STATE OF NEW JERSEY
DEPARTMENT OF ENVIRONMENTAL PROTECTION

DIVISION OF WATER RESOURCES



SPECIAL REPORT NO. 34

GROUND-WATER RESOURCES CUMBERLAND COUNTY, NEW JERSEY

PREPARED IN COOPERATION WITH
UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

1971

GROUND WATER RESOURCES, CUMBERLAND COUNTY, N.J.

By

James G. Rooney

Hydrologist, U.S. Geological Survey

Water Resources Division

Trenton, N. J.

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Richard J. Sullivan, Commissioner

DIVISION OF WATER RESOURCES

Charles M. Pike, Director

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LETTER OF TRANSMITTAL

Honorable Richard J. Sullivan, Commissioner
Department of Environmental Protection
Labor and Industry Building
John Fitch Plaza
Trenton, New Jersey 08625

Dear Sir:

I am transmitting a report entitled "Ground-Water Resources, Cumberland County, New Jersey," which was completed under the cooperative agreement with the Water Resources Division, U. S. Geological Survey, as part of the State-wide program authorized by the 1958 Water Bond Act.

The report evaluates the general water-bearing characteristics of the aquifers of Cumberland County and points out that while adequate water resources are available to meet the foreseeable future needs, they must be protected by long range planning and careful local control of development.

The information in this report is of vital importance to the growth of the County and provides a basis for the protection and safe development of the ground-water resources essential for such growth. I therefore recommend that this report be published as a Special Report of the Division of Water Resources.

This report is one of the last of a series of county reports on ground-water resources completed with bond funds. These reports are not meant to be final reports but are the basis for more detailed work. The Division of Water Resources proposes to continue with additional investigations under similar cooperative agreements with the U. S. Geological Survey as funds are made available. Water is a dynamic resource for which we must constantly update our knowledge.

Respectfully submitted,

Charles M. Pike, Director
Division of Water Resources

March 21, 1971

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A B S T R A C T

Cumberland County is located in the Atlantic Coastal Plain physiographic province along the northeastern shore of Delaware Bay in Southwestern New Jersey.

An average annual hydrologic budget was computed for Cumberland County. Water gains are: precipitation, 1,050 mgd (million gallons per day); surface-water inflow, 142 mgd; ground-water inflow negligible. Water losses are: evapotranspiration, 685 mgd; surface-water outflow, 370 mgd; ground-water outflow, 137 mgd.

Unconsolidated and semiconsolidated Coastal Plain sediments, 2,500 to 4,500 feet thick, and ranging in age from Cretaceous to Holocene, consist of layers of clay, silt, sand and gravel. Aquifers composed mainly of sand and gravel occur in the Potomac Group and Raritan and Magothy Formations, the Wenonah Formation and Mount Laurel Sand, the Piney Point Formation, and the Kirkwood Formation and Cohansey Sand.

Aquifers in the Potomac-Raritan-Magothy sequence contain saline water and are not currently utilized in Cumberland County. However, they may be utilized in the future for underground storage of fresh water, or possibly other uses when more is known about this aquifer system.

The aquifer in the Wenonah Formation and Mount Laurel Sand is not presently utilized in Cumberland County. It is probably suitable for future development, however, of wells yielding as much as 300 gpm (gallons per minute) of good quality water in the northern part of the county.

The Piney Point Formation is tapped in Cumberland County by only a few wells; each of these generally yield less than 100 gpm. Additional small supplies can be developed from this aquifer. Water from this aquifer requires little or no treatment for domestic use.

Two principal aquifers occur in the Kirkwood Formation and Cohansey Sand: (1) the lower Kirkwood aquifer and (2) the Cohansey-Kirkwood aquifer. Most wells tapping the lower Kirkwood aquifer yield less than 50 gpm but are capable of yielding as much as 400 gpm. Wells in the lower Kirkwood range in depth from 200 to 370 feet. The Cohansey-Kirkwood aquifer is the shallowest and most important source of ground-water in the county but is highly susceptible to surface contamination. This aquifer is highly permeable; analysis of data from two pumping tests indicates permeabilities of 1,200 and 2,700 gpm per square foot. It generally yields large supplies of water (300 to 1,200 gpm) to wells from depths of less than 180 feet. Water in the Cohansey-Kirkwood aquifer is characterized by low dissolved-solids content (63 mg/l, median), low hardness (21 mg/l, median), and low pH values (5.5 pH units, median).

Water use in Cumberland County varies and is highly seasonal, mainly because of increasing requirements for irrigation and the food processing industries in the county. In 1964 seasonal use ranged from 27 mgd in March to 145 mgd in August. This is much higher than withdrawals in neighboring Salem and Cape May Counties. In 1964 withdrawals in Cumberland County averaged about 51 mgd; almost all of this, 49.4 mgd, was from ground-water supplies. The total annual water use in 1964 according to type of use was: for public supply, 10.6 mgd; for industrial uses, 19.0 mgd; irrigation, 15.4 mgd; suburban, rural, residential, institutional, farm, and commercial, 5.9 mgd.

INTRODUCTION

Purpose and Scope

This investigation is part of a reconnaissance program to evaluate the ground-water resources of New Jersey by the U. S. Geological Survey in cooperation with the N. J. Department of Environmental Protection, Division of Water Resources, in accordance with the State-wide program authorized by the Water Bond Act of 1958. The purpose of this investigation was to describe the availability, quantity, quality, and utilization of ground-water in Cumberland County as far as practicable and to define problems that may affect future ground-water development.

The future growth and development of Cumberland County depends, in large part, upon the availability, optimum development and protection of its ground-water resources. Wise water-resources planning and management must be exercised to insure sound and orderly development of the resource and, in particular to protect it from contamination and salt-water intrusion.

This report presents the factual results of the ground-water investigation of Cumberland County. It includes a quantitative estimate of the average annual hydrologic budget for the county and a discussion of important sources of ground-water for present and future development. The quality of the ground-water, including contamination and salt-water intrusion problems and the quantity of ground-water used by different types of supply systems, are also considered. Records of about 300 selected wells are presented in Table 14, and chemical analyses of water from other selected wells are presented in Table 15. Thirty-two logs are presented in Table 16a to show the areal differences and the different sediments that may be encountered in the county.

Geography

Cumberland County is located in the Coastal Plain physiographic province along the Northeastern Shore of Delaware Bay in Southwestern New Jersey (figure 1). The Philadelphia-Camden metropolitan area is about 40 miles to the north and the Atlantic City resort area is about 35 miles to the east. Total area of Cumberland County is 502 square miles of which 113 square miles or about 22 percent is tidal marsh or swamp area.

The county lies almost entirely in the Delaware River basin. All streams draining the county flow south and southwestward toward Delaware Bay except the Tuckahoe River which flows south and then eastward to the Atlantic Ocean.

In General, the land surface of Cumberland County is a broad silty sand and gravel plain sloping gently southwestward toward Delaware Bay.

In the north, surface altitudes are as much as 130 feet above mean sea level; in the southern part of the county along the bay, tidal marsh with altitudes near sea level extends from 1 to 5 miles inland.

The climate is characterized by mild winters and warm humid summers. Temperatures at Bridgeton average 33.7°F in January and 76.5°F in July. The average annual temperature is 54.7°F. Precipitation at Bridgeton averages 44.35 inches per year (U. S. Dept. of Commerce, 1955).

Cumberland County has a wide diversity of economic interests and is rapidly developing industrially. Manufacturing industries include textiles, clothing, lumber, printing and publishing, shipbuilding, metals, chemicals and glass. Glass manufacturing is the largest industry and is closely linked to the abundant high-quality glass sand that is mined in the county. Cumberland County is one of New Jersey's leading agricultural counties specializing in truck farming. Irrigation is practiced extensively to produce high-value vegetable crops. The county is one of the largest egg and poultry producing regions in the country, and is considered the home of the oyster industry in New Jersey. Food processing is, therefore, important to the economy of the county.

There are three cities, one borough, and ten townships within the county. The locations of these municipal divisions are shown on figure 1.

The population of Cumberland County has increased from 51,190 in 1900 to 88,600 in 1950, and to 106,850 in 1960. The 1966 population of the county was estimated to be over 122,000 (Cumberland County Planning Board, 1966b, p. 33-53). The majority of the population (about 85-percent) live in the "tri-city area" in the north-central part of the county, which includes the cities of Bridgeton, Millville, and Vineland; the borough of Shiloh and the Townships of Hopewell, Deerfield, and Upper Deerfield. This area had a population density of 807 persons per square mile in 1966, whereas the remaining seven townships had a population density of only 68 persons per square mile in 1966.

Methods of Investigation

An extensive inventory of wells in Cumberland County was made. Records of about 300 selected wells are given in Table 14. Water samples were collected and chemical analyses made from many of these wells. Analyses are shown in Table 15. Well logs and geophysical logs were compiled; Table 16 gives 32 selected well logs that show the character and thickness of the sediments. Basic data, including well records, drillers' and geophysical logs, and chemical analyses, used in this study can be obtained from files of the U. S. Geological Survey and the New Jersey Division of Water Resources.

All of the wells listed in this report were located in the field. Their locations are shown on figure 2 and 13. Whenever possible, water-

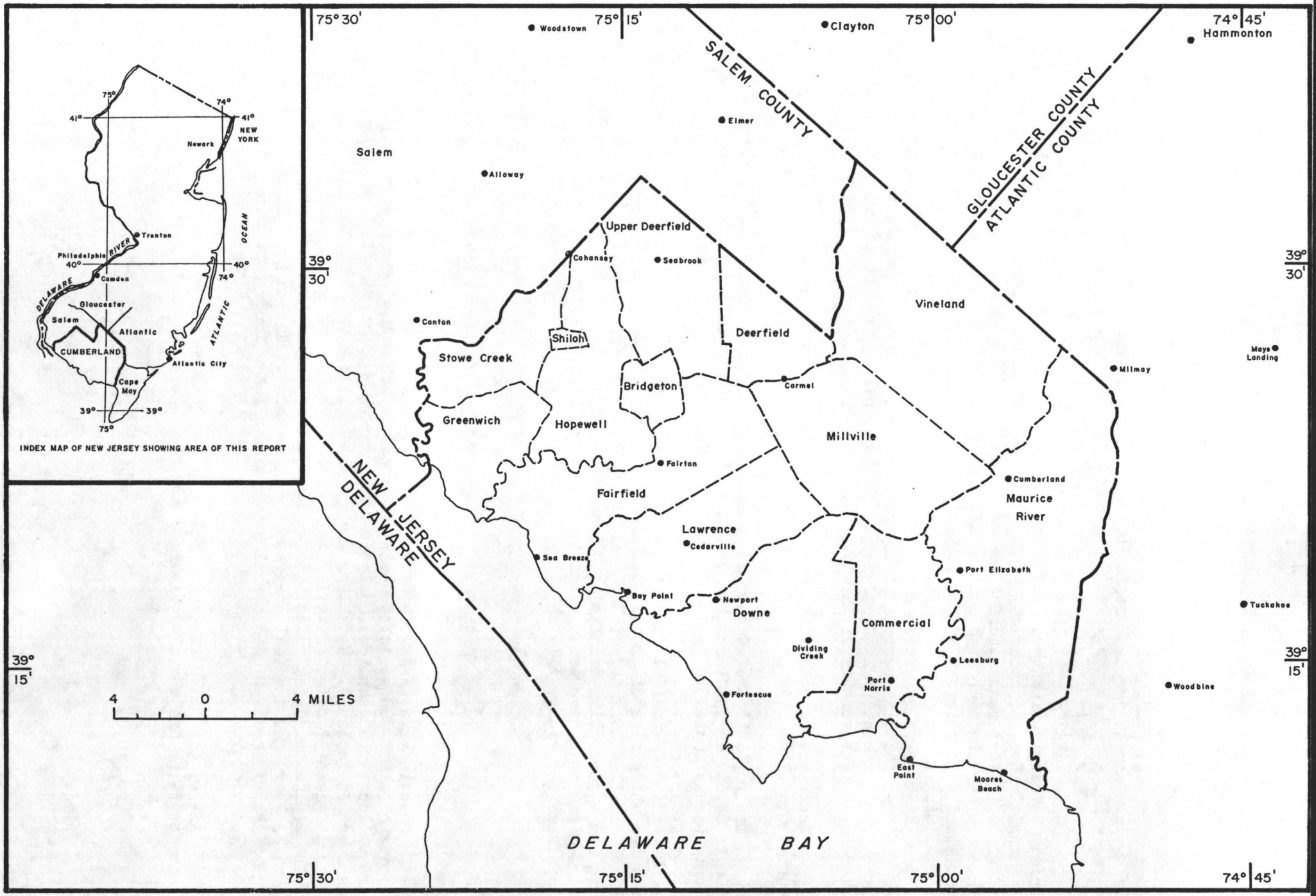


Figure 1.--Map showing location of Cumberland County, its municipal boundaries, and places named in the report.

level measurements were made. Information on well use and pumpage data were obtained in the field and from files of the N. J. Division of Water Resources.

Previous Studies

Many workers have contributed to the knowledge of the ground-water resources of Cumberland County.

Minard and others (1955) mapped the soils of the county. The geologic formations in New Jersey were mapped and described by Lewis and Kümmel (Kümmel, 1940). The geologic map of New Jersey was later revised by Johnson (1950). The Quaternary formations covering much of the county were described by Salisbury and Knapp (1917).

Gill (1962) contributed significant new knowledge on the geology and hydrology of neighboring Cape May County that is partly applicable to Cumberland County. Remson and Fox (1954) investigated the possibilities of artificial recharge to the Cohansey Sand at a waste-water spreading area at Seabrook, N. J.

Acknowledgments

The author is grateful to many individuals and organizations, both public and private, for supplying useful information and assistance during this study. Particular acknowledgment is made to the Cumberland County Planning Board. Well records and logs were made available largely from the New Jersey Division of Water Resources, Bureau of Geology and Topography. Well drillers furnished well records and drilling samples and many industrial and private well owners furnished information on water use and made their wells available for tests and the collection of water samples.

Well-Numbering System

The wells used in this report are grouped by municipality--township, city, or borough-- and are numbered serially, generally starting from the northwesterly margins of each municipality. The number is prefixed with an abbreviation of the name of each municipality, as shown in the table below:

Name of municipality	Abbreviation	Name of municipality	Abbreviation
Bridgeton	Br	Lawrence Twp.	La
Commercial Twp.	Co	Maurice River Twp.	Mr
Deerfield Twp.	Dr	Millville	Ml
Downe Twp.	Dn	Shiloh Borough	Sh
Fairfield Twp.	Fa	Stow Creek Twp.	SC
Greenwich Twp.	Gr	Upper Deerfield Twp.	UD
Hopewell Twp.	Ho	Vineland	Vi

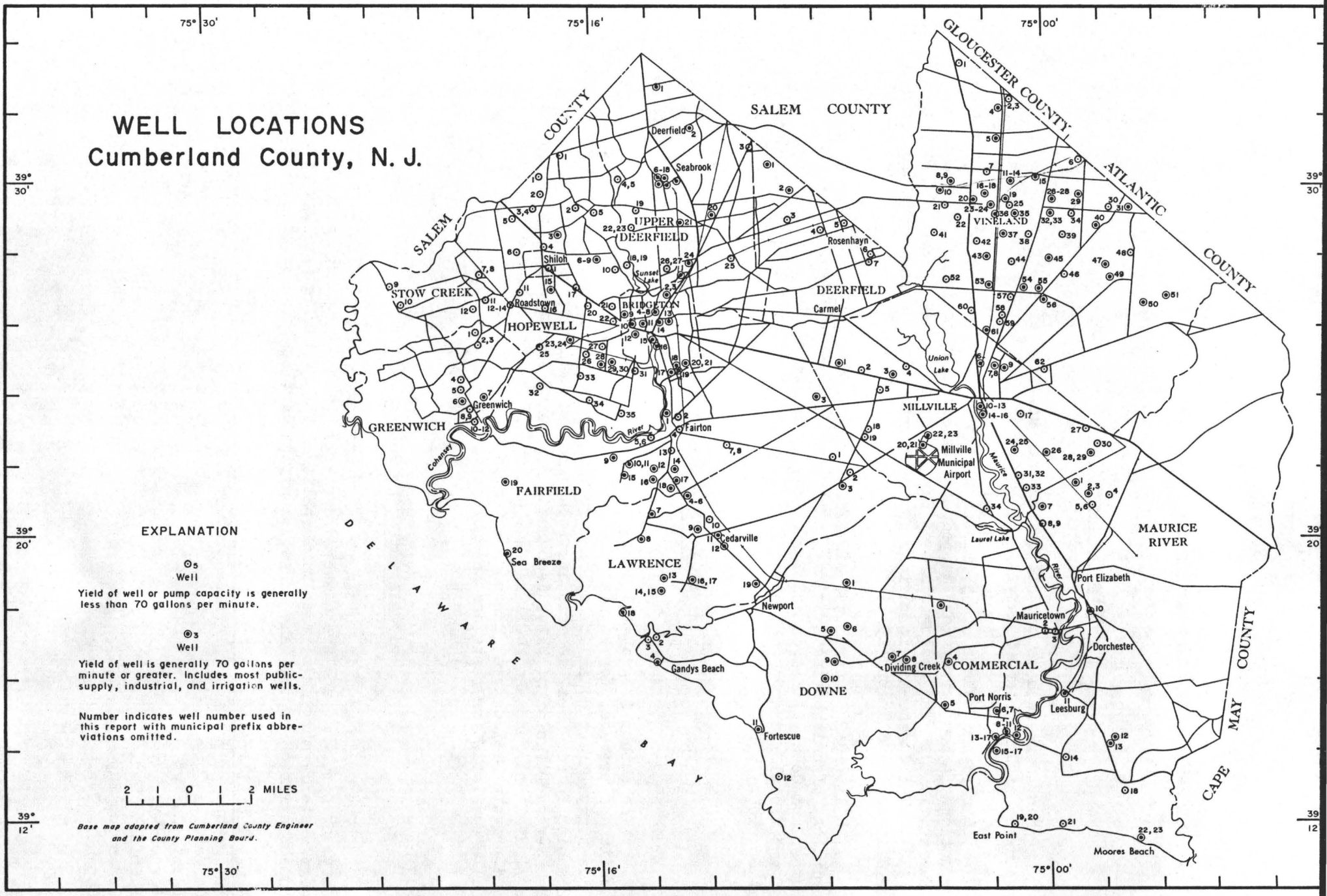


Figure 2.--Map showing location of wells used in this report

It should be noted, however, that the well number prefix has been omitted in some tables and figures for convenience.

THE WATER SUPPLY

The water available to any area is a dynamic resource. Quantities vary greatly from time to time and place to place. Some water is continually being exchanged in a circulatory pattern between the earth and the atmosphere. In general, the amount of precipitation ultimately determines the amount of water available for man's use. Some of the precipitation that falls on land evaporates where it falls, some is used by plants that later transpire the water back to the atmosphere, some flows overland to streams, and some infiltrates into the ground to become ground water, which in part is later discharged back into most streams. The streams flow to the oceans, from which water is evaporated back to the atmosphere.

In order for man to properly manage the available water supply, he should know the quantities of water involved in this hydrologic cycle: precipitation, stream runoff, evaporation, transpiration, infiltration into the soil, and changes in ground-water storage. These quantities can be estimated for some areas in a water budget.

Water Budget and the Hydrologic Equation

A water budget for an area may be prepared by the use of the hydrologic equation which is basically, a statement of the law of conservation of matter. It states that all water entering an area during any period of time must either go into storage, be exported, or discharged from the area as evapotranspiration, surface runoff, or ground-water discharge, during the same period of time. In its simplest form: water gains equal water losses. The equation is expressed by:

$$P + SW(in) + GW(in) = ET + SW(out) + \Delta S$$

where

P = precipitation on the area
SW(in) = surface-water inflow to the area
GW(in) = ground-water inflow
ET = evaporation and transpiration losses (evapotranspiration)
SW(out) = surface-water outflow
GW(out) = ground-water outflow
ΔS = net change in soil moisture and surface-water and ground-water storage

For large areas such as Cumberland County, the hydrologic equation should be used with caution and with an understanding of its limitations. The usefulness of the equation is dependent upon the accuracy with which each item can be measured. Some of the items, such as precipitation and surface-water runoff, can be measured relatively accurately with proper instrumentation. Other items such as ground-water inflow and outflow cannot readily be measured by existing techniques or, they may be too costly to measure.

Also, some items are very small in comparison to others. Small errors in measuring the larger items, such as precipitation and evapotranspiration, tend to produce large errors when determining unknown small items such as ground-water outflow. However, if the selected time period is sufficiently long, usually several to many years, the average net changes in storage are negligible and can be usually dropped from the equation.

An accurate determination of all items in the hydrologic budget for Cumberland County was not feasible within the scope of this investigation. However, a partial evaluation and estimate of the long-term average annual water gains and water losses will be described in following sections of this report. A more accurate quantitative evaluation by aquifers, which is the objective of the cooperative program between the U.S. Geological Survey and New Jersey Division of Water Resources was initiated with the completion of the current series of county reports undertaken by the Water Supply Act of 1958.

