PREPARED IN COOPERATION WITH THE
NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION

HYDROLOGY OF THE UNCONFINED AQUIFER SYSTEM, SALEM RIVER AREA: SALEM RIVER AND RACCOON, OLDMANS, ALLOWAY, AND STOW CREEK BASINS, NEW JERSEY, 1993-94

By Melissa L. Johnson and Emmanuel G. Charles

ABSTRACT

The Salem River study area consists of five surface-water drainage basins — Salem River and Raccoon, Oldmans, Alloway, and Stow Creeks — and the unconfined aquifers that lie beneath them. The unconfined aquifers in the study area are (1) sand and gravel parts of the undifferentiated hydrogeologic unit, (2) the Kirkwood-Cohansey aquifer system, (3) the outcrop of the Vincentown aquifer, (4) the outcrop of the Wenonah-Mount Laurel aquifer, (5) the outcrop of the Englishtown aquifer system, and (6) the outcrop of the Upper Potomac-Raritan-Magothy aquifer. A water-level map of the unconfined ground-water system, constructed from water-level measurements made during October, November, and December 1993 in 122 wells and at 175 stream sites, shows that water levels ranged from below sea level to 140 feet above sea level. In general, seasonal fluctuations of water levels in five observation wells range approximately from 2 to 9 feet. The horizontal hydraulic conductivities determined from aquifer tests range from 5 to 250 feet per day, the transmissivities range from 411 to 19,800 feet squared per day, and the storage coefficients range from 0.000027 to 0.044. The vertical hydraulic conductivities of the confining units in the study area range from 0.00002 to 0.24 feet per day.

Base-flow separation was used to divide total surface-water discharge into base-flow and direct-runoff components for the Salem River and Raccoon, Oldmans, and Alloway Creeks. Mean annual base flow for the Salem River during 1940-90 was 12 cubic feet per second, or 64 percent of total flow; for Raccoon Creek during 1966-92 was 30 cubic feet per second, or 75 percent of total flow; for Oldmans Creek during 1932-40 was 21.14 cubic feet per second, or 74 percent of total flow; and for Alloway Creek during 1953-72 was 16.4 cubic feet per second, or 70 percent of total flow. In addition, low-flow correlation analyses were made, and mean discharge and base flow were estimated for 12 low-flow partial-record gaging stations. Mean annual precipitation in the study area during 1949-92 was 43 inches and mean annual potential evapotranspiration estimated from mean monthly temperature was 30 inches. A water budget calculated for the study area shows that ground-water recharge is about 13 inches per year, or about 30 percent of mean annual precipitation.

Approximately 47 percent of the land in the study area is used for agricultural purposes, 24 percent is forested, 12 percent is wetland, 8 percent is urban land, 5 percent is barren land, and 3 percent is water. The report identifies 21 sanitary landfills and 8 hazardous-waste sites in the study area. A sample was collected for water-quality analysis at each of 15 ground-water- and 5 surface-water-sampling sites distributed throughout the study area. Sites that may be affected by point contamination sources were avoided. U.S. Environmental Protection Agency primary drinking-water regulations for nitrate plus nitrite were exceeded in six ground-water samples. The predominant cations in the ground and surface water were calcium or magnesium; the predominant anions in the ground water were nitrate plus nitrite and chlorides; and in the surface water were carbonate plus bicarbonate. The pattern of ground- and surface-water chemistry in the study area reflects the variations in residence time of ground water in the unconfined aquifer system.

Total consumptive water use in the study area from surface water and unconfined ground water was more than 1,500 million gallons in 1990: 437 million gallons for public and private domestic water supply, 418 million gallons for irrigation, 433 million gallons for industry, and 235 million gallons for thermoelectric-power generation.

INTRODUCTION

Unconfined (water-table) aquifer systems are present throughout most of the Coastal Plain of New Jersey. These unconfined aquifers are a major source of water supply in the Coastal Plain, and withdrawals from these are expected to increase. A detailed study of these aquifer systems, and the surface-water systems that are hydraulically connected to them, was needed to obtain hydrologic information on which to base decisions that will ensure that the increasing demand for water from these aquifers will be met as the population grows. Therefore, in 1986 the U.S. Geological Survey (USGS), in cooperation with the New Jersey Department of Environmental Protection (NJDEP), began to compile data for selected ground- and surface-water systems in the Coastal Plain of New Jersey. These ground- and surface-water systems coincide with Regional Water Resource Planning Areas, which are single drainage basins or groups of drainage basins delineated in the New Jersey Statewide Water Supply Master Plan (CH2M Hill; Metcalf and Eddy, Inc.; and New Jersey First, Inc.; 10 volumes with various publication dates)[1]. Information from the study described in this report can be used to plan for the optimal management of the unconfined ground water and the surface water in the Salem River and Raccoon, Oldmans, Alloway, and Stow Creek Basins.

[1] Available from the New Jersey Department of Environmental Protection, Trenton, N.J.

Purpose and Scope

This report presents the results of a 2-year study conducted during 1993-94 to investigate the hydrology of the unconfined aquifer systems and the surface-water systems of the Salem River and the Raccoon, Oldmans, Alloway, and Stow Creek Basins, New Jersey. The combined areas of these five basins, referred to as the Salem River study area in this report, correspond to Regional Water Resource Planning Area number 20, the Salem River planning area, in the New Jersey Statewide Water Supply Master Plan. New data in this report include the results of water-level measurements in 122 wells and at 175 surface-water sites. Results of chemical analyses of water samples from 15 wells and 5 surface-water sites for selected inorganic and organic constituents are presented and interpreted. The extent of hydrogeologic units in the study area, approximated from published maps and reports, is described. Results of base-flow-separation analyses of discharge measurements at 4 streamflow-gaging stations and results of low-flow correlations of streamflow records from 12 low-flow partial-record stations are presented. A hydrologic budget developed to estimate recharge in the study area is presented; included in this budget are measurements of precipitation and stream discharge and estimates of water use and evapotranspiration.

