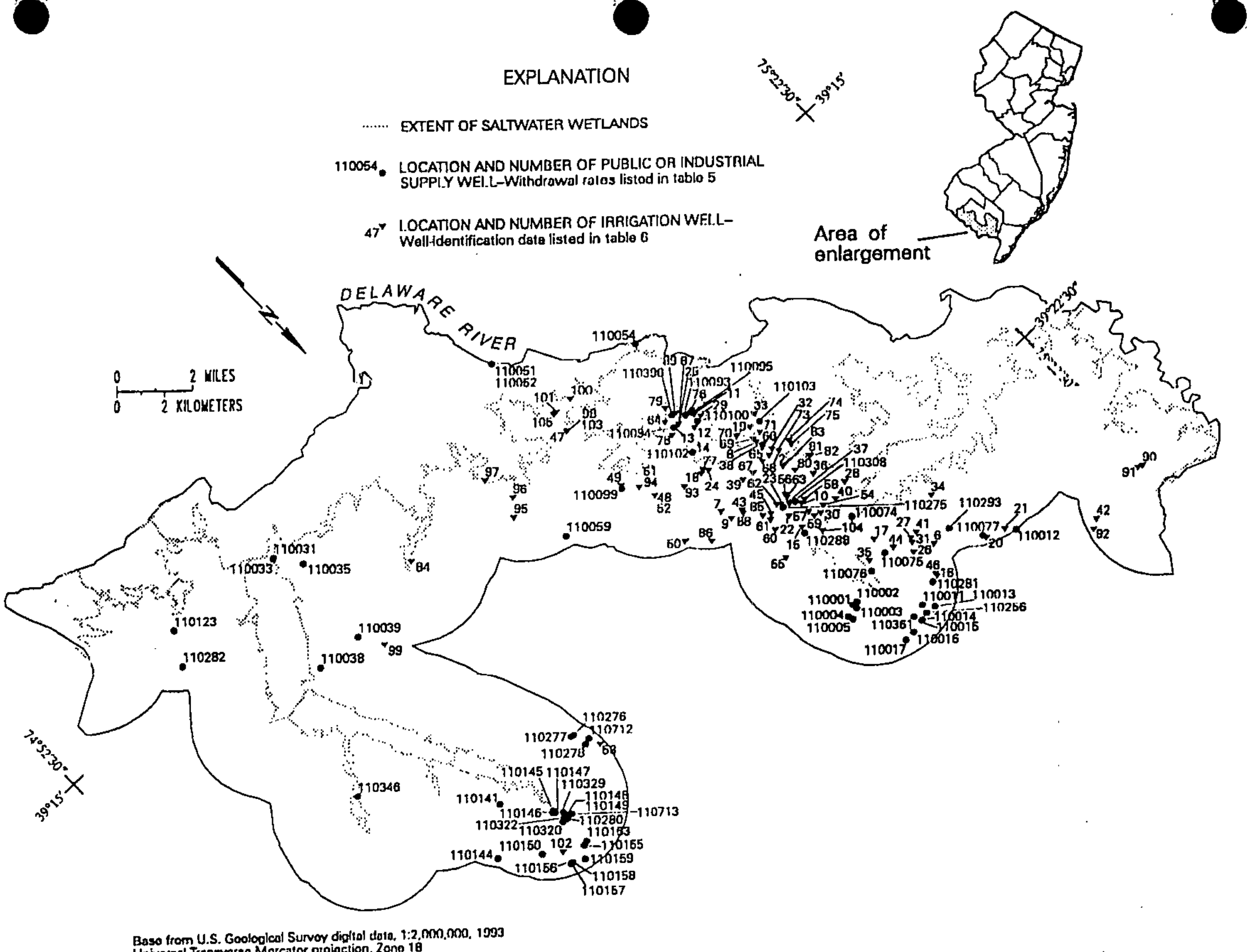


Figure 28. Withdrawal wells in Cumberland County located within 2 miles of saltwater wetlands or the Delaware River.

Agency's (USEPA) secondary drinking-water regulation (U.S. Environmental Protection Agency, 1989) for the recommended maximum concentration of dissolved chloride is 250 mg/L. Because of the relatively high concentration of chloride in seawater compared to the drinking-water standard, it is evident that only a small proportion of seawater could render drinking-water supplies unpotable. The water of Delaware Bay is a mixture of freshwater from the river and saltwater from the Atlantic Ocean; therefore, the dissolved-chloride concentration is lower than that of the ocean. The point in the Bay where the chloride concentration is about one-half that of seawater is in the reach adjacent to Salem and Cumberland Counties (Sharp, 1988, p. 46). The exact location of this point moves continuously and dependents on conditions of tide, wind, and flow of the Delaware River. Upstream from Philadelphia, the dissolved-chloride concentration in the Delaware River is generally less than 20 mg/L (McCarthy and Keighton, 1964, table 7).

The chloride concentration in ground water in the study area can provide the baseline for comparison to future data or prediction of possible future effects of saltwater intrusion, and for comparison to the concentrations in Delaware Bay and the Delaware River outlined above. This information is presented herein by county. Wells in Gloucester County located within 2 miles of saltwater wetlands or the Delaware River for which dissolved-chloride-concentration data is available are shown in figure 29. The wells where the dissolved chloride concentration exceeds the USEPA standard of 250 mg/L are noted on the map. Similarly, wells in Salem County located within 2 miles of saltwater wetlands or the Delaware River for which dissolved-chloride-concentration data are available are shown in figure 30. Wells in Cumberland County located within 2 miles of saltwater wetlands or the Delaware River for which dissolved-chloride-concentration data are available are shown in figure 31. The data on dissolved chloride concentration shown in figures 29, 30, and 31 are tabulated in table 7 (at end of report). This represents the most recent information available from the USGS, New Jersey District, water-quality data base.

Well-Location and -Construction Data

Location and construction information for wells used in this report are presented in table 8 (at end of report). This information was retrieved from the USGS, New Jersey District, Ground-Water Site Inventory data base (GWSI).

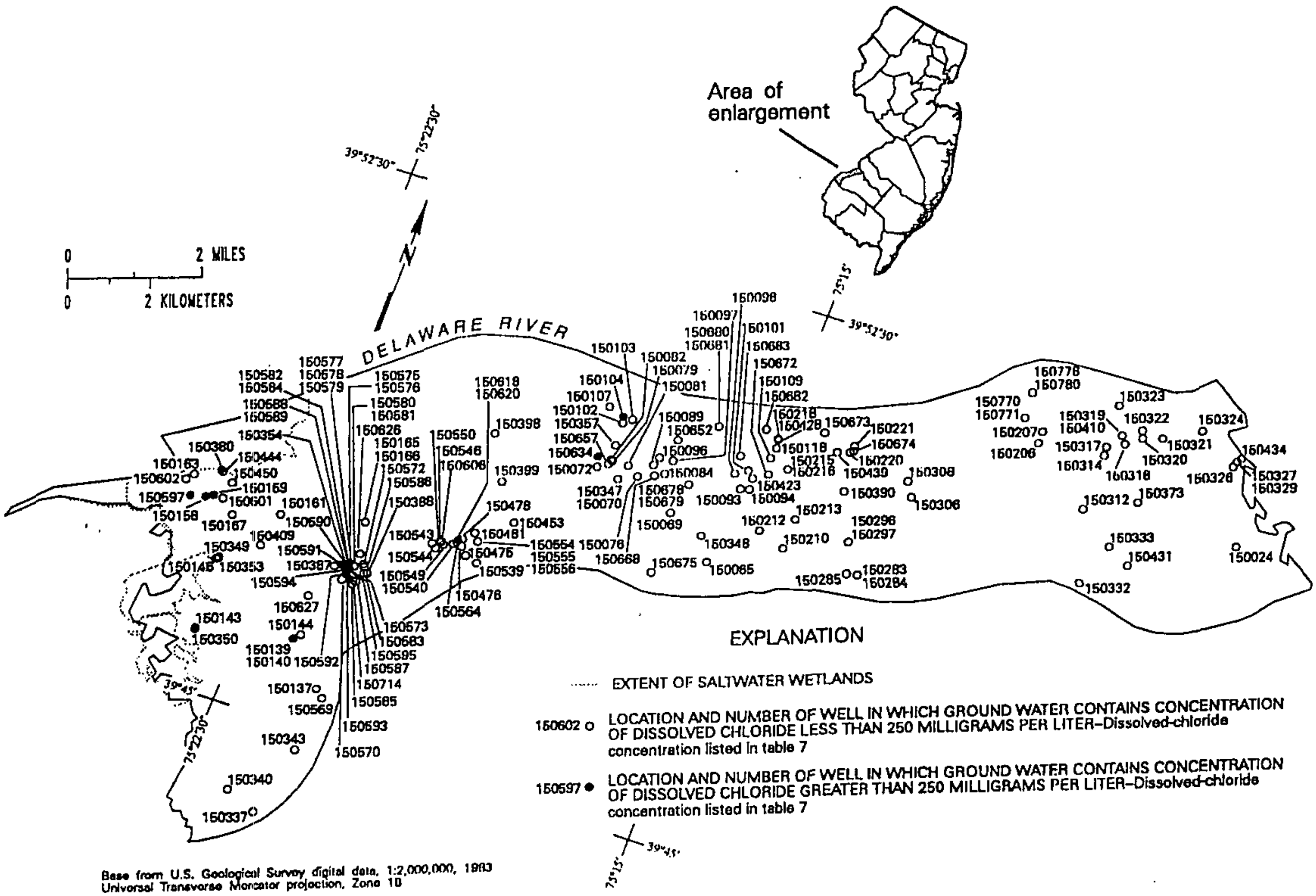
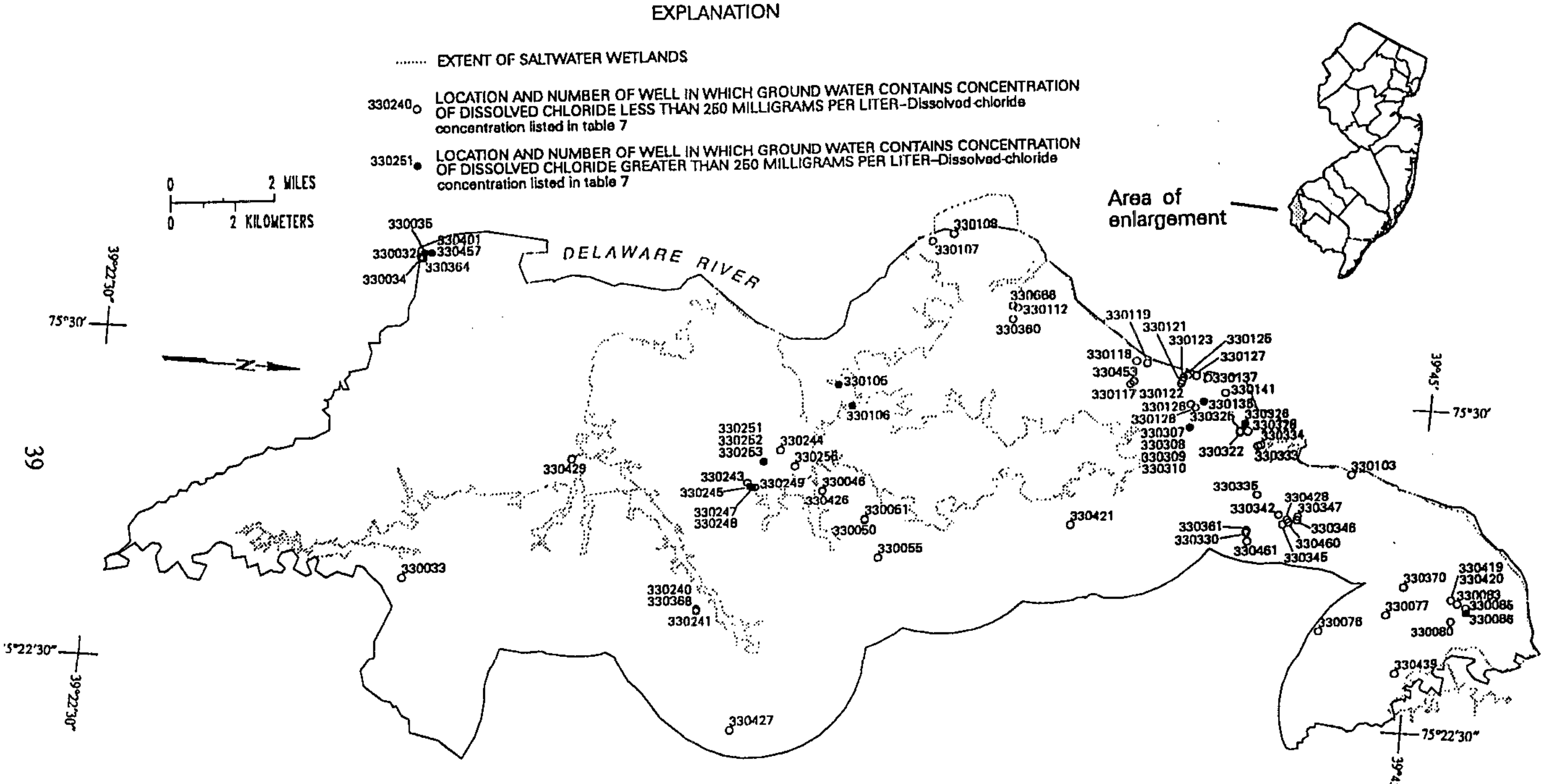


Figure 29. Wells in Gloucester County located within 2 miles of saltwater wetlands or the Delaware River for which dissolved-chloride concentration data are available.



Base from U.S. Geological Survey digital data, 1:2,000,000, 1983
Universal Transverse Mercator projection, Zone 18

Figure 30. Wells in Salem County located within 2 miles of saltwater wetlands or the Delaware River for which dissolved-chloride concentration data are available.