Water Gains

Precipitation

Most of the gains to the water supply of Cumberland County come from precipitation. Precipitation is not uniform in time and place. It varies between periods of wetness and periods of drought. Table 1 shows the annual precipitation and departures from long-term averages at Fortescue, Shiloh, and Vineland for the period 1951-66 (see fig. 1). Periods of drought, such as 1954-55 and 1962-66, and wet years, such as 1958, are clearly indicated by the departures from the averages. Table 1 also indicates the areal variability of precipitation in Cumberland County. Because of these variations in precipitation, the water supply is not replenished uniformly throughout the county each year.

The long-term average annual precipitation in Cumberland County is about 44 inches as estimated from maps prepared by Hely and others (1961, pl. 2). This is equal to about 1,050 million gallons of water per day for the entire 502 square-mile area of the county.

Average monthly precipitation also varies in the county, although only slightly, from month to month. Average monthly precipitation at Fortescue is 3.25 inches and at Shiloh 3.65 inches as shown in Table 2. The largest monthly amounts usually fall in August generally because of heavy summer storms.

Table 1. - Annual Precipitation data at Fortescue, Shiloh, and Vineland, N.J.
(in inches)

Year	Fortescue		Shiloh		Vineland 1/	
	Precipitation	Departure from long-term average (1951-66)	Precipitation	Departure from long-term average (1931-60)	Precipitation	Departure from long-term average (1951-59
1951	39.32	+1.36	44.41	+0.57	50.09	+4.84
1952	49.79	+10.83	45.84	+2.00	57.75	+12.50
1953	41.24	+2.28	46.42	+2.58	49.37	+4.12
1954	33.69	-5.27	38.03	-5.81	36.02	-9.23
1955	-----	-----	36.27	-7.57	36.54	-8.71
1956	-----	-----	48.35	+4.51	46.19	+0.94
1957	29.06	-9.90	-----	-----	33.52	-11.73
1958	51.13	+12.17	51.38	+7.54	56.53	+11.28
1959	44.69	+5.73	40.04	-3.80	-----	-----
1960	43.05	+4.09	46.35	+2.51	-----	-----
1961	44.13	+5.17	40.88	-2.96	-----	-----
1962	36.94	-2.02	35.74	-8.10	-----	-----
1963	37.74	-1.22	33.83	-10.01	-----	-----
1964	33.51	-5.45	34.26	-9.56	-----	-----
1965	23.05	-15.91	20.52	-23.32	-----	-----
1966	37.23	-1.73	36.47	-7.37	-----	-----

1/ Station discontinued in 1959

Source: U. S. Dept. of Comm., ESSA Weather Bureau, 1952-1967

Table 2. - Average and normal monthly precipitation and temperature at Fortescue and Shiloh, N. J.

Month	Fortescue 1/ (1948-1966)		Shiloh (1930-1960)	
	Precipitation (inches)	Temperature (°F)	Precipitation (inches)	Temperature (°F)
January	2.85	----	3.67	34.3
February	2.82	----	2.81	34.9
March	3.69	----	3.84	42.2
April	3.15	----	3.13	52.7
May	3.38	----	4.20	63.0
June	2.57	----	3.44	71.7
July	3.43	----	3.86	76.7
August	4.33	----	5.10	73.9
September	3.51	----	3.91	67.1
October	2.39	----	3.12	56.8
November	3.66	----	3.64	45.8
December	3.18	----	3.12	35.2
Average month	3.25	----	3.65	----
Annual	38.96	----	43.74	53.9

1/ Average precipitation only based on 19 years record, 1948-1966

Source: U. S. Dept. Comm., ESSA Weather Bureau

The normal monthly temperature at Shiloh is also shown in Table 2. Although monthly temperature is not directly related to precipitation, it is related to the seasonal variations in the use and replenishment of water supplies. This is particularly important in the summer when evaporation and transpiration rates are high during the time of agricultural and other plant growth. In summer, because of high temperatures, almost all water losses combined are generally greater than water gains and water supplies are taken from storage. In winter, losses are generally less than gains and water supplies are replenished.

Surface Water Inflow

Surface-water inflow from adjacent areas outside of the county contribute significant amounts to the water-supply gains of Cumberland County. Figure 3 shows the principal surface drainage basins in the Cumberland County area.

The Maurice River, having the largest basin, drains an area of 384 sq mi (square miles) above its mouth at Delaware Bay. About 284 sq mi or about 75-percent are in Cumberland County. The U. S. Geological Survey maintains a stream-gaging station on the Maurice River at Norma which measures runoff from a 113 sq mi drainage area, of which about 100 sq mi is in Salem and Gloucester Counties, and about 13 sq mi in Cumberland County. The average annual discharge of the Maurice River at Norma between 1932 and 1961 was 0.98 mgd (million gallons per day) per square mile. Assuming uniform hydrologic conditions exist throughout the basin, the 100 sq mi area in Salem and Gloucester Counties contributes an average of 98 mgd of surface-water inflow to Cumberland County at the Norma gaging station. Additional surface-water inflow, estimated as 44 mgd from Salem County and flowing in the Maurice River below the gage, comes from an area of about 45 sq mi that is drained by Muddy Run (see fig. 3). Therefore, the estimated total inflow contributed by the Maurice River to the water-supply gains of Cumberland County is about 142 mgd. This is equal to about 6 inches of water over the 502 square mile area of the county.

The Cohansey River drains an area of about 106 sq mi almost all of which is within Cumberland County. Insignificant amounts of inflow come the headwaters of the Cohansey and Manumuskin River and Manantico Creek as indicated in figure 3.

Surface-water inflow to Cumberland County varies seasonally and annually. It also varies from wet years to years of drought. This inflow or water supply gain to the county depends mainly on amounts of precipitation, storm runoff, and discharge from the ground-water reservoir. Most dry-weather streamflow comes from ground-water discharge. Table 3 shows the mean monthly and mean annual discharge of the Maurice River at Norma for the 29-year period, 1932-61, and for 1965. Monthly runoff in 1965, a drought year, ranged from 0.84 mgd per sq mi (million gallons per day per square mile) in April, to only 0.23 mgd per sq mi in August and September. The total annual runoff in 1965 was only about half the 29-year average runoff.

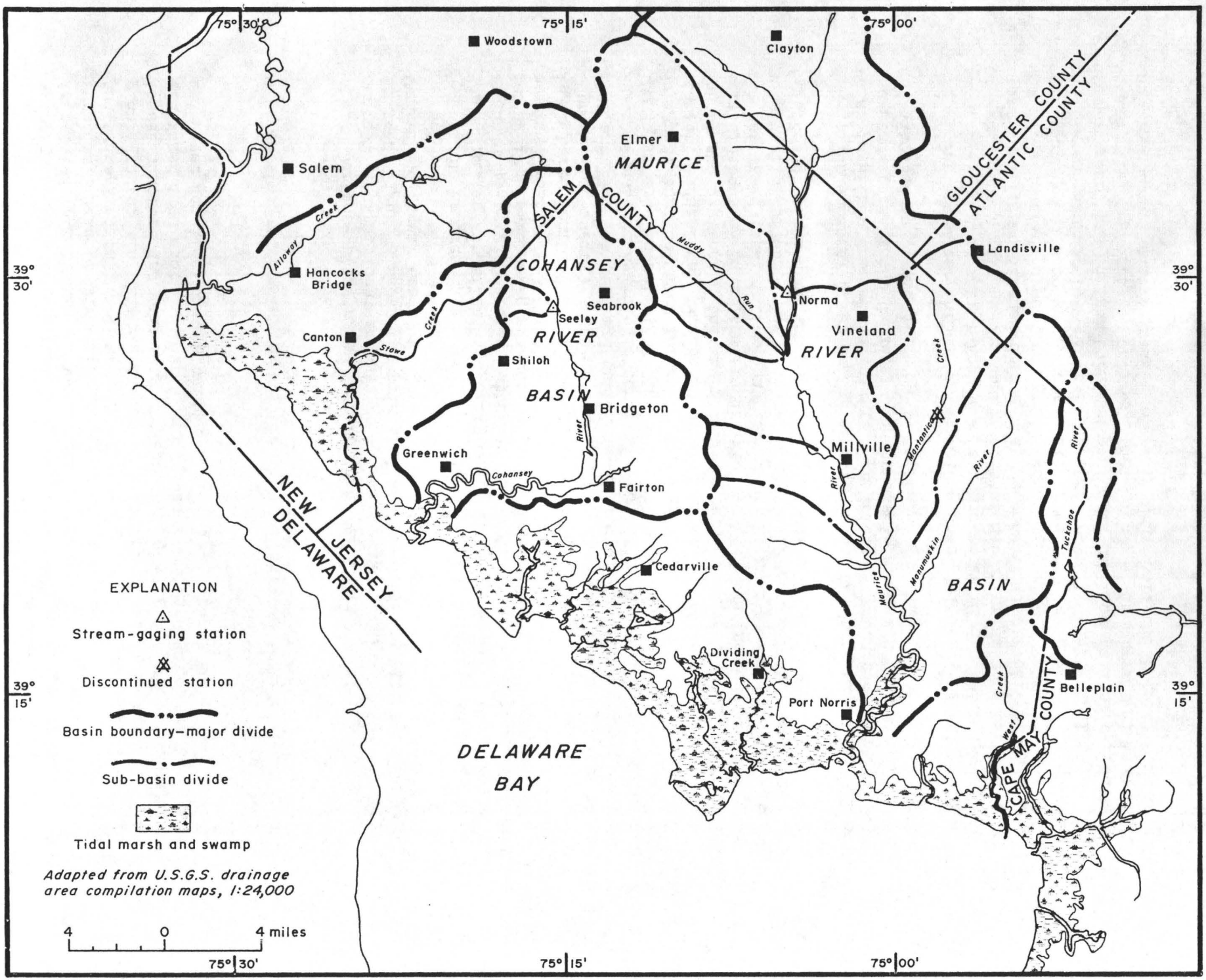


Figure 3.--Map showing the principal drainage basins in the Cumberland County area.

Table 3. - Mean monthly discharge of the Maurice River at Norma, N.J., 1932-61 and 1965

(Drainage area - 113 sq mi)

Month	Cubic feet per second		Million gallons per day		Million gallons per day per square mile		Inches of runoff	
	1932-61	1965	1932-61	1965	1932-61	1965	1932-61	1965
January	195	130	126	84	1.11	0.74	1.99	1.33
February	212	152	137	98	1.22	0.87	1.97	1.40
March	243	143	157	92	1.39	0.82	2.48	1.46
April	230	152	149	98	1.32	0.84	2.27	1.50
May	195	91	126	59	1.11	0.52	1.99	0.93
June	148	74	96	47	0.84	0.42	1.46	0.73
July	123	60	80	39	0.70	0.34	1.26	0.61
August	136	40	88	26	0.78	0.23	1.39	0.41
September	150	41	97	26	0.86	0.23	1.50	0.41
October	118	49	76	31	0.67	0.28	1.20	0.50
November	149	48	96	30	0.85	0.27	1.48	0.46
December	169	57	109	37	0.94	0.32	1.73	0.58
Annual Mean	172	86	111	56	0.98	0.49	20.72	10.30

Ground-Water Inflow

Ground-water inflow to Cumberland County from adjacent counties cannot be readily measured. Most shallow ground-water basins in Cumberland County have shapes and boundaries that are similar to their overlying surface drainage basins. Based on the surface-water divides shown on figure 3 and ground-water divides in figure 8, the total shallow ground-water inflow to Cumberland County is believed negligible compared to the total amounts of precipitation and surface-water inflow; some additional inflow to the county may occur as deep percolation in the deep aquifers. However, because of the general lack of data, meaningful extimates of the total ground-water inflow from the deep aquifers cannot be made for this report.

Water Losses

Evapotranspiration

Evapotranspiration includes all the water that is evaporated from soils, ponds, lakes, and streams and that which is transpired from plants. Rates of evapotranspiration vary seasonally and annually and are not uniform throughout Cumberland County. Actual rates depend mostly on climatic conditions, especially temperature, the distribution, intensity and duration of precipitation and sunshine, and on the availability of soil moisture.

Variations in precipitation and temperature were discussed previously and indicated to some degree the areal, seasonal, and annual variation in potential evapotranspiration. Transpiration may often be greater than evaporation especially in swampy areas where plant roots reach the shallow water table, while evaporation from free water surfaces is greater than transpiration in areas where the water-table is deeper than plant roots. In their hydrologic investigation of the Delaware River basin, Parker and others (1964) found that, in general, there is only a slight difference between annual rates of evaporation from free water surfaces and water losses from both evapotranspiration and ground-water outflow combined. Annual rates of evaporation published by Parker for Cumberland County range from 35.2 inches along Delaware Bay to 35.4 inches near Bridgeton to 35.6 inches near Millville and Vineland.

Evapotranspiration is the largest water loss item in the hydrologic budget of Cumberland County. As computed by the Thornthwaite and Mather (1955) method using data from the period 1931-60 at Shiloh, evapotranspiration is estimated to average 28.7 inches, or about 685 mgd each year. Figure 4 shows the normal monthly potential evapotranspiration rates for the 1931-60 period computed by the Thornthwaite and Mather (1955) method for the Shiloh area of Cumberland County. Monthly rates at Shiloh range from nearly zero in December and January to nearly 6 inches in July. About 85 percent (24 inches) of evapotranspiration occurs during the growing season from mid-April through mid-October.

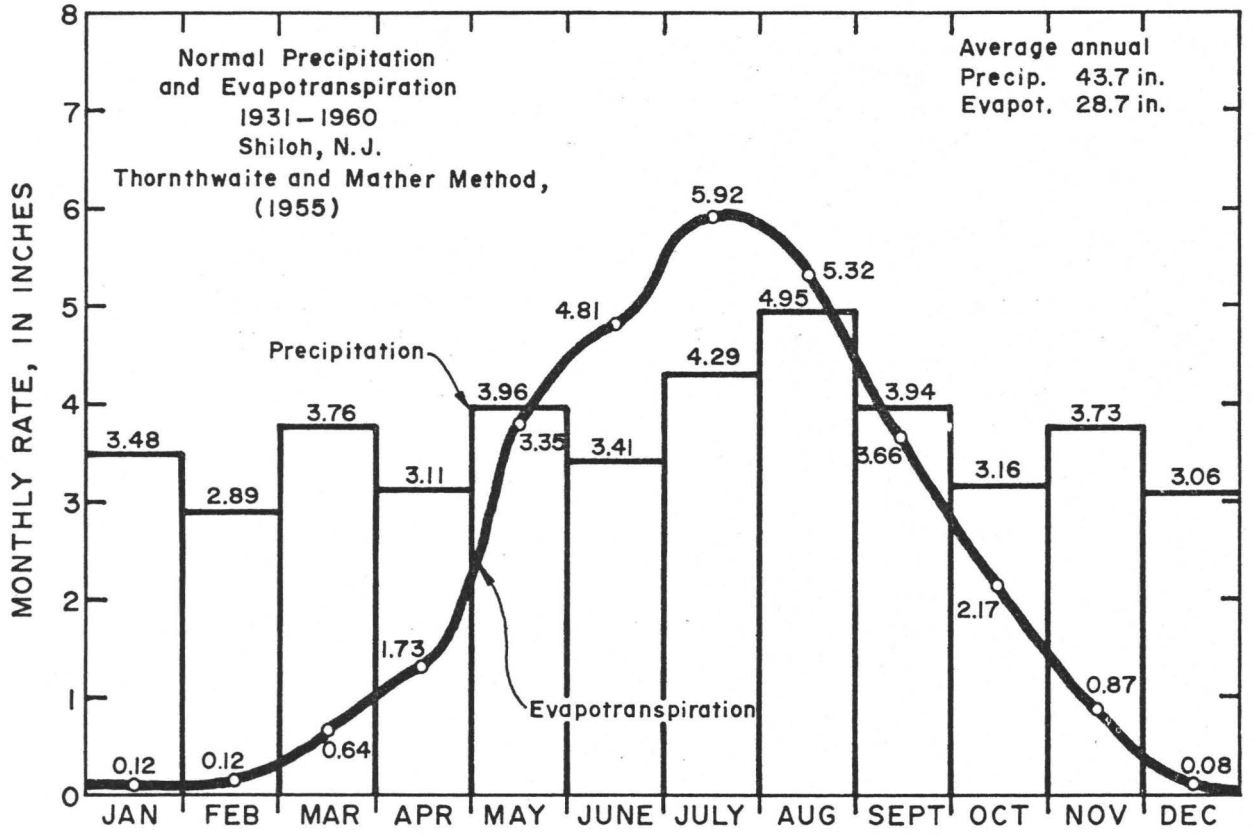


Figure 4.--Graph showing normal precipitation and potential evapotranspiration at Shiloh, N. J. (1931-60).

Surface-and Ground-Water Outflow

Surface- and ground-water outflow from Cumberland County was not measured directly during this investigation because difficulty in obtaining the very low hydraulic gradients, low velocities, tidal fluctuations, and general lack of other hydrologic data. Streamflow is affected by tides as far as 10 miles inland to Bridgeton and Millville on the Cohansey and Maurice Rivers, respectively.

Surface- and ground-water outflow from the county has been estimated indirectly, however, based on estimates of the other known quantities in the hydrologic equation. If the long-term water gain and loss items in the hydrologic equation have been correctly evaluated, the combined surface-water and ground-water outflow from Cumberland County can be determined from the hydrologic equation:

$$P + SW(in) + GW(in) = ET + \left[SW(out) + GW(out)\right].$$

Substituting numerical values (in inches) from the previous discussions, the equation becomes:

$$44 + 6 + 0 = 28.7 + \left[SW(out) + GW(out)\right]$$

or

$$\left[SW(out) + GW(out)\right] = 21.3 \text{ inches}$$

Parker and others (1964, plate 12) estimate SW(out) along Delaware Bay is about 15.5 inches. Although streamflow data along Delaware Bay are not available, the author believes the 15.5 inches is accurate within 1 or 2 inches. Hence, annual ground-water outflow from the county directly to tidal marshes and Delaware Bay is estimated to be about 5.8 inches.

There are both seasonal and annual variations in outflow from Cumberland County. Most outflow occurs in winter when water losses by evapotranspiration are minimal and runoff in streams is greatest. In summer, evapotranspiration rates exceed precipitation (figure 4), especially in the tidal marshes along Delaware Bay; outflow is minimal, and the position of the salt water-fresh water interface in both the streams and aquifer moves inland. In winter, the interface usually moves seaward.

Water Budget of Cumberland County

Table 4 summarizes the estimated values for the average annual water budget of Cumberland County. These estimated values are presented only to show the relative magnitude of the most important items in an average annual water budget for the county. As better data become available and our understanding of hydrologic conditions in the county improve, refinements of these estimates may and should be made.

Table 4. - Estimated average annual hydrologic budget for Cumberland County, N.J.

Item		Inches	Million gallons per day
Water Gains			
Precipitation		44	1,050
Surface-water inflow from Salem and Gloucester Counties		6	142
Ground-water inflow		0	0
	Total	50	1,192
Water Losses			
Evapotranspiration		28.7	685
Surface-water outflow		15.5	370
Ground-water outflow		5.8	137
	Total	50	1,192

General Considerations

Water beneath the land surface occurs in two general zones: the unsaturated zone, commonly called the zone of aeration, and the saturated zone which is generally considered to underly the unsaturated zone. In the unsaturated zone the pore spaces and voids between sediment grains are commonly occupied by both air and water. In the saturated zone the spaces between grains are completely filled with water which is called ground water. A body of rock, including unconsolidated material such as sand and gravel, that is filled with ground water and is capable of yielding water in useful quantities is called an aquifer. In Cumberland County, ground water occurs in almost all of the unconsolidated sedimentary rocks and the upper part of the consolidated bedrock surface which occurs at depths ranging from about 2,500 to 4,500 feet below sea level. However, only a few of the more sandy zones within the unconsolidated sedimentary rocks are considered to be aquifers.

Ground water may occur under water-table or artesian conditions. Under water-table conditions the top of the zone of saturation, which is called the water table, is at atmospheric pressure. In areas not affected by pumping, the water table generally reflects the topography in a subdued manner. Hence, the water table is at higher altitudes beneath hills than beneath nearby valleys. Where the water table is at the land surface, water discharges either as a spring or as seepage directly into a stream, pond, or other surface-water body.

Artesian conditions occur where the water is confined under hydrostatic pressure in an aquifer by relatively impermeable overlying and underlying materials. The hydrostatic pressure of ground water is generally due to the weight of water at higher levels in the same zone of saturation and if a particular zone is confined it is considered an artesian aquifer. The water level in a well tapping an artesian aquifer is then above the top of the penetrated aquifer. The potentiometric (piezometric) surface of an aquifer is the surface to which water from the aquifer will rise under its full head or hydrostatic pressure. Where the altitude of the potentiometric surface of an artesian aquifer is above that of the land surface, a well tapping that aquifer will flow. Numerous flowing wells are found in Cumberland County, particularly in the lowlands between Greenwich and the Port Norris area. The natural rate of flow from one well near Dividing Creek was measured to be 138 gallons per minute (Well No. Dn-9 table 14).

The source of all fresh ground water in Cumberland County is precipitation. Water from precipitation infiltrates through the soil and moves through the interstitial voids of pore spaces in the rock under the influence of gravity or pressure gradients.