Description of the Study Area

The Salem River study area consists of five principal drainage basins that make up an area of approximately 365 mi^2 in parts of Cumberland, Gloucester, and Salem Counties (fig. 1-1, 1-2) and that include parts of 24 municipalities (fig. 1-3). The study area and basin boundaries can be defined by either topographic divides or ground-water-drainage divides, which are nearly coincident and, for the purposes of this report, are considered to be the same. The western half of the study area is a region of low relief and relatively low elevation in contrast to the eastern half, which is a region of relatively higher relief and entrenched stream channels. Elevation of the land surface ranges from about 160 ft near Daretown along the eastern margin of the study area to sea level along the Delaware River and Delaware Bay. Approximately 47 percent of the study area is used for agricultural purposes, 24 percent is forested, 12 percent is wetland, 8 percent is urban land, 5 percent is barren land, and 3 percent is water (fig. 1-4) (land-use data modified from a U.S. Geological Survey land-use data set developed from the Landsat Thematic Mapper (1985) and U.S. Geological Survey 1:250,000-scale land-use/land-cover data (GIRAS) (unpublished data on file at the U.S. Geological Survey office in West Trenton, N.J.)).

Well-Numbering System

The well-numbering system used in this report is based on the system used by the USGS in New Jersey since 1978. It consists of a county-code number and a sequence number of the well within the county. County codes used in this report are Cumberland (11), Gloucester (15), and Salem (33). For example, well number 33-139 represents the 139th well inventoried in Salem County. Construction details for wells with this type of identifier are stored in the USGS Ground Water Site Inventory (GWSI) data base.

Acknowledgments

The authors acknowledge and appreciate the cooperation of the many individuals and organizations who allowed us access to their observation, public supply, farm, commercial, industrial, or domestic wells for water-level measurements and collection of water-quality samples. We also thank Jane Uptegrove of the New Jersey Geological Survey for directing us to sources containing details about the geology of the study area.

GEOLOGIC AND HYDROGEOLOGIC UNITS

The Salem River study area is in the Coastal Plain physiographic province of New Jersey. The Coastal Plain consists of two types of unconsolidated sediments: (1) relatively flat-lying fluvial sediments of upper Holocene, Pleistocene, and upper Miocene age (younger than the Cohansey Sand); and (2) a seaward-dipping wedge of predominantly marine sediments that range in age from middle Miocene to lower Cretaceous (Cohansey Sand and older units). The flat-lying fluvial sediments are present only at the surface and in this report comprise what are referred to as "surficial geologic units." Geologic units in the seaward-dipping wedge of marine sediments are referred to here as "bedrock geologic units." The surficial geologic units are hydrologically significant in the study area and, where present, overlie the older bedrock geologic units. Many of the bedrock geologic units of the Coastal Plain crop out in the study area. The interpretations in this report are based on geologic and hydrogeologic data from published maps and reports, and on 10 geophysical well logs (Lewis and others, 1991; Zapecza, 1989).

A hydrogeologic unit consists of one or more adjacent geologic units or parts of geologic units that have similar water-bearing and water-transmitting characteristics. Where ground water is present in sand or gravel that is not overlain by a confining unit, and the sand and gravel is thick enough to provide useful quantities of water, that hydrogeologic unit is considered an unconfined aquifer. Where ground water is present in silt or clay, the hydrogeologic unit is considered a "non-aquifer," or confining unit. In this report, a hydrogeologic unit is referred to as "undifferentiated" where ground water is present in geologic material for which the distribution, thickness, kind of material, or hydraulic properties are too uncertain or variable to allow the entire unit to be called either an aquifer or a confining unit.

The outcrop areas of geologic units in the study area (figs.1-5 and 1-6) were used to approximate the outcrop areas of the hydrogeologic units shown in the sections in figure 1-7. Lithology interpreted from 10 existing borehole geophysical logs was used to show the subsurface extent of the hydrogeologic units shown in the sections.

The unconfined ground-water system in the Salem River study area consists of six unconfined aquifers and four confining units (table 1-1). The unconfined aquifers are (1) sand and gravel parts of the undifferentiated hydrogeologic unit, (2) the Kirkwood-Cohansey aquifer system, (3) the outcrop of the Vincentown aquifer, (4) the outcrop of the Wenonah-Mount Laurel aquifer, (5) the outcrop of the Englishtown aquifer system, and (6) the outcrop of the Upper Potomac-Raritan-Magothy aquifer. The confining units are (1) clay and silt parts of the undifferentiated hydrogeologic unit; (2) the Alloway Clay Member of the Kirkwood Formation; (3) the Hornerstown Sand and Navesink Formation; and (4) the silt and very fine sand of the Wenonah Formation, the Marshalltown Formation, the clay-silt part of the Englishtown Formation, and the Merchantville Formation. The discussion that follows describes the hydrogeologic units in the study area, from youngest to oldest.

The undifferentiated hydrogeologic unit consists of surficial geologic units of Holocene, Pleistocene, and upper-Miocene age. This unit is discontinuous in roughly the western two-thirds of the study area. The Holocene-age deposits, called alluvial deposits in table 1-1, are found in swamps, in tidal marshes, and in and adjacent to stream channels, and are thickest adjacent to the Delaware River and Bay. The alluvial deposits are not shown in figure 1-5 because a comprehensive map of alluvial deposits is not available. Results of a geophysical survey by Duran (1986) show that the alluvium in the Delaware River channel next to the Salem River study area contains sections of sand, but is principally clay and silt. Hardt and Hilton (1969, p. 32) and Rosenau and others (1969, p. 53) describe the alluvial deposits adjacent to the Delaware River as mostly silt and clay and, therefore, non-aquifer material.

In addition to the Holocene deposits, the undifferentiated hydrogeologic unit consists of the Pleistocene-age Van Sciver Lake Beds, the Spring Lake Beds, and the upper-Miocene-age Pensauken Formation. Figure 1-5 shows the approximate areal extent of these three surficial geologic units except where they are covered by tidal-marsh deposits in coastal areas. The map extent of the geologic units shown in figure 1-5 is from the compilation of Johnson (1950), which is based mostly on the results of work by Salisbury and Knapp (1917).