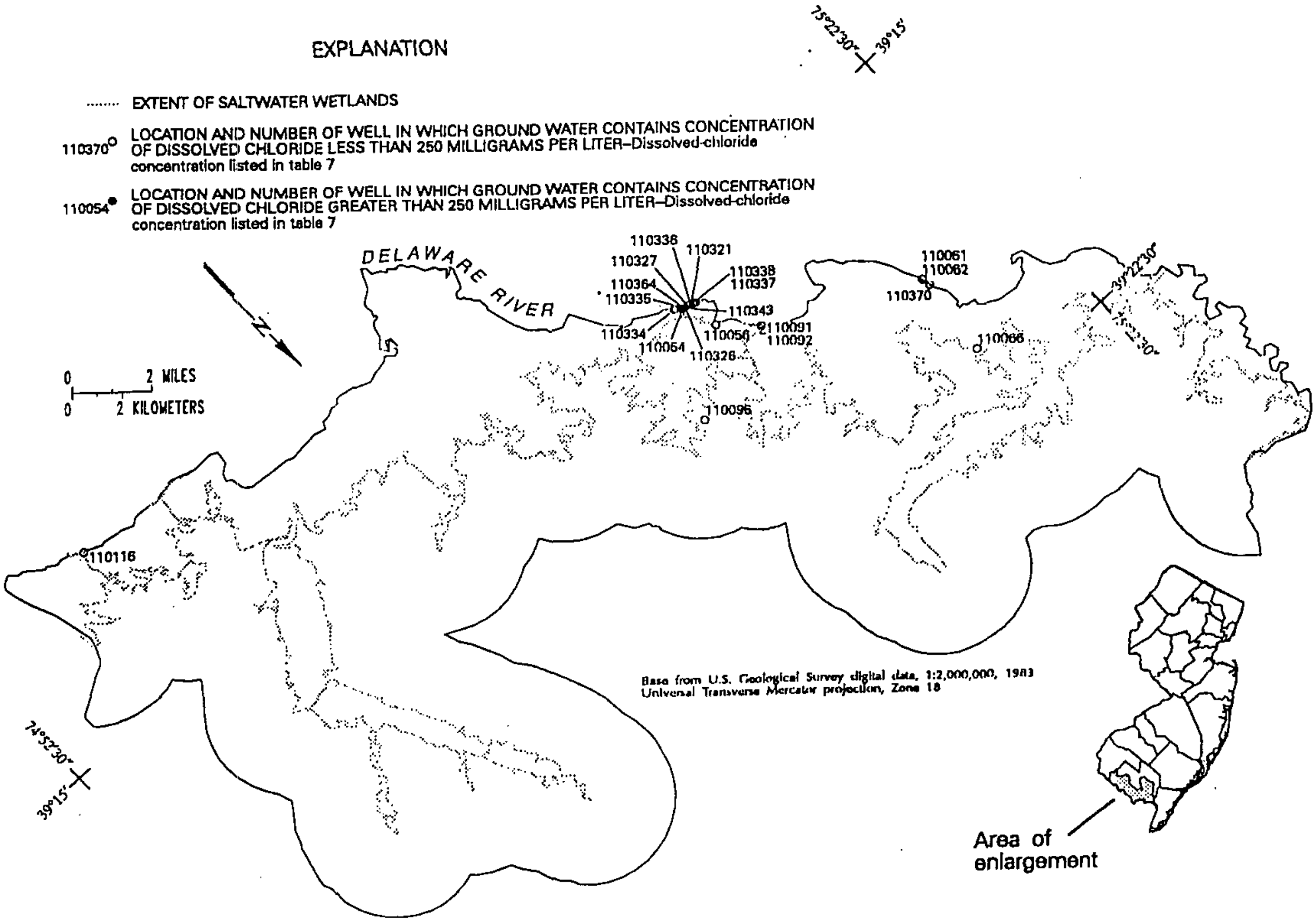


Figure 31. Wells in Cumberland County located within 2 miles of saltwater wetlands or the Delaware River for which dissolved-chloride concentration data are available.

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Table 3. Withdrawal wells in Gloucester County located within 2 miles of saltwater wetlands or the Delaware River

[MRPA, Potomac-Raritan-Magothy aquifer system (undifferentiated); MRPAL, Lower Potomac-Raritan-Magothy aquifer; MRPAM, Middle Potomac-Raritan-Magothy aquifer; MRPAU, Upper Potomac-Raritan-Magothy aquifer; QRNR, Quaternary sands; --, missing information; TWP, Township; BORO, Borough; MUA, Municipal Utilities Authority; WD, Water Department; WC, Water Company; WSC, Water Supply Company; IN, industrial; IR, irrigation; WS, public supply; CO, commercial or company, U, unused; Z, destroyed]

Well Number	Owner	Local Identifier	Aquifer	Use	N.J. Well Permit Number	1992 Withdrawals (Mgal/y)
150024	DEPTFORD TWP MUA	DTMUA 4	MRPAM	WS	31-05513	127.110
150065	GREENWICH TWP WD	GTWD 2(NEW 3)	MRPAU	WS	30-00036	63.802
150069	GREENWICH TWP WD	GTWD 3(NEW 4)	MRPAM	WS	30-00757	101.534
150070	GREENWICH TWP WD	GTWD 1(NEW 2)	MRPAM	U	--	0.000
150072	E I DUPONT	REPAUNO 3	MRPAM	IN	30-00037	13,413.500
150073	E I DUPONT	REPAUNO NITR 3	MRPAM	IN	30-00078	0.000
150076	HERCULES CHEMICAL	4 1970	MRPAM	IN	30-01224	10.647
150078	E I DUPONT	REPAUNO 4	MRPAM	IN	--	0.000
150079	E I DUPONT	REPAUNO 6	MRPAM	IN	30-01145	86.630
150080	E I DUPONT	REPAUNO 2	MRPAM	IN	--	0.000
150081	E I DUPONT	REPAUNO 5	MRPAM	IN	30-00907	0.000
150082	E I DUPONT	REPAUNO 1	MRPAM	IN	--	0.000
150084	HERCULES CHEMICAL	GIBBSTOWN 2	MRPAM	U	30-00231	0.000
150089	HERCULES CHEMICAL	GIBBSTOWN 1	MRPAM	IN	30-00230	0.000
150091	E I DUPONT	REPAUNO W	MRPAL	IN	30-00024	0.000
150092	HERCULES CHEMICAL	GIBBSTOWN TH 6	MRPAM	U	30-00317	0.000
150093	MOBIL OIL CORPORATION	MOBIL 46	MRPAM	IN	30-00049	3,573.268
150094	MOBIL OIL CORPORATION	MOBIL 44	MRPAM	IN	50-00019	0.000
150098	MOBIL OIL CORPORATION	MOBIL 45	MRPAM	IN	50-00020	0.000
150101	MOBIL OIL CORPORATION	MOBIL 40	MRPAL	U	--	0.000
150102	E I DUPONT	REPAUNO 20	MRPAL	IN	--	0.000
150103	E I DUPONT	REPAUNO H	MRPAL	IN	--	0.000
150104	E I DUPONT	REPAUNO J	MRPAL	IN	--	0.000
150106	E I DUPONT	REPAUNO G	MRPA	IN	--	0.000
150109	MOBIL OIL CORPORATION	MOBIL 41	MRPAL	IN	50-00018	0.000
150118	MOBIL OIL CORPORATION	MOBIL 47	MRPAL	IN	30-00198	75.450
150144	PURELAND WC	1-1973	MRPAM	WS	30-01370	85.669
150154	ROLLINS ENVIRONMENTAL	1	MRPAM	U	30-01181	0.000
150158	MONSANTO COMPANY	BRIDGEPORT W2	MRPA	IN	30-00873	207.580
150159	MONSANTO COMPANY	BRIDGEPORT E1	MRPA	IN	30-00872	53.480
150166	PENNS GROVE WSC	BRIDGEPORT 2	MRPAM	WS	30-00410	0.000
150207	NATIONAL PARK BORO WD	NPWD 2	MRPAL	WS	31-02555	71.814
150210	PAULSBORO WD	6-1973	MRPAM	WS	30-01348	292.085
150212	PAULSBORO WD	PWD 4	MRPAM	WS	30-00069	16.926
150213	PAULSBORO WD	PWD 5	MRPAM	WS	30-00602	7.364
150215	PAULSBORO WD	PWD 2	MRPAM	WS	--	0.000

Table 3. Withdrawal wells in Gloucester County located within 2 miles of saltwater wetlands or the Delaware River -- continued

Well Number	Owner	Local Identifier	Aquifer	Use	Well Permit Number	1992 Withdrawals (Mgal/y)
150216	PAULSBORO WD	PWD 3	MRPAM	WS	--	0.000
150218	MOBIL OIL CORPORATION	MOBIL 33	MRPAL	U	--	0.000
150220	ESSEX CHEMICAL CO	OLIN 1	MRPAL	IN	30-00281	0.000
150221	ESSEX CHEMICAL CO	PAULSBORO 1	MRPAL	IN	30-01185	0.000
150304	PENNWALT CORPORATION	418	MRPAL	IN	30-01173	266.680
150306	PENNWALT CORPORATION	417	MRPAL	IN	30-01174	266.680
150312	WEST DEPTFORD WD	6 RED BANK AVE	MRPAL	WS	51-00063	79.219
150313	WEST DEPTFORD WD	WDTWD 2	MRPAL	WS	31-04231	0.000
150314	COASTAL EAGLE POINT OIL	EAGLE POINT 6	MRPAL	IN	31-00029	1,827.560
150317	COASTAL EAGLE POINT OIL	EAGLE POINT 7	MRPAL	IN	31-06834	90.471
150318	COASTAL EAGLE POINT OIL	EAGLE POINT 2	MRPAL	IN	31-00009	0.000
150319	COASTAL EAGLE POINT OIL	EAGLE POINT 4	MRPAL	IN	31-00002	0.000
150320	COASTAL EAGLE POINT OIL	EAGLE POINT 1	MRPAL	IN	31-00007	147.983
150321	COASTAL EAGLE POINT OIL	EAGLE POINT 5	MRPAL	IN	31-00028	0.000
150322	COASTAL EAGLE POINT OIL	EAGLE POINT 3	MRPAL	IN	31-00008	0.000
150326	WESTVILLE BORO WD	WWD 5	MRPAL	WS	31-05689	0.193
150327	WESTVILLE BORO WD	WWD 4	MRPAL	WS	31-03418	1.177
150329	WESTVILLE BORO WD	WWD 1	MRPAU	WS	--	0.000
150333	WOODBURY W D	TATUM 4	MRPAU	U	31-00787	0.000
150347	GREENWICH TWP WD	GTWD 5 (2-A)	MRPAM	WS	30-01545	89.052
150348	GREENWICH TWP WD	GTWD 6	MRPAM	WS	30-01776	63.802
150373	WEST DEPTFORD WD	WDTWD 7	MRPAL	WS	31-17452	241.080
150406	MOBIL OIL CORPORATION	POLLUTE 1	MRPAM	Z	30-01966	0.000
150407	MOBIL OIL CORPORATION	POLLUTE 2	MRPAU	IN	30-01965	33.640
150409	LOGAN TWP MUA	NO-1-1975	MRPAM	WS	30-01448	0.000
150410	COASTAL EAGLE POINT OIL	EAGLE POINT 4A	MRPAL	IN	31-10647	0.000
150411	AIR PRODUCTS & CHEMICALS	NO-1-1978	MRPAL	IN	30-01639	0.000
150416	MOBIL OIL CORPORATION	2-1978	MRPAU	Z	30-01812	0.000
150423	MOBIL OIL CORPORATION	MOBIL 28	MRPAM	U	--	0.000
150428	MOBIL OIL CORPORATION	MOBIL 36	MRPAM	U	--	0.000
150430	COASTAL EAGLE POINT OIL	EAGLE POINT 6A	MRPAL	IN	31-17788	288.890
150434	WESTVILLE BORO WD	WWD 6	MRPAL	WS	31-17923	0.000
150437	POLYREZ COMPANY INC	1R	MRPAU	IN	31-17980	0.000
150439	ESSEX CHEMICAL CO	ESSEX 2	MRPAL	IN	30-01175	0.000
150533	NATIONAL PARK BORO WD	NPWD 6	MRPAL	WS	31-17938	71.814
150548	CHEMICAL LEAMAN	CLDW	MRPAU	IN	30-02504	0.000
150632	HERCULES CHEMICAL	HERCULES PW 6	QRNR	IN	30-03315	0.000
150672	AIR PRODUCTS & CHEMICALS	NORTH WELL	MRPAL	IN	30-01640	0.000
150692	E I DUPONT	INTERCEPTOR 46	MRPAM	IN	30-03594	152.010
150814	MOBIL OIL CORPORATION	RW-12	QRNR	IN	30-02336	37.190
150815	MOBIL OIL CORPORATION	RW-11	QRNR	U	30-02335	0.000

Table 3. Withdrawal wells in Gloucester County located within 2 miles of saltwater wetlands or the Delaware River -- continued

Well Number	Owner	Local Identifier	Aquifer	Use	Well Permit Number	1992 Withdrawals (Mgal/y)
150816	MOBIL OIL CORPORATION	RW-17	QRNR	U	30-02338	0.000
150817	MOBIL OIL CORPORATION	RW-16	QRNR	IN	30-02341	2.376
150818	MOBIL OIL CORPORATION	RW-15	QRNR	IN	30-02339	0.170
150819	MOBIL OIL CORPORATION	RW-14	QRNR	IN	30-02334	21.420
150820	MOBIL OIL CORPORATION	RW-2	QRNR	U	--	0.000
150821	MOBIL OIL CORPORATION	RW-3	QRNR	IN	30-01908	75.450
150822	MOBIL OIL CORPORATION	RW-4	QRNR	IN	30-01910	38.420
150823	MOBIL OIL CORPORATION	RW-5	QRNR	IN	30-01909	30.781
150824	MOBIL OIL CORPORATION	RW-6	QRNR	IN	30-01905	76.659
150825	MOBIL OIL CORPORATION	RW-7	QRNR	U	--	0.000
150826	MOBIL OIL CORPORATION	RW-8	QRNR	IN	30-01906	35.025
150827	MOBIL OIL CORPORATION	RW-9	QRNR	IN	--	33.643
150828	MOBIL OIL CORPORATION	RW-18	QRNR	IN	--	0.860
150832	MOBIL OIL CORPORATION	RW-13	QRNR	U	30-02340	0.000
150833	HERCULES CHEMICAL	PW-10	MRPAM	IN	--	10.647
150834	HERCULES CHEMICAL	PW-9	MRPAM	U	--	0.000
150835	HERCULES CHEMICAL	PW-8B	MRPAM	U	--	0.000
150836	HERCULES CHEMICAL	PW-8	QRNR	U	--	0.000
150837	HERCULES CHEMICAL	PW-7B	MRPAM	IN	--	0.403
150838	HERCULES CHEMICAL	PW-5B	MRPAM	IN	--	6.893
150839	BP OIL COMPANY	RW-3	QRNR	U	30-03430	0.000
150963	POLYREZ COMPANY INC	POLYREZ 1-1971	MRPAM	U	30-01252	.000
151034	HERCULES CHEMICAL	HERCULES PW 11	MRPAM	IN	30-04319	52.040
151061	MOBIL OIL CORPORATION	W-4D	MRPAL	IN	30-03612	0.000
151062	MOBIL OIL CORPORATION	4-C	MRPAL	U	30-03611	0.000

Table 4. Withdrawal wells in Salem County located within 2 miles of saltwater wetlands or the Delaware River

[MRPA, Potomac-Raritan-Magothy aquifer system (undifferentiated); MRPAL, Lower Potomac-Raritan-Magothy aquifer; MRPAM, Middle Potomac-Raritan-Magothy aquifer; MRPAU, Upper Potomac-Raritan-Magothy aquifer; MLRW, Wenonah-Mount Laurel aquifer; VNCN, Vincentown aquifer; --, missing information; WD, Water Department; WC, Water Company; WSC, Water Supply Company; CC, Country Club; GC, Golf Club; SA, Sewer Authority; ST, sewage treatment; IN, industrial; IR, irrigation; WS, public supply; CO, commercial or company; PN, thermo-electric-nuclear; PF, thermoelectric-fossil fuel; U, unused; T, institutional; Z, destroyed; C, commercial]