The direction of ground-water movement in confined and unconfined aquifers is from areas of higher to lower hydraulic head. In unconfined aquifers water moves in fairly direct paths from topographic highs to lower

discharge areas where the water table intersects the land surface. In artesian aquifers the confined water may move in less direct paths from the recharge area to a discharge area which may be miles down gradient. Most natural ground-water discharge from the confined and unconfined aquifers in Cumberland County occurs along streams, in swamps and tidal marshes, and as underflow to Delaware Bay.

The permeability of a rock determines its capability to transmit water under a given hydraulic gradient. The field coefficient of permeability is defined as the rate of flow of water under prevailing conditions, including water temperature, in gallons per day through a cross-sectional area of 1 square foot (gpd per sq ft) under a hydraulic gradient of 100 percent. Permeability varies largely with size and degree of sorting of the individual grains in unconsolidated materials. A well-sorted gravel, for example, has a higher permeability than a well-sorted coarse sand. Gravel mixed with a moderate percentage of medium- and fine-grained material, however, may be less permeable than a uniformly sorted coarse sand. In a poorly sorted material, the finer materials fill the pore spaces between the coarser materials thus reducing the permeability.

The hydraulic properties most useful in evaluating aquifers are the coefficients of transmissitivity, which is commonly termed transmissibility, and storage. The coefficient of transmissitivity is a measure of the capability of an aquifer to transmit water. It is the rate of flow of water under prevailing conditions, in gallons per day, through a vertical strip of the aquifer 1 foot wide extending the full saturated height of the aquifer, under a hydraulic gradient of 100 percent. The coefficient of transmissitivity of an aquifer is equal to its average coefficient of permeability multiplied by its saturated thickness.

The coefficient of storage of an aquifer is the volume of water released from or taken into storage per unit surface area of the aquifer per unit change in the component of head normal to that surface. Specific yield is the quantity of water yielded by gravity drainage from saturated water-bearing material and is expressed as a percentage of the total volume of the material drained. For water-table aquifers, the coefficient of storage is approximately equal to the specific yield and is generally between 10- and 30-percent. For artesian aquifers, the coefficient of storage is considerably smaller than the specific yield and generally is between 5×10^{-3} and 5×10^{-5}.

Water-Level Fluctuations

Ground-water levels fluctuate in response to such factors as recharge from precipitation, discharge to streams, atmospheric pressure changes, evapotranspiration, and artificial ground-water withdrawals. When recharge exceeds discharge, water levels rise; conversely, when discharge from wells or to surface-water bodies or through processes of evapotranspiration exceeds recharge, water levels decline. Records of water levels in wells therefore are useful in evaluating seasonal and long-term changes in ground-water storage and in evaluating local and regional effects of pumpage from wells.

Figure 5 shows the water-level record from two U. S. Geological Survey observation wells in Cumberland County. One well, (SC-2 West Branch No. 15), located in the western part of the county near Shiloh, is 25 feet deep and furnishes a record of water-level fluctuations in the unconfined water-table aquifer. The other well, (M1-24 Orange Street Well), located in the eastern part of the county in Millville, is 150 feet deep. It furnishes a record of water levels in the deeper part of the shallow and semiconfined aquifer in the Cohansey and Kirkwood Formations.

The records show that water levels are quite variable from year to year and from season to season. Highest annual levels generally occur in the spring and lowest annual levels generally occur in the fall and early winter months. The average annual fluctuation of the water table near Shiloh is about 2.5 feet from highest to lowest levels.

Periods of wetness and drought are reflected in the water-level record. A wet period occurred in 1958-61 (See Table 1) when precipitation and ground-water recharge were generally above average. The effect of the extended and severe drought of the 1960's which affected the entire northeastern part of the country is clearly shown by the water-level record of the observation well SC-2 near Shiloh. During the period 1961 through 1966, there was a cumulative precipitation deficiency of about 61 inches below normal at Shiloh (See Table 1). In 1962 water levels were above average reflecting antecedent conditions of above normal precipitation and ground-water recharge in the spring of 1961. At the beginning of 1963 water levels fell below average. In April 1964 drought conditions intensified, becoming severe in 1965. Precipitation was 23.32 inches below the normal at Shiloh in 1965. In April 1965 water levels fell below the previous record lows, and they continued to set new record lows during the rest of 1965, throughout 1966 and into 1967 due mainly to the deficiency of precipitation during this period. Since March 1967, levels have been rising and they approached average levels by the middle of 1968.

The drought of the 1960's seriously affected the water supplies of Cumberland County during the drought period. Average water levels were as much as 6 feet below previous averages. Many shallow wells went dry when water use increased for watering lawns and irrigating farm crops. Natural streamflow, derived from ground-water discharge also was well below average during this period (See Table 3) but began to recover as precipitation during 1967 and 1968 approached average conditions.

WATER QUALITY

Of all present and future problems relating to the development of the ground-water resources of Cumberland County, those associated with water quality promise to be the most troublesome. Most of the available ground water in Cumberland County is of good quality. However, some small local areas have always yielded ground water of relatively poor quality. In other very small areas, water quality has been contaminated as a result of man's

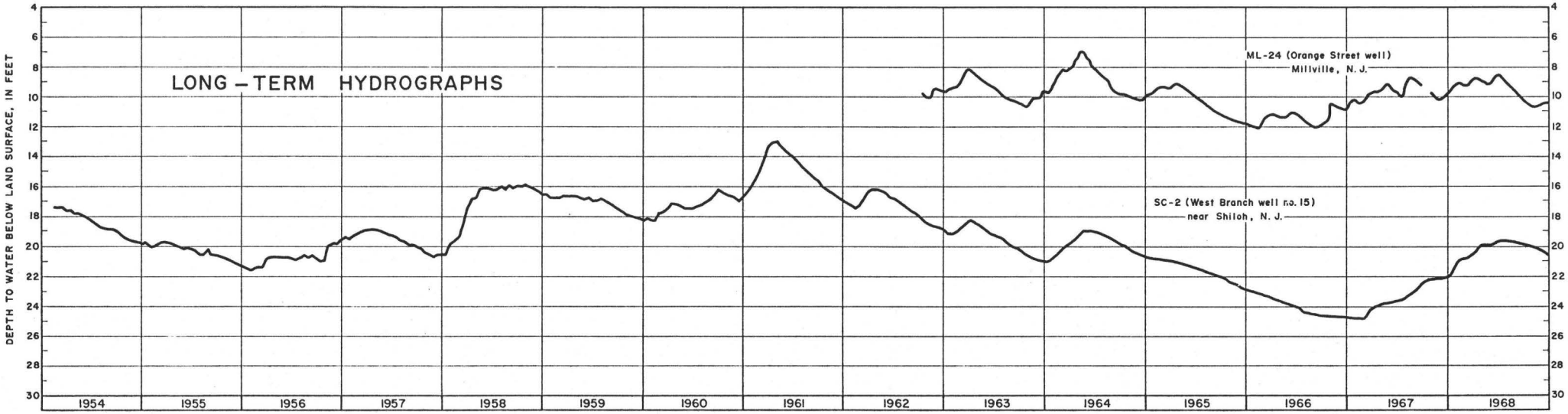


Figure 5.- Long-term hydrographs of two shallow wells in the Cohansey-Kirkwood aquifer.

activities. Because the quality of water determines its utility and economic worth in any area, knowledge of water quality is necessary for the proper management, protection, and economical development of ground-water resources.

Water quality is described primarily by the amount of matter dissolved or suspended in pure water. It determines the utility of the water and the treatment needed for specific uses, such as for irrigation or food processing.

The principal source for replenishment of water to underground supplies is by direct vertical infiltration of precipitation through the soils into the underlying rocks. Most dissolved or suspended matter in natural ground water comes from the weathering of minerals in the soil and rocks, and from biological activity in the soil. Also, it can be expected that any soluble foreign material applied or dumped on the land surface will influence the quality of the ground water.

Many chemical and physical properties are determined in laboratory analyses of ground water. Quantitative chemical properties include concentrations of the different elements which are often expressed as milligrams per liter (mg/l) or parts per million. Dissolved solids are the total of all the mineral matter in solution. Specific conductance, the ability of water to conduct an electric current is generally expressed in micromhos per centimeter and can be used to estimate dissolved solids. Hardness is a common physical property generally related to the amount of calcium and magnesium present in water and largely determines the amount of soap needed for clean laundering. Values of pH are a measure of the acidity and alkalinity of water; values lower than 7.0 pH units indicate acid water and values greater than 7.0 indicate alkaline water. Other physical properties commonly reported in a water analysis include temperature, color, turbidity, odor and taste.

The physical and chemical potable-water standards of the New Jersey State Department of Health (1967) for the most common properties normally found in natural ground waters are summarized below. These standards refer to the water which is consumed, not raw water, which may be treated to conform with them.

"The physical characteristics of water intended for potable purposes shall not exceed the following limits:

a. Turbidity - not to exceed 5 mg/l (milligrams per liter).
b. Color - not to exceed 10 units.
c. Taste - the water shall have no objectionable taste.

The following chemical substances should not be present in a water intended for potable purposes in excess of the listed concentrations. Their presence may constitute grounds for the rejection of the supply if, in the opinion of this Department, such substances, either singly or in combination, are present in such concentrations as would render the water unduly corrosive, unpalatable, hazardous to the consumers, or aesthetically objectionable."

Constituent	Recommended maximum Concentration (mg/l)
Alkyl benzene sulfonate (detergents)	0.5 mg/l
Chloride (Cl_3)	250 mg/l
Copper (Cu)	1.0 mg/l
Fluoride (F)	1.5 mg/l
Hardness (as $CaCO_3$)	150 mg/l
Iron (Fe)	.3 mg/l
Manganese (Mn)	.05 mg/l
Nitrate (NO_3)	30 mg/l
Phenolic compounds (as phenol)	.001 mg/l
Sodium (Na)	50 mg/l
Sulfate (SO_4)	250 mg/l
Total dissolved solids	500 mg/l

The quality of ground-water in Cumberland County ranges from excellent to poor. It depends mostly upon the depth of the water below the surface and the specific location within the county. Most of the ground-water of relatively poor quality is salty and occurs in three principal zones: 1) at shallow depths, generally less than 100 feet, along the tidal flats and tributary estuaries of Delaware Bay; 2) at deeper depths ranging from below about 200 feet at Greenwich, to about 750 feet between Bridgeton (see Table 5a) and Port Norris and, 3) at depths greater than 1000 feet throughout the county. Water of excellent quality occurs throughout most of the interior parts of the county in all the other upper water-bearing sand and gravel formations. Most of the wells in use in the county obtain water from these upper sediments (0-180 feet). Representative analyses of water from wells in Cumberland County are given in Table 15. The water quality of the more important aquifers is summarized in the section describing the geology and hydrology of the sediments.

Ground-water supplies have been contaminated in a few areas in the county largely as a result of the leaching of agricultural fertilizers and the improper disposal of industrial wastes and domestic sewage. Practices and processes that can lead to contamination of ground-water supplies are: poorly managed land-fill and excavation operations; leakage of soluble sewage wastes from cesspools and septic tanks; water movement from an aquifer containing poor quality water to an aquifer containing better quality water; and salt-water intrusion from tidal streams or from deeper, residual saline ground water. Contamination problems have been reported in several shallow wells from several of these sources in Cumberland County. (See Table 11).

Increasing concentrations of nitrate, chloride, and dissolved solids in water from shallow wells in the county indicate probable contamination. Concentrations of nitrate (NO_3) reported in Tables 11 and 15 ranged from 0.16 to 65 mg/l. The N.J. State Department of Health (1967) recommends a maximum concentration from potable water of 30 mg/l nitrate (NO_3). It is

widely recommended that water containing more than 45 mg/l nitrate should not be used in infant feeding as cyanosis due to methemoglobinemia may result (Rainwater and Thatcher, 1960, p. 216). The high concentrations of chloride and dissolved solids in water from wells Vi-36 and Vi-58 in Table 11 indicate local contamination of the ground-water supplies from improper disposal of industrial wastes and poor management of sanitary land-fill operations.

Salt-Water Intrusion

One of the important factors limiting the future development of ground-water supplies in Cumberland County is the actual or potential threat of intrusion of salt water into fresh-water aquifers. It is a continuous threat to shallow aquifers along Delaware Bay and along the tidal reaches of most streams. In the deeper aquifers slightly salty to brackish water from residual water, in which the sediments were originally deposited, underlies most of the county. Future encroachment of this saline water into fresh-water aquifers is a possibility. A limited number of out-post wells is maintained by the U.S. Geological Survey and the N.J. Division of Water Resources under a cooperative agreement in order to monitor increases in salinity and changes in hydraulic gradient. However, this network must be expanded with the development of the county's ground water resources. Once ground water is contaminated by salt water many years may be required to remedy the situation.

The location and depth of saline ground water is different in each aquifer. In general, however, the salt water extends farthest inland from Delaware Bay and the Atlantic Ocean in the successively deeper aquifers. Because it is denser than fresh water, salt water typically occurs below the fresh water. A general rule to determine the vertical position of the salt water-fresh water interface is based on the Ghyben-Herzberg principle.

According to the Ghyben-Herzberg principle (Drabbe and Ghyben, 1889 and Herzberg, 1901) the hydrostatic pressure at the base of a 41-foot column of fresh water of density 1.000 equals the hydrostatic pressure at the base of a 40-foot column of salt water with an average density of 1.025. Applying this relation to coastal aquifers, salt water theoretically occurs 40 feet below sea level where the ground-water head in a well is 1.0 foot above sea level. Similarly, salt water would occur 80 feet below sea level where the ground-water head was 2.0 feet above sea level.

Salt-water intrusion may eventually occur when the fresh-water head is lowered relative to that of the salt water. The hydraulic head may be lowered or reversed by pumping of wells or when natural ground-water discharge rates, especially those caused by evapotranspiration in the tidal marsh areas, exceed recharge rates. Such conditions are most apt to occur during extended periods of drought such as the drought of 1962-66 when ground-water levels were well below normal and water use was much greater than normal.

Salt-water intrusion may occur seasonably in low-lying tidal areas of Cumberland County where shallow aquifers are hydraulically connected to Delaware Bay or other salt-water estuaries. Because of greater ground-water use by plants and lower ground-water levels from pumpage in summer than in winter, water quality in many shallow wells near the tidal portions of Cohansey and Maurice Rivers probably deteriorates seasonally. For such areas ground-water diversions must be carefully monitored to avoid damage to the water supply.

The salinity of surface-water estuaries also varies seasonally, and depends largely on the amounts of fresh-water outflow to Delaware Bay. Figure 6 indicates the seasonal variation in the salinity of the Delaware River at Reedy Island Jetty which is about 14 miles northwest of Greenwich. Dissolved solids, computed from the measurements of specific conductance, range from an average of 4,200 mg/l in the spring, when fresh-water outflow is maximum, to about 13,000 mg/l in the fall when fresh-water outflow is minimal. (In ocean water dissolved solids are about 35,000 mg/l). Similar seasonal variations probably occur in the larger tidal streams in Cumberland County although salinities depend also on distance from Delaware Bay as well as the amount of fresh-water discharge in the streams.

As additional supplies of ground water are developed from aquifers near tidal streams and along Delaware Bay, the water quality should be monitored by sampling from suitable observation wells. An indication of the possibility of potential salt-water intrusion may be obtained by monitoring both ground-water pumpage and ground-water levels in near-shore areas.

GEOLOGY AND HYDROLOGY OF THE SEDIMENTS

Cumberland County is underlain by unconsolidated and semiconsolidated sedimentary rocks of the Atlantic Coastal Plain ranging in age from Cretaceous to Holocene. Most of these rocks are in the zone of saturation; some are important aquifers. The Coastal Plain deposits consist mainly of a sequence of alternating layers of clay, silt, sand, and gravel overlying a stream-eroded and differentially warped bedrock surface of crystalline rocks. The depth to bedrock and, hence, the thickness of Coastal Plain sediments in Cumberland County ranges from about 2,500 feet in the northwestern part of the county to about 4,500 feet in the southeastern part.

The Coastal Plain formations underlyong Cumberland County ate described in Table 5 and Table 5a, which show the stratigraphic relations of the formations and their general geologic and water-bearing characteristics.

Sediments of Cretaceous age, which are found only in the subsurface in Cumberland County contain several water-bearing beds or aquifers. These aquifers are in the Potomac-Raritan-Magothy sequence and in the Wenonah Formation and Mount Laurel Sand. Most of the Cretaceous sediments were deposited in marine environments and consist mainly of silt, clay, and fine-grained glauconitic and quartz sand and are largely non-water bearing

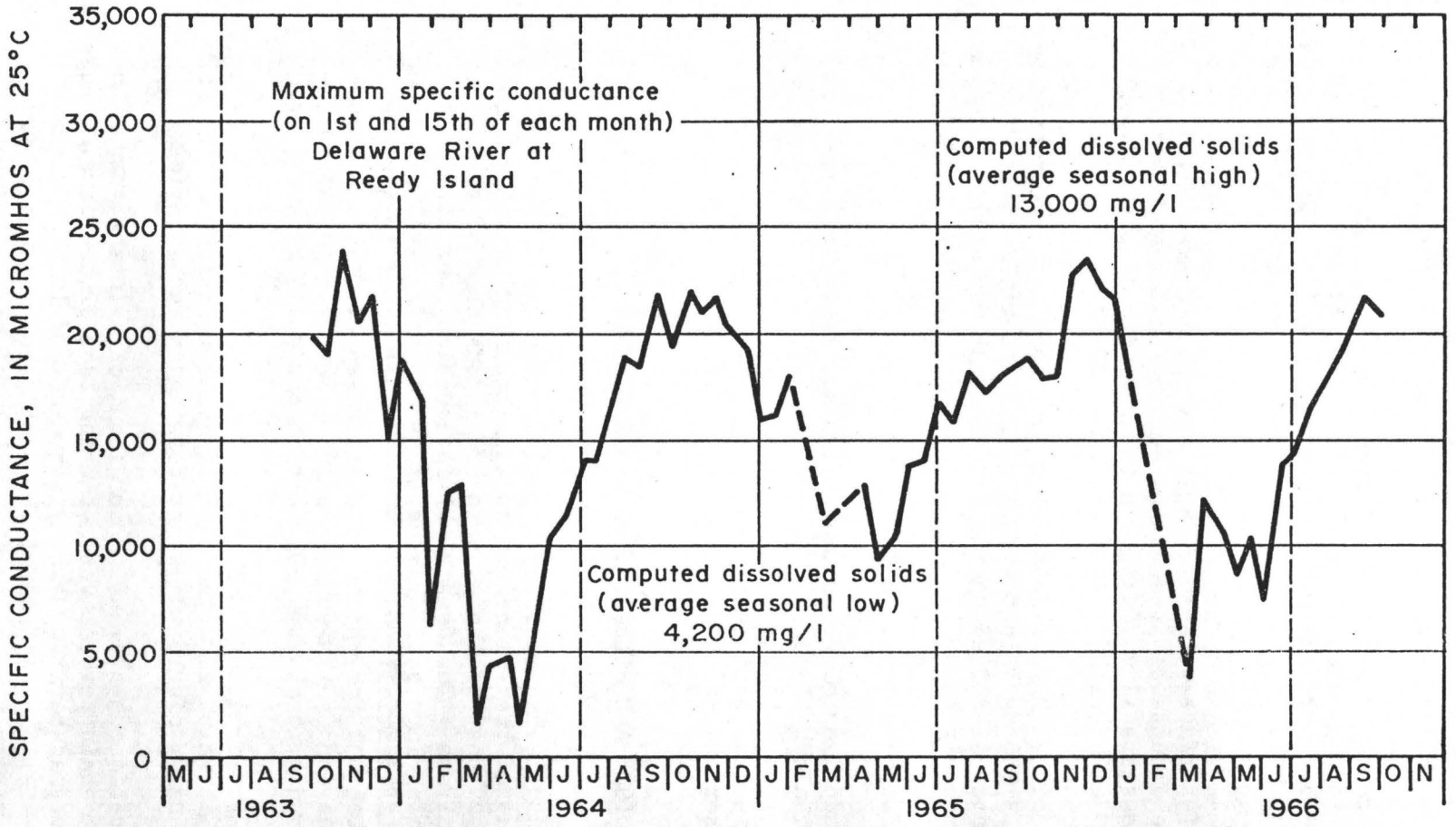


Figure 6.--Graph showing salinity, expressed as specific conductance, of the Delaware River at Reedy Island near Cumberland County, N.J. (1963-66).

in Cumberland County. Aquicludes or semiconfining units of Cretaceous age include the Merchantville, Woodbury, Englishtown, Marshalltown, and Navesink Formations.

Deposits of Tertiary age overlying the Cretaceous sediments consist of alternating layers of sand, silt, and clay. Several water-bearing beds occur in the Piney Point and Kirkwood Formations and in the Cohansey Sand. Other formations, such as the Vincentown Formation and Hornerstown Sand are hydrologically confining or semiconfining units in Cumberland County. The Cohansey and Kirkwood Formations are the only Tertiary units that crop out in the county.