Owens and Minard (1979) renamed the geologic units that Johnson (1950) shows as the Cape May Formation as the Van Sciver Lake Beds and Spring Lake Beds. The lithology of these units varies considerably (Owens and Minard, 1979) but can be summarized as gravelly sand, sand, and clay-silt layers. The combined thickness of these geologic units can be as great as 150 ft (Rosenau, 1969). These units are not considered aquifers where they consist mostly of clay and silt, or where they overlie confining units and are too thin to provide useful quantities of water to wells. However, these Pleistocene-age units are locally unconfined aquifers where the gravelly sand and sand layers overlie confining units and are thick enough to provide useful quantities of water to wells (Rosenau, 1969). The Pleistocene-age units are considered part of the underlying unconfined aquifer where any thickness of the gravelly sand and sand layers directly overlies and is in hydraulic connection with the Potomac-Raritan-Magothy aquifer system, the Wenonah-Mount Laurel aquifer, or the Vincentown aquifer.

The sand and clay-silt layers of the Pensauken Formation are discontinuous. This unit is found almost exclusively above confining units and is not in hydraulic connection with other unconfined parts of the regional aquifer system. It is not designated as a separate aquifer unit because the maximum thickness is about 30 ft (Rosenau, 1969) and it generally does not yield large quantities of water .

The bedrock geologic units that crop out in the Salem River study area form a series of parallel bands that trend northeast-southwest (fig. 1-6). The outcrop areas of the geologic units that are predominantly, or a combination of, gravel and fine- to coarse-grained sand constitute unconfined aquifers. These unconfined aquifers thicken from a featheredge along their northwestern boundary to their maximum thickness at the southeastern boundary of their outcrop area. The bedrock geologic units are youngest along the southeastern margin of the study area and are progressively older toward the northwest (Zapecza, 1989).

The Kirkwood-Cohansey aquifer system is the second youngest unconfined aquifer in the Salem River study area. It consists of the Bridgeton Formation (fig. 1-5), the Cohansey Sand, and the Grenloch Sand Member of the Kirkwood Formation (fig. 1-6). North of Oldmans Creek, the Kirkwood Formation consists of the fine sand of the Grenloch Sand Member (Isphording, 1970), which functions as an aquifer and is hydraulically connected to the overlying Cohansey Sand and the Bridgeton Formation where one or both of these formations are present. The sand of the Bridgeton Formation also functions as an aquifer and in most places is hydraulically connected to the Cohansey Sand. In the few places where the Bridgeton Formation overlies the Alloway Clay Member of the Kirkwood Formation (Isphording, 1970), the potential of the Bridgeton Formation as an unconfined aquifer depends on its extent and thickness. Together these three hydraulically connected geologic units (Grenloch Sand Member of the Kirkwood Formation, Cohansey Sand, and Bridgeton Formation) make up the unconfined Kirkwood-Cohansey aquifer system in the study area. Well-log data (fig. 1-7, section *A-A'*), in combination with the water-level data (sheet 2), show that, at well 33-280, the unconfined Kirkwood-Cohansey aquifer system consists of about 20 ft of unsaturated material and 25 ft of saturated unconfined aquifer. At the study-area boundary 0.5 mi southeast of well 33-280, the unconfined system reaches a maximum thickness of about 20 ft of unsaturated material and 50 ft of saturated aquifer as determined from land-surface elevation, water levels, and the regional dip of the Cohansey Sand. These thicknesses include the Bridgeton Formation, which is present at both locations.

The outcrop of the Kirkwood Formation consists of the Alloway Clay Member in most of the study area (fig. 1-6). The Member is a low-permeability clayey silt and, in the southern part of the study area, includes marl. The Alloway Clay Member extends from the Delaware Bay to Oldmans Creek, where it abruptly adjoins the Grenloch Sand Member of the Kirkwood Formation (Isphording, 1970). In the southern part of the study area, the Kirkwood Formation locally contains sands that yield usable quantities of water to wells (Rosenau and others, 1969, app., table 6).

The unconfined part of the Vincentown aquifer coincides with the outcrop area of the Vincentown Formation. The only large outcrop of the Vincentown aquifer is in the southwestern part of the Salem River study area (fig. 1-6). This unit is confined where it is covered by tidal marsh and silty alluvial deposits near the Delaware River. Interpolation of well-log (sheet 1) and water-level data (sheet 2) shows that the 10-ft maximum thickness of the Vincentown Formation along section *B-B'* (fig. 1-7) contains less than 5 ft of saturated unconfined aquifer. Along section *C-C'* (fig. 1-7), interpolation of well-log and water-level data shows that the maximum thickness and maximum saturated thickness of the unconfined Vincentown aquifer are about 60 and 50 ft, respectively.

The Hornerstown Sand and the Navesink Formation function as a confining unit underlying the Vincentown aquifer. At land-surface these units crop out northwest of the outcrop of the Vincentown Formation and the Kirkwood Formation where the Vincentown Formation is absent (fig. 1-6). This hydrogeologic unit is present throughout the Salem River study area and can yield small quantities of water for domestic purposes in areas where it is sandy (Rosenau and others, 1969).

The unconfined part of the Wenonah-Mount Laurel aquifer is located northwest of the outcrop of the Hornerstown Sand and Navesink Formation (fig. 1-6). This major unconfined aquifer consists of the outcrop of the Mount Laurel Sand and the upper sandy part of the Wenonah Formation. Near the Delaware River this unit is confined where it is covered by tidal-marsh and alluvial deposits. Interpolation of well-log data collected along sections *A-A'* and *B-B'* (sheet 1, fig. 1-7) and water levels (sheet 2, fig. 2-1) shows that the maximum thickness of the unconfined Wenonah-Mount Laurel aquifer is approximately 90 ft.