Well Number	Owner	Local Identifier	Aquifer	Use	N.J. Well Permit Number	1992 Withdrawals (Mgal/y)
330032	PUBLIC SERVICE ELEC & GAS	PW 3	MLRW	IN	34-00758	53.985
330034	PUBLIC SERVICE ELEC & GAS	PW 1	MLRW	IN	34-00737	0.000
330035	PUBLIC SERVICE ELEC & GAS	PW 2	MLRW	IN	34-00757	0.010
330037	PUBLIC SERVICE ELEC & GAS	PW 4	MLRW	U	34-00759	0.000
330043	MANNINGTON MILLS INC	3-1956	MLRW	IN	--	0.000
330044	MANNINGTON MILLS INC	SCHULTES 3	MLRW	IN	30-00735	0.000
330045	MANNINGTON MILLS INC	1-1956	MLRW	IN	--	0.000
330046	MANNINGTON MILLS INC	SCHULTES 2	MLRW	IN	--	0.000
330048	MANNINGTON MILLS INC	2-1956	MLRW	IN	--	0.000
330050	SALEM MEM HOSPITAL	1-1950	MLRW	T	--	0.000
330051	SALEM MEM HOSPITAL	2-1954	MLRW	T	30-00279	0.000
330077	PENNSGROVE WSC	PEDRICKTOWN 11	MRPAM	WS	--	101.760
330079	NOSTRIP CORP	NOSTRIP 1	MRPAM	IN	30-01149	0.000
330080	AIRCO INDUSTRIAL GASES	AIRCO 1	MRPAM	IN	30-00974	0.000
330082	BRIDGE BRUCE	BRIDGE	MRPA	--	30-00660	0.000
330083	B F GOODRICH CO	#9 (PW-1)	MRPAM	IN	--	99.019
330085	B F GOODRICH CO	#6 (PW-2)	MRPAM	IN	30-01141	160.350
330086	B F GOODRICH CO	#4 (PW-3)	MRPAL	IN	30-01139	99.019
330103	PENNSGROVE SA	SA 1	MRPAM	Z	30-00467	0.000
330104	E I DUPONT	RANNEY CP	MRPA	IN	50-00039	0.000
330108	U S ARMY	FINNS POINT	MRPAM	T	30-00052	0.000
330109	GANES CHEMICALS INC	1973-1	MRPAU	IN	30-01322	5.962
330112	TOWNSHIP OF PENNSVILLE	PTWD 4	MRPAU	WS	30-01033	0.000
330117	TOWNSHIP OF PENNSVILLE	PTWD 3	MRPAU	WS	30-00451	0.000
330118	TOWNSHIP OF PENNSVILLE	PTWD 1	MRPAM	WS	50-00041	51.380
330119	TOWNSHIP OF PENNSVILLE	PTWD 2	MRPAM	WS	30-00018	0.000
330122	ATLANTIC CITY ELECTRIC CO	DEEPWATER 3R	MRPAM	IN	30-01234	19.826
330123	ATLANTIC CITY ELECTRIC CO	DEEPWATER 2	MRPAM	IN	50-00001	19.820
330125	ATLANTIC CITY ELECTRIC CO	DEEPWATER 5	MRPAM	IN	30-00151	29.558
330126	E I DUPONT	RANNEY 7	MRPAU	IN	30-01080	0.000
330127	ATLANTIC CITY ELECTRIC CO	DEEPWATER 6	MRPAM	IN	30-00698	0.000
330128	E I DUPONT	RANNEY 6	MRPAU	IN	--	0.000
330129	E I DUPONT	CHAMBERS INJ 1	MRPAM	--	30-01018	0.950
330135	E I DUPONT	RANNEY 5	MRPAU	IN	30-00987	158.130
330136	E I DUPONT	CHAMBERS INJ 2	MRPAL	--	30-01053	0.870
330137	E I DUPONT	DRINKWATER 8	MRPAL	IN	50-00003	0.000
330138	E I DUPONT	CHAMBERS INJ 3	MRPAL	--	30-01049	0.480
330240	CITY OF SALEM WD	SWD 3	VNCN	WS	--	67.457
330241	CITY OF SALEM WD	QUINTON	MLRW	WS	--	0.000

Table 4. Withdrawal wells in Salem County located within 2 miles of saltwater wetlands or the Delaware River -- continued

Well Number	Owner	Local Identifier	Aquifer	Use	N.J. Well Permit Number	1992 Withdrawals (Mgal/y)
330244	CITY OF SALEM WD	SWD 4	MLRW	WS	--	0.000
330245	CITY OF SALEM WD	SCWD 5	MLRW	WS	30-00877	0.000
330246	CITY OF SALEM WD	SWD TW 3	MLRW	WS	30-00822	0.000
330249	CITY OF SALEM WD	SWD 2	MLRW	WS	50-00042	53.860
330256	CITY OF SALEM WD	SWD 1	MLRW	WS	--	0.000
330310	E I DUPONT	RANNEY 4	MRPA	IN	--	0.000
330313	E I DUPONT	107	MRPAM	IN	--	0.000
330314	E I DUPONT	105	MRPAM	IN	30-01273	0.000
330316	E I DUPONT	102	MRPAU	IN	30-02322	196.689
330317	E I DUPONT	LAYNE 2	MRPAM	IN	--	0.480
330318	E I DUPONT	LAYNE 1	MRPAL	IN	--	0.000
330319	E I DUPONT	104	MRPAM	IN	30-01272	0.000
330320	E I DUPONT	LAYNE 3	MRPA	IN	--	0.480
330321	E I DUPONT	103	MRPAM	IN	30-01271	228.120
330322	E I DUPONT	CARNEY PT 2	MRPAM	IN	30-00004	12.232
330326	E I DUPONT	CARNEY PT 4	MRPAU	IN	50-00423	0.000
330327	E I DUPONT	1	MRPA	IN	--	0.000
330328	E I DUPONT	CARNEY PT 1	MRPAM	IN	30-01109	13.720
330330	PENNSGROVE WSC	LAYTON 11	MRPAL	WS	50-00098	0.000
330331	PENNSGROVE WSC	SCHULTES WELL	MRPAM	WS	30-01099	73.690
330333	E I DUPONT	CARNEY PT 5	MRPAU	IN	30-00620	0.000
330334	E I DUPONT	CARNEY PT 6	MRPAM	IN	30-00621	0.000
330335	E I DUPONT	CARNEY PT 7	MRPAL	IN	30-01133	11.625
330337	PENNSGROVE WSC	LAYNE TEST 3	MRPA	WS	30-00524	101.760
330345	PENNSGROVE WSC	PGWSC 2B	MRPAU	WS	50-00102	0.000
330346	PENNSGROVE WSC	LAYNE 1	MRPAL	WS	30-00563	242.845
330347	PENNSGROVE WSC	RANNEY	MRPAU	U	50-00040	0.000
330360	TOWNSHIP OF PENNSVILLE	PTWD 5	MRPAU	WS	28-10466	174.740
330361	PENNSGROVE WSC	SCHULTES 4	MRPAU	WS	30-01815	3.690
330364	PUBLIC SERVICE ELEC & GAS	PW5	MRPAM	IN	34-01031	74.030
330368	CITY OF SALEM WD	QUINTON 5	VNCN	WS	--	0.000
330381	MANNINGTON MILLS INC	MILLS 6	MLRW	IN	30-01505	0.000
330383	PUBLIC SERVICE ELEC & GAS	1-74	MLRW	IN	--	53.985
330385	PUBLIC SERVICE ELEC & GAS	3-74	MRPA	IN	--	9.440
330406	PENNSGROVE WSC	NO-1-1956	MRPAL	WS	30-00563	0.000
330409	MANNINGTON MILLS INC	REPL 1968	MLRW	IN	30-01153	0.000
330426	MANNINGTON MILLS INC	2-1967	MLRW	IN	--	0.000
330428	PENNSGROVE WSC	PGWSC 2A	MRPAU	WS	--	0.000
330430	B F GOODRICH CO	1	MRPA	IN	--	0.000
330432	B F GOODRICH CO	3	MRPAL	IN	30-00079	0.000
330435	B F GOODRICH CO	2	MRPAM	IN	--	.000
330452	PUBLIC SERVICE ELEC & GAS	HOPE CREEK	MRPAM	IN	34-01074	0.000

Table 4. Withdrawal wells in Salem County located within 2 miles of saltwater wetlands or the Delaware River -- continued

Well Number	Owner	Local Identifier	Aquifer	Use	N.J.Well Permit Number	1992 Withdrawals (Mgal/y)
330453	TOWNSHIP OF PENNSVILLE	PTWD 6	MRPA	WS	30-03013	98.290
330457	PUBLIC SERVICE ELEC & GAS	PSEG 6	MRPA	C	--	0.000
330460	PENNSGROVE WSC	PGWSC 1A/RF2A	MRPAU	WS	30-03310	0.000
330553	SALEM FARMS CORP	SALEM FARMS	MLRW	IR	30-03440	18.200
330602	E I DUPONT	CHAMBERS 108	MRPAM	IN	30-03368	163.825
330657	MUSUMECI, ANTHONY	MUSUMECI IRRIG	MRPAM	IR	30-02862	0.000
330671	TOWNSHIP OF PENNSVILLE	PTWD 3A	MRPAU	WS	30-05148	95.298
330683	E I DUPONT	RANNEY 5-R	MRPAU	IN	--	0.000

Table 5. Withdrawal wells in Cumberland County located within 2 miles of saltwater wetlands or the Delaware River

[PNPN, Piney Point aquifer; CKKD, Kirkwood-Cohansey aquifer system; --, missing information; WC, water company; WD, Water Department; WW, water works; IN, industrial; IR, irrigation; MI, mining; WS, public supply; CO, commercial or company; PF, thermoelectric-fossil fuel; T, instutional; U, unused]

Well Number	Owner	Local Identifier	Aquifer	Use	N.J. Well Permit Number	1992 Withdrawals (Mgal/y)
110001	CITY OF BRIDGETON	BWD 7	CKKD	WS	54-00004	0.000
110002	CITY OF BRIDGETON	BWD 2 REP	CKKD	WS	34-00561	41.996
110003	CITY OF BRIDGETON	BWD 6	CKKD	WS	54-00003	0.000
110004	CITY OF BRIDGETON	BWD 9	CKKD	WS	54-00006	15.644
110005	CITY OF BRIDGETON	BWD 8	CKKD	WS	54-00005	1.825
110011	CITY OF BRIDGETON	BWD 4	CKKD	WS	--	0.000
110012	EARNEST FARM	1	CKKD	IR	34-01090	0.000
110013	CITY OF BRIDGETON	BWD 11	CKKD	WS	34-00598	125.921
110014	CITY OF BRIDGETON	BWD 1	CKKD	WS	--	0.000
110015	CITY OF BRIDGETON	1-A	CKKD	WS	34-00769	29.933
110016	MARTIN CORPORATION	MARTIN	CKKD	U	--	0.000
110017	CITY OF BRIDGETON	BWD 5	CKKD	U	--	0.000
110031	CLAMCO CORP	CLAMCO 1	CKKD	IN	35-01239	0.000
110033	CLAMCO CORP	CLAMCO 1973	CKKD	IN	--	0.000
110035	PORT NORRIS ELEMENTARY SCL	BOARD OF ED	CKKD	T	35-00931	0.000
110038	JESSIE S MORIE & SON	J S MORIE 2	CKKD	IN	35-00984	0.000
110039	CAPALDI, PHILIP	1	CKKD	IR	35-00888	0.000
110051	FORTESCUE REALTY CO	FORTESCUE 3	CKKD	WS	35-00149	0.427
110052	FORTESCUE REALTY CO	FORTESCUE 4	CKKD	WS	35-01299	0.000
110054	GANDY BEACH WW	GANDYS BEACH	PNPN	WS	--	0.000
110059	PENNSYLVANIA GLASS SAND CO	2	CKKD	IN	35-01192	41.096
110074	DICKSON, THOMAS	1	CKKD	IR	34-00756	0.000
110075	UHLAND BROS	1	CKKD	IR	34-00722	2.850
110076	SUNNY SLOPE FARM	SUNNYSLOPE 1	CKKD	IR	--	3.360
110077	ERNEST, WILBERT	1	CKKD	IR	34-00891	0.000
110093	CEDARBROOK FARMS	COOK FARM 1	CKKD	IR	34-00041	0.000
110094	CEDARBROOK FARMS	BANKS FARM 1	CKKD	IR	34-00570	0.000
110095	CEDARBROOK FARMS	COOK FARM 2	CKKD	IR	--	0.000
110099	AKERBOOM NURSERIES INC	IRR-1974	CKKD	IR	35-01253	8.266
110100	CEDARBROOK FARMS	HOWELL FARM 1	CKKD	IR	34-00460	0.000
110102	CEDARBROOK FARMS	SHAFFER FARM 1	CKKD	IR	34-00571	0.000
110103	HOLDING, DAVID	IRR-1970	CKKD	IR	34-00792	0.000
110123	N J DEPT OF CORRECTIONS	LEESBURG 3	CKKD	T	--	0.000
110141	MILLVILLE WD	ORANGE ST	CKKD	WS	--	611.670
110144	MILLVILLE WD	TEST 2-67	CKKD	U	35-00953	0.000
110145	ARMSTRONG CORK	CORK 1	CKKD	IN	35-00718	12.058
110146	ARMSTRONG CORK	CORK 3	CKKD	IN	35-00720	12.050
110147	ARMSTRONG CORK	CORK 2	CKKD	IN	35-00719	4.340
110148	MILLVILLE WD	MILLVILLE 13	CKKD	WS	--	0.000
110149	MILLVILLE WD	BRIDGETON PIKE	CKKD	WS	--	0.000

Table 5. Withdrawal wells in Cumberland County located within 2 miles of saltwater wetlands or the Delaware River -- continued

Well Number	Owner	Local Identifier	Aquifer	Use	N.J.Well Permit Number	1992 Withdrawals (Mgal/y)
110150	MILLVILLE BOARD OF ED	BOARD OF ED	CKKD	IN	35-00932	0.000
110153	WHEATON GLASS CO	1970 WELL	CKKD	IN	35-00996	90.112
110155	WHEATON GLASS CO	1970 WELL	CKKD	IN	35-01155	64.971
110156	THE WEST CO	3	CKKD	IN	35-00973	92.509
110157	WHEATON GLASS CO	10	CKKD	IN	35-00977	0.890
110158	THE WEST CO	4	CKKD	IN	35-00986	0.000
110159	WHEATON GLASS CO	11	CKKD	IN	35-00969	116.710
110256	BRIDGETON BOARD OF ED	BBD 1	CKKD	WS	--	0.000
110275	LANING BROS FARMS INC	LANING 1-R	CKKD	IR	34-01344	0.000
110276	MILLVILLE WD	AIRPORT 1	CKKD	WS	55-00056	778.670
110277	MILLVILLE WD	AIRPORT 2	CKKD	WS	55-00057	0.000
110278	MILLVILLE WD	AIRPORT 3	CKKD	WS	35-00862	0.000
110280	MILLVILLE WD	WARE AVE 1	CKKD	WS	35-00841	778.670
110281	CITY OF BRIDGETON	BWD 13	CKKD	WS	34-01194	251.751
110282	N J DEPT OF CORRECTIONS	LEESBURG 4	CKKD	WS	35-00948	0.000
110288	DIX KARL	DIX BROS	CKKD	IR	34-00594	0.000
110293	SUNNY SLOPE FARM	SUNNYSLOPE 3	CKKD	IR	34-01466	0.000
110308	SORATINO JOHN	1-1959	CKKD	IR	34-00436	0.000
110320	MILLVILLE WD	MILLVILLE 16	CKKD	WS	35-02522	0.000
110322	MILLVILLE WD	MILLVILLE 15	CKKD	WS	--	0.000
110329	MILLVILLE WD	MILLVILLE 10A	CKKD	WS	35-00968	0.000
110346	WHITEHEAD BROTHERS	1	CKKD	C	35-03763	33.099
110361	CITY OF BRIDGETON	BWD 16	CKKD	WS	--	189.780
110396	MAPLE RUN FARM	--	CKKD	IR	34-02006	0.000
110712	MILLVILLE CITY	AIRPORT TW 4	CKKD	U	35-12630	0.000
110713	MILLVILLE CITY	OW 13-A REPLACE	CKKD	WS	35-12150	0.000