During the Pleistocene Epoch, fluctuations of sea level resulted in alternating periods of erosion and deposition of sediments. During an early stage of the Pleistocene, the Bridgeton Formation was deposited as terrace alluvium that now caps most of the higher upland and interbasin divides in Cumberland County. As sea level was lowered, streams eroded the Bridgeton Formation, cutting channels into the underlying Cohansey Sand and, possibly, into the Kirkwood Formation. Prior to the advance of the last glacier, during later stages of the Pleistocene, sea level rose and the Cape May Formation was deposited, filling the eroded stream channels and covering much of the valley lowland. Much of the Cape May Formation was then eroded as sea level again fell to about its present level. Deposition of stream alluvium and beach deposits is occurring along most present day stream channels and Delaware Bay.

Table 5a is a driller's description of most of the unconsolidated sediments in Cumberland County. These formations were penetrated in a test well which was drilled in 1939 at Bridgeton, N.J.

Potomac Group, Raritan and Magothy Formations

Aquifers in the Potomac-Raritan-Magothy sequence of Cretaceous age contain saline water and are not currently utilized in Cumberland County. This sequence, however, contains some of the most productive fresh-water aquifers in other parts of Southern New Jersey. They have been utilized at Deepwater, in Salem County to store large volumes of injected fresh water which is later recovered; without its quality impaired, for use in periods of heavy demand. It is quite possible that aquifers in the Potomac-Raritan-Magothy sequence in Cumberland County may possibly serve as temporary underground storage reservoirs for fresh water, or possibly a brackish water source for some industries.

Little information is available on the hydrologic characteristics of the Potomac-Raritan-Magothy sediments in Cumberland County. If aquifers in these sediments are to be utilized in the future, they will have to be explored by deep test drilling and their hydrologic characteristics determined.

The Potomac-Raritan-Magothy sediments are overlain by a sequence of confining units. These units, from oldest to youngest, are the Merchantville,

Table 5.--Generalized geologic section and hydrology of Cumberland County, N.J.

System or Period	Thickness (in feet)	Series or Epoch	Geologic Units or Aquifers	Geologic and Hydrologic Characteristics
QUATERNARY	0 - 15	Holocene	Beach and steam alluvium deposits	Beach sand is generally a well sorted, homogeneous, fine to medium-grained well-rounded, quartz found along Delaware Bay. Stream alluvium occurs along present channels in intermingled layers of clay, silt and sand.
	0 - 15		Tidal-marsh and swamp deposits	Interbedded fine-grained sand, silt, and clay and much organic material. Generally these deposits are soft and, in part, semifluid. Function primarily as large ground-water discharge areas with high rates of evapotranspiration.
	0 - 120	Pleistocene	Cape May Formation	Predominately low-level terrace deposits consisting of loose, uniform sand and silty sand generally not distinguishable from older sediments. Relatively unimportant as a source of fresh-water supplies. May contain salty water near tidal areas such as found to occur about Mauricetown.
	0 - 30		Bridgeton Formation	These deposits are found capping most of the flatter upland areas and basin divides. They are generally above the water table and consist of reddish-brown, intermixed clayey silt, sand, and gravel with ironstone layers in some areas.
TERTIARY	30 - 180	Pliocene(?) Miocene(?)	Cohansey Sand and upper part of Kirkwood Formation (Cohansey-Kirkwood Aquifer-Unit 4)	The most productive fresh-water aquifer in the county. It occurs from near land surface to a depth of about 180 feet. Well yields range up to about 1,200 gpm. It consists of fine, to medium, to coarse sand with layers of clay. Materials in the Cohansey Sand could not be differentiated from materials in the upper-water-bearing sand of the Kirkwood Formation. Combined, they are called the Cohansey-Kirkwood aquifer in this report.
	30 - 90	Miocene	Kirkwood Formation (Unit 3)	Generally, a semiconfining unit consisting of gray and brown, silty to sandy, micaceous, and lignitic clay through which vertical leakage of water may occur both downward and upward, between the shallow Cohansey-Kirkwood aquifer and the lower Kirkwood aquifer.
	10 - 90		Lower Kirkwood Aquifer (Unit 2)	Utilized mostly in the eastern half of the county and along Delaware Bay where static water levels are generally above sea level. Consists of gray, fine to coarse-grained sand with some gravel and shells.
	40 - 130		Kirkwood Formation (Unit 1)	Confining unit consisting of dark-gray and brown silty clay. Micaceous and lignitic. Maximum thickness in the county is about 130 feet. Shells common near the middle of the unit.
	30 - 80	Eocene	Piney Point Formation	A minor aquifer presently tapped by only a few wells for domestic supplies in the western part of the county. Probably contains salty water in the southeastern part of the county where it occurs at greater depths. Consists mostly of fine to medium-grained glauconitic sand and layers of greenish-gray silty clay.
	170±	Paleocene	Vincentown Formation and Hornerstown Sand	Probably act as leaky semiconfining units in the western part of the county along with the underlying Navesink Formation. Consist of greenish-black fine glauconitic sandy clay.
CRETACEOUS	25 - 40	Upper Cretaceous	Navesink Formation	A leaky semiconfining unit northwest of Cumberland County. Consists of a glauconitic greenish-black clayey sand.
	75 - 110		Mount Laurel Sand and Wenonah Formation	An aquifer for possible future development for fresh-water supplies in the northern part of the county where static water levels are well above sea level. Water becomes more salty in the eastern and southwestern parts of the county along Delaware Bay. The aquifer consists of fine- to coarse-grained quartz with some mica, glauconite and shells.
	400±		Marshalltown, Englishtown Woodbury, and Merchantville Formations	These units of dark silty clay are primarily confining units in the county.
	2,200±		Magothy and Raritan Formations Potomac Group	Contain deepest known aquifers beneath the county but contain saline water. Available geologic and hydrologic data are sparse for this sequence in Cumberland County. In other areas of southern New Jersey north of Cumberland County, some aquifers in this sequence have large permeabilities and other favorable water-bearing characteristics not currently used in Cumberland County.

TABLE 5a.-- DESCRIPTION OF THE UNCONSOLIDATED SEDIMENTS IN CUMBERLAND COUNTY, PENETRATED IN A 1939 TEST WELL AT BRIDGETON, N.J.

Well Br-3: City of Bridgeton, Layne Test Well 1, (1939)
Location : Cumberland Avenue, Bridgeton
Remarks : Adapted from the driller's log by Layne-New York Co., Inc.
Altitude : 80 feet

	Thickness (feet)	Depth (feet)
Pleistocene Series:		
Bridgeton Formation:		
Sand, brown and coarse gravel.....	24	24
Pliocene (?) and Miocene (?) Series:		
Cohansey Sand:		
Clay, yellow	3	27
Sand, brown, coarse and some gravel	21	48
Clay, blue	13	61
Sand, yellow, fine	6	67
Sand, yellow, coarse and fine gravel.....	8	75
Kirkwood (?) Formation:		
Sand, yellow, coarse	26	101
Kirkwood Formation:		
Mud, soft, black	38	139
Lower Kirkwood aquifer (?)		
Sand gray, medium coarse	25	164
Kirkwood Formation - Unit 1		
Clay, blue, soft.....	66	230
Eocene Series:		
Piney Point (?) Formation:		
Marl, black, clay and shells	48	278
Sand, black, fine shells and thin clay streaks	17	295
Clay or marl black, soft, shells	60	355
Marl, black.....	19	374
Clay, blue; streaks of hardpan	26	400
Clay, blue, tough	51	451
Paleocene Series:		
Vincentown Formation:		
Clay, blue, tough; streaks of hardpan	10	461
Clay, blue, soft	20	481
Clay, blue, tough	119	600
Clay, blue, tough; soft streaks	107	707

Table 5a.--Description of the unconsolidated sediments in Cumberland County, penetrated in a 1939 test well at Bridgeton, N.J.--Continued

Well Br-3: City of Bridgeton, Layne Test Well 1, (1939)--Continued

	Thickness (feet)	Depth (feet)
Paleocene Series: (Continued)		
Hornerstown Sand:		
Marl, black; shells and clay	42	749
Upper Cretaceous Series:		
Navesink Formation:		
Marl, black, soft; (contains) shells, fine sand and clay	31	780
Clay, blue, tough; streaks of marl	28	808
Mount Laurel Sand and Wenonah Formations (undifferentiated):		
Clay, black, and streaks of marl	95	903
Marshalltown Formation:		
Boulder		at 903
Clay, hard	31	934
Englishtown Formation:		
Clay, sandy	5	939
Clay, sandy, hard; marl	26	965
Boulders	2	967
Clay, marl and boulders	58	1,025
Clay, sandy	18	1,043
Sand, black, fine; hard	51	1,094
Driller reports chloride concentrations of 3,120 ppm between 1,043 - 1,094		
Woodbury and Merchantville Formations (undifferentiated):		
Clay, tough and hard	56	1,150
Clay, red, tough	50	1,200
Clay, hard	40	1,240
Magothy and Raritan Formations (undifferentiated):		
Clay, red and gray, tough and hard	80	1,320
Clay, tough	15	1,335
Clay, sandy	35	1,370
Clay, sandy, tough streaks	21	1,391
Clay, sandy and streaks of conglomerate, some gravel (tough streaks all along).....	34	1,425
Clay, with soft streaks	45	1,470

Table 5a.--Description of the unconsolidated sediments in Cumberland County, penetrated in a 1939 test well at Bridgeton, N.J.--Continued

Well Br-3: City of Bridgeton, Layne Test Well 1, (1939)--Continued

Upper Cretaceous Series: (Continued)	Thickness (feet)	Depth (feet)
Magothy and Raritan Formations (undifferentiated)		
Clay, red, tough	50	1,520
Clay, sandy; tough streaks	20	1,540
Clay, sandy and quicksand	60	1,600
Quicksand, red	5	1,605
Rock	2	1,607
Streaks of sandy clay with tough streaks and streaks of rock	44	1,651

Woodbury, Englishtown and Marshalltown Formations. This sequence is about 400 feet thick in Cumberland County.

Wenonah Formation and Mount Laurel Sand

The next higher aquifer above those in the Potomac-Raritan-Magothy sequence which may be of importance for future development in Cumberland County occurs in the Wenonah Formation and Mount Laurel Sand. Although this aquifer is not presently utilized in Cumberland County, it is the principal source for domestic and public-water supplies in parts of neighboring Salem County. An unused well located near Sea Breeze in Cumberland County is believed to tap this aquifer (Table 14, Well Fa-19).

The lithologic character, thickness, and the stratigraphic relation of the Wenonah and Mount Laurel aquifer to underlying and overlying geologic formations are shown in the log (Table 6), of a test well at Elmer in Salem County and the log (Table 5a), of a test well at Bridgeton. These logs show that the Wenonah and Mount Laurel aquifer is about 100 feet thick and consists of a fine- to coarse-grained, clear and iron-stained quartz containing layers of clay, some mica, glauconite, and shells. In its outcrop in Salem County, the Wenonah Formation is a silty, fine- to very-fine grained, quartz and glauconitic sand; the overlying Mount Laurel Sand is mostly a medium- to coarse-grained glauconitic sand. Mica and carbonaceous matter are particularly diagnostic of the Wenonah Formation (Minard, 1965). The Wenonah Formation and Mount Laurel Sand overlie the Marshalltown Formation. They are, in turn, overlain by a sequence of semiconfining units in Cumberland County. From oldest to youngest these are the Navesink Formation, Hornerstown Sand, and Vincentown Formation.

The water-bearing characteristics of the Wenonah and Mount Laurel aquifer in Cumberland County are largely unknown. However, data on this aquifer obtained from Salem County are probably indicative of the aquifer's water-bearing characteristics in Cumberland County. The coefficient of permeability of the Wenonah and Mount Laurel aquifer was determined to be about 100 gpd per sq ft at a well field in the City of Salem. Vertical ground-water leakage from the overlying, semiconfining Navesink and Hornerstown Formations was indicated by the data. A relatively low coefficient of permeability-- probably somewhat less than 100 gpd per sq ft--is also indicated by a specific capacity of 2.0 gpm per ft drawdown at a public-supply well at Elmer in Salem County. This well is 6 inches in diameter, has 40 feet of screen, and was pumped at 400 gpm.

Based on the hydrologic characteristics of the Wenonah and Mount Laurel aquifer obtained from the test at Salem and assuming the aquifer is completely confined and unaffected by vertical leakage, the effects of pumping from a well tapping the Wenonah and Mount Laurel aquifer are shown in the following table:

Pumping Rate (gpm)	Duration of Pumping	Drawdown (in ft) at a Distance of 1000 ft	Drawdown (in ft) at a Distance of 1.0 mile
100	24 hrs	2.5	negligible
500	24 hrs	13.0	less than 1.0
500	10 days	28.0	8.0

Because vertical leakage to the aquifer occurs through the overlying semiconfining Navesink and Hornerstown Formations from the Vincentown and Piney Point Formations, pumpage from the Wenonah and Mount Laurel aquifer will cause somewhat lesser drawdowns than those given above.

The regional direction of ground-water movement can be determined from static-water levels. The static level in the Wenonah and Mount Laurel aquifer ranges from at least 52 feet above mean sea level at Elmer in Salem County (Rosenau and others, 1969) to about sea level along Delaware Bay at Canton in Salem County and Sea Breeze in Cumberland County. The general direction of ground-water movement in Northwestern Cumberland County, therefore, is from Salem County southwestward through Cumberland County toward Delaware Bay. The direction of ground-water movement in the southeastern part of the county is presently unknown.

Ground water in the Wenonah and Mount Laurel aquifer in the northern part of Cumberland County is probably fresh and similar in quality to water from the well at Elmer in Salem County (Table 7). In the southwestern part of the county, particularly near Delaware Bay, the water is more saline as indicated by chemical analyses of water from wells near Sea Breeze and near Canton in Salem County (Table 7). Concentrations of chloride and dissolved solids are as high as 295 mg/l and 859 mg/l respectively in the well near Sea Breeze.

The Wenonah and Mount Laurel aquifer may be an important source for future potable fresh-water supplies in areas of Northwestern and North-central Cumberland County where the shallower aquifers generally have a lower permeability or are susceptible to local contamination. Future development of the aquifer, however, may be limited to wells having small to moderate (up to 300 gpm) yields. Before development of the aquifer by large (greater than 300 gpm) yielding wells occurs, the aquifer should be further explored by test drilling to better define its hydrologic characteristics. When this aquifer is developed further, records of water levels and water-quality samples should be collected from suitable observation wells to monitor possible advances of salt-water encroachment into the aquifer.

TABLE 6.--DESCRIPTION OF SEDIMENTS PENETRATED IN A TEST WELL AT ELMER, SALEM COUNTY, N.J.

Location : Water Dept. pumping station just west of Main Street, between State and Broad Streets
Elevation: 105 feet (msl)

Drillers' log by Layne-New York Co., Inc.

Correlations and lithologic descriptions adapted from drillers' log, gamma-ray log, and samples from 163 feet to 573 feet.

	Thickness (feet)	Depth (feet)
Fill.....	3	3
Pleistocene Series:		
Coarse gravel and white sand	18	21
Pliocene (?) and Miocene(?) Series:		
Cohansey Sand:		
Sand, reddish brown; some yellow clay streaks	39	60
Miocene Series:		
Kirkwood Formation:		
Clay, dark-gray; some fine-grained, gray sand streaks; some shells	103	163
Clay, gray and brown; silty and micaceous with embedded shell fragments; streaks of sand and gravel	22	185
Sand, gray, fine- to coarse-grained; shells	10	195
Clay, dark-brown and black containing shell fragments; streaks of sand and gravel	51	246
Eocene Series:		
Piney Point (?) Formation:		
Sand, greenish-gray, clayey, fine- to coarse grained; contains shell fragments; 60 to 80 percent fine-grained glauconite; some olive-gray, silty, glauconitic clay.	62	308
Clay, greenish-gray, sandy; contains abundant fine-grained glauconite	32	340

Table 6.--Description of Sediments penetrated in a test well at Elmer, Salem County, N.J.
Continued

	Thickness (feet)	Depth (feet)
Eocene Series: Continued		
Vincentown (?) Formation:		
Sand, clayey, fine- to medium-grained; 85 to 95 percent glauconite; contains a few broken shell fragments and pieces of light greenish-gray clay	40	380
Cretaceous and Paleocene Series:		
Hornerstown Sand and Navesink Formation undifferentiated:		
Sand, clayey; fine- to coarse-grained quartz and 40 to 50 percent glauconite; contains broken shell fragments and greenish-gray clay	40	420
Upper Cretaceous:		
Wenonah Formation and Mount Laurel Sand undifferentiated:		
Sand, yellowish-gray, fine- to coarse-grained; clear and iron-stained quartz; contains about 5 percent glauconite and a few broken shell fragments and some clay	112	532
Marshalltown (?) and Englishtown (?) Formations:		
Clay, dark-gray	41	573

TABLE 7.--CHEMICAL ANALYSES OF GROUND WATER FROM THE WENONAH FORMATION AND MOUNT LAUREL SAND

(constituents in mg/l except pH and conductance)

Well Location and Owner	Elmer, Salem Co. Elmer Water Dept.	Canton, Salem Co. Lower Alloway Creek Township School	Well Fa-19 near Sea Breeze, Cumberland Co. N.J.Fish & Game Comm.
Depth of well (feet)	460	325	310 ?
Date of collection	9-18-64	9-16-64	4-17-63
Silica	8.1	8.1	38
Iron (Total)	0.25	0.65	0.80
Manganese	.00	.00	.00
Calcium	6.8	18	34
Magnesium	3.2	6.8	16
Sodium	68	77	270
Potassium	6.4	9.5	10
Bicarbonate	203	231	371
Sulfate	8.6	6.6	12
Chloride	4.8	34	295
Fluoride	0.6	0.5	0.3
Nitrate	1.0	0.1	0.5
Hardness ($CaCO_3$)	30	73	151
Dissolved Solids	208	275	859
Specific conductance (micromhos at 25°C)	335	467	1,570
pH	8.0	8.0	8.0

Piney Point Formation

The Piney Point Formation, the deepest known aquifer in the Tertiary System, occurs only in the subsurface in New Jersey. It overlies the Vincentown Formation and is in turn overlain by the Kirkwood Formation.

According to drillers' well logs, it consists mostly of fine- to medium-grained, glauconitic, salt-and-pepper colored, clayey sand, and contains layers of greenish-gray, silty clay. In the eastern part of the county the sand beds appear to be thinner and finer-grained and, therefore, probably less permeable than in the western part of the county (see Tables 5a and 6). The formation consists of glauconitic sand and greenish-gray clay in adjacent Salem County where it is about 94 feet thick, as indicated by the log of the test well at Elmer (Table 6).

The Piney Point Formation dips and thickens to the southeast. Near Stow Creek it is found at about 90 feet below land surface and is about 50 feet thick. In Millville it is believed to occur between 480 to 560 feet below land surface as determined from a test well (Well M1-25 in Table 16).

The Piney Point Formation is tapped in Cumberland County by only a few wells in the western part of the county and along Delaware Bay. Yields of these wells are generally 100 gpm or less. Additional small to possibly moderately yielding wells (50 to 100 gpm) tapping this formation can be developed. However, if future development does occur, records should be kept of ground-water pumpage; water samples should be collected; and water levels should be measured periodically to momitor potential salt-water intrusion into presently fresh supplies.

Water from wells tapping the Piney Point Formation requires little to no treatment to be acceptable for domestic supplies. Table 8 presents a summary of chemical analyses of water from wells tapping this aquifer. However, the ground water probably becomes more saline with increasing depths and down dip toward Delaware Bay. Water from the deeper wells sampled in this investigation contains higher concentrations of sodium, chloride, and dissolved solids than does water from wells tapping shallower fresh ground water.

Kirkwood Formation and Cohansey Sand

The most heavily utilized aquifers in Cumberland County are in the Kirkwood Formation and in the Cohansey Sand. Probably more than 95 percent of the ground water pumped from wells in the county in 1964 came from two water-bearing units within these formations. These units are a lower Kirkwood aquifer (unit 2, described in the following section on geology) and the Cohansey-Kirkwood aquifer, in which the uppermost Kirkwood Formation and the overlying Cohansey Sand cannot be differentiated.

TABLE 8.-- SUMMARY OF CHEMICAL ANALYSES OF GROUND WATER FROM THE PINEY POINT FORMATION, CUMBERLAND COUNTY, N.J.

(constituents in mg/l except pH and conductance)

	Range (6 samples)	Median (6 samples)
Depth of aquifer sampled (feet below land surface)	147 - 400	360
Silica	13 - 58	16
Iron (total)	0.0 - 1.0	0.30
Manganese	.00	0.00
Calcium	11 - 20	19
Magnesium	1.7 - 9.2	6.8
Sodium	46 - 135	120
Potassium	5.0 - 11	6.2
Bicarbonate	164 - 334	309
Sulfate	0.0 - 5.7	5.5
Chloride	5.0 - 72	65
Fluoride	0.3 - 1.0	1.0
Nitrate	0.2 - 1.1	0.7
Hardness	35 - 86	74
Dissolved solids	209 - 440	422
Specific conductance (micromhos at 25°C)	292 - 822	754
pH	7.5 - 8.2	7.9

Geology

The Kirkwood Formation overlies the Piney Point Formation which is in turn overlain by the Cohansey Sand. The Kirkwood is generally poorly exposed throughout much of Cumberland County where it is largely concealed by the Cohansey Sand or by deposits of Pleistocene and Holocene age. Therefore the descriptions of the Kirkwood in Cumberland County in this report are based largely on well logs and samples of materials obtained from drilled wells. (See Tables 5 and 6).