An areally extensive confining unit at the land surface northwest of the unconfined Wenonah-Mount Laurel aquifer (fig. 1-6) consists principally of clay-silt and silt. It is made up of all except the uppermost part of the Wenonah Formation, the Marshalltown Formation, most of the Englishtown Formation, and the Merchantville Formation.

In the northern part of the study area, the Englishtown Formation contains beds of sand that can function as an unconfined aquifer. This sand is shown in figure 1-6 and corresponds to the extent of the Englishtown Formation shown on the geologic map of New Jersey (Lewis and Kummel, 1912), as noted by Owens and others (1970, p. 10). Toward the southwest, the sand of the Englishtown Formation makes an abrupt transition (Johnson and Richards, 1952; Minard, 1965) into a clay-silt unit that is similar to, and was initially mapped as, Woodbury Clay (Lewis and Kummel, 1912). This clay-silt portion of the Englishtown Formation is located in the central and southern part of the study area and is included in the Wenonah-Marshalltown-Englishtown-Merchantville confining unit. The sand part of the Englishtown Formation is thickest in the vicinity of Swedesboro Borough and is considered part of the Englishtown aquifer system. Well-log data from Lewis and others (1991) and water levels indicate that the maximum thickness of the saturated part of the unconfined Englishtown aquifer system is about 40 ft in the Swedesboro area.

The Potomac-Raritan-Magothy aquifer system crops out along the Delaware River in the northwesternmost part of the study area. The Middle and Lower Potomac-Raritan-Magothy aquifers are likely confined in the study area because detailed work by Lewis and others (1991) in Logan Township, in the northwestern corner of the study area, shows that these aquifers are covered by surficial geologic material that consists of silt and clay. They also found that the surficial silt and clay typically is not present more than 2,000 ft from the Delaware River. The Upper Potomac-Raritan-Magothy aquifer is unconfined northeast of Oldmans Township because it is either exposed or largely covered by surficial geologic material that consists of sand and gravel. Southwest of Oldmans Township the Upper Potomac-Raritan-Magothy aquifer is likely to be confined because it is close to the river channel and likely covered with surficial silt and clay. Interpolation of well-log data along section *A-A'* (sheet 1, fig. 1-7) and water levels (sheet 2) shows that in this area the maximum saturated thickness of the unconfined Upper Potomac-Raritan-Magothy aquifer, including any part of the undifferentiated hydrogeologic unit that may directly overlie it, is about 75 ft.

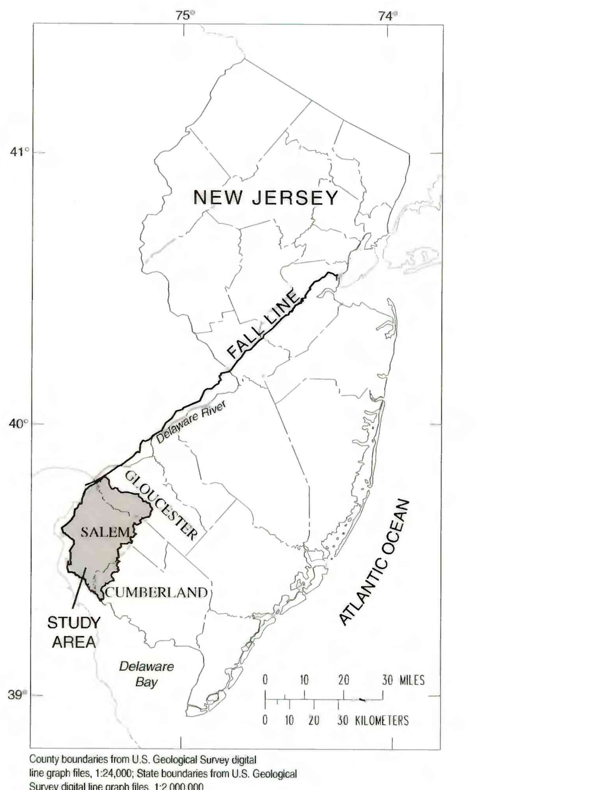


Figure 1-1. Location of the Salem River study area, New Jersey.