Table 6. Irrigation wells in Gloucester, Salem, and Cumberland Counties located within 2 miles of saltwater wetlands or the Delaware River

[Irrigation-well information is derived from N.J. Department of Environmental Protection files and is not maintained in USGS Ground-Water Site Inventory records]

Owner	Local Identifier	N.J. Well Permit Number
JOSEPH MAUGERI FARMS	MAUGERI 1	30-00431
BRIDGE, BRUCE	WELL 1	30-00680
MUSUMECI, JOSEPH A	WELL 1	30-01078
WRIGHT, GEORGE B	WELL 1	30-01146
MUSUMECI, ANTHONY	MUSUMECI IRRIG	30-02862
SALEM FARMS CORP	SALEM FARMS 1	30-03440
CARL AYERS ORCHARDS	WELL 1	34-00008
ROMANO, L LEVEL ACRE FARM	WELL #1	34-00051
SHEPPARD, DAVID	SHEPPARD 1	34-00084
ROMANO, LOUIS, JR	WELL 2	34-00086
SORATINO, JOHN	1-1959	34-00436
SHEPPARD FARMS INC	WELL 1	34-00459
CEDARBROOK FARMS	HOWELL FARM 1	34-00460
CEDARBROOK FARMS	BANKS FARM 1	34-00570
CEDARBROOK FARMS	SHAFFER FARM 1	34-00571
DIX, KARL	DIX BROS	34-00594
SUNNY SLOPE FARM	SUNNYSLOPE 1	34-00626
NEWKIRK, RAYMOND	1	34-00668
BAITINGER, FRANK P III	HOLDING 1	34-00677
UHLAND BROS	1	34-00722
SORATINO FARMS INC	WELL 3	34-00747
HOLDINGS, DAVID	IRR-1970	34-00792
EARNEST, WILBERT	1	34-00891
EARNEST FARM	1	34-01090
POPLAR BRAND FARMS INC	WELL 2	34-01331
LANING BROS FARMS INC	LANING 1-R	34-01344
TAYLOR, CLAIR	1	34-01457
SUNNY SLOPE FARM	SUNNYSLOPE 3	34-01466
ADAMUCCI NICK	WELL #2	34-01899
DIX BROS INC	WELL 2	34-01989
MAPLE RUN FARM	MAPLE RUN FARM	34-02006
LANING BROS FARMS INC	WELL 7	34-02007
ADAMUCCI, NICK	WELL #1	34-02022
SHEPPARD FARMS	FARM 2	34-02047
HOLDING, BILL	WELL 2	34-02132
MANETAS FARMS INC	WELL #1	34-02168
NEWKIRK WALTER G	WELL 1	34-02195
BROTTKAMP, GERARD	WELL 1	34-02350
PETO SEED FARM INC	WELL 1	34-02388
DIX BROS INC	WELL 3	34-02541

Table 6. Irrigation wells in Gloucester, Salem, and Cumberland Counties located within 2 miles of saltwater wetlands or the Delaware River -- continued

Owner	Local Identifier	N.J. Well Permit Number
--	--	34-02543
--	--	34-02566
--	--	34-02567
WIDE SKY FARM	WELL 2	34-02608
--	--	34-02615
ADAMUCCI, NICK	WELL #3	34-02747
--	--	34-03150
--	--	34-03166
--	--	34-03364
--	--	34-03419
--	--	34-03428
--	--	34-03537
--	--	34-04223
--	--	34-04287
--	--	35-00392
HESS NURSERIES	WELL	35-01203
AKERBOOM NURSERIES INC	IRR-1974	35-01253
CEDARVILLE COOP MARKETING	WELL 35	35-05768
--	--	35-07088
HESS NURSERIES	NEWPORT-CTR GROV	35-08387
--	--	35-09150
MACCAROM, SAM	WELL 1	50-00097
LANING BROS FARMS INC	WELL 1	54-00026
LANING BROS FARMS INC	WELL 3	54-00027
LANING BROS FARMS INC	WELL 5	54-00028
LANING BROS FARMS INC	WELL 6	54-00029
LANING BROS FARMS INC	WELL 2	54-00030
LANING BROS FARMS INC	WELL 1	54-00031
SORANTINO, J	WELL 3	54-00033
SORANTINO, J	WELL 4	54-00034
SORANTINO, J	WELL 5	54-00035
SORANTINO, J	WELL 6	54-00036
SORANTINO, J	WELL 7	54-00037
BOWMAN, ELMER	WELL 1	54-00038
BOWMAN, ELMER	WELL 2	54-00039
SHEPPARD FARMS	WELL 2	54-00040
SHEPPARD FARMS	WELL 1	54-00041
SHEPPARD FARMS	WELL 3	54-00042
SHEPPARD FARMS	WELL 4	54-00043
SHEPPARD FARMS	--	54-00044
SHEPPARD FARMS	--	54-00045

Table 6. Irrigation wells in Gloucester, Salem, and Cumberland Counties located within 2 miles of saltwater wetlands or the Delaware River -- continued

Owner	Local Identifier	N.J. Well Permit Number
SHEPPARD FARMS	WELL 2	54-00046
SHEPPARD FARMS	WELL 3	54-00047
SHEPPARD FARMS	WELL 4	54-00048
CEDARBROOK FARMS	WELL 1	54-00049
SHEPPARD FARMS	WELL 2	54-00050
SHEPPARD FARMS	WELL 3	54-00051
SHEPPARD FARMS	WELL 4	54-00052
MEADOW BEND FARMS	WELL #1	54-00059
MEADOW BEND FARMS	WELL #2	54-00060
MEADOW BEND FARMS	WELL 3	54-00061
MEADOW BEND FARMS	WELL 4	54-00062
HEADLY, DAN	WELL 1	54-00064
LEVEL ACRE FARM WRIGHT JA	WELL 1	54-00065
TAYLOR CLAIR	WELL #2	54-00066
TAYLOR CLAIR	WELL #3	54-00067
MAPLE RUN FARM ROMANO L	WELL #1	54-00072
MAPLE RUN FARM ROMANO L	WELL #2	54-00073
LOCKEWOOD FARM	WELL 1	54-00074
LOCKEWOOD FARM	WELL 2	54-00075
WIDE SKY TURF FARM	WELL 1	54-00076
COOMBS, GEORGE	WELL 1	55-00092
BOWMAN ELMER	WELL 1	55-00107
NATURAL LANDS TRUST	WELL 1	55-00120
NATURAL LANDS TRUST	WELL 2	55-00121
NATURAL LANDS TRUST	WELL 3	55-00122
CASPER EARL	WELL 1	55-00144
FERRARI, EDWIN	WELL 1	55-00170
VAN BREEMEN FARMS LH	WELL #1	55-00187
VAN BREEMEN FARMS LH	WELL #2	55-00188
ALDERMAN DAVID B	WELL 1	55-00189
STEINHAUER CHAS & PHYLIS	WELL #1	55-00269
BLEW VALLEY FARM	WELL 1	55-00275
HIBBITTS RALPH	WELL	55-00279
--	--	99-99991
--	--	99-99992
--	--	99-99912

Table 7. Dissolved-chloride-concentration data for wells in Gloucester, Salem, and Cumberland Counties located within 2 miles of saltwater wetlands or the Delaware River

[MRPA, Potomac-Raritan-Magothy aquifer system undifferentiated; MRPAU, Upper Potomac-Raritan-Magothy aquifer; MRPAM, MiddlePotomac-Raritan-Magothy aquifer; MRPAL, Lower Potomac-Raritan-Magothy aquifer; PNPN, Piney Point aquifer; KRKDU, upper Kirkwood sand aquifer; MLRW, Wenonah-Mount Laurel aquifer; WBMV, Woodbury-Merchantville confining unit; mg/L, milligrams per liter]

Well Number	Date of Sample	Dissolved-Chloride Concentration (mg/L)	Aquifer
110054	09/11/1992	620	PNPN
110056	09/11/1992	87	PNPN
110061	08/28/1989	66	PNPN
110062	05/08/1975	67	PNPN
110066	03/17/1972	230	MLRW
110091	09/16/1964	72	PNPN
110092	09/01/1988	82	PNPN
110096	09/09/1993	3.6	PNPN
110116	08/07/1979	3.3	KRKDU
110321	08/22/1991	61	PNPN
110326	08/24/1990	300	PNPN
110327	09/11/1992	210	PNPN
110334	09/01/1982	42	PNPN
110335	09/01/1982	47	PNPN
110336	08/28/1989	51	PNPN
110337	09/15/1992	55	PNPN
110338	09/09/1987	58	PNPN
110343	08/24/1990	57	PNPN
110364	09/05/1986	170	PNPN
110370	09/15/1992	200	PNPN
150024	07/12/1985	6	MRPAM
150065	07/13/1967	7.8	MRPAU
150069	11/05/1986	13	MRPAM
150070	08/14/1967	18	MRPAM
150072	11/08/1984	87	MRPAM
150076	11/18/1982	16	MRPAM
150079	09/17/1985	94	MRPAM
150081	10/07/1986	27	MRPAM
150082	08/20/1951	96	MRPAM
150084	08/14/1967	16	MRPAM
150089	08/14/1967	20	MRPAM
150093	07/09/1951	14	MRPAM
150094	07/29/1981	46	MRPAM
150096	12/06/1982	79	MRPAM
150097	10/11/1985	120	MRPAM

Table 7. Dissolved chloride data for wells in Gloucester, Salem, and Cumberland Counties located within 2 miles of saltwater wetlands or the Delaware River -- continued

Well Number	Date of Sample	Dissolved-Chloride Concentration (mg/L)	Aquifer
150098	09/09/1986	79	MRPAM
150101	11/05/1976	180	MRPAL
150102	05/23/1973	140	MRPAL
150103	08/20/1951	180	MRPAL
150104	06/01/1949	320	MRPAL
150107	06/01/1949	54	MRPAL
150109	10/18/1985	92	MRPAL
150118	09/09/1986	110	MRPAL
150137	08/27/1992	26	MRPAM
150139	11/10/1986	820	MRPAL
150140	11/20/1985	33	MRPAM
150143	10/31/1984	7.1	MRPAM
150144	08/08/1991	21	MRPAM
150146	10/01/1980	81	MRPAM
150158	09/08/1983	280	MRPA
150159	09/26/1984	300	MRPA
150161	10/20/1982	7.8	MRPAM
150163	06/04/1984	160	MRPA
150165	09/20/1973	14	MRPAM
150166	09/01/1992	18	MRPAM
150206	08/29/1966	95	MRPAU
150207	09/01/1992	30	MRPAL
150210	09/02/1992	30	MRPAM
150212	10/22/1986	16	MRPAM
150213	10/24/1986	29	MRPAM
150215	07/12/1967	22	MRPAM
150216	07/12/1967	18	MRPAM
150218	08/26/1963	66	MRPAL
150220	10/11/1983	160	MRPAL
150221	10/14/1986	150	MRPAL
150283	08/08/1991	140	MRPAL
150284	09/02/1992	23	MRPAU
150285	08/15/1967	170	MRPAL
150296	10/16/1986	190	MRPAL
150297	10/16/1986	14	MRPAU
150306	11/03/1986	74	MRPAL
150308	09/26/1985	79	MRPAL
150312	12/17/1986	42	MRPAL
150314	09/24/1985	24	MRPAL
150317	09/09/1980	20	MRPAL

Table 7. Dissolved chloride data for wells in Gloucester, Salem, and Cumberland Counties located within 2 miles of saltwater wetlands or the Delaware River -- continued

Well Number	Date of Sample	Dissolved-Chloride Concentration (mg/L)	Aquifer
150318	09/19/1984	29	MRPAL
150319	06/30/1974	28	MRPAL
150320	09/09/1980	25	MRPAL
150321	08/09/1982	16	MRPAL
150322	10/09/1981	32	MRPAL
150323	10/04/1985	38	MRPAL
150324	11/19/1982	21	MRPAL
150326	09/17/1982	12	MRPAL
150327	09/10/1982	11	MRPAL
150329	10/11/1950	12	MRPAU
150332	10/29/1986	31	MRPAU
150333	05/09/1975	18	MRPAU
150337	10/14/1980	2.4	MRPAU
150340	10/20/1980	1.9	MRPAU
150343	05/29/1957	2.6	MRPAU
150347	11/05/1986	18	MRPAM
150348	08/29/1988	13	MRPAM
150349	10/01/1980	110	MRPAL
150350	10/31/1984	380	MRPAL
150353	04/18/1985	67	MRPAU
150354	06/06/1984	25	MRPAM
150357	10/08/1986	96	MRPAL
150373	10/13/1983	27	MRPAL
150380	10/28/1982	340	MRPA
150387	06/07/1984	90	MRPAM
150388	10/09/1986	23	MRPA
150390	09/26/1985	90	MRPAM
150398	11/17/1986	140	MRPAL
150399	09/15/1980	29	MRPAM
150409	10/09/1980	4.5	MRPAM
150410	08/09/1982	30	MRPAL
150423	07/09/1951	38	MRPAM
150428	07/09/1951	23	MRPAM
150431	10/29/1986	21	MRPAM
150434	09/17/1982	11	MRPAL
150439	09/25/1985	130	MRPAL
150444	05/31/1984	70	MRPA
150450	06/01/1984	190	MRPAM
150453	06/06/1986	14	MRPAM
150475	05/17/1984	11	MRPAU

Table 7. Dissolved chloride data for wells in Gloucester, Salem, and Cumberland Counties located within 2 miles of saltwater wetlands or the Delaware River -- continued