Four hydrogeologic units can be recognized in the Kirkwood Formation in Cumberland County. From the oldest to the youngest they are: (1) a basal clay, (2) a lower water-bearing sand, (3) an intermediate clay, and (4) an upper water-bearing sand. Gill (1962, p. 17) divided the Kirkwood in Cape May County into five units. The four hydrogeologic units in Cumberland County are believed to be the same as the four deepest units in Cape May County. Gill's fifth and highest unit, a clay, was not identified in Cumberland County although it may occur below the Cohansey Sand in the eastern part of the county. In the western part of Cumberland County near the outcrop area, the top of the Kirkwood Formation has an irregular erosional surface, especially along Delaware Bay and in the major present-day stream channels (see Table 5a). For this reason, the four units in the Kirkwood could not be differentiated west of the Cohansey River.

The basal unit in Cumberland County is a dark gray, silty to sandy, micaceous clay with streaks of brown, very micaceous lignitic clay, which generally has a thin sandy layer of shells near the middle. The basal unit has a maximum known thickness of about 130 feet. The base of the unit (No. 1) dips to the southeast; it is found at about 150 feet below sea level in the northwestern part of the county and at about 600 feet below sea level near Millville in the southeastern part of the county.

The next higher unit (No. 2) overlying the basal clay is a water-bearing, gray, fine- to coarse-grained sand containing some gravel and shells. This unit, is referred to in this report as the lower Kirkwood aquifer. It ranges in thickness from about 10 to 90 feet.

The intermediate clay unit (No. 3) overlying the lower aquifer is a gray, silty to sandy, micaceous and lignitic clay. It is generally a semiconfining unit. In the central part of the county, it consists of silty to sandy clay through which water may leak between the lower water-bearing sand and the overlying Cohansey - Kirkwood aquifer. This intermediate clay unit is about 60 feet thick throughout much of Cumberland County.

The shallowest unit (No. 4) in the Kirkwood Formation in Cumberland County is generally a gray to brownish water-bearing sand. The sand is fine- to coarse-grained and is generally coarser grained and more permeable east of the Cohansey River than west of the river. This sand generally cannot be distinguished from the similar, lower water-bearing sands of the Cohansey Sand.

The Cohansey Sand in Cumberland County generally consists of medium- to coarse-grained sand with some clay and silt. Gravel is present throughout the formation but is locally concentrated near the base of well-defined channel deposits. Dark, massive, carbonaceous and micaceous, silty clay beds occur locally in the upper part of the Cohansey, particularly on the slopes and divides of the larger present-day drainage basins. Massive ironstone beds are common near the top of the formation. The color of the Cohansey varies from yellowish gray, light gray, brown, moderate red, to very dark red.

The Cohansey Sand and the upper water-bearing sand of the Kirkwood Formation act as a single hydrologic unit and are referred to in this report as the Cohansey-Kirkwood aquifer.

Thickness of this aquifer varies considerably. West of the Cohansey River and northward into Salem County it is about 50 feet thick or less. In Bridgeton, along the Cohansey River, it is about 100 feet thick but may include the more sandy units of the lower part of the Kirkwood (unit No. 2). In vineland the Cohansey-Kirkwood aquifer is as much as 180 feet thick (see Table 5).

The Cohansey-Kirkwood aquifer in the area between the Cohansey and Maurice Rivers generally is overlain by a sandy to silty clay layer in the Cohansey Sand. This layer is about 35 feet thick but thins towards the valleys and stream channels where the Cohansey-Kirkwood aquifer generally is overlain by sands of the Cape May Formation.

Hydrology

Lower Kirkwood aquifer.--Most of the wells tapping the lower Kirkwood aquifer in Cumberland County are located in the eastern half of the county and along the near-shore area of Delaware Bay. Depths of these wells range from about 200 to about 370 feet below land surface.

In 1969, most wells tapping the lower Kirkwood aquifer in Cumberland County yield less than 50 gpm. However, properly designed and constructed wells may yield as much as 400 gpm. For example, well M1-12 in Millville had a specific capacity of 3.0 gallons per minute per foot of drawdown, and wells tapping the lower aquifer in the Port Norris area have specific capacities that average about 8.0 gpm per foot. The thickness and permeability of the aquifer and, consequently, its capacity to yield water to wells increases from near the Kirkwood outcrop area in Salem and Western Cumberland Counties eastward and southeastward toward Atlantic City and Cape May County.

Recharge to the lower Kirkwood aquifer probably comes mainly from vertical leakage from overlying aquifers, such as in the Cohansey River basin where the lower aquifer is found at relatively shallow depths. Some discharge from the lower aquifer is believed to occur as leakage upward to streams where the aquifer is near land surface and, by evapotranspiration in or near its outcrop areas. Additional discharge probably occurs as

vertical leakage to the higher Cohansey-Kirkwood aquifer in the lowlands along the Maurice River and Delaware Bay. Aong the Maurice River at Millville, static water levels in the lower aquifer are about 20 feet higher than in the Cohansey-Kirkwood aquifer indicating the potential for upward vertical leakage (Table 14, wells Ml 10, 11, 12). It should be noted that some water in the lower aquifer may move eastward from Cumberland County toward areas of heavy ground-water withdrawal along the Atlantic Coast such as toward the Atlantic City area where heavy pumpage has created a large cone of depression extending inland toward Cumberland County.

The general quality of water in the lower Kirkwood Formation aquifer is indicated in Table 9; individual chemical analyses of water from wells tapping the lower aquifer in the Kirkwood are shown in Table 15. The water is soft to moderately soft (30 to 77 mg/l) and generally needs little treatment except to remove high concentrations of iron. Iron content of the water is generally high (up to 1.9 mg/l) and is usually above the recommended maximum limits of the New Jersey Department of Health Potable Water Standards. Dissolved solids content ranges from 86 to 161 mg/l and chloride concentrations ranges from 2.4 to 4.2 mg/l. These low chloride and dissolved solids concentrations indicate that salt water is presently not a problem in the lower aquifer. Also, static water levels in the aquifer are generally well above sea level near Delaware Bay and, at present, the potential for intrusion of salt water is minimal.

Future development of the lower Kirkwood aquifer for additional fresh-water supplies in Cumberland County should proceed with caution. This aquifer in the Atlantic City area may be recharged with ground water flowing from Cumberland County. If this is the case, additional development in Cumberland County may reduce the amount of water available to the aquifer near Atlantic City.

Cohansey-Kirkwood aquifer.--The Cohansey-Kirkwood aquifer is generally the shallowest source of ground water throughout most of Cumberland County and is the most important source of water in the county. Nearly all (49.4 mgd in 1964) of the ground water used in the county comes from this aquifer. It is also particularly subject to surface contamination.

The water-bearing characteristics of the Cohansey-Kirkwood aquifer are not fully known. Transmissitivity was determined from a pumping test near Elmer in Salem County, to be about 30,000 gpd per ft of aquifer (Rosenau and others, 1969). As the aquifer is about 25 feet thick at this site, the permeability is about 1,200 gallons gpd per sq ft. The coefficient of storage was calculated to be about 3.0×10^{-4} indicating artesian or semi-artesian conditions at this site. Vertical leakage from adjacent semiconfining beds occurred during the test. Remson and Fox (1954), in a study of a waste water spreading area at Seabrook, determined that the permeability of the Cohansey Sand, (Cohansey-Kirkwood aquifer in this report), is about 2,700 gpd per sq ft and that the specific yield in the zone of water-level fluctuations is about 30 percent.

TABLE 9--SUMMARY OF CHEMICAL ANALYSES OF GROUND WATER FROM THE LOWER KIRKWOOD AQUIFER, CUMBERLAND COUNTY, N.J.

(constituents in mg/l except pH and conductance)

	Range (7 samples)	Median (7 samples)
Depth of aquifer sampled (feet below land surface)	242 - 365	270
Silica	23 - 71	47
Iron (total)	0.0 - 1.9	1.2
Manganese	0.0 - 0.1	0.0
Calcium	9.6 - 24	22
Magnesium	1.5 - 4.1	2.2
Sodium	2.6 - 10	5.5
Potassium	0.8 - 3.2	2.4
Bicarbonate	36 - 94	85
Sulfate	7.8 - 12	8.8
Chloride	2.4 - 4.2	3.0
Fluoride	0.0 - 0.2	0.2
Nitrate	0.2 - 0.8	0.5
Hardness	30 - 77	64
Dissolved solids	86 - 161	153
Specific conductance (micromhos at 25°C)	90 - 186	177
pH	6.5 - 8.1	7.4

Because it is highly permeable and relatively thick, the Cohansey-Kirkwood aquifer is generally capable of yielding abundant supplies of water to wells. Large water supplies (300 to 1,200 gpm) of acceptable quality for public-supply systems, industrial facilities, and irrigation systems, can generally be obtained from wells that are less than 180 feet deep. Yields from large-diameter wells have been reported to be as much as 1,300 gpm (table 14, well Fa-3). Smaller domestic and commercial supplies (10-50 gpm) can generally be obtained from wells that are less than 100 feet deep. Some dug and driven wells that tap the aquifer for water are only 15 to 20 feet deep.

Specific capacities of large diameter wells tapping the Cohansey-Kirkwood aquifer in Cumberland County range from about 7 gpm per foot of drawdown to as high as 57 gpm per foot of drawdown (well UD-9); the average is about 20 gpm per foot of drawdown.

The great capacity of this aquifer to accept recharge has been shown by Remson and Fox (1954). At Seabrook approximately one billion gallons of food processing waste water,are disposed annually by spreading the water over a woodland tract, using large irrigation nozzles. Tests in the uncultivated woodland indicated infiltration capacities of 54, 57, and 75 inches per hour. Tests in a cultivated clover field indicated an infiltration rate of 4.6 inches per hour. The lower infiltration rate in the tilled soil is attributed by Remson and Fox (1954, p. 89) to several causes. These include "the presence of a plow sole" and the affect of cultivation on "soil aggregate and the plant and animal structure and channels."

Even after extended periods of heavy pumpage,water levels in the Seabrook Farms well field recover to near-normal conditions as shown by the hydrograph for Seabrook Farms Well No. 5 for 1951-52 (Figure 7). The wells in this field are all about 160 feet deep and have an average pumping level of about 70 feet below land surface. Lowest pumpage demands are generally in March (0.63 mgd), and maximum demands are in October (10.7 mgd). Water levels in Well UD-9 (Seabrook Farms No. 5) show no permanent depletion after a season of heavy pumpage. Long-term records from this well also show no water-level decline indicating a potential high rate of recharge to the aquifer. It is probable that water levels in wells penetrating similar materials in the Cohansey-Kirkwood aquifer recover seasonally throughout most of the county under present pumping and land-use conditions.

The Cohansey-Kirkwood aquifer is generally a water-table aquifer in Cumberland County. It is recharged principally from precipitation in the county; very little recharge to the aquifer comes from areas outside the county (see figure 3 and figure 8). Where the aquifer is partially confined by clayey layers of lower permeability, it is recharged principally by leakage around and possibly through these clay layers. Available data indicate that there is hydraulic interconnection throughout this water-bearing unit from the surface downward to about 180 feet below the surface in most of the county east of Bridgeton.

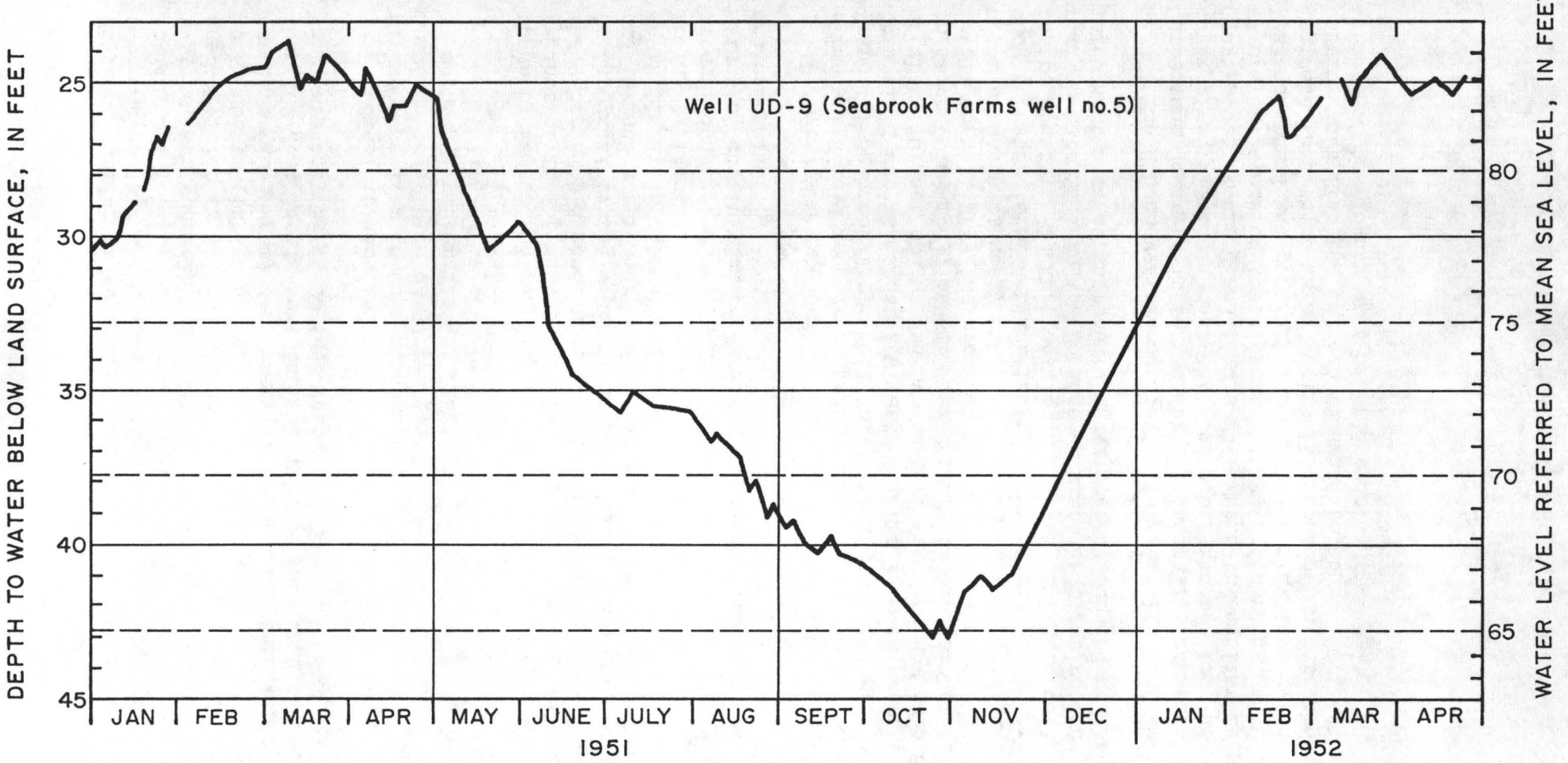


Figure 7.--Hydrograph of Seabrook Farms Well No. 5 tapping the Cohansey-Kirkwood aquifer, January 1951-April 1952.

Areas of recharge and discharge, and the pattern of water movement in the Cohansey-Kirkwood aquifer in Cumberland County can be inferred from the generalized water-level map in figure 8. Lateral and deep percolating ground-water flow is from higher elevations in the northern parts of the county to lower areas along stream valleys and Delaware Bay. The water-level contours in figure 8 are based on typical water-levels during the period 1950-60 obtained from wells in upland areas and on data obtained from surface drainage elevations using U. S. Geological Survey $7\frac{1}{2}$ minute quadrangle maps. The water level map in figure 8 should be used with caution, however, in any quantitative evaluation of the hydrology of the county, since water levels continually change in response to recharge and discharge.

The exact time of the year in which maximum storage occurs in the Cohansey-Kirkwood aquifer varies areally. Figure 9 shows hydrographs from three water-table wells located in different parts of the West Branch Cohansey River basin, in Cumberland County. Well SC-2 is located near the head waters about 0.6 miles from the river and about 2.5 miles upstream from its mouth. Well SC-4 is located about 0.7 miles from the river near the southwestern divide of the basin about 2.5 miles upstream from its mouth. Well HO-5 is located about 0.15 miles from the river on the southern flank of the basin about 0.6 mile upstream from its mouth.

The hydrographs show that highest water levels, and hence periods of greatest amounts of ground-water storage occur at different times of the year at each well. Maximum storage in the aquifer occurs earliest near the river as shown by the water levels in HO-5, while in SC-2 and SC-4 which are further from the river, maximum storage occurs several months later. At locations close to normally discharging areas and along streams, discharge from the aquifer comes into equilibrium with recharge more rapidly than at locations more distant from discharge areas. At the more distant locations, more time is required for recharge from precipitation to reach the zone of saturation and for water levels to rise high enough so that increased ground water gradients to the discharge area will permit discharge to equal recharge.

The quality of ground water in the Cohansey-Kirkwood aquifer is summarized in Table 10. Natural surface-water quality, typically, is similar to the ground-water quality in the Cohansey-Kirkwood aquifer as shown by the analysis of water from the Maurice River (Table 10).

The water in the Cohansey-Kirkwood aquifer is characterized by low dissolved solids, low hardness, and low pH values. Median values are 63 mg/l, 21 mg/l, and 5.5 pH units respectively. The characteristically low pH indicates the water is excessively corrosive. Corrosive water can dissolve cement building materials, iron and copper pipes, and plumbing fixtures and fittings, leading to possible leaks and costly repairs. Yellow to brown stains on fixtures and laundered clothing indicate water is high in iron concentration; light blue stains may indicate the presence of copper that may have been dissolved from plumbing equipment by corrosive water. Therefore, treatment to adjust pH from acidic values to more neutral values probably is desirable for most domestic or other potable well supplies from the Cohansey-Kirkwood aquifer in Cumberland County.

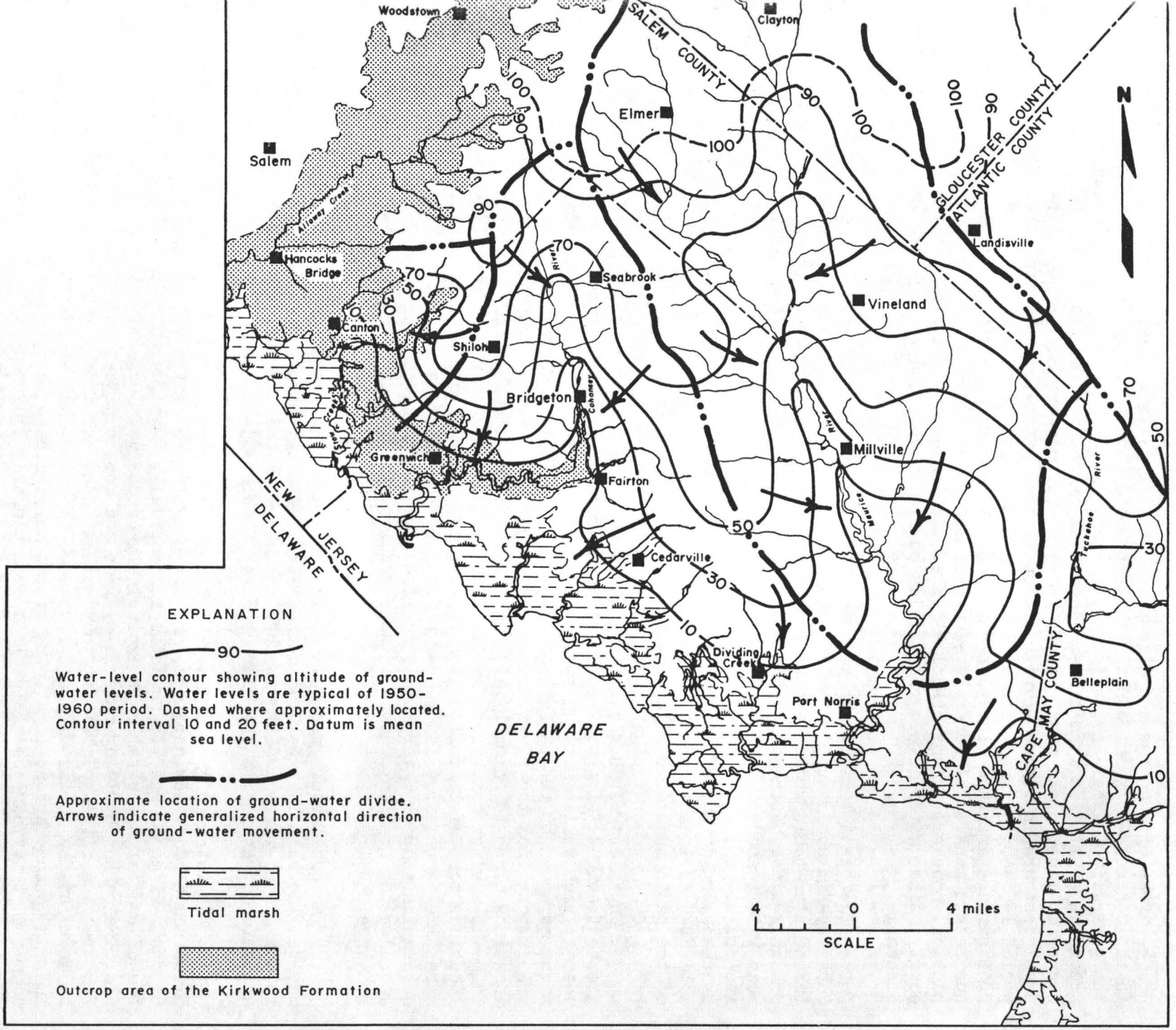


Figure 8.--Generalized water levels in the Cohansey-Kirkwood aquifer.