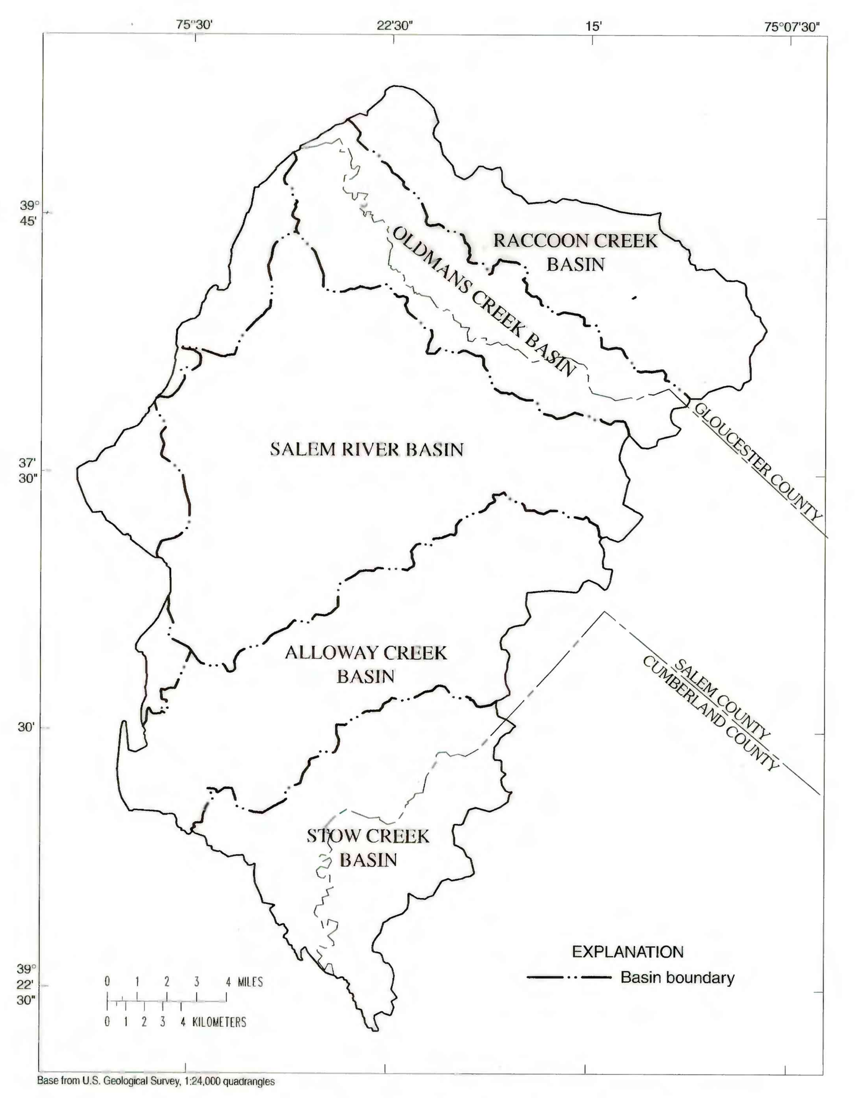


Figure 1-2. Major surface-water drainage basins in the Salem River study area, New Jersey.

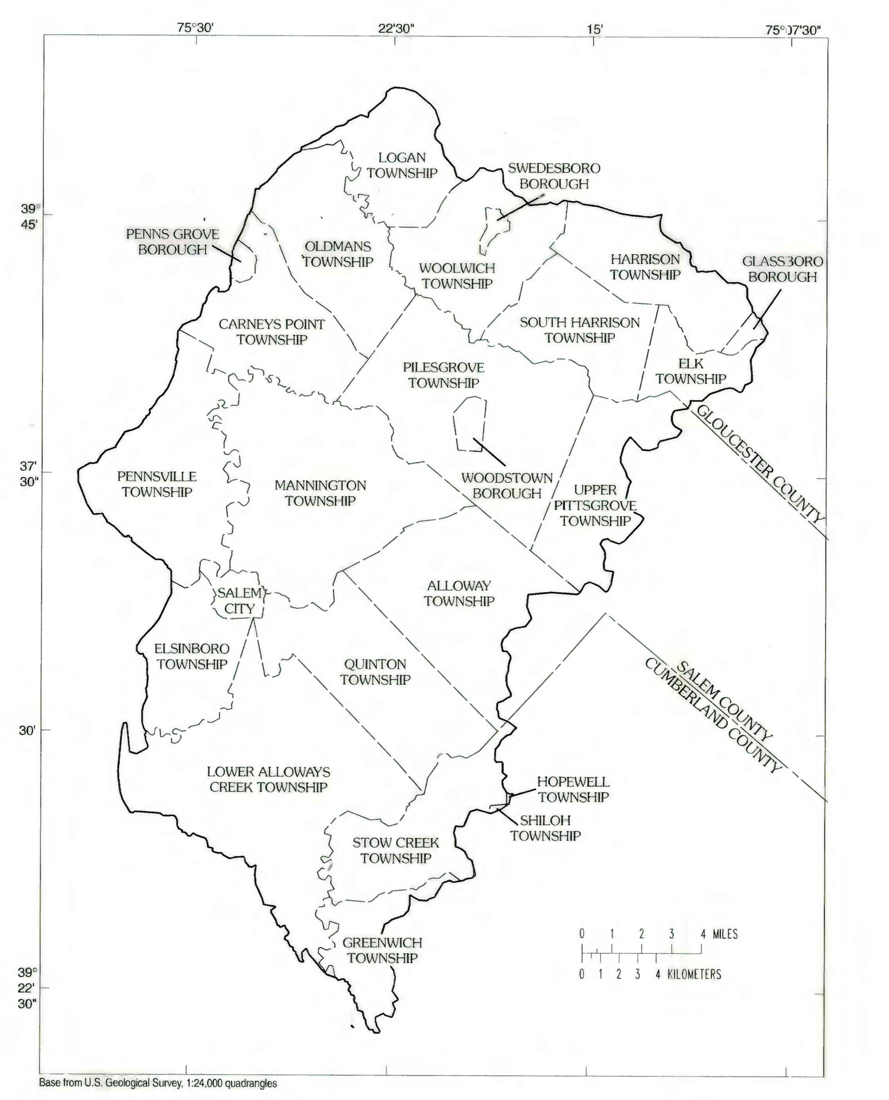
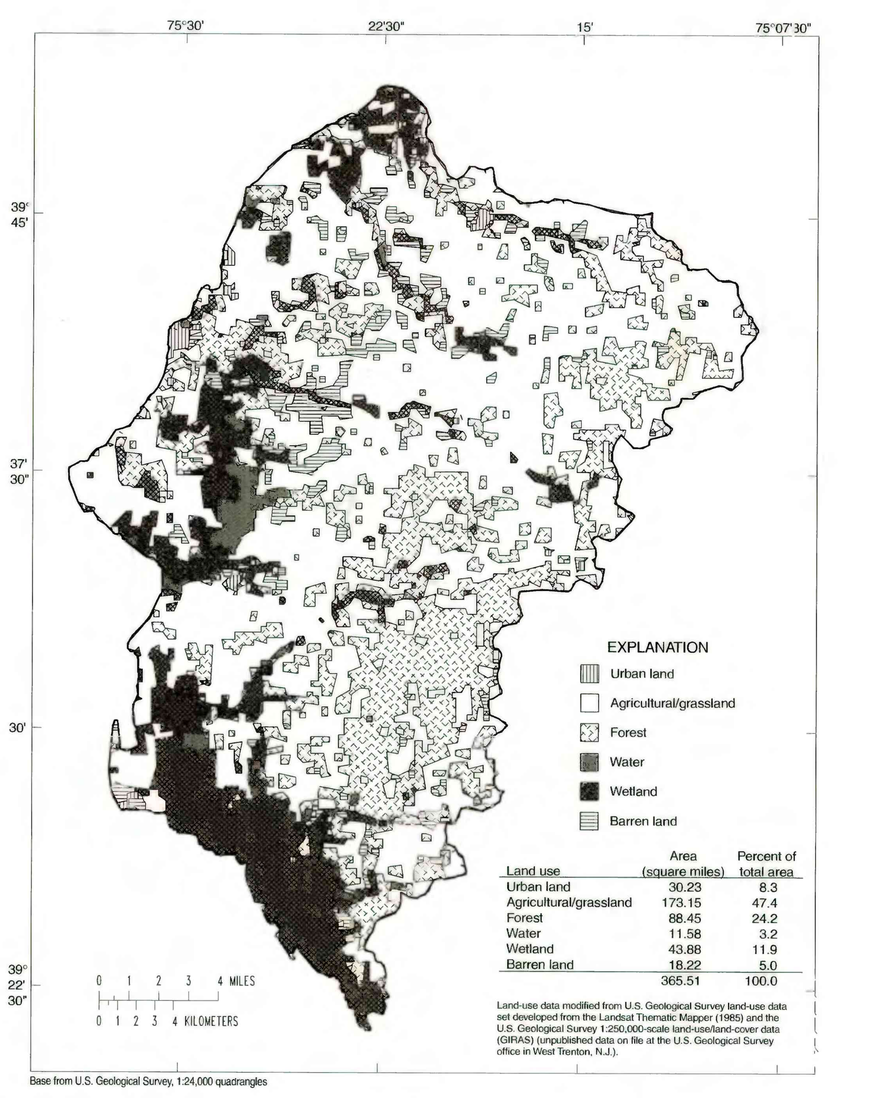