Well Number	Date of Sample	Dissolved-Chloride Concentration (mg/L)	Aquifer
150476	05/17/1984	12	MRPAU
150478	05/16/1984	22	MRPAU
150481	05/16/1984	22	MRPAM
150539	05/17/1984	14	MRPAM
150540	12/10/1985	8.9	MRPAM
150543	06/20/1984	37	MRPAU
150544	06/20/1984	29	MRPAU
150546	06/19/1984	57	MRPAU
150549	06/19/1984	160	MRPA
150550	06/19/1984	13	MRPAM
150554	05/18/1984	89	MRPAU
150555	05/18/1984	180	MRPAM
150556	05/18/1984	25	MRPAM
150564	11/25/1986	12	MRPAU
150569	08/25/1989	18	MRPAM
150570	06/08/1984	12	MRPAU
150572	06/13/1984	32	MRPAU
150573	06/07/1984	2.3	MRPAU
150575	10/09/1986	30	MRPAM
150576	06/11/1984	21	MRPAU
150577	06/12/1984	55	MRPAM
150578	06/12/1984	23	MRPAU
150579	06/12/1984	55	MRPAU
150580	06/11/1984	21	MRPAM
150581	06/11/1984	33	MRPAU
150582	06/15/1984	1,100	MRPA
150583	06/15/1984	820	MRPAU
150584	06/15/1984	210	MRPAU
150585	06/06/1984	24	MRPAM
150586	06/06/1984	16	MRPAM
150587	06/08/1984	7.4	MRPAU
150588	06/14/1984	560	MRPAM
150589	06/14/1984	180	MRPAU
150590	06/14/1984	450	MRPAU
150591	06/13/1984	2,000	MRPAU
150592	06/13/1984	2,100	MRPAU
150593	06/12/1984	530	MRPAU
150594	06/13/1984	420	MRPAU
150595	06/14/1984	220	MRPAU
150597	05/31/1984	350	MRPA

Table 7. Dissolved chloride data for wells in Gloucester, Salem, and Cumberland Counties located within 2 miles of saltwater wetlands or the Delaware River -- continued

Well Number	Date of Sample	Dissolved-Chloride Concentration (mg/L)	Aquifer
150601	05/29/1984	150	MRPAM
150602	06/04/1984	220	MRPA
150606	06/20/1984	72	MRPAU
150615	12/02/1986	790	MRPAL
150617	12/03/1986	11	MRPAU
150618	11/24/1986	400	MRPAL
150620	11/25/1986	4.3	MRPAM
150626	12/05/1986	14	MRPAU
150627	10/06/1986	77	MRPAU
150634	10/08/1986	520	MRPAL
150652	10/28/1986	61	MRPAM
150657	10/07/1986	24	MRPAM
150668	10/28/1986	68	MRPAM
150672	10/30/1986	150	MRPAL
150673	10/23/1986	170	MRPAU
150674	10/14/1986	60	MRPAU
150675	10/17/1986	140	WBMV
150678	09/23/1986	130	MRPAL
150679	09/23/1986	120	MRPAM
150680	09/22/1986	71	MRPAL
150681	09/22/1986	53	MRPAM
150682	11/14/1986	22	MRPAM
150683	11/14/1986	65	MRPAM
150714	12/01/1986	14	MRPAU
150770	08/25/1987	30	MRPAL
150771	07/16/1987	20	MRPAM
150778	08/28/1987	36	MRPAL
150780	08/27/1987	34	MRPAM
330032	08/15/1991	32	MLRW
330033	11/07/1984	42	MLRW
330034	11/07/1984	88	MLRW
330035	08/23/1990	460	MLRW
330046	06/11/1964	8	MLRW
330050	08/29/1974	26	MLRW
330051	04/12/1960	10	MLRW
330055	07/21/1959	33	MLRW
330065	05/01/1967	18	MRPAM
330066	05/01/1967	17	MRPAM
330076	10/20/1980	4.3	MRPAU
330077	02/16/1968	4.5	MRPAM

Table 7. Dissolved chloride data for wells in Gloucester, Salem, and Cumberland Counties located within 2 miles of saltwater wetlands or the Delaware River -- continued

Well Number	Date of Sample	Dissolved-Chloride Concentration (mg/L)	Aquifer
330080	10/03/1980	5.2	MRPAM
330083	09/09/1992	51	MRPAM
330085	09/09/1992	36	MRPAM
330086	09/09/1992	270	MRPAL
330103	09/22/1980	8.8	MRPAM
330105	08/25/1958	440	MRPAU
330106	10/10/1980	460	MRPAM
330107	10/05/1978	91	MRPAM
330108	09/10/1992	110	MRPAM
330112	08/14/1991	14	MRPAU
330117	09/19/1985	19	MRPAU
330118	09/09/1992	64	MRPAM
330119	09/09/1992	87	MRPAM
330121	09/21/1973	44	MRPAM
330122	09/10/1992	73	MRPAM
330123	09/10/1992	130	MRPAM
330125	09/10/1992	76	MRPAM
330126	10/21/1980	13	MRPAU
330127	09/25/1986	69	MRPAM
330128	12/07/1967	56	MRPAU
330135	01/19/1968	630	MRPAU
330137	08/17/1988	76	MRPAL
330141	08/23/1990	140	MRPAM
330241	08/17/1979	10	MLRW
330243	11/18/1965	4	MLRW
330244	05/19/1964	100	MLRW
330245	10/04/1974	45	MLRW
330247	08/31/1965	350	MLRL
330249	09/27/1977	26	MLRW
330251	11/22/1982	1,900	MRPAM
330252	07/26/1993	86	MLRW
330253	09/24/1993	670	MRPAU
330256	12/21/1950	6.6	MLRW
330299	05/01/1967	180	MRPAM
330300	05/01/1967	42	MRPAM
330302	05/01/1967	42	MRPAM
330304	05/01/1967	30	MRPAM
330307	12/07/1967	180	MRPAU
330308	12/07/1967	84	MRPAL
330309	12/07/1967	20	MRPAU

Table 7. Dissolved chloride data for wells in Gloucester, Salem, and Cumberland Counties located within 2 miles of saltwater wetlands or the Delaware River -- continued

Well Number	Date of Sample	Dissolved-Chloride Concentration (mg/L)	Aquifer
330310	12/07/1967	290	MRPA
330322	11/16/1982	58	MRPAM
330325	02/16/1968	180	MRPAU
330326	02/16/1968	280	MRPAU
330328	02/16/1968	190	MRPAM
330330	02/16/1968	240	MRPAL
330333	02/16/1968	21	MRPAU
330334	02/16/1968	73	MRPAM
330335	02/16/1968	100	MRPAL
330342	05/06/1976	10	MRPAU
330345	09/09/1992	13	MRPAU
330346	09/09/1992	220	MRPAL
330347	01/11/1951	9.4	MRPAU
330360	07/25/1986	7.2	MRPAU
330361	09/23/1980	19	MRPAU
330364	09/10/1992	25	MRPAM
330370	07/17/1986	8.7	MRPAU
330401	09/09/1980	300	MRPA
330419	11/21/1980	6.2	MRPAM
330420	11/21/1980	7.4	MRPAM
330421	11/20/1980	35	MRPAM
330426	09/29/1981	17	MLRW
330428	08/14/1991	15	MRPAU
330439	07/25/1986	27	MRPAU
330453	08/22/1990	36	MRPA
330457	09/10/1992	200	MRPA
330460	08/14/1991	16	MRPAU
330461	07/17/1986	13	MRPA
330686	09/09/1992	11	MRPAU

Table 8. Well-location and construction data

[MRPA, Potomac-Raritan-Magothy aquifer system (undifferentiated); MRPAL, Lower Potomac-Raritan-Magothy aquifer system; MRPAM, Middle Potomac-Raritan-Magothy aquifer system; MRPAU, Upper Potomac-Raritan-Magothy aquifer system; WBMV, Woodbury-Merchantville confining unit; MLRW, Wenonah-Mount Laurel aquifer; PNPN, Piney Point aquifer; VNCN, Vincentown aquifer; KRKDU, upper Kirkwood sand; CKKD, Kirkwood-Cohansey aquifer system; QRNR, Quaternary sands; n/a, not applicable; --, missing information; DMS, degrees, minutes, seconds; BD OF BD, Board of Education; CO, Company or County; FD, Fire Department; SA, Sewer Authority; TWD, Township Water Department; MUA, Municipal Utilities Authority; WD, Water Department; WC, Water Company; WCM, Water Commission; TSA, Township Sewer Authority; WSC, water-spply company; INST, institute; ft asl, feet above sea level; ft bls, feet below land surface]

Well Number	Lati-tude	Longi-tude	Owner	Local Identifier	Land-Surface Elevation (ft asl)	Depth of Well (ft bls)	Aquifer	Depth to top of Well Opening (ft bls)	Depth to Bottom of Well Opening (ft bls)	N.J. Well Permit Number
110001	392430	751305	BRIDGETON WD	BWD 7	25.	84.	CKKD	64.	84.	54-00004
110002	392432	751312	BRIDGETON WD	BWD 2 REP	30.	98.	CKKD	72.	98.	34-00561
110003	392437	751305	BRIDGETON WD	BWD 6	43.	104.	CKKD	84.	104.	54-00003
110004	392439	751243	BRIDGETON WD	BWD 9	35.	103.	CKKD	78.	103.	54-00006
110005	392446	751245	BRIDGETON WD	BWD 8	48.	91.	CKKD	71.	91.	54-00005
110011	392538	751435	BRIDGETON WD	BWD 4	53.	92.	CKKD	77.	92.	--
110012	392548	751813	WILBERT, EARNEST	1	100.	125.	CKKD	85.	125.	34-01090
110013	392552	751450	BRIDGETON WD	BWD 11	65.	117.	CKKD	76.	117.	34-00598
110014	392555	751414	BRIDGETON WD	BWD 1	7.	70.	CKKD	50.	70.	--
110015	392555	751415	BRIDGETON WD	1-A	18.	77.	CKKD	57.	77.	34-00769
110016	392600	751348	MARTIN CORP	MARTIN	55.	114.	CKKD	94.	114.	--
110017	392601	751328	BRIDGETON WD	BWD 5	32.	87.	CKKD	67.	87.	--
110031	391415	750134	CLAMCO CO	CLAMCO 1	15.	237.	CKKD	217.	237.	35-01239
110033	391416	750132	CLAMCO CO	CLAMCO 1973	5.	237.	CKKD	217.	237.	--
110035	391450	750205	PORT NORRIS BD OF ED	BOARD OF EDUC	10.	242.	CKKD	227.	242.	35-00931
110038	391658	750015	J S MORIE INC	J S MORIE 2	10.	205.	CKKD	175.	205.	35-00984
110039	391702	750141	CAPALDI, PHILIP	1	30.	238.	CKKD	178.	238.	35-00888
110051	391420	751023	FORTESCU REALTY	FORTESCUE 3	8.	303.	CKKD	283.	303.	35-00149
110052	391420	751023	FORTESCU REALTY	FORTESCUE 4	8.	303.	CKKD	283.	303.	35-01299
110054	391618	751354	GANDYS BEACH WC	GANDYS BEACH	5.	402.	PNPN	378.	402.	--
110056	391704	751415	MONEY IS MARINA	POLLINO 1	4.	370.	PNPN	350.	370.	--
110059	391837	750821	PA GLASS SAND	2	55.	82.	CKKD	52.	82.	35-01192
110061	391926	751921	GRIFFITH, MAE	SEA BREEZE	4.	354.	PNPN	281.	354.	34-01191
110062	391926	751920	GRIFFITH, MAE	SEA BREEZE TAV	4.	287.	PNPN	--	--	--
110066	392124	751904	NJ FISH GAME	HOLTON FARMS	7.	310.	MLRW	--	--	--

Table 8. Well-location and -construction data -- continued

Well Number	Lati-tude	Longi-tude	Owner	Local Identifier	Land-Surface Elevation (ft asl)	Depth of Well (ft bls)	Aquifer	Depth to top of Well Opening (ft bls)	Depth to Bottom of Well Opening (ft bls)	N.J. Well Permit Number
110158	392432	750133	WEST CO	4	40.	147.	CKKD	92.	147.	35-00986
110159	392440	750153	WHEATON GLASS CO	11	40.	150.	CKKD	120.	150.	35-00969
110256	392551	751430	BRIDGETON BD OF ED	BBD 1	50.	90.	CKKD	--	--	34-01240
110275	392138	751338	LANING BROTHERS	LANING 1-R	30.	150.	CKKD	--	--	34-01344
110276	392217	750417	MILLVILLE WD	AIRPORT 1	70.	181.	CKKD	179.	181.	55-00056
110277	392216	750412	MILLVILLE WD	AIRPORT 2	75.	170.	CKKD	168.	170.	55-00057
110278	392238	750420	MILLVILLE WD	AIRPORT 3	70.	191.	CKKD	161.	191.	35-00862
110280	392341	750222	MILLVILLE WD	WARE AVE 1	20.	167.	CKKD	147.	167.	35-00841
110281	392523	751519	BRIDGETON WD	BWD 13	75.	146.	CKKD	86.	146.	34-01194
110282	391420	745750	STATE OF NJ	LEESBURG 4(OUR	12.	269.	CKKD	249.	269.	35-00948
110288	392227	751334	DIX, KARL	DIX BROS	30.	151.	CKKD	115.	151.	34-00594
110293	392442	751648	SUNNYSLOPE FARM	SUNNYSLOPE 3	95.	140.	CKKD	70.	140.	34-01466
110308	392144	751401	SORANTINO, JOHN	1-1959	20.	--	CKKD	--	--	34-00436
110320	392340	750212	MILLVILLE WD	MILLVILLE 16	30.	106.	CKKD	86.	106.	35-02522
110321	391620	751410	GONDOLF, RICHARD	1	5.	425.	PNPN	405.	425.	34-00754
110322	392337	750218	MILLVILLE WD	MILLVILLE 15	9.	110.	CKKD	--	--	--
110326	391617	751355	STANGER, GEORGE	1	5.	440.	PNPN	--	--	--
110327	391619	751357	MYERS, H	1	5.	409.	PNPN	399.	409.	35-01270
110329	392330	750225	MILLVILLE WD	MILLVILLE 10A	40.	102.	CKKD	82.	102.	35-00968
110334	391611	751343	WEISGERBER, FRANK	1	5.	420.	PNPN	400.	420.	34-01727
110335	391612	751346	MOOTZ, CHARLES	1	5.	--	PNPN	--	--	--
110336	391620	751406	ROSSI, EDWARD	1	5.	400.	PNPN	--	--	--
110337	391622	751414	COVE RD WATER ASSOC	1	5.	393.	PNPN	373.	393.	34-01193
110338	391623	751418	MAZZOLA, JOSEPH	1	5.	--	PNPN	--	--	--
110343	391619	751405	NEIL, A	1	5.	459.	PNPN	--	--	--
110346	391950	745819	WHITEHEAD BROS	1	10.	104.	CKKD	84.	104.	35-03763
110361	392538	751434	BRIDGETON WD	16	53.	90.	CKKD	75.	90.	34-01945
110364	391617	751355	DURR, MADELYN	DOMESTIC-1985	5.	420.	PNPN	400.	420.	34-02333