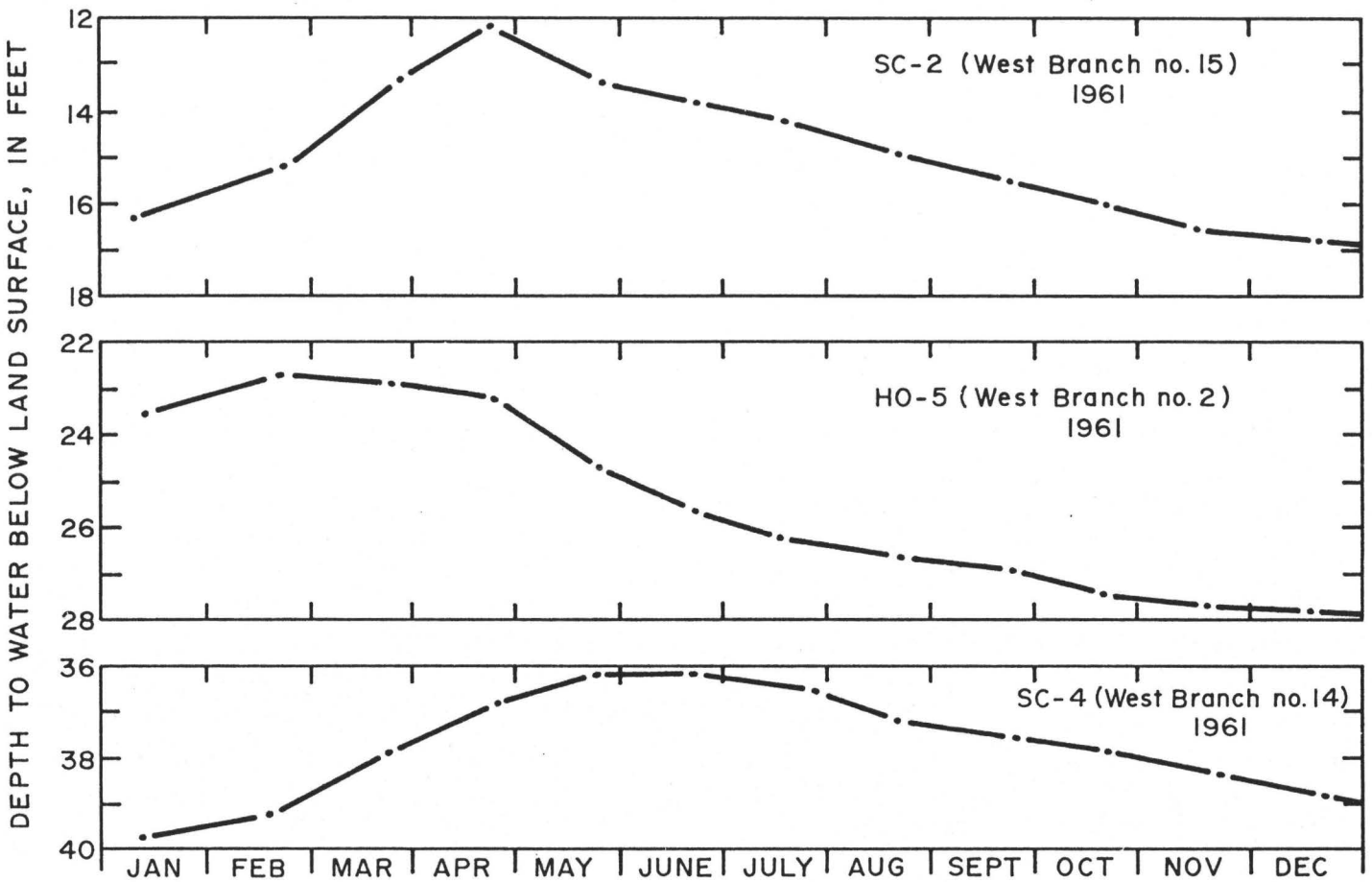


Figure 9.--Hydrographs of three water-table wells in West Branch Cohansey River basin, 1961.

TABLE 10.--SUMMARY OF CHEMICAL ANALYSES OF GROUND WATER FROM THE COHANSEY KIRKWOOD AQUIFER, CUMBERLAND COUNTY AND A CHEMICAL ANALYSIS OF WATER FROM THE MAURICE RIVER AT NORMAN, N.J.

(constituents in mg/l except pH and specific conductance)

	GROUND WATER			SURFACE WATER
	Number of samples or wells	Range	Median	Maurice River at Norma (11-15-62)
Depth of aquifer sampled (feet below land surface)	44	26 - 191	125	
Temperature	23	55 - 58		44
Silica	36	3.2 - 71	9.0	7.8
Iron (total)	43	0.2 - 15	0.1	.31
Manganese				.02
Calcium	31	0.3 - 31	7.2	3.2
Magnesium	30	0.5 - 35	2.9	3.4
Sodium and Potassium	26	0.5 - 146	4.8	6.6
Bicarbonate	39	1.0 - 292[a]	10	12
Sulfate	33	0.0 - 56	0.8	10
Chloride	44	2.4 - 250[a]	7.0	7.5
Fluoride	16	0.0 - 0.1	0.1	.3
Nitrate (as NO_3)	18	0.0 - 65	0.7	4.4
Hardness (as $CaCO_3$)	39	.3 - 222	21	22
Dissolved solids	27	21 - 742[a]	63	49
Specific conductance (micromhos at 25°C)	22	21 - 1460[a]	71	69
pH	40	4.2 - 7.0	5.5	6.2

[a] Maximum value is from contaminated well (Vi-59) drilled in a sanitary land fill (see Table 11).

Iron concentrations in water samples from the Cohansey-Kirkwood aquifer ranged from 0.1 to 15 mg/l. Most water samples contained less than 3.0 mg/l of iron; the median concentration was 0.1 mg/l. Lowest concentrations of iron were found in samples from wells located in the upland areas of the county; highest concentrations were found in the lowlands. The maximum measured concentration of 15 mg/l is from a well (Vi-36) in Vineland that was contaminated by leaching of nearby industrial wastes.

Because the Cohansey-Kirkwood aquifer is generally under water-table conditions, it is particularly subject to surface contamination. Nitrate concentrations in water from the aquifer ranged from 0.0 to 65 mg/l; the median concentration was 0.7 mg/l. Nitrate concentrations higher than about 1.0 mg/l may indicate contamination resulting from land-use practices. Agricultural fertilizers and organic wastes leaching to the shallow aquifers are probably the principal sources of nitrates. High concentrations of aluminum, sulfate and chloride indicate contamination. Examples of contaminated ground water in Vineland and near Greenwich are shown in the analyses in Table 11.

Salt-water intrusion in the Cohansey-Kirkwood aquifer is presently not a serious problem in the county. Chloride concentrations are generally much less than the 250 mg/l recommended limit of the New Jersey State Department of Health for potable use. However, minor intrusion problems may occur seasonally along the lowlands near Delaware Bay and its tidal estuaries as shown by the chemical analysis (Table 11) from a shallow well (Gr 7) near Greenwich.

Bridgeton and Cape May Formations

The Bridgeton Formation of Pleistocene age covers much of Cumberland County, occurring generally as an older, higher level, terrace deposit than the Cape May Formation. Bridgeton deposits are found covering most of the flatter upland areas and basin divides in the northern, central, and northeastern parts of Cumberland County.

The altitude of the base of the Bridgeton ranges from about 140 feet near Elmer in Salem County to about 60 feet at Dividing Creek. According to Salisbury and Knapp (1917, p. 37-42), the base declines slightly toward the Cohansey River from both sides of the valley, suggesting that there was an ancestral valley in pre-Bridgeton time near the Cohansey River.

The Bridgeton Formation generally consists of reddish-brown to dull red, intermixed clayey silt, sand, and gravel and contains some thin layers of silty clay. The gravel is usually scattered throughout the Bridgeton rather than in well-defined layers. In some areas ironstone layers occur several feet below land surface. The formation ranges in thickness from about 0 to 30 feet.

The Bridgeton Formation is largely above the water-table in much of the upland areas of Cumberland County. It serves as a collecting unit for infiltrating recharge from precipitation to the underlying Cohansey-Kirkwood

TABLE 11 -- EXAMPLE OF CHEMICAL ANALYSES OF CONTAMINATED WATER FROM THE COHANSEY-KIRKWOOD AQUIFER, CUMBERLAND COUNTY, N.J.

(constituents in mg/l except pH and conductance)

	Vi 36[a]	Vi 58[b]	Vi 59[c]	Gr 7[d]
Screen Seeting (feet below land surface)	142 - 158	26 - 30	92 - 98	27 - 39
Date of Collection	7-7-49	1-10-63	1-10-63	10-1-63
Silica	5.0	3.2	6.9	23
Iron (total)	15	5.3	.39	2.5
Manganese	.10	.56	.05	.03
Calcium		31	6.8	44
Magnesium		35	8.3	12
Sodium		140	9.5	92
Potassium		6.5	2.2	5.0
Bicarbonate	292	270	3	52
Sulfate	56	.0	.0	42
Chloride	30	250	13	188
Nitrate		.0	65	3.4
Hardness (as $CaCO^3$)	132	222	51	160
Dissolved Solids	250	742	134	466
Specific conductance (micromhos at 25°C)		1460	200	799
pH	6.5	5.2	5.2	6.4
Aluminum		4.9	0.1	
Remarks	"Had chemical odor".	Sample had strong odor when collected		

[a] Located in Vineland on S. West Blvd., 0.1 mile south of Chestnut Ave. Analysis by Hungerford and Terry, Inc.

[b] Test well located in an abandoned sanitary land-fill approximately 700 feet north of Sheridan Ave., Vineland. Analysis by U. S. Geological Survey.

[c] Located on Sheridan Ave., Vineland, south of the test well above which is in the sanitary land-fill. Analysis by U. S. Geological Survey.

[d] Located along a tidal tributary of the Cohansey River 0.4 mile northeast of Greenwich. Analysis by U. S. Geological Survey.

aquifer. Locally, however, infiltration may be impeded by silt and clay layers. Few wells tap the Bridgeton Formation for water supplies although some shallow wells may obtain small domestic supplies where the Bridgeton is part of the water-table aquifer.

The older Bridgeton Formation sediments were partially removed by erosion prior to the deposition of the Cape May Formation.

The Cape May Formation, of Pleistocene age, occurs in Cumberland County mainly in two belts. One belt parallels the Delaware Bay shore adjacent to the tidal marshes. This belt ranges up to about seven miles in width (see figure 3). A second belt, ranging up to about $2\frac{1}{2}$ miles in width, extends up the Maurice River Valley to about the Gloucester County line. The altitude of the top of the formation ranges from near sea level along Delaware Bay to about 40 feet above sea level near Millville.

According to Gill (1962, p. 21), the Cape May Formation in Cape May County was probably deposited in three separate environments--estuarine, marine, and deltaic. The estuarine environment resulted in two distinct facies: a basal sand and an overlying black clay. Overlying the estuarine black clay in Cape May County are deltaic sediments consisting mainly of coarse-grained sand and fine gravel which Gill named the Holly Beach aquifer. Marine sediments in Cape May County are contemporaneous with the deltaic sediments in Cumberland County, the former occurring along Delaware Bay. The estuarine and deltaic sediments have been tentatively identified in Cumberland County. The marine sediments have not been recognized in Cumberland County. A typical log of materials found in the Cape May Formation is given in Table 12.

The thickness of the Cape May Formation ranges from about 0 to about 120 feet in Cumberland County.

The Cape May Formation is relatively unimportant as a source of large, fresh-water supplies in Cumberland County although it is an important aquifer to the southeast, in Cape May County. A few domestic wells tap local aquifers in the Cape May Formation in Cumberland County. Drillers' logs of wells (Table 12 and 14) indicate salty water occurs in the Cape May aquifers in the Mauricetown area and near-shore communities along Delaware Bay.

Tidal Marsh and Swamp Deposits

Tidal marshes and swamps are areas of considerable ground water discharge. They compose about 22 percent, or about 112 square miles of the county and are located mainly, adjacent to Delaware Bay and along the flood plains of larger streams extending about 5 to 12 miles inland from the shore of Delaware Bay (See figure 3).

Tidal marsh and swamp deposits are primarily a soft, compressible mixture of dark-gray and brown decomposed organic matter, silt and clay are as much as 15 feet thick along Delaware Bay. They are of Holocene age and overlie older Pleistocene alluvial and marine sediments of the Cape May Formation.

Table 12.--Composite drillers' log from two wells penetrating the Cape May Formation and Cohansey Sand, Cumberland County, N.J.

Wells CO-2 and 3 in Table 14

Both wells are located in Mauricetown about 1,200 feet west of the Maurice River. Land surface elevation: 20 feet above sea level

	Thickness (feet)	Depth (feet)
No record.....	11	11
Pleistocene:		
Cape May Formation:		
Deltaic		
Sand and gravel	29	40
Estuarine clay		
Clay	23	63
Estuarine sand		
Sand, coarse; "very smelly water" "brackish"	15	78
Sand and gray clay mixture; "brackish water"	28	106
Tertitary:		
Cohansey (?) Sand:		
Sand, clean, coarse; "water tested pure for human use"	21	127

All of the salt marsh and swamp areas are covered, at least intermittently, by tides or are water logged because the water table is close to or above land surface.

Tidal inundation occurs along Delaware Bay and in the estuaries of the larger streams to about Fairton, Cedarville, Dividing Creek, and Port Elizabeth. These salt-marsh and swamp deposits may serve as portals for salt-water encroachment in areas where the fresh-water head has been reversed in the shallow aquifer and has been lowered below tide levels by pumpage from wells or by drainage operations. Large areas have been extensively drained by ditches along the Delaware Bay where salt-marsh hay is grown.

The threat of salt-water intrusion from Delaware Bay is, therefore, greatest in summer when ground-water discharge and surface-water outflow are reduced by high rates of pumpage from wells and by large losses through evapotranspiration.

Beach and Alluvial Deposits

Beach sand of Holocene age, usually deposited by near-shore wave action and reworked by wind, occurs along the shores of Delaware Bay. It forms low, narrow strips of beach southeastward from Cedar Creek into Cape May County. These areas of beach sand generally are only a few feet above sea level. Beach sand is generally a well sorted, homogeneous material consisting primarily of well-rounded, fine- to medium-grained, light-gray quartz sand containing significant amounts of organic material near the surface. It is commonly underlain by tidal marsh deposits of Holocene age and older sediments.

Alluvial deposits are found adjacent to present stream channels. These deposits commonly occur as discontinuous or interbedded layers of differing texture. Grain size ranges from clay and silt to sand and gravel depending on the type of soils from which they originated. The Alluvium along many streams is interbedded with swamp and tidal-marsh deposits.

The beach and alluvial deposits in Cumberland County are relatively unimportant hydrologically, because they are thin, small in areal extent, and occur at low altitudes where they are subject to salt-water intrusion.

USE OF GROUND WATER IN CUMBERLAND COUNTY

Pumpage for water supplies in the county in 1964 averaged about 51 mgd (million gallons per day); 49.4 mgd was from ground-water supplies. Cumberland County uses more ground water than do neighboring Salem (12 mgd in 1964 and Cape May (10 mgd in 1958) Counties. The larger withdrawals in Cumberland County are due mainly to the demands of large water-using industries and extensive irrigation in the county. This is reflected in the large variations in seasonal demands.

Seasonal Differences In Water Demands

There are large seasonal differences in water use in Cumberland County. Seasonal and annual use are shown in Table 13. As high as this use appears, it is considered conservative by the New Jersey Division of Water Resources. In August 1964 ground-water pumpage averaged 144.7 mgd whereas in March it was only 26.8 mgd.

During the summer, evaporation and transpiration by plants reaches a maximum in July and August. If rainfall is insufficient, agricultural crops need supplemental irrigation water to maintain optimum plant growth. Also, lawns are watered, and wading and swimming pools are filled; the food processing industry increases its need for water after the harvesting of crops in early summer. In winter, the water demands for the above uses are minimal. Typical seasonal differences in monthly water demands are illustrated in figure 10 which shows the monthly ground-water pumpage by the municipal-supply systems.

Withdrawals by the Different Types of Supply Systems

Public Supplies

Public water supplies for residential and other uses exist in three communities in the county--Bridgeton, Millville, and Vineland. Public water supplies are available to virtually the entire population living in Bridgeton. Presently the water distribution systems of Millville and Vineland do not extend to the more rural areas where water supplies are obtained largely from individual private wells. The Cumberland County Planning Board (1965, p. 81-87) estimates that about 50 percent of the total county population was served by the three public-supply systems in 1964. Smaller local semi-public systems serve Seabrook, part of Newport, and parts of the Delaware Bay communities of Sea Breeze, Bay Point, Money Island, Gandy's Beach, Fortescue, East Point, and Moores Beach.

In 1964 the public and semi-public systems pumped almost 4 billion gallons of water at an average rate of 10.6 mgd. All of this was from ground-water supplies with one exception; in 1964 Millville pumped about 1.5 mgd from Union Lake and about 1.8 mgd from wells. However, Millville abandoned its surface-supply system at Union Lake in 1965 and is presently utilizing only ground-water supplies. Annual pumpage in 1964 by the Bridgeton, Millville, and Vineland systems was nearly equal as seen in Table 13. However, seasonal demands of the food processing plants increased Bridgeton's summer pumpage rates in comparison with those of Millville and Vineland.

Figure 11 shows the annual pumpage and the average daily pumpage rate in the month of maximum demand by the municipal public supply systems from 1950 to 1966. Vineland's water demand has shown an upward trend that is attributed to increasing residential use of water, additional commercial and industrial demands, and an expansion of the water distribution system to suburban areas.

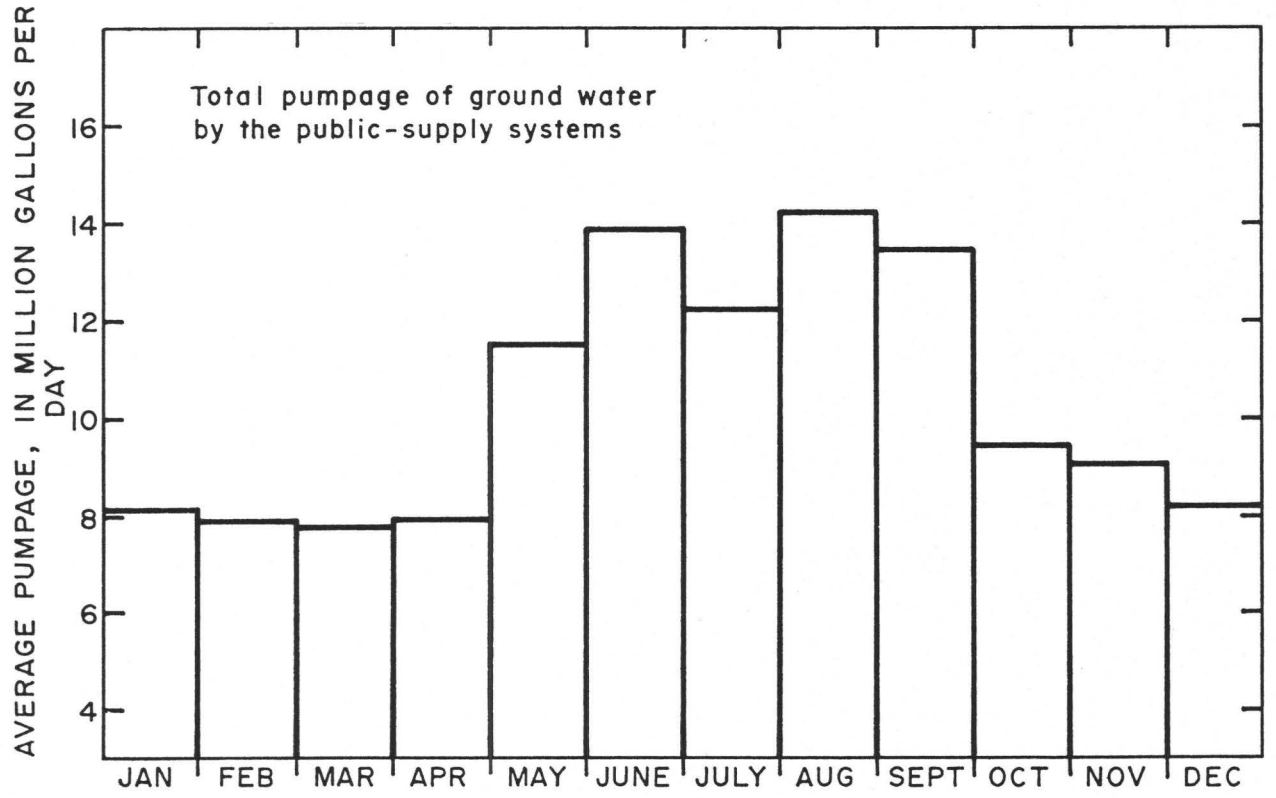


Figure 10.--Graph showing monthly water use by the public-supply systems of Bridgeton, Millville, and Vineland, 1964.