Figure 1-3. Municipalities in the Salem River study area, New Jersey.

Table 1-1. Hydrogeologic characteristics of geologic units in the Salem River study area, New Jersey
[Modified from Zapecza, 1989, table 2]

SYSTEM	SERIES	GEOLOGIC UNIT	LITHOLOGY	HYDROGEOLOGIC UNIT	HYDROLOGIC CHARACTERISTICS
Quaternary	Holocene	Alluvial deposits	Clay, silt and black mud and sand	Undifferentiated	Surficial material, commonly hydraulically connected to underlying aquifers. Locally some units may act as confining layers and others can yield large amounts of water where permeable and thick.
	Pleistocene	Van Sciver Lake Beds	Gravelly sand, sand, clay and silt layers		
		Spring Lake Beds			
Tertiary	Miocene	Pensauken Formation			
		Bridgeton Formation	Sand, clayey sand; brown clay-silt layers	Kirkwood-Cohansey aquifer system	A major unconfined aquifer in the eastern part of the study area. North of Oldmans Creek the Kirkwood Formation consists of the Grenloch Sand Member and is aquifer material.
		Cohansey Sand	Sand, quartz, light-colored, medium- to coarse-grained, pebbly; local clay layers		
		Kirkwood Formation	Sand, quartz, gray, tan, fine- to medium-grained, micaceous; tan to dark-colored clayey silt	Confining unit	From Oldmans Creek to the Delaware Bay the Kirkwood Formation consists of the confining material of the Alloway Clay Member.
	Paleocene	Vincentown Formation	Sand, quartz, gray, green, brown, fine- to coarse-grained, glauconitic, clayey, fossiliferous	Vincentown aquifer	An unconfined aquifer only in the southern half of the study area
		Hornerstown Sand	Sand, silt, clay, glauconitic, dark green, fine to coarse-grained	Confining unit	Low-permeability sediments
Cretaceous	Upper Cretaceous	Navesink Formation	Sand, silt, clay, glauconitic, green and black, medium to coarse-grained		
		Mount Laurel Sand	Sand, quartz, brown and gray, fine- to coarse-grained, slightly glauconitic	Wenonah-Mount Laurel aquifer	A major unconfined aquifer in the study area
		Wenonah Formation	Sand, very fine to fine-grained, gray and brown, silty, slightly glauconitic		
		Marshalltown Formation	Clay, silty, dark greenish gray, glauconitic quartz sand	Confining units	Low-permeability sediments
		Englishtown Formation	Clay-silt, sand, quartz, tan and gray, glauconitic	Englishtown aquifer system	Locally an unconfined aquifer in the northern part of the study area
		Merchantville Formation	Clay, glauconitic, micaceous, gray and black; locally very fine glauconitic sand		Low-permeability sediments
		Magothy Formation	Sand, quartz, light-gray, fine- to coarse-grained; local beds of dark lignitic clay	Potomac-Raritan-Magothy aquifer system: Upper aquifer	The outcrop of the upper aquifer is mostly unconfined in the study area because it is covered by permeable surficial material. The outcrops of the middle and lower aquifers are confined by a covering of silt and clay in the study area.
		Raritan Formation	Sand, quartz, gray, pebbly, red, white, and variegated clay	Confining unit; Middle aquifer; Confining unit	
	Lower Cretaceous	Potomac Group	Alternating clay, silt, sand, and gravel	Lower aquifer	



Land use	Area (square miles)	Percent of total area
Urban land	30.23	8.3
Agricultural/grassland	173.15	47.4
Forest	88.45	24.2
Water	11.58	3.2
Wetland	43.88	11.9
Barren land	18.22	5.0
	365.51	100.0

Land-use data modified from U.S. Geological Survey land-use data set developed from the Landsat Thematic Mapper (1985) and the U.S. Geological Survey 1:250,000-scale land-use/land-cover data (GIRAS) (unpublished data on file at the U.S. Geological Survey office in West Trenton, N.J.).

Figure 1-4. Land use in the Salem River study area, New Jersey.