Table 8. Well-location and -construction data -- continued

Well Number	Lati-tude	Longi-tude	Owner	Local Identifier	Land-Surface Elevation (ft asl)	Depth of Well (ft bls)	Aquifer	Depth to top of Well Opening (ft bls)	Depth to Bottom of Well Opening (ft bls)	N.J. Well Permit Number
110370	391938	751923	SOBUSIAK, WALTER	SOBUSIAK 1	5.	350.	PNPN	--	--	--
110396	391810	751311	MAPLE RUN FARMS	MAPLE RUN FARM	8.	70.	CKKD	30.	70.	34-02006
110712	392235	750432	MILLVILLE CITY	AIRPORT TW 4	75.	222.	CKKD	162.	217.	35-12630
110713	392340	750233	MILLVILLE CITY	WARE AVE OW 13-A	63.	288.	CKKD	252.	288.	35-12150
150024	395115	750706	DEPTFORD T MUA	DTMUA 4	40.	345.	MRPAM	282.	345.	31-05513
150065	394851	751526	GREENWICH TWD	GTWD 2(NEW 3)	20.	98.	MRPAU	69.	98.	30-00036
150069	394920	751619	GREENWICH TWD	GTWD 3(NEW 4)	10.	168.	MRPAM	108.	168.	30-00757
150070	394932	751722	GREENWICH TWD	5/GTWD 1 (NEW 2)	10.	96.	MRPAM	76.	96.	--
150072	394936	751747	E I DUPONT	REPAUNO 3	6.	101.	MRPAM	91.	101.	30-00037
150073	394936	751747	E I DUPONT	REPAUNO NITR 3	0.	87.	MRPAM	67.	87.	30-00078
150076	394939	751704	HERCULES CHEMICAL	4 1970	15.	120.	MRPAM	90.5	120.	30-01224
150078	394944	751711	E I DUPONT	REPAUNO 4	9.	99.	MRPAM	81.	99.	--
150079	394944	751734	E I DUPONT	REPAUNO 6	10.	109.	MRPAM	84.	109.	30-01145
150080	394944	751735	E I DUPONT	REPAUNO 2	11.	105.	MRPAM	89.	105.	--
150081	394945	751717	E I DUPONT	REPAUNO 5	10.	99.	MRPAM	81.	99.	30-00907
150082	394945	751736	E I DUPONT	REPAUNO 1	10.	105.	MRPAM	75.	105.	--
150084	394948	751639	HERCULES CHEMICAL	GIBBSTOWN 2	12.	146.	MRPAM	121.	146.	30-00231
150089	394952	751653	HERCULES CHEMICAL	GIBBSTOWN 1	10.	103.	MRPAM	77.5	97.5	30-00230
150091	394952	751730	E I DUPONT	REPAUNO W	10.	103.	MRPAL	84.	103.	30-00024
150092	394954	751642	HERCULES CHEMICAL	GIBBSTOWN TH 6	4.	112.	MRPAM	107.	113.	30-00317
150093	394956	751521	MOBIL OIL COMPANY	MOBIL 46	6.	136.	MRPAM	111.	136.	30-00049
150094	394958	751512	MOBIL OIL COMPANY	MOBIL 44	7.	136.	MRPAM	116.	136.	50-00019
150096	394959	751650	HERCULES CHEMICAL	GIBBSTOWN OB 2	14.18	134.	MRPAM	129.	134.	30-00188
150097	395000	751636	HERCULES CHEMICAL	GIBBSTOWN TH8/TW8	5.61	107.	MRPAM	102.	107.	30-00315
150098	395006	751532	MOBIL OIL COMPANY	MOBIL 45	3.	118.	MRPAM	95.	115.	50-00020
150101	395012	751520	MOBIL OIL COMPANY	MOBIL 40	20.	225.	MRPAL	195.	225.	--
150102	395016	751738	E I DUPONT	REPAUNO 20	3.	103.	MRPAL	73.	103.	--
150103	395021	751730	E I DUPONT	REPAUNO 11	2.	103.	MRPAL	83.	103.	--

Table 8. Well-location and -construction data -- continued

Well Number	Lati-tude	Longi-tude	Owner	Local Identifier	Land-Surface Elevation (ft asl)	Depth of Well (ft bls)	Aquifer	Depth to top of Well Opening (ft bls)	Depth to Bottom of Well Opening (ft bls)	N.J. Well Permit Number
150104	395021	751740	E I DUPONT	REPAUNO J	2.	103.	MRPAL	74.	103.	--
150106	395022	751729	E I DUPONT	REPAUNO G	2.	107.	MRPA	87.	107.	--
150107	395025	751757	E I DUPONT	REPAUNO C	2.	105.	MRPAL	75.	105.	--
150109	395027	751503	MOBIL OIL COMPANY	MOBIL 41	20.	260.	MRPAL	229.	259.	50-00018
150118	395036	751501	MOBIL OIL COMPANY	MOBIL 47	18.	240.	MRPAL	220.	240.	30-00198
150132	394500	751349	VASALLI, JOSEPH	VASALLI 1	85.	385.	MRPA	355.	385.	30-01258
150137	394535	752054	PURELAND WC	PURE 2(3-1973)	29.	208.	MRPAM	158.	208.	30-01371
150139	394608	752135	PURELAND WC	TEST WELL 3	7.	345.	MRPAL	301.	345.	30-01223
150140	394608	752135	PURELAND WC	TEST WELL 4	6.1	184.	MRPAM	132.	184.	30-01248
150143	394551	752313	PURELAND WC	LANDTECT TW-6C	19.4	152.	MRPAM	102.	152.	30-01312
150144	394613	752129	PURELAND WC	1-1973	7.6	138.	MRPAM	81.	136.	30-01370
150146	394648	752318	PURELAND WC	LANDTECT TW-9	4.8	101.	MRPAM	82.	101.	--
150154	394716	752113	ROLLINS ENV SERVICES	1	10.	96.	MRPAM	66.	96.	30-01181
150158	394733	752351	MONSANTO CHEM	BRIDGEPORT W2	12.	82.	MRPA	57.	82.	30-00873
150159	394736	752344	MONSANTO CHEM	BRIDGEPORT E1	11.	81.	MRPA	56.	81.	30-00872
150161	394739	752232	MONSANTO CHEM	OB1(TW5-OBC)	8.	90.	MRPAM	70.	90.	30-00801
150163	394747	752410	MONSANTO CHEM	OB3(TW1-OBA)	10.1	100.	MRPA	95.	100.	30-00795
150165	394755	752108	PENNS GROVE WSC	BRIDGEPORT 1	5.	41.	MRPAM	30.5	40.5	--
150166	394755	752108	PENNS GROVE WSC	BRIDGEPORT 2	5.	88.	MRPAM	65.4	85.4	30-00410
150206	395146	751053	NATIONAL PARK WD	NPWD 1	10.	85.	MRPAU	64.	85.	--
150207	395156	751053	NATIONAL PARK WD	NPWD 2	30.	282.	MRPAL	241.	282.	31-02555
150210	394921	751417	PAULSBORO WD	6-1973	15.	230.	MRPAM	185.	227.	30-01348
150212	394929	751447	PAULSBORO WD	PWD 4	25.	220.	MRPAM	192.	220.	30-00069
150213	394947	751416	PAULSBORO WD	PWD 5	10.	175.	MRPAM	135.	175.	30-00602
150215	395023	751442	PAULSBORO WD	PWD 2	16.	100.	MRPAM	70.	100.	--
150216	395023	751442	PAULSBORO WD	PWD 3	16.	140.	MRPAM	115.	140.	--
150218	395044	751503	MOBIL OIL COMPANY	MOBIL 33	20.	236.	MRPAL	169.	236.	--

Table 8. Well-location and -construction data -- continued

Well Number	Lati-tude	Longi-tude	Owner	Local Identifier	Land-Surface Elevation (ft asl)	Depth of Well (ft bls)	Aquifer	Depth to top of Well Opening (ft bls)	Depth to Bottom of Well Opening (ft bls)	N.J. Well Permit Number
150220	395051	751349	ESSEX CHEMICAL CO	OLIN 1	10.	256.	MRPAL	234.	256.	30-00281
150221	395057	751347	ESSEX CHEMICAL CO	PAULSBORO 1	10.	286.	MRPAL	258.	286.	30-01185
150283	394919	751256	HUNTSMAN POLYP CORP	SHELL 3	30.	384.	MRPAL	358.	383.	30-00900
150284	394919	751256	HUNTSMAN POLYP CORP	SHELL 4	30.	159.	MRPAU	127.	157.	30-00901
150285	394917	751307	HUNTSMAN POLYP CORP	SHELL 1	12.	360.	MRPAL	328.	358.	30-00898
150296	394942	751317	HUNTSMAN POLYP CORP	SHELL 5 OBS	20.76	327.	MRPAL	321.	326.	30-00902
150297	394942	751317	HUNTSMAN POLYP CORP	SHELL 6 OBS	20.5	120.	MRPAU	113.	118.	30-00903
150304	395032	751241	PENNWALT CORP	418	10.	290.	MRPAL	237.	289.	30-01173
150306	395033	751233	PENNWALT CORP	417	10.	278.	MRPAL	234.	276.	30-01174
150308	395044	751242	PENNWALT CORP	TEST WELL 8	10.	271.	MRPAL	231.	271.	--
150312	395107	750946	W DEPTFORD TWD	6 RED BANK AVE	20.	372.	MRPAL	322.	372.	51-00063
150313	395139	750949	W DEPTFORD TWD	WDTWD 2	23.	353.	MRPAL	307.	353.	31-04231
150314	395153	750946	COASTAL EAGLE PT OIL CO	EAGLE POINT 6	15.	318.	MRPAL	280.	318.	31-00029
150317	395200	750947	COASTAL EAGLE PT OIL CO	EAGLE POINT 7	10.	306.	MRPAL	261.	301.	31-06834
150318	395207	750930	COASTAL EAGLE PT OIL CO	EAGLE POINT 2	17.	289.	MRPAL	259.	289.	31-00009
150319	395213	750936	COASTAL EAGLE PT OIL CO	EAGLE POINT 4	14.	289.	MRPAL	259.	289.	31-00002
150320	395216	750915	COASTAL EAGLE PT OIL CO	EAGLE POINT 1	20.	288.	MRPAL	248.	288.	31-00007
150321	395221	750856	COASTAL EAGLE PT OIL CO	EAGLE POINT 5	13.	277.	MRPAL	237.	277.	31-00028
150322	395222	750918	COASTAL EAGLE PT OIL CO	EAGLE POINT 3	20.	288.	MRPAL	258.	288.	31-00008
150323	395235	750950	COASTAL EAGLE PT OIL CO	EAGLE POINT 3 OBS	20.96	276.	MRPAL	255.	275.	31-00037
150324	395236	750821	COASTAL EAGLE PT OIL CO	EAGLE PT OBS 4	10.	224.	MRPAL	214.	224.	31-00036
150326	395216	750739	WESTVILLE WD	WWD 5	12.	277.	MRPAL	243.	277.	31-05689
150327	395221	750737	WESTVILLE WD	WWD 4	16.	319.	MRPAL	286.	313.	31-03418
150329	395221	750737	WESTVILLE WD	WWD 1	16.	112.	MRPAU	69.	112.	--
150332	395009	750922	WOODBURY WD	PARKING LOT 3	50.	188.	MRPAU	148.	188.	51-00100
150333	395044	750907	WOODBURY WD	TATUM 4	20.	167.	MRPAU	129.	167.	31-00787
150337	394346	752110	MAUGERI, SAL	MAUGERI S1	47.5	152.	MRPAU	128.	148.	30-00431
150340	394356	752143	CATALANO, FRANK	1	50.	114.	MRPAU	108.	114.	--

Table 8. Well-location and -construction data -- continued

Well Number	Latitude	Longitude	Owner	Local Identifier	Land-Surface Elevation (ft asl)	Depth of Well (ft bls)	Aquifer	Depth to top of Well Opening (ft bls)	Depth to Bottom of Well Opening (ft bls)	N.J. Well Permit Number
150343	394443	752052	CASELLA BROS INC	1953 WELL	65.	121.	MRPAU	115.	121.	--
150347	394932	751722	GREENWICH TWD	GTWD 5 (2-A)	20.	122.	MRPAM	82.	117.	30-01545
150348	394910	751541	GREENWICH TWD	GTWD 6	20.	138.	MRPAM	105.	135.	30-01776
150349	394650	752316	PURELAND WC	LANDTECT 2	6.	220.	MRPAL	170.	220.	--
150350	394550	752313	PURELAND WC	LANDTECT 1	20.4	284.	MRPAL	234.	284.	--
150353	394649	752316	PURELAND WC	LANDTECT 3	6.	17.5	MRPAU	7.5	17.5	--
150354	394716	752112	ROLLINS ENV SERVICES	DP 2	13.3	91.	MRPAM	81.	91.	30-01472
150357	394957	751737	E I DUPONT	OBS 7	4.	105.	MRPAL	--	--	--
150373	395126	750856	W DEPTFORD TWD	WDTWD 7	28.	366.	MRPAL	323.	363.	31-17452
150380	394757	752346	MONSANTO CHEM	OBS 2	17.7	76.	MRPA	71.	76.	--
150387	394713	752121	ROLLINS ENV SERVICES	DP 1	10.2	90.	MRPAM	80.	90.	30-01471
150388	394716	752047	ROLLINS ENV SERVICES	DP 3	22.3	85.	MRPA	75.	85.	--
150390	395020	751340	GLOUCESTER CO SA	GCSA 1 71	10.	107.	MRPAM	91.	106.	30-01262
150398	394935	751938	PETTIT, LOUIS	419	1.	60.	MRPAL	50.	60.	30-02016
150399	394900	751913	ALLIED ENERGY	NO-1 1977	10.	101.	MRPAM	71.	91.	30-01616
150406	395033	751527	MOBIL OIL COMPANY	POLLUTE 1	20.	91.	MRPAM	51.	91.	30-01966
150407	395020	751527	MOBIL OIL COMPANY	POLLUTE 2	20.	91.	MRPAU	51.	91.	30-01965
150409	394710	752240	LOGAN TWP MUA	NO-1-1975	20.	93.9	MRPAM	49.9	93.9	30-01448
150410	395213	750936	TEXAS OIL CO	EAGLE POINT 4A	5.	296.	MRPAL	256.	296.	31-10647
150411	395113	751513	AIR PRODUCTS	NO-1-1978	20.	273.	MRPAL	238.	268.	30-01639
150416	395020	751513	MOBIL OIL COMPANY	2-1978	20.	48.	MRPAU	18.3	48.	30-01812
150423	395007	751513	MOBIL OIL COMPANY	MOBIL 28	10.	136.	MRPAM	87.	136.	--
150428	395043	751502	MOBIL OIL COMPANY	MOBIL 36	25.	138.	MRPAM	111.	138.	--
150430	395156	750938	COASTAL EAGLE PT OIL CO	EAGLE POINT 6A	15.	331.	MRPAL	256.	328.	31-17788
150431	395034	750842	WOODBURY WD	RED BANK 6	30.	305.	MRPAM	211.	305.	33-07973
150434	395224	750734	WESTVILLE WD	WWD 6	15.	--	MRPAL	265.	317.	31-17923
150437	395008	751007	POLYREZ CO	POLYREZ 1R	50.	142.	MRPAU	127.	142.	31-17980