Table 13.--Seasonal and Annual Use of Ground Water, Cumberland County, N.J., 1964.

(In million gallons per day)

Type of Supply Systems	Summer month of maximum demand (August)	Winter month of minimum demand (March)	Average annual use
Public supplies			
Bridgeton	5.36	2.26	3.26
Millville	3.87	2.68	3.32[1/]
Vineland	4.98	2.72	3.76
Semi-public	.40	.20	.30
Public supply total	14.61	7.86	10.64
Suburban and rural residential	5.8	3.4	4.4
Industrial	31.2	14.9	19.0
Irrigation	91.0	0.0	15.4
Other (Institutional, farm use, etc.)	2.1	1.1	1.5
County total	144.7	27.2	50.9

[1/] 1.5 mgd was from surface water supply

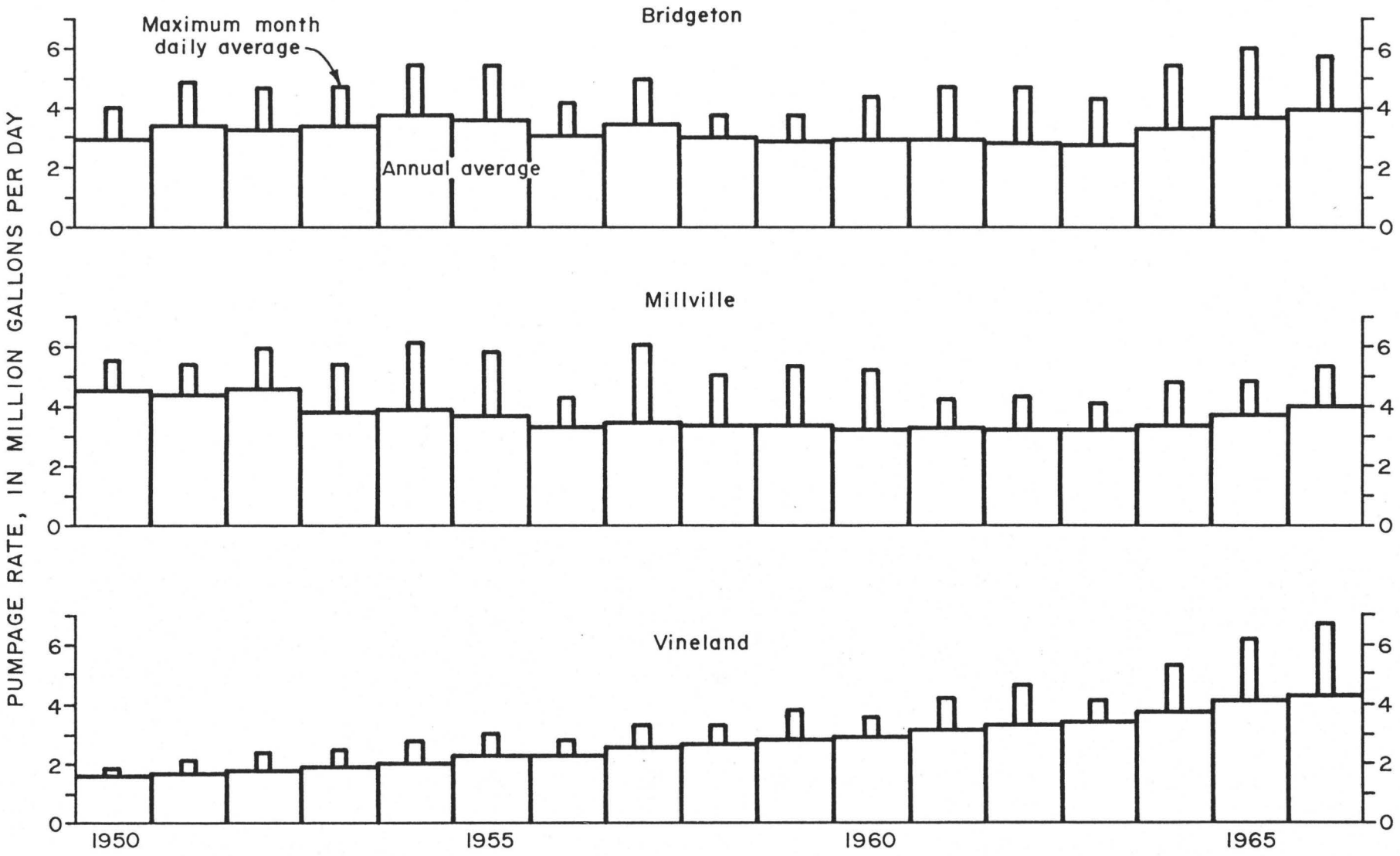


Figure 11.--Graph showing annual water use by the public-supply systems, 1950-66.

Suburban and Rural Residential Use

Most of the population of Cumberland County not served by the public or semi-public water-supply systems obtains water from individual wells. The Cumberland County Planning Board (1965, p. 81-87) estimates that this population was about 58,000 in 1964. Based on an assumed per capita use of 75 gpd derived from studies of water use in Elmer and Woodstown, N.J.--two public supply systems in neighboring Salem County which serve no large water-using industries--about nine percent, or 4.4 mgd, of all water withdrawals in the county was pumped from private residential wells in 1964.

Suburban and rural residential water demands in Cumberland County vary seasonally, probably in much the same pattern as the demands of the public-supply systems of Elmer and Woodstown. Thus, residential use in the county is estimated to range from about 3.4 mgd in March 1964 to about 5.8 mgd in August 1964.

Industrial Pumpage

Industry uses the greatest amounts of ground water in Cumberland County annually accounting for about 37 percent of all annual water withdrawals (table 13). According to data in a report by Sherman and Grossman (1963) on the use of water by manufacturing industries in New Jersey, most industries in Cumberland County depend on self-supplied water. Only about 5 percent of industry's water requirements were purchased from the public-supply systems in 1960 (Sherman and Grossman, 1963). The largest users of water in Cumberland County are industries that process and manufacture sand and glass products and those processing food products. These industries accounted for about 92 percent of the total 19.0 mgd of ground water withdrawn by industry in 1964.

Industrial water demands are also seasonal as shown in Table 13. Large demands by the food processing industry in the summer and fall account for a large part of seasonal differences. Industrial water use during August 1964 was about 31 mgd, more than twice the amount used in March 1964

Most of the ground-water withdrawals by industry are concentrated in Bridgeton, Millville, Vineland, Seabrook, and at a sand plant near Dividing Creek.

Irrigation

The use of water for irrigation is increasing rapidly in New Jersey; particularly, in Cumberland County. The county has been the consistent leader in the number of acres irrigated; having more than one-fifth of the total acres irrigated in the State in 1964. Figure 12 shows how the number

of acres irrigated has increased in New Jersey from 7,902 acres in 1935, to 96,439 in 1964, and in Cumberland County from 4,418 acres in 1949, to 20,743 in 1964, (U.S. Bureau of the Census, 1936-65).

According to records of the N. J. Division of Water Resources, the annual application rate of water for irrigation in Cumberland County averages about 12 inches on each acre irrigated. In Cumberland County ground-water constitutes about 83 percent of the water used for agricultural irrigation (U.S. Bureau of the Census, 1960). Assuming that 83 percent (17,258 acres) of all the reported acres (20,793) irrigated in the county in 1964 received 12 inches of ground water per year, the annual demands for irrigation averaged approximately 15.4 mgd from ground-water supplies. During August, however, they averaged about 91 mgd or 63 percent of all ground-water withdrawals in the county.

Most of the large ground-water withdrawals for irrigation during the growing season are concentrated in the northwestern part of the county near Bridgeton and in the farming areas of the western and southern parts of Vineland. Large withdrawals are also concentrated in a belt about three miles wide in the southwestern part of the county extending from the Cohansey River near Fairton, through Cedarville to Port Norris.

Other Supply Systems

Estimated withdrawals by all other water-supply systems accounted for the remaining 4-percent, or about 1.5 mgd, of the total ground water used in the county in 1964. This includes water used on the farm for livestock, as well as self-supplied water for commercial use and public and private institutional use where these facilities are not served by a municipal system. In estimating their water use, it was assumed for this report that the seasonal characteristics of the demands of these other types of supplies were about the same as those of the public-supply systems in the county.

SUMMARY AND CONCLUSIONS

The magnitude of the water resources for Cumberland County has been estimated based on a generalized, long-term, average annual hydrologic budget of water gains and losses. Precipitation, the principal source of the resource averages 1,050 mgd (44 inches per year). Surface-water inflow contributes another 142 mgd (6 inches per year). Ground-water inflow to the county is probably negligible. Evapotranspiration, the largest water loss from the county, averages about 685 mgd (28.7 inches per year). Surface-water outflow amounts to about 370 mgd (15.5 inches per year) and ground-water outflow from the county is estimated to be about 137 mgd (5.8 inches annually). These values given for this hydrologic budget of the county, however, are at best, rough estimates. When more hydrologic data become available, refinement of these estimates should be made.

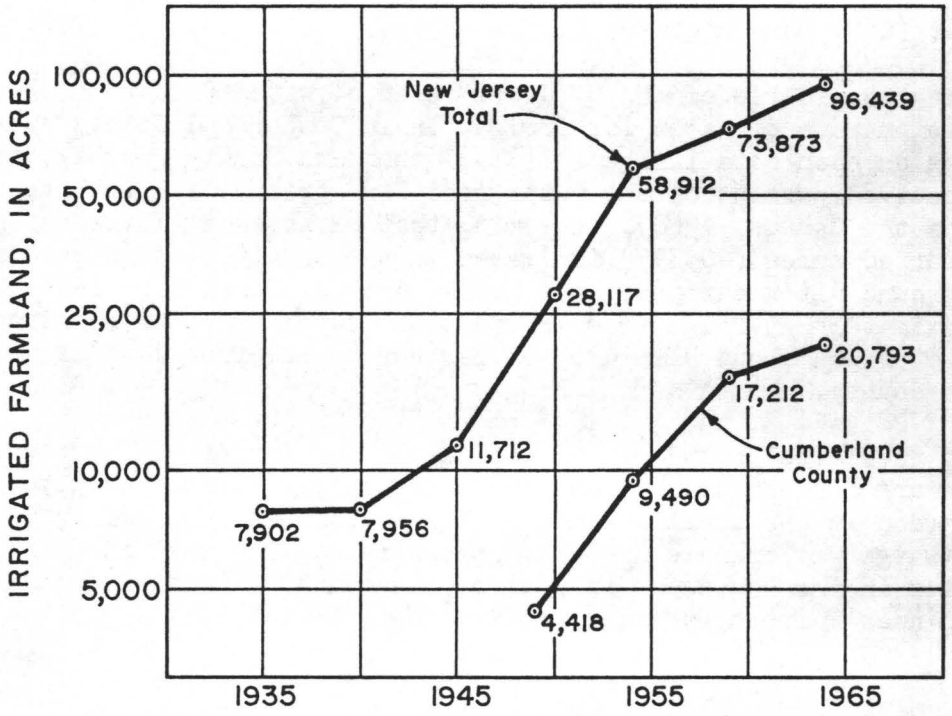


Figure 12.--Graph showing number of acres of farmland irrigated in New Jersey and Cumberland County, N. J., 1935-65.

Surface- and ground-water outflow to Delaware Bay are greatest in winter when the water-table and stream gradients are highest and lowest in summer when evapotranspiration rates are highest. During the summer ground-water levels may fall below sea level locally and tidal inflow and salt-water intrusion from Delaware Bay and its estuaries may occur.

Almost all water supplies in Cumberland County are obtained from wells tapping shallow ground-water supplies. Most wells are less than 180 feet deep and obtain water from the Cohansey-Kirkwood aquifer. Successively deeper aquifers occur in the lower part of the Kirkwood Formation, in the Piney Point Formation, in the Wenonah Formation and Mount Laurel Sand, and in the Potomac Group and Magothy and Raritan Formations. Each of these aquifers are separated by confining or semiconfining clay layers of varying thicknesses and permeabilities.

The Cohansey-Kirkwood aquifer is generally considered to be a water-table aquifer throughout most of Cumberland County although semiconfining conditions occur locally. Its principal recharge area is in the uplands in the northern part of the county and its main discharge areas are in the eroded stream valleys and tidal marsh areas along Delaware Bay. Large water supplies (300 to 1,200 gpm) of acceptable chemical quality for most uses can generally be obtained from this aquifer. High yielding wells tapping this aquifer are generally less than 180 feet deep. Domestic and commercial supplies (10-50 gpm) can be obtained from wells in the Cohansey-Kirkwood aquifer, that are generally less than 100 feet deep. Typical specific capacities of selected wells throughout the county range from about 7 to 80 gpm per foot of drawdown and average about 20 gpm per foot.

Ground-water in the Cohansey-Kirkwood aquifer generally is low in dissolved solids (usually less than 100 mg/l), has a low pH (4.2 to 7.0), and is usually corrosive. The water locally contains objectionable concentrations of iron (up to 15 mg/l), and nitrate (up to 65 mg/l). Much of the excessive concentrations of nitrate probably originate from contamination by agricultural fertilizers and organic wastes from cesspools or other sources of contamination. Because of the high infiltration capacity of the soils over most of the county, the dumping or spreading of soluble materials on the land surface will affect the water quality in the shallow Cohansey-Kirkwood aquifer. Salt-water intrusion in the Cohansey-Kirkwood aquifer is presently not a serious problem. However, potential minor intrusion problems have occurred seasonally in centers of pumpage near the Greenwich and the Port Norris areas and along other tidal lowlands near Delaware Bay.

The second most important source of ground-water in Cumberland County is the lower Kirkwood aquifer. Most existing wells tapping this aquifer in Cumberland County generally yield less than 50 gpm, but the aquifer is capable of yielding as much as 400 gpm. Reported wells are about 200 to 350 feet deep, and are located mostly in the eastern part of the county. Spedific capacities of wells tapping the lower Kirkwood aquifer range from 3 to 18 gpm per foot of drawdown.

The quality of water in this aquifer is suitable for most uses. Concentrations of iron average 1.2 mg/l. Dissolved solids range from about 85 to 161 mg/l and chlorides are generally less than 5.0 mg/l. The high fresh-water head in this aquifer along the Maurice River and Delaware Bay indicates that the potential for salt-water intrusion is minimal under present pumpage rates in Cumberland County.

Most recharge to the lower Kirkwood aquifer in Cumberland County probably comes from vertical leakage from the overlying Cohansey-Kirkwood aquifer in the western part of the county and therefore is also subject to surface contamination. Some discharge probably occurs as vertical leakage upward to higher aquifers in the lowlands along streams and Delaware Bay.

The future development of the lower Kirkwood aquifer for additional fresh-water supplies should proceed with caution. If this aquifer in the Atlantic City area and other coastal areas receives recharge from upland areas in Cumberland County, additional large withdrawals in the intake areas in the Cumberland County area may reduce the amount of recharge reaching the coastal areas.

The Piney Point Formation, underlying the Kirkwood Formation, is a minor aquifer in Cumberland County. Only a few wells tap it for small domestic and farm supplies in the southwestern part of the county, mostly along Delaware Bay. Available information indicates only small yields (about 50 gpm) can be expected from wells in the Piney Point Formation. Water from the Piney Point aquifer requires little or no treatment for potable uses.

The aquifer in the Wenonah Formation and Mount Laurel Sand offers a potential source of additional fresh-water supplies in Northern Cumberland County. This aquifer is not presently utilized in the county, however, because adequate supplies are available from much shallower aquifers. Water quality in the northern part of the county, where water levels in the Wenonah-Mount Laurel aquifer are well above sea level, is very good as indicated by analyses of ground-water in nearby Salem County and from one analysis in Cumberland County. The water becomes more salty toward Delaware Bay. Water from an unused well in this aquifer near Sea Breeze contained 295 mg/l of chloride and 859 mg/l of dissolved solids. Collection of additional hydrologic data from test and observation wells in the Wenonah and Mount Laurel would give needed information on the extent of this salty water and the aquifer's fresh water-bearing characteristics in Cumberland County.

Aquifers in the Potomac-Raritan-Magothy sequence contain saline water and are not currently utilized in Cumberland County. However, they have been used successfully in other areas of New Jersey to store injected fresh-water which is later recovered during periods of heavy demand with its quality unimpaired. However, if they are to be utilized in the future in Cumberland County area for such purposes, they will have to be explored by deep test drilling to determine the effects on the overall hydrologic system in the region.

Total annual withdrawals of ground-water in Cumberland County averaged 49.4 mgd in 1964. Water for industry and irrigation in 1964 averaged 19 mgd and 15.4 mgd, respectively. The three public-supply systems in the county, Bridgeton, Millville, and Vineland, serve about half of the population of the county. These three systems and several small semipublic systems pumped a combined average of about 10.6 mgd of water in 1964. Pumpage from private wells for domestic, farm, institutional, and commercial use averaged about 5.9 mgd in 1964.

Seasonal use of water ranged from about 27 mgd in March to about 145 mgd in August 1964. In August 1964 water use for industry and irrigation was 31.2 and 91 mgd, respectively, accounting for nearly 85 percent of the total ground-water used in the county. Their combined seasonal demands are expected to increase in future years.

Most ground-water withdrawals are concentrated in the more densely populated areas of Bridgeton, Millville and Vineland. Greatest demands in the future are also likely to be in these areas.

This investigation has indicated the need to obtain additional data to improve our knowledge of the geologic and hydrologic characteristics of the aquifers and other hydrologic conditions of the county. Observation wells are needed to monitor the effects of large ground-water withdrawals and to indicate potential contamination and salt-water intrusion of fresh-water supplies. Additional geologic information is needed to determine more exactly the boundaries and geometry of the aquifers.

In order to properly manage the ground-water supply, it is necessary to know the effects of present and past water use. Water demands in Cumberland County will continue to increase substantially for agricultural irrigation, and probably more slowly for industrial, commercial, and domestic uses. Reliable and current records of water use by the different types of supply systems are needed to make management decisions concerning future patterns of ground-water withdrawals.

Water is a dynamic resource, and for no area can it be said that knowledge of its occurrence is adequate for all needs. Ground-water problems more often involve its availability, quantity, quality, distribution, and management and development. Contamination and conflicts of interest are generally difficult problems to solve. Obviously then, those areas in Cumberland County where problems exist or soon will exist should be further investigated. Adequate data for use in planning and management and orderly development of the ground-water resources of Cumberland County are essential if the potential supply is to be utilized to its optimum extent.

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APPENDIX

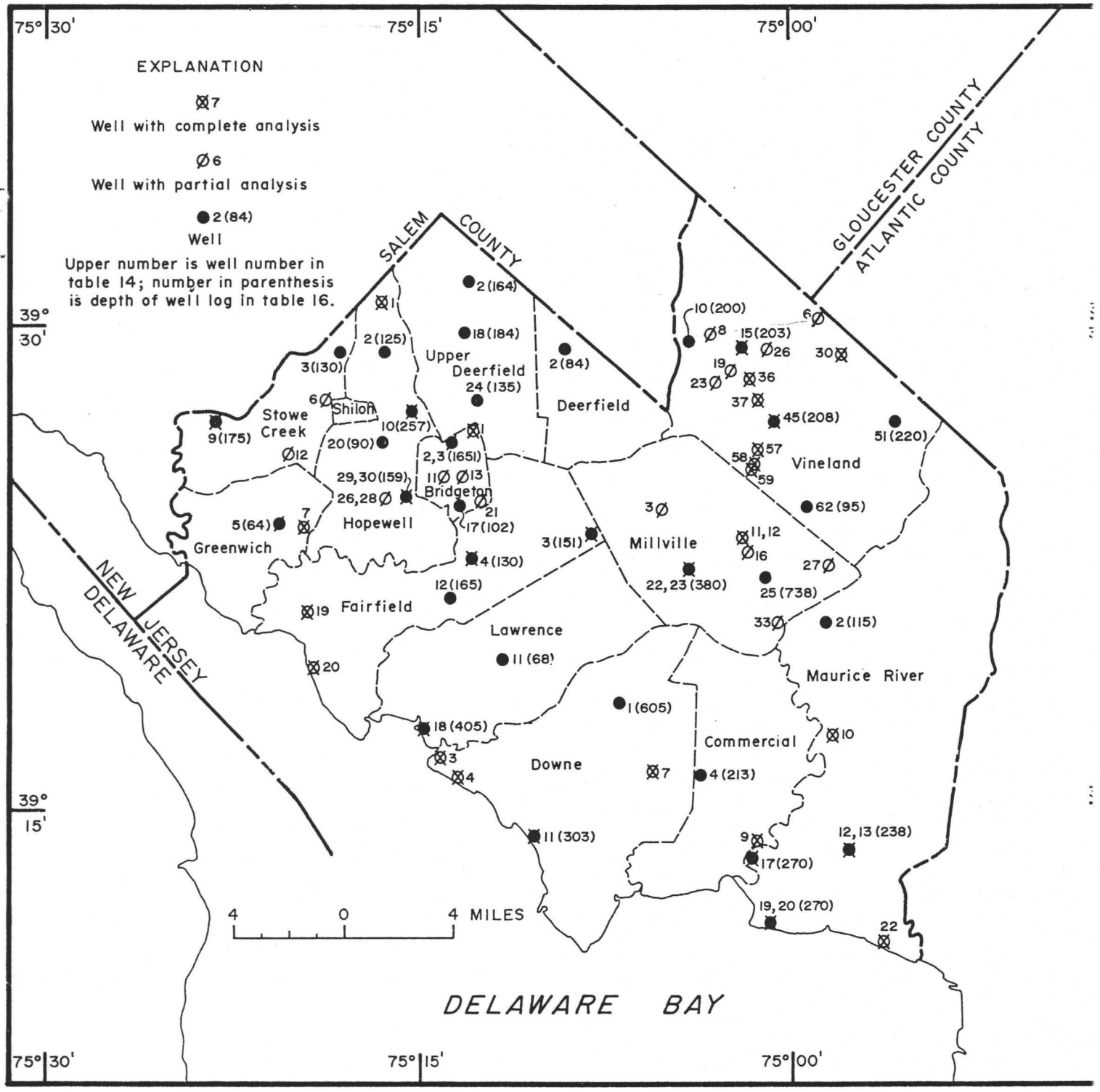


Figure 13.--Map showing locations of wells having chemical analyses of water in table 15 and logs in table 16.