Conversion factors and vertical datum

Multiply	by	To obtain
Length		
inch	25.4	millimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
foot per mile (ft/mi)	0.1894	meter per kilometer
Area		
acre	4,047	square meter
square mile (mi^2)	2.590	square kilometer
Volume		
million gallons (Mgal)	3,785	cubic meter
Flow		
inch per year	2.54	centimeter per year
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
gallon per minute (gal/min)	0.06308	liter per second
gallon per day (gal/d)	0.003785	cubic meter per day
million gallons per day (Mgal/d)	0.04381	cubic meter per second
Transmissivity		
foot squared per day (ft^2/d)*	0.09290	square meter per day
Hydraulic conductivity		
foot per day (ft/d)	0.3048	meter per day

Temperature conversion formula: $°F = 1.8 \times °C + 32$

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

* This unit is used to express transmissivity, the capacity of an aquifer to transmit water. Conceptually, transmissivity is cubic feet of water per day per square foot (of aquifer area) times feet (of aquifer thickness), or $(ft^3/d)/ft^2 \times ft$. In this report, this expression is reduced to its simplest form, ft^2/d.

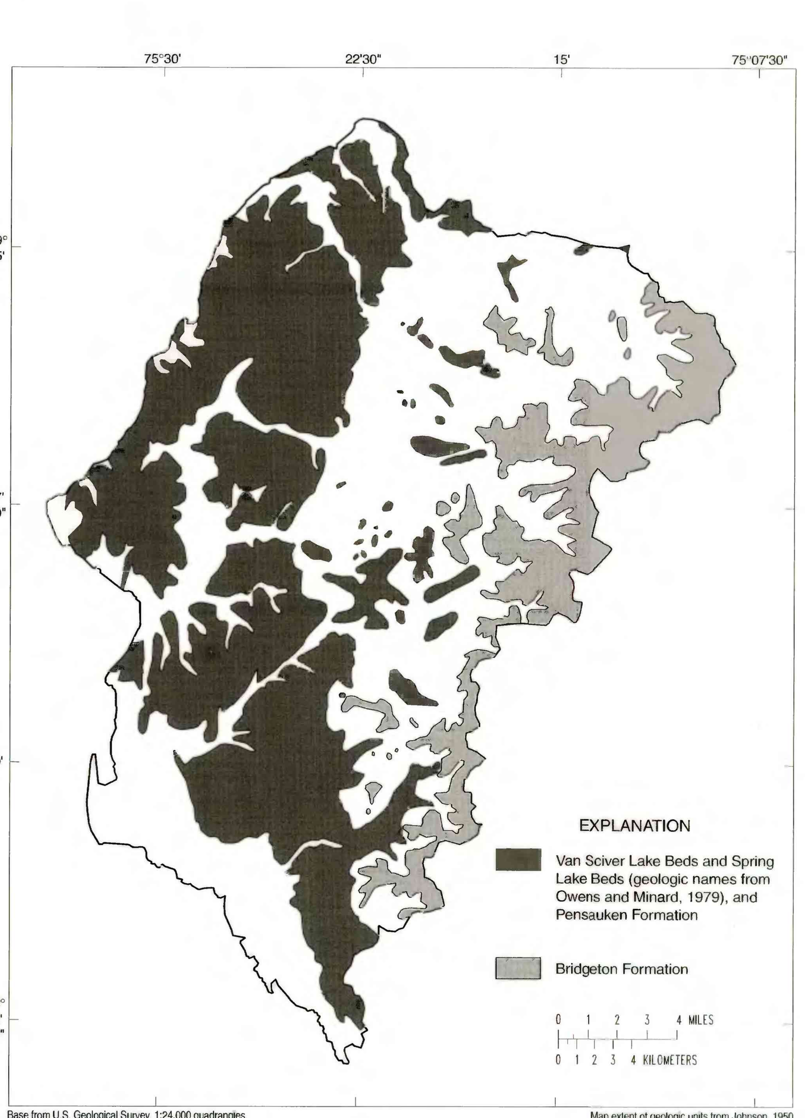


Figure 1-5. Surficial geologic units in the Salem River study area, New Jersey.