Table 8. Well-location and -construction data -- continued

Well Number	Lati-tude	Longi-tude	Owner	Local Identifier	Land-Surface Elevation (ft asl)	Depth of Well (ft bls)	Aquifer	Depth to top of Well Opening (ft bls)	Depth to Bottom of Well Opening (ft bls)	N.J. Well Permit Number
150439	395048	751401	ESSEX CHEMICAL CO	ESSEX 2	10.	235.	MRPAL	215.	235.	30-01175
150444	394756	752344	MONSANTO CHEM	7D	15.7	70.	MRPA	65.	70.	30-02032
150450	394750	752331	MONSANTO CHEM	10D	12.9	65.3	MRPAM	60.3	65.3	30-02026
150453	394832	751846	GAVENTA, AL & SON	30-1946	10.	61.	MRPAM	51.	61.	30-01946
150475	394754	751920	US EPA	101	8.57	37.	MRPAU	35.	37.	30-02376
150476	394800	751927	US EPA	102	15.05	38.	MRPAU	36.	38.	30-02377
150478	394806	751929	US EPA	104	10.05	21.	MRPAU	19.	21.	--
150481	394814	751920	US EPA	107	9.3	38.	MRPAM	36.	38.	30-02381
150533	395155	751051	NATIONAL PARK WD	NPWD 6	22.	272.	MRPAL	240.	272.	31-17938
150539	394751	751907	US EPA-SWINDELL, NORMAN	S-6	6.	70.	MRPAM	60.	70.	30-03067
150540	394800	751936	US EPA	EPA 108	7.1	97.	MRPAM	87.	97.	30-02621
150543	394755	751956	CHEMICAL LEAMAN	CL1	13.82	30.	MRPAU	15.	30.	30-02384
150544	394752	751951	CHEMICAL LEAMAN	CL4	8.2	46.	MRPAU	41.	46.	30-02385
150546	394759	751948	CHEMICAL LEAMAN	CL2	10.17	30.	MRPAU	20.	30.	30-02387
150548	394755	751952	CHEMICAL LEAMAN	CLDW	10.	45.	MRPAU	30.	45.	30-02504
150549	394757	751945	CHEMICAL LEAMAN	DW1	7.04	97.	MRPA	94.5	97.	30-02423
150550	394759	751949	CHEMICAL LEAMAN	DW2	10.17	102.	MRPAM	99.5	102.	30-02425
150554	394808	751914	US EPA REGION II	S-2A	9.	14.	MRPAU	4.	14.	30-03071
150555	394808	751914	US EPA REGION II	S-2B	10.89	50.	MRPAM	40.	50.	30-03072
150556	394808	751914	US EPA REGION II	S-2C	11.13	108.	MRPAM	98.	108.	30-03073
150564	394802	751933	US EPA-GAVENTA	S-9	6.8	52.	MRPAU	42.	52.	30-03081
150569	394529	752045	PURELAND WATER CO	PWC 3	32.	201.	MRPAM	161.	201.	30-02405
150570	394705	752109	ROLLINS ENV SERVICES	W23	0.47	13.5	MRPAU	8.5	13.5	30-02521
150572	394722	752054	ROLLINS ENV SERVICES	W18	12.95	20.1	MRPAU	10.1	20.1	--
150573	394715	752050	ROLLINS ENV SERVICES	U	22.11	22.2	MRPAU	19.7	22.2	--
150575	394719	752108	ROLLINS ENV SERVICES	MA 11D	1.31	55.	MRPAM	45.	55.	30-02511
150576	394719	752108	ROLLINS ENV SERVICES	MA 11I	1.22	29.	MRPAU	19.	29.	30-02512
150577	394717	752108	ROLLINS ENV SERVICES	MA 8D	1.89	49.	MRPAM	39.	49.	30-02497

Table 8. Well-location and -construction data -- continued

Well Number	Latitude	Longitude	Owner	Local Identifier	Land-Surface Elevation (ft asl)	Depth of Well (ft bls)	Aquifer	Depth to top of Well Opening (ft bls)	Depth to Bottom of Well Opening (ft bls)	N.J. Well Permit Number
150578	394717	752108	ROLLINS ENV SERVICES	MA 8I	1.89	35.	MRPAU	25.	35.	30-02498
150579	394717	752108	ROLLINS ENV SERVICES	MA 8S	1.84	13.5	MRPAU	8.5	13.5	30-02499
150580	394718	752102	ROLLINS ENV SERVICES	MA 5D	2.45	60.	MRPAM	50.	60.	30-02488
150581	394718	752102	ROLLINS ENV SERVICES	MA 5I	2.48	37.	MRPAU	27.	37.	30-02489
150582	394715	752106	ROLLINS ENV SERVICES	MA 1D	1.64	67.	MRPA	57.	67.	30-02482
150583	394715	752106	ROLLINS ENV SERVICES	MA 1I	1.67	35.	MRPAU	25.	35.	30-02483
150584	394715	752106	ROLLINS ENV SERVICES	MA 1S	1.68	10.	MRPAU	5.	10.	30-02484
150585	394704	752058	ROLLINS ENV SERVICES	DP5	7.5	89.	MRPAM	79.	89.	30-02522
150586	394720	752052	ROLLINS ENV SERVICES	DP4	11.6	125.	MRPAM	95.	125.	30-02539
150587	394707	752055	ROLLINS ENV SERVICES	C	9.6	35.	MRPAU	30.	35.	--
150588	394717	752109	ROLLINS ENV SERVICES	31D	5.6	70.	MRPAM	40.	70.	30-02634
150589	394717	752109	ROLLINS ENV SERVICES	31S	5.6	40.	MRPAU	10.	40.	30-02633
150590	394717	752112	ROLLINS ENV SERVICES	26	7.5	25.	MRPAU	15.	25.	50-00021
150591	394716	752115	ROLLINS ENV SERVICES	25	3.4	19.7	MRPAU	9.7	19.7	30-01303
150592	394710	752107	ROLLINS ENV SERVICES	22 (RP OBS 2/12)	5.6	19.7	MRPAU	9.7	19.7	30-01305
150593	394707	752102	ROLLINS ENV SERVICES	20B	4.2	25.	MRPAU	15.	25.	--
150594	394714	752110	ROLLINS ENV SERVICES	15	9.1	26.	MRPAU	12.	26.	--
150595	394714	752106	ROLLINS ENV SERVICES	4	5.52	18.5	MRPAU	14.	18.5	--
150597	394730	752406	MONSANTO CHEM	28D	8.	68.	MRPA	63.	68.	30-02136
150601	394736	752334	MONSANTO CHEM	35D	17.3	75.	MRPAM	70.	75.	30-02123
150602	394741	752416	MONSANTO CHEM	5D	10.	89.	MRPA	84.	89.	30-02135
150606	394758	751948	CHEMICAL LEAMAN	TP-9	4.67	5.63	MRPAU	0.63	5.63	--
150615	394637	751916	US GEOLOGICAL SURVEY	SHIVELER LOWER	29.3	388.	MRPAL	378.	388.	--
150617	394637	751916	US GEOLOGICAL SURVEY	SHIVELER UPPER	30.6	70.	MRPAU	60.	70.	--
150618	394804	751933	US GEOLOGICAL SURVEY	GAVENTA DEEP	7.	240.	MRPAL	230.	240.	--
150620	394804	751933	US GEOLOGICAL SURVEY	GAVENTA MIDDLE 1	7.	141.	MRPAM	131.	141.	30-03677
150626	394729	752101	ROLLINS ENV SERVICES	MW 102 S	11.78	19.	MRPAU	9.	19.	30-33900
150627	394644	752136	LOGAN TWP-PURELAND	MW 103 D	7.38	75.	MRPAU	65.	75.	30-33926

Table 8. Well-location and -construction data -- continued

Well Number	Lati-tude	Longi-tude	Owner	Local Identifier	Land-Surface Elevation (ft asl)	Depth of Well (ft bls)	Aquifer	Depth to top of Well Opening (ft bls)	Depth to Bottom of Well Opening (ft bls)	N.J. Well Permit Number
150632	394945	751649	HERCULES INC	HERCULES PW 6	9.	19.	QRNR	14.	19.	30-03315
150634	394944	751750	E I DUPONT	OBS 40	5.	141.	MRPAL	136.	141.	--
150652	395017	751639	HERCULES CHEMICAL	MW 12	1.2	24.	MRPAM	17.	24.	30-03024
150657	394941	751737	E I DUPONT	OBS 38	9.16	94.	MRPAM	89.	94.	30-03461
150668	394944	751648	HERCULES CHEMICAL	MW 10C	7.83	112.	MRPAM	92.	112.	30-03370
150672	395014	751459	AIR PRODUCTS	2-NORTH WELL	20.	264.	MRPAL	244.	264.	30-01640
150673	395100	751420	BP OIL	BL-3	5.4	95.	MRPAU	70.	95.	30-02856
150674	395053	751346	ESSEX CHEMICAL CO	OBS 1	9.	40.5	MRPAU	20.5	40.5	30-01511
150675	394829	751615	EM DIAGNOSTIC SYSTEMS	MW-4	12.8	10.	WBMV	3.	10.	30-03856
150678	394946	751612	MOBIL OIL COMPANY	W-5C	9.4	204.	MRPAL	194.	204.	30-03625
150679	394946	751612	MOBIL OIL COMPANY	W-5D	9.7	128.	MRPAM	118.	128.	30-03624
150680	395038	751605	MOBIL OIL COMPANY	W-7C	8.66	196.	MRPAL	186.	196.	30-03602
150681	395038	751605	MOBIL OIL COMPANY	W-7D	8.7	70.	MRPAM	60.	70.	30-03601
150682	395048	751518	MOBIL OIL COMPANY	W-8D	10.79	115.	MRPAM	105.	115.	30-03607
150683	395021	751533	MOBIL OIL COMPANY	W-9D	10.7	102.	MRPAM	92.	102.	30-03613
150692	394952	751734	E I DUPONT	INTERCEPTOR 46	5.	136.	MRPAM	96.	136.	30-03594
150714	394707	752058	ROLLINS ENV SERVICES	GG	8.46	13.7	MRPAU	10.7	13.7	--
150770	395202	751115	US GEOLOGICAL SURVEY	NAT PK #1-PW-L	10.	229.	MRPAL	204.	224.	31-26237-6
150771	395202	751115	US GEOLOGICAL SURVEY	NAT PK #2-PW-M	10.	128.	MRPAM	92.3	123.	31-26243
150778	395223	751117	US GEOLOGICAL SURVEY	NAT PK #9-OW-BL	20.	195.	MRPAL	170.	190.	31-26245
150780	395223	751117	US GEOLOGICAL SURVEY	NAT PK #10-OW-BM	5.	90.	MRPAM	75.	85.	31-26244
150814	395024	751521	MOBIL OIL COMPANY	RW-12	21.3	60.	QRNR	15.	55.	30-02336
150815	395027	751528	MOBIL OIL COMPANY	RW-11	18.5	57.	QRNR	12.	52.	30-02335
150816	395035	751543	MOBIL OIL COMPANY	RW-17	23.2	24.	QRNR	3.	15.	30-02338
150817	395039	751547	MOBIL OIL COMPANY	RW-16	17.4	24.	QRNR	4.	16.	30-02341
150818	395005	751517	MOBIL OIL COMPANY	RW-15	13.7	24.	QRNR	2.	10.	30-02339
150819	395011	751513	MOBIL OIL COMPANY	RW-14	17.	60.	QRNR	15.	55.	30-02334
150820	395038	751514	MOBIL OIL COMPANY	RW-2	21.5	48.3	QRNR	18.3	48.3	--

Table 8. Well-location and -construction data -- continued

Well Number	Lati-tude	Longi-tude	Owner	Local Identifier	Land-Surface Elevation (ft asl)	Depth of Well (ft bls)	Aquifer	Depth to top of Well Opening (ft bls)	Depth to Bottom of Well Opening (ft bls)	N.J. Well Permit Number
150821	395047	751512	MOBIL OIL COMPANY	RW-3	22.1	59.	QRNR	19.	54.	30-01908
150822	395042	751515	MOBIL OIL COMPANY	RW-4	20.3	56.	QRNR	16.	51.	30-01910
150823	395037	751500	MOBIL OIL COMPANY	RW-5	25.4	58.	QRNR	18.	53.	30-01909
150824	395033	751457	MOBIL OIL COMPANY	RW-6	18.8	53.5	QRNR	13.5	48.5	30-01905
150825	395027	751506	MOBIL OIL COMPANY	RW-7	17.3	53.5	QRNR	13.5	48.5	--
150826	395022	751458	MOBIL OIL COMPANY	RW-8	19.	55.	QRNR	15.	50.	30-01906
150827	395021	751533	MOBIL OIL COMPANY	RW-9	11.1	50.5	QRNR	5.5	45.5	--
150828	395024	751600	MOBIL OIL COMPANY	RW-18	11.7	30.	QRNR	1.	17.	--
150832	395043	751527	MOBIL OIL COMPANY	RW-13	19.8	58.	QRNR	13.	53.	30-02340
150833	394942	751655	HERCULES CHEMICAL	PW-10	11.	44.5	MRPAM	14.5	44.5	--
150834	394941	751650	HERCULES CHEMICAL	PW-9	11.1	43.	MRPAM	13.	43.	--
150835	394938	751653	HERCULES CHEMICAL	PW-8B	12.2	75.	MRPAM	29.5	69.5	--
150836	394937	751655	HERCULES CHEMICAL	PW-8	14.5	19.9	QRNR	9.9	19.9	--
150837	394938	751649	HERCULES CHEMICAL	PW-7B	15.2	75.	MRPAM	35.	75.	--
150838	394942	751655	HERCULES CHEMICAL	PW-5B	11.6	43.	MRPAM	23.	43.	--
150839	395052	751408	BP OIL CO	RW-3	11.6	85.	QRNR	25.	85.	30-03430
150963	394822	752025	POLYREZ CO INC	POLYREZ 1-1971	10.	90.2	MRPAM	60.	85.	30-01252
151034	394910	751658	HERCULES INC	HERCULES PW 11	10.	120.	MRPAM	90.	120.	30-04319
151061	394948	751526	MOBIL OIL COMPANY	W-4D	4.	152.	MRPAL	142.	152.	30-03612
151062	394948	751526	MOBIL OIL COMPANY	4-C	4.	198.	MRPAL	188.	198.	30-03611
330032	392740	753201	PUBLIC SERVICE E-G	PW 3	12.	293.	MLRW	242.	293.	34-00758
330033	392751	752441	L ALLOWAY CR SC	LACTES 1	14.	340.	MLRW	--	--	--
330034	392742	753200	PUBLIC SERVICE E-G	PW 1	17.	298.	MLRW	248.	298.	34-00737
330035	392744	753206	PUBLIC SERVICE E-G	PW 2	9.	281.	MLRW	230.	281.	34-00757
330037	392800	753208	PUBLIC SERVICE E-G	PW 4	20.	265.	MLRW	215.	265.	34-00759
330043	393446	752720	MANNINGTON MILLS	3-1956	10.	142.	MLRW	122.	142.	--
330044	393446	752721	MANNINGTON MILLS	SCHULTES 3	10.	127.	MLRW	96.	127.	30-00735
330045	393451	752716	MANNINGTON MILLS	1-1956	20.	135.	MLRW	115.	135.	--