TABLE 14.--RECORDS OF SELECTED WELLS IN CUMBERLAND COUNTY, N.J.

Aquifer: CM, Cape May Formation
CM-KW, Cape May or Kirkwood
Ch-KW, Cohansey-Kirkwood
LKW, Lower Kirkwood
PP, Piney Point
MW, Mount Laurel and Wenonah
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Well Number	Owner and Owner's Well Number	Location	Altitude of land surface (feet)	Drilling Contractor	Year Drilled	Total depth drilled (feet)	Diameter of casing (inches)	Aquifer	Screen setting (feet)	Well performance test					Remarks
										Yield (gpm)	Static water level (feet)	Drawdown (feet)	Specific capacity (gpm/ft of drawdown)	Date	
BRIDGETON															
Br- 1	City of Bridgeton (No. 10)	Logan St. in the extreme NE corner of the city	90	Layne-New York Co.	1949	118	24	Ch-Kw	77- 97	430	32	24	18	4- 4-62	Public supply well.
2	City of Bridgeton (No. 3)	Cumberland Ave. between Chestnut and Pearl St.	80	do.	1940	139	18	Ch-Kw	91- 111	395	40	37	11	7-15-62	Public supply well
3	City of Bridgeton	do.	80	do.	1939	1,651	6 or 8	E-T	1,060-1,090	75	75	75	1.0	1939	Driller's report "Water at 1090 ft contained a very high chloride (3120 mg/l) and iron content and not suitable for public consumption." 1939 test well.
	Do.	do.	do.	do.	do.	--	--	Ch-Kw	61- 101	500?	--	--	--	Oct. 1939?	
	Do.	do.	do.	do.	do.	--	--	LKW	139- 164	10	--	--	--	do.	
	Do.	do.	do.	do.	do.	--	--	PP	278- 295	--	--	--	--	Nov. 1939	
4	Owens-Illinois (No. 1)	N. Laurel St.	40	do.	1935	168	18	Ch-Kw	68- 98	528	30	21	25	6-19-35	
5	Do. (No. 2)	do.	50	do.	1935	123	18	Ch-Kw	78- 108	540	38	23	23	6-25-35	
6	Do. (No. 3)	do.	55	do.	1942	107	16	Ch-Kw	71- 91	510	40	13	39	11- 6-41	
7	Do. (No. 4)	do.	--	do.	1948	94	16	Ch-Kw	67- 87	533	37	22	24	3-17-48	
8	Do. (No. 5)	do.	--	do.	1954	130	16	Ch-Kw	98- 108	517	54	34	15	3-18-54	
9	City of Bridgeton	Alberton Ave. and Budd St.	80	C. W. Lauman Co.	1944	135	--	Ch-Kw	110- 123	--	50	--	--	12- 1-44	Test well. Water sample contained 13 mg/l of iron. Lauman test well.
10	City of Bridgeton	West Ave. and Commerce St. at Junior High School	65	Layne-New York Co.	1960	204	10	Ch-Kw	98- 118	344	26	52	6.6	8-24-60	Layne test well.
11	City of Bridgeton (No. 1)	Jeddy's Pond and Park Dr.	7	Fairbanks & Morse Co.	1930	75	16	Ch-Kw	20- 70	155	2	27	5.7	7-10-60	Public supply well.
12	City of Bridgeton (No. 4)	Giles and Academy St.	53	Layne-New York Co.	1940	138	18	Ch-Kw	77- 92	880	40	37	24	July 1962	Public supply well.
13	City of Bridgeton (No. 5)	Irving Ave.	32	do.	1942	118	18	Ch-Kw	67- 87	385	12	64	6.0	July 1962	This well not in use since 1957.
14	Martin Corp.	Irving Ave. and Pearl St.	55	Haines & Moore	1944	114	12	Ch-Kw	94- 114	400	--	--	--		Used for industrial dying.
15	P. J. Ritter Co.	South Ave. and Glass St. on east bank of Cohansey River	10	A. C. Schultes & Sons	1946	68	10	Ch-Kw	46- 66	246	3	37	6.6	--	Used for food processing.
16	N. J. Hunt Foods, Inc.	Grove St. on east bank of Cohansey River	10		1947	84	12	Ch-Kw	70- 84	500	--	--	--	1963	One of four wells formerly owned by Prichard &
17	City of Bridgeton (No. 2)	Rocaps Run and S. East Ave.	28	Fairbanks & Morse Co.	1931	102	16	Ch-Kw	62- 92	401	18	35	11	July 1962	Public supply well.
18	City of Bridgeton (No. 6)	Approx. 1000 ft. north of Rocaps Run along N.J. Central Railroad	43	Layne-New York Co.	1945	150	18	Ch-Kw	84- 104	--	28	52	--	July 1962	do.
19	City of Bridgeton (No. 7)	700 ft south of well no. 6	25	do.	1945	106	18	Ch-Kw	64- 84	465	7	48	9.7	July 1962	do.
20	City of Bridgeton (No. 8)	Approx. 1600 ft NE of well no. 6 on west side of Burlington Rd.	48	do.	1946	130	18	Ch-Kw	70- 90	525	23	38	14	July 1962	do.
21	City of Bridgeton (No. 9)	Burlington Rd. and 900 ft south of well no. 8	35	do.	1946	113	18	Ch-Kw	77- 102	626	12	45	14	July 1962	do.
COMMERCIAL TOWNSHIP															
Co- 1	Whitehead Brothers Co.	South side of Central Railroad of N.J.; 3.0 mi NW of Dividing Creek	15	Vance Skinner	1958	184	6	Ch-Kw	175- 182	75	Flowing	9	8.3	12-10-58	

TABLE 14.--RECORDS OF SELECTED WELLS IN CUMBERLAND COUNTY, N.J.--Continued

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										Yield (gpm)	Static water level (feet)	Drawdown (feet)	Specific capacity (gpm/ft of drawdown)	Date	
COMMERCIAL TOWNSHIP--Continued															
Co- 2	G. Schreib	High St., Mauricetown	18	Gus Hauser	1951	113	4	Ch-Kw	103- 109	30	11	10	3.0	8-27-51	Driller reports "very smelly water" between 63' - 78'.
3	David Dows, Jr.	2nd St. between High and Noble St.	20	do.	1947	127	4	Ch-Kw	115- 125	50	20	3	17	11-24-47	Driller reports "Brackish water sands" between 35' to 106'.
4	King Farms	Dragston Rd., 2.3 mi east of Dividing Creek	15	Vance Skinner	1957	213	5	LKW	174- 213	80	0	5.5	15	3-12-57	Irrigation well.
5	Miller Berry	Rt. 533; 2.5 mi southeast of Dividing Creek	12	do.	1953	194	4	LKW	188- 194	100	0	20	5.0	4-20-53	Serves several homes.
6	Port Norris Fire Co.	Port Norris	8	do.	1949	203	4	LKW	193- 203	80	Flowing	8.5	9.4	12-28-49	
7	Mathias Taylor	North Ave., Port Norris	12	Gus Hauser	1953	222	4	LKW	208- 222	200	6	--	--	11-17-53	Irrigation well.
8	Peterson Packing Co.	Shell Pile	10	Vance Skinner	1955	237	6	LKW	217- 237	200	Flowing	--	--	1955	
9	Dave Berry	do.	5	do.	1951	125	4	Ch-Kw	115- 125	60	Flowing	14	4.3	5- 5-51	
10	Port Norris Oyster Co.	do.	6	do.	1956	275	6	LKW	215- 235	300	Flowing	--	--	2- 2-56	
11	Riggins & Robbins	do.	10	do.	1948	270	5	LKW	250- 270	75	Flowing	--	--	1948	
12	Robbins Brothers	do.	10	do.	1950	222	5	LKW	192- 212	200	Flowing	--	--	1950	
13	Shell Rock Oyster Co.	Bivalve	3	do.	1949	233	3	LKW	224- 233	80	Flowing	--	--	1949	
14	E. C. DuBois	do.	5	do.	1956	255	6	LKW	217- 237	85	Flowing	4	21	11-28-56	
15	Delaware Bay Packing Co.	do.	5	do.	1947	235	6	LKW	215- 235	110	Flowing	--	--	1947	
16	J. N. Fowler & Son	do.	5	A. C. Schultes & Sons	1947	255	6	LKW	233- 252	250	Flowing	--	--	12-15-47	Flowed 50 gpm in 1947.
17	Bivalve Packing Co.	do.	5	do.	1947	220	6	LKW	200- 220	200	Flowing	--	--	1947	
DEERFIELD TOWNSHIP															
Dr- 1	Seabrook Farms Co.	1.5 miles south of Centerton	100	Wm. Stothoff	1945	155	12	Ch-Kw	33- 58	650	--	--	--	1963	Owner has 5 irrigation wells in this area.
2	Joseph Sparacio, Sr.	Parvin Mill Rd., 2.5 mi NE of Woodruff	110	D'Agostino Well Drilling Co.	1955	84	6	Ch-Kw	62- 84	350	--	--	--	1955	Irrigation well.
3	John Marone	Bridgeton-Vineland Pike 2 mi east of Woodruff	115	do.	1956	73	3	Ch-Kw	63- 73	--	37	--	--	5- 5-56	
4	Max Wurtzel	Morton Ave., Rosenhayn	100	do.	1953	75	4	Ch-Kw	62- 72	50	26	6	8.3	5-26-53	
5	Sam Schwartz	Cedar Ave., Rosenhayn	105	do.	1953	74	4	Ch-Kw	62- 71	45	34	--	--	5-24-53	
6	Dominic Rados	Tuska Ave., Rosenhayn	80	Gus Hauser	1953	72	4	Ch-Kw	62- 68	36	27	4	8.0	5- 9-53	
7	Sol L. Davidow	Lebanon Rd., Rosenhayn	85	do.	1953	60	4	Ch-Kw	50- 56	84	30	--	--	10-24-53	
DOWNE TOWNSHIP															
Dn- 1	Pennsylvania Glass Sand Corp.	N. side of Central Railroad of N.J. 1.0 mi west of Rt. 555	48	Carolina Well and Pump Co.	1963	605	--	--	--	--	--	--	--	--	Geohydrologic test well.
2	J. H. Branin	Money Island	5	Gus Hauser	1952	134	4	Ch-Kw	124- 130	60	6	--	--	2-26-52	Driller reports "salt-water sand" between 78' - 99'
3	Pollino's Money Island Marina	do.	5	Vance Skinner	1948	376	4	PP	350- 370	50	Flowing	30	1.7	5- 6-48	
4	Gandys Beach Water Co.	Gandy Beach	5	do.	1945	402	6	PP	378- 400	40	Flowing	--	--	3-16-62	Semipublic supply well.

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										Yield (gpm)	Static water level (feet)	Drawdown (feet)	Specific capacity (gpm/ft of drawdown)	Date	
DOWNE TOWNSHIP--Continued															
Dn- 5	Dayton Warfle	Turkey Point Corner 2.0 mi NW of Dividing Creek	8	do.	1952	151	5	Ch-Kw	126- 151	30	Flowing	--	--	1963	Irrigation well.
6	H. King	0.8 mi NE of Turkey Point Cor. and 1.5 mi NW of Dividing Creek	12	do.	1954	157	4	Ch-Kw	135- 157	10	Flowing	--	--	4-25-62	do.
7	Marcus King (Campbell Farm)	Haleyville Rd., 0.5 mi NE of Dividing Creek	--	do.	--	157	4	Ch-Kw	140- 150	--	--	--	--	--	do.
8	M. King (Locke Farm)	Haleyville Rd., 0.8 mi NE of Dividing Creek	7	do..	1948	140	4	Ch-Kw	130- 140	--	Flowing	--	--	5- 9-62	do.
9	Dayton Warfle (Turkey Point Farm)	Turkey Point Rd. and Hickman Ave., Dividing Creek	8	do.	1952	151	5	Ch-Kw	(?)- 150	138	Flowing	--	--	5- 8-62	Flowing 138 gpm.
10	H. King (Turkey Point Farm)	0.5 mi west of Turkey Point Rd. and 1.3 mi south of Turkey Point.Cor.	6	do.	1945	158	4	Ch-Kw	158- 179	10	Flowing	--	--	6- 5-45	Irrigation well, capacity greater than 70 gpm.
11	Fortescue Realty Co.	Fortescue	5	Gus Hauser	1953	303	4	LKW	283- 303	96	0	--	--	4-14-53	Semipublic supply well
12	Clarence Dare	Fishing Creek, 1.6 mi south of Fortescue	5	do.	1962	326	4	LKW	--	--	--	--	--	--	
FAIRFIELD TOWNSHIP															
Fa- 1	Cohanzick Country Club	0.5 mi north of Fairton on Bridgeton Rd.	60	Ray Simpkins	1959	170	8	Ch-Kw	--	500	--	--	--	--	Irrigation well 500 gpm pump.
2	George Trego	Gouldtown Rd. 0.3 mi NE of Bridgeton-Fairton Rd.	55	Gus Hauser	1950	126	4	Ch-Kw	117- 123	15	36	--	--	7-29-50	
3	Seabrook Farms Co.	4.6 mi east of Fairton and 0.3 mi north of Millville-Fairton Rd.	73	Vance Skinner	1956	151	12 to 8	Ch-Kw	95- 135	1,300	22	46	28	6-15-56	Irrigation well.
4	Fairton Public School	Ramah Rd., 0.1 mi east of Bridgeton Rd.	30	D'Agostino Well Drilling Co.	1962	130	6	Ch-Kw	120- 130	25	25	1.5	17	11- 8-62	
5	Wm. Alvino	South bank of Cohansey River, Fairton	20	Gus Hauser	1951	75	4	Ch-Kw	61- 71	20	14	5	4.0	11- 1-51	
6	Jean M. Greene	do.	22	Haines & Moore	1958	63	4	Ch-Kw	57- 62	25	21	5	5.0	8-29-58	
7	Neil West	Ramah Rd., 1.7 mi east of Fairton	85	Wm. Shephard	1952	85	3	Ch-Kw	--	5	50	--	--	10-11-52	
8	E. M. Davis	do.	60	Gus Hauser	1954	73	3	Ch-Kw	63- 69	24	35	12	2.0	4-24-54	
9	James Manetas	Back Neck Rd.	--	Vance Skinner	1951	104	5	Ch-Kw	84- 104	300	0	22	14	11-21-56	Irrigation well.
10	Glen Johnson	Rockville Rd.	15	do.	1951	150	5	Ch-Kw	114- 135	200	5	12	17	2- 1-51	do.
11	Laning Brothers	do.	--	do.	1951	149	5	Ch-Kw	--	500	4	--	--	11-20-56	do.
12	Cedar Brook Farms	New England Crossroads	22	Delmarva Drilling Co.	1959	153	17	Ch-Kw	90- 131	1,280	15	40	32	4- 2-59	Concrete irrigation well.
13	Oakwood Luncheonette	0.8 mi south of Fairton on Cedarville Rd.	47	Gus Hauser	1952	65	4	Ch-Kw	55- 61	9	31	2	4.5	5-24-52	
14	April Brothers	New England Crossroads 1.4 mi south of Fairton	40	Vance Skinner	1950	130	10	Ch-Kw	74- 129	600	29	26	23	7-15-50	Irrigation well
15	Karl Dix	Rockville Rd., 0.7 mi south of Back Neck Rd.	17	do.	1950	144	6	Ch-Kw	108- 142	300	8	10	30	8-17-50	do.
16	Albert Hepner	Sayres Neck Rd., 1.8 mi south of Fairton	15	do.	--	134	5	Ch-Kw	104- 134	500	4	20	25	12-15---	do.

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										Yield (gpm)	Static water level (feet)	Drawdown (feet)	Specific capacity (gpm/ft of drawdown)	Date	
Fa-17	Level Acre Farms	Cedarville-Bridgeton Rd. 2.0 mi NW of Cedarville	32	Vance Skinner	1953	145	12	Ch-Kw	74- 144	700	20	35	20	5- 4-53	Irrigation well.
18	do.	do.	30	do.	1952	131	10	Ch-Kw	108- 130	600	20	40	15	5- 5-52	do.
19	N.J. Fish & Game Comm. (Holton Farm)	1.0 mi west of Sea Breeze Rd. and 3.3 mi north of Sea Breeze	7	Ray Simpkins	1957	312(?)	5	MW	--	1	Flowing	--	--	4-17-63	QW-295 mg/l chlorides.
20	Mae Griffith	Sea Breeze (Delaware Bay beach)	5	--	1940	287	4	PP	--	30	Flowing	--	--	4-17-63	QW-65 mg/l chlorides.
GREENWICH TOWNSHIP															
Gr- 1	H. H. Mills	Othello Road, 1.4 mi SW of Roadstown	95	Haines & Moore	1952	100	4	Ch-Kw	93- 99	15	58	10	1.5	1- 9-52	
2	F. L. Hine (No. 1)	Othello Rd., 1.6 mi SW of Roadstown	75	do.	1953	90	4	Ch-Kw	83- 89	12	41	19	--	10-31-53	
3	do. (No. 2)	do.	70	do.	1954	91	4	Ch-Kw	84- 90	20	35	25	0.8	4-12-54	For swimming pool.
4	James Orr	Greenwich Rd., 0.5 mi south of Othello	12	Gus Hauser	1953	40	4	CM-Kw	30- 36	9	6	--	--	8-13-53	
5	Greenwich School	N. Main St., Greenwich	15	D'Agostino Well Drilling Co.	1962	64	4	CM-Kw	44- 64	50	8	27	1.9	10- -62	
6	R. S. Watson & Son	do.	15	Haines & Moore	1955	34	6	CM-Kw	27- 33	60	10	22	2.7	8-12-55	Canning house well.
7	Finkelstein Brothers	Bridgeton Rd., 0.4 mi NE of Greenwich	5	do.	1947	39	6	CM-Kw	27- 39	90	1	--	--	10- 1-63	188 mg/l chlorides (10-1-63).
8	Elizabeth Moore	Main St., Greenwich	15	do.	1958	33	4	CM-Kw	27- 32	18	9	3	6.0	8- 7-58	
9	C. K. Landis	do.	14	Gus Hauser	1951	35	4	CM-Kw	25- 31	10	12	--	--	11- 3-51	
10	P. Reinhart	S. Main St., Greenwich	15	Haines & Moore	1951	37	4	CM-Kw	30- 36	4	14	--	--	11-30-51	
11	Seifert Lodge	South Greenwich	15	do.	1952	30	4	CM-Kw	23- 29	15	10	--	--	5-24-52	
12	Harry H. Johnson	do.	10	Charles H. Lupton	1954	30	2	CM-Kw	25- 30	20	10	--	--	7- 2-54	
HOPEWELL TOWNSHIP															
Ho- 1	Horace Beal	Cohansey	117	Haines & Moore	1962	54	4	Ch-Kw	45- 50	23	22	8	2.9	11-15-62	
2	Burpee Seeds	2.2 mi NE of Shiloh and 2.1 mi SE of Cohansey	100	Ray Simpkins	1962	125	4	Ch-Kw	36- 46	30	25	3	10	2-15-62	Test well No. 1.
3	George Sigars	1.0 mi NE of Shiloh and 2.9 mi south of Cohansey	105	Gus Hauser	1953	233	8	Ch-Kw	50- 90	480	29	--	--	6-11-53	Irrigation well.
4	Victor Fox