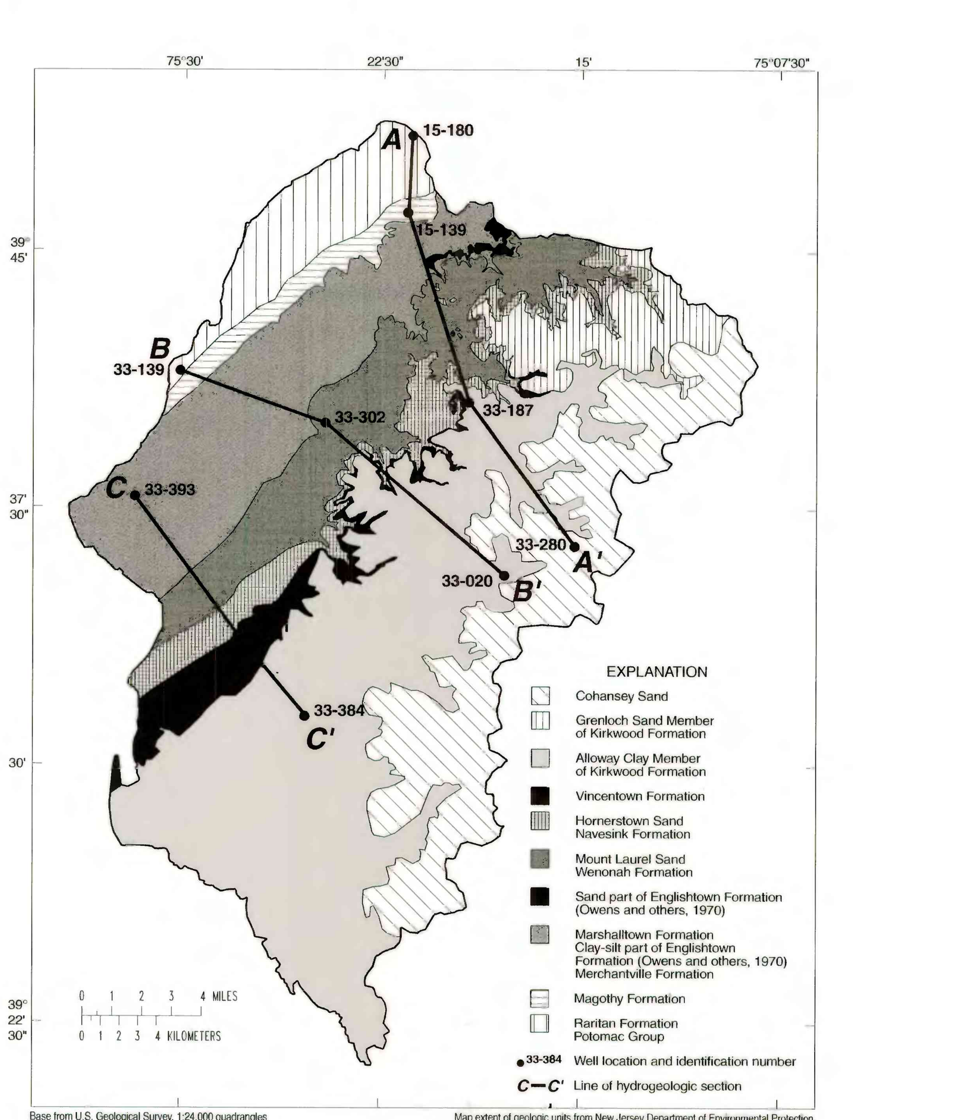


Figure 1-6. Outcrop areas of the bedrock geologic units in the Salem River study area, New Jersey, and the location of hydrogeologic sections *A-A'*, *B-B'*, and *C-C'*.

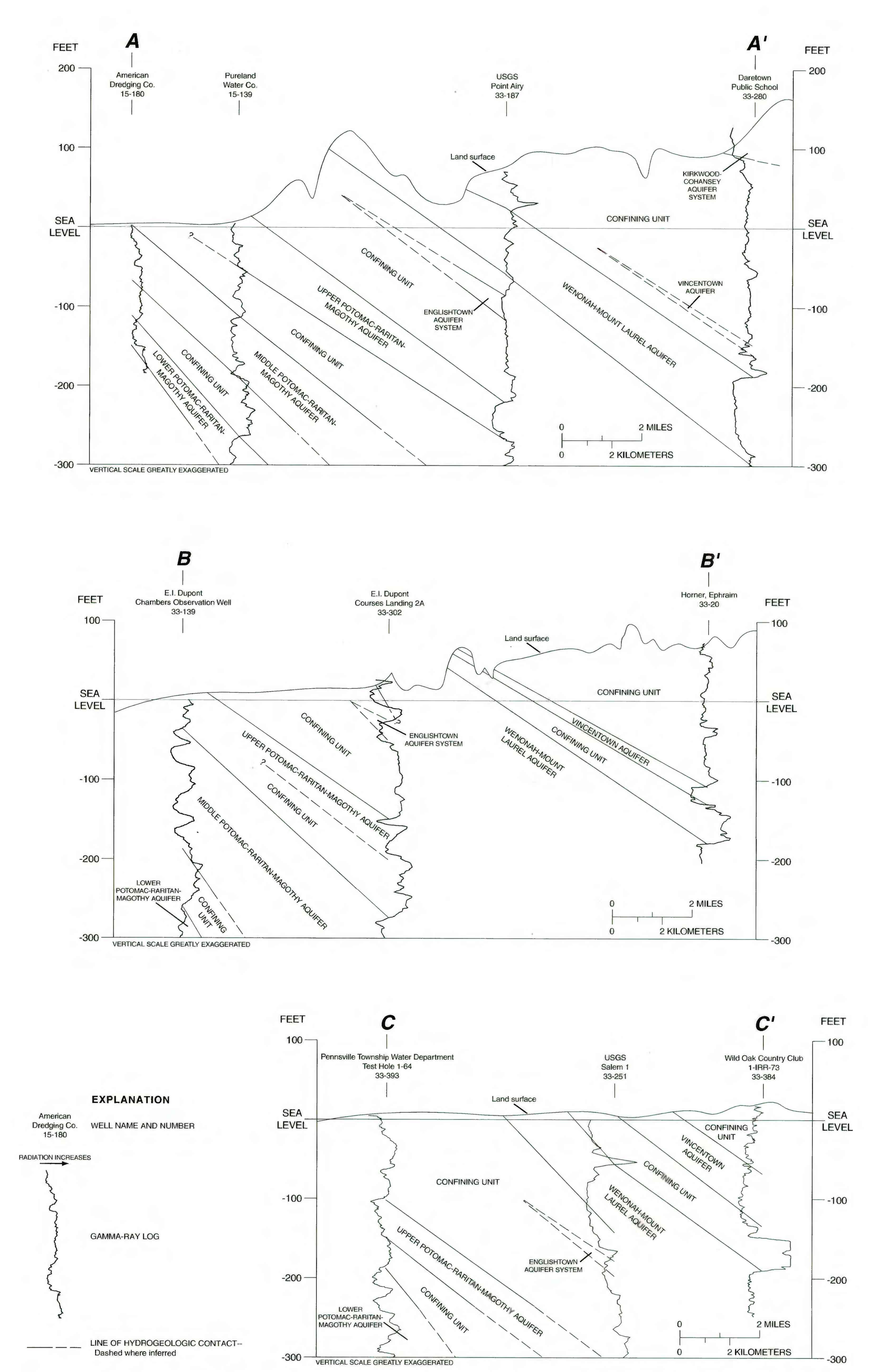


Figure 1-7. Hydrogeologic sections *A-A'*, *B-B'*, and *C-C'* through the Salem River study area, New Jersey, based on gamma-ray logs. (Lines of section shown in figure 1-6. Top and base of hydrogeologic units from Zapecza, 1989, table 4, and Lewis and others, 1991, table 3.)

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