Table 8. Well-location and -construction data -- continued

Well Number	Lati- tude	Longi- tude	Owner	Local Identifier	Land-Surface Elevation (ft asl)	Depth of Well (ft bls)	Aquifer	Depth to top of Well Opening (ft bls)	Depth to Bottom of Well Opening (ft bls)	N.J. Well Permit Number
330046	393451	752719	MANNINGTON MILLS	SCHULTES 2	20.	130.	MLRW	90.	130.	--
330048	393454	752723	MANNINGTON MILLS	2-1956	5.	135.	MLRW	115.	135.	--
330050	393538	752640	SALEM MEM HOSP	HOSP 1-1950	20.	100.	MLRW	73.	97.	--
330051	393538	752642	SALEM MEM HOSP	HOSP 2-1954	20.	112.	MLRW	82.	112.	30-00279
330055	393555	752550	HARRIS, EDWARD F	HARRIS 1	27.	38.	MLRW	31.	38.	--
330065	393912	752436	E I DUPONT	COURSE LAND 3B	30.	512.	MRPAM	501.	512.	--
330066	393912	752436	E I DUPONT	COURSE LAND 3C	30.	386.	MRPAM	375.	386.	--
330076	394328	752446	DAWSON, H W	DAWSON 1	27.	124.	MRPAU	118.	123.	30-00661
330077	394434	752514	PENNS GROVE WSC	PEDRICKTOWN 11	10.	178.	MRPAM	133.	178.	--
330079	394540	752519	NOSTRIP CHEMICALS	NOSTRIP 1	10.	122.	MRPAM	107.	122.	30-01149
330080	394542	752510	AIR REDUCTION	AIRCO 1	15.	132.	MRPAM	112.	132.	30-00974
330082	394542	752603	BRIDGE, BRUCE H	BRIDGE	6.	205.	MRPA	--	--	30-00660
330083	394547	752535	B F GOODRICH CO	9 (PW-1)	10.	133.	MRPAM	93.	133.	--
330085	394556	752530	B F GOODRICH CO	6 (PW-2)	10.	129.	MRPAM	109.	129.	30-01141
330086	394557	752523	B F GOODRICH CO	4 (PW-3)	13.	189.	MRPAL	169.	189.	30-01139
330103	394346	752828	PENNS GROVE SA	SEWERAGE AUTH1	8.	60.	MRPAM	50.	60.	30-00467
330104	394220	752727	E I DUPONT	RANNEY WELL CP	11.	49.	MRPA	45.	49.	50-00039
330105	393458	752945	LOVELAND, S C III	DILWORTH/LOVELAN	10.	263.	MRPAU	--	--	--
330106	393514	752917	LINSKI, ALEX	1	5.	366.	MRPAM	359.	365.	--
330107	393620	753310	NJ DEPT CONSERV	FT MOTT SP 1	8.	320.	MRPAM	300.	320.	--
330108	393641	753322	US ARMY	FINNS POINT	7.	319.	MRPAM	290.	319.	30-00052
330109	393734	753149	SIEGFRIED CHEM	1973-1	5.	131.	MRPAU	116.	131.	30-01322
330112	393754	753147	PENNSVILLE TWD	PTWD 4	10.	137.	MRPAU	117.	137.	30-01033
330117	393954	753013	PENNSVILLE TWD	PTWD 3	7.	102.	MRPAU	87.	102.	30-00451
330118	393958	753045	PENNSVILLE TWD	PTWD 1	8.	238.	MRPAM	213.	238.	50-00041
330119	394009	753043	PENNSVILLE T WD	PTWD 2	7.	232.	MRPAM	210.	230.	30-00018
330121	394046	753022	ATLANTIC CITY ELEC	DEEPWATER 3	19.	239.	MRPAM	169.	239.	--
330122	394045	753018	ATLANTIC CITY ELEC	DEEPWATER 3R	10.	235.	MRPAM	165.	235.	30-01234

Table 8. Well-location and -construction data -- continued

Well Number	Lati-tude	Longi-tude	Owner	Local Identifier	Land-Surface Elevation (ft asl)	Depth of Well (ft bls)	Aquifer	Depth to top of Well Opening (ft bls)	Depth to Bottom of Well Opening (ft bls)	N.J. Well Permit Number
330123	394047	753027	ATLANTIC CITY ELEC	DEEPWATER 2	10.	235.	MRPAM	154.	234.	50-00001
330125	394051	753030	ATLANTIC CITY ELEC	DEEPWATER 5	10.	219.	MRPAM	149.	219.	30-00151
330126	394057	752950	E I DUPONT	RANNEY 7	15.	140.	MRPAU	52.	140.	30-01080
330127	394100	753030	ATLANTIC CITY ELEC	DEEPWATER 6	10.	188.	MRPAM	158.	188.	30-00698
330128	394102	752946	E I DUPONT	RANNEY 6/(INT-106)	15.	60.	MRPAU	50.	60.	--
330129	394107	752858	E I DUPONT	CHAMBERS INJ 1	8.	240.	MRPAM	--	--	30-01018
330135	394110	752955	E I DUPONT	RANNEY 5	16.	116.	MRPAU	47.	116.	30-00987
330136	394110	753013	E I DUPONT	CHAMBERS INJ 2	4.	247.	MRPAL	--	--	30-01053
330137	394112	753028	E I DUPONT	DRINKWATER 8	14.	361.	MRPAL	317.	347.	50-00003
330138	394131	753008	E I DUPONT	CHAMBERS INJ 3	5.	462.	MRPAL	314.	462.	30-01049
330141	394131	753009	E I DUPONT	CHAMBERS OB3-3	5.	207.	MRPAM	197.	207.	30-01052
330240	393253	752425	SALEM CITY WD	SWD 3	7.	140.	VNCN	--	--	--
330241	393253	752422	SALEM CITY WD	QUINTON	10.	248.	MLRW	--	--	--
330243	393334	752724	US GEOLOGICAL SURVEY	SALEM KMW 3	11.	140.	MLRW	--	--	--
330244	393404	752811	SALEM CITY WD	SWD 4	10.	124.	MLRW	93.	124.	--
330245	393337	752719	SALEM CITY WD	SCWD 5	8.	168.	MLRW	96.	168.	30-00877
330246	393337	752720	SALEM CITY WD	SWD TW 3	10.	147.	MLRW	102.	147.	30-00822
330247	393339	752718	US GEOLOGICAL SURVEY	USGS KMW 1	8.	120.	MLRL	110.	120.	--
330249	393342	752718	SALEM CITY WD	SWD 2	5.	157.	MLRW	110.	150.	50-00042
330251	393348	752755	US GEOLOGICAL SURVEY	SALEM 1 OBS	3.	709.	MRPAM	699.	709.	--
330252	393348	752755	US GEOLOGICAL SURVEY	SALEM 2 OBS	3.25	96.	MLRW	91.	96.	--
330253	393348	752755	US GEOLOGICAL SURVEY	SALEM 3 OBS	3.	340.	MRPAU	335.	340.	--
330256	393420	752751	SALEM CITY WD	SWD 1	17.	136.	MLRW	86.	136.	--
330299	393957	752432	E I DUPONT	COURSE LAND 1A	26.	614.	MRPAM	604.	614.	30-01081
330300	393957	752432	E I DUPONT	COURSE LAND 1B	25.	517.	MRPAM	507.	517.	--
330302	394000	752439	E I DUPONT	COURSE LAND 2A	30.	593.	MRPAM	583.	593.	--
330304	394000	752439	E I DUPONT	COURSE LAND 2C	30.	445.	MRPAM	435.	445.	--
330307	394058	752918	E I DUPONT	RANNEY 1	8.	60.	MRPAU	--	--	--

Table 8. Well-location and -construction data -- continued

Well Number	Latitude	Longitude	Owner	Local Identifier	Land-Surface Elevation (ft asl)	Depth of Well (ft bls)	Aquifer	Depth to top of Well Opening (ft bls)	Depth to Bottom of Well Opening (ft bls)	N.J. Well Permit Number
330308	394058	752918	E I DUPONT	RANNEY 2	18.	480.	MRPAL	--	--	--
330309	394058	752918	E I DUPONT	RANNEY 3	18.	69.	MRPAU	49.	69.	--
330310	394058	752918	E I DUPONT	RANNEY 4	8.	69.	MRPA	49.	69.	--
330313	394110	753008	E I DUPONT	107	5.	109.	MRPAM	--	--	--
330314	394112	752928	E I DUPONT	105	8.	111.	MRPAM	--	--	30-01273
330316	394121	752921	E I DUPONT	102	5.	85.	MRPAU	--	--	30-02322
330317	394127	752953	E I DUPONT	LAYNE 2	5.	159.	MRPAM	--	--	--
330318	394127	753020	E I DUPONT	LAYNE 1	6.	360.	MRPAL	--	--	--
330319	394139	752925	E I DUPONT	104	5.	105.	MRPAM	--	--	30-01272
330320	394140	752953	E I DUPONT	LAYNE 3	5.	190.	MRPA	--	--	--
330321	394143	752940	E I DUPONT	103	5.	92.	MRPAM	--	--	30-01271
330322	394149	752916	E I DUPONT	CARNEY PT 2	5.	219.	MRPAM	169.	219.	50-00004
330325	394149	752918	E I DUPONT	CARNEY PT 3	5.	102.	MRPAU	--	--	--
330326	394153	752928	E I DUPONT	CARNEY PT 4	5.	86.	MRPAU	--	--	30-00423
330327	394153	752927	E I DUPONT	1	5.	200.	MRPA	--	--	--
330328	394157	752918	E I DUPONT	CARNEY PT 1	5.	194.	MRPAM	175.	195.	30-01109
330330	394205	752657	PENNS GROVE WSC	LAYTON 11	16.	394.	MRPAL	--	--	50-00098
330331	394205	752657	PENNS GROVE WSC	SCHULTES WELL	14.	62.	MRPAM	47.	62.	30-01099
330333	394208	752859	E I DUPONT	CARNEY PT 5	5.	81.	MRPAU	--	--	30-00620
330334	394211	752901	E I DUPONT	CARNEY PT 6	5.	185.	MRPAM	157.	182.	30-00621
330335	394212	752751	E I DUPONT	CARNEY PT 7	11.	435.	MRPAL	270.	430.	30-01133
330337	394214	752851	E I DUPONT	LAYNE TEST 3	5.	86.	MRPA	62.	86.	30-00524
330342	394236	752724	STATE OF NJ-WATER POLICY	PENNS GROVE 24	17.94	51.	MRPAU	46.	51.	--
330345	394241	752711	PENNS GROVE WSC	PGWSC 2B/RF1A	10.	60.	MRPAU	45.	58.	50-00102
330346	394256	752718	PENNS GROVE WSC	LAYNE 1	19.	357.	MRPAL	317.	357.	30-00563
330347	394256	752723	PENNS GROVE WSC	RANNEY	17.	34.	MRPAU	--	--	50-00040
330360	393750	753131	PENNSVILLE T WD	PTWD 5	10.	125.	MRPAU	101.	117.	28-10466
330361	394205	752700	PENNS GROVE WSC	SCHULTES 4	13.	64.	MRPAU	44.	54.	30-01815

Table 8. Well-location and -construction data -- continued

Well Number	Lati-tude	Longi-tude	Owner	Local Identifier	Land-Surface Elevation (ft asl)	Depth of Well (ft bls)	Aquifer	Depth to top of Well Opening (ft bls)	Depth to Bottom of Well Opening (ft bls)	N.J. Well Permit Number
330364	392743	753158	PUBLIC SERVICE E-G	PW 5	17.	840.	MRPAM	765.	840.	34-01031
330368	393253	752425	SALEM CITY WD	QUINTON 5	7.	133.	VNCN	--	--	--
330370	394449	752554	GRIM, EUGENE	1	25.	52.	MRPAU	42.	52.	30-01800
330381	393453	752709	MANNINGTON MILLS	MILLS 6	10.	135.	MLRW	84.7	125.	30-01505
330383	392743	753128	PUBLIC SERVICE E-G	1-74	15.	310.	MLRW	--	--	--
330385	392754	753215	PUBLIC SERVICE E-G	3-74	5.	946.	MRPA	--	--	--
330401	392751	753207	PUBLIC SERVICE E-G	TEST 1-80	20.	1,130.	MRPA	1,110.	1,130.	--
330406	394300	752713	PENNS GROVE WSC	NO-1-1956/LAYNE 7	20.	360.	MRPAL	317.	357.	30-00563
330409	393500	752647	MANNINGTON MILLS	REPL 1968	10.	155.	MLRW	130.	155.	30-01153
330419	394540	752540	NL INDUSTRIES	MONITOR 8R	10.	108.	MRPAM	101.	108.	--
330420	394540	752540	NL INDUSTRIES	MONITOR 9R2	10.	61.	MRPAM	53.	61.	--
330421	393907	752652	SPARKS, MAYHEW	1	15.	340.	MRPAM	332.	340.	34-00707
330426	393451	752718	MANNINGTON MILLS	2-1967	10.	127.	MLRW	87.	127.	--
330428	394245	752718	PENNS GROVE WSC	PGWSC 2A	19.	60.	MRPAU	--	--	--
330430	394546	752521	B F GOODRICH CO	1	10.	133.	MRPA	93.2	133.	--
330432	394553	752513	B F GOODRICH CO	3	10.	195.	MRPAL	180.	195.	50-00079
330435	394548	752530	B F GOODRICH CO	2	10.	124.	MRPAM	104.	124.	--
330439	394449	752351	BOND, WILLARD K	1	25.	59.	MRPAU	49.	59.	30-02665
330452	392751	753207	PUBLIC SERVICE E-G	HOPE CREEK	10.	817.	MRPAM	746.	817.	34-01074
330453	393957	753017	PENNSVILLE T WD	PTWD 6	10.	114.	MRPA	99.	114.	30-03013
330457	392751	753207	PUBLIC SERVICE E-G	PSEG 6	20.	1,130.	MRPA	1,110.	1,130.	--
330460	394247	752714	PENNS GROVE WSC	PGWSC 1A/RF2A	19.	61.	MRPAU	41.	61.	30-03310
330461	394207	752645	TOMARCHIO, FRED W	DOMESTIC	20.	--	MRPA	--	--	30-03814
330553	393700	752538	SEABROOK, JOHN M	SALEM FARMS	5.	50.	MLRW	20.	50.	30-03440
330602	394043	753030	E I DUPONT	CHAMBERS 108	5.	86.2	MRPAM	43.1	86.2	30-03368
330657	394358	752344	MUSUMECI, ANTHONY	MUSUMECI IRRIG	45.	260.	MRPAM	160.	260.	30-02862
330671	393954	753013	PENNSVILLE TWD	PTWD 3A	7.	104.	MRPAU	87.	102.	30-05148
330683	394109	752954	E I DUPONT	RANNEY 5-R	16.	118.	MRPAU	47.	117.	--
330686	393749	753149	PENNSVILLE TWP	PTWD 4A RPL	10.	130.	MRPAU	110.	130.	30-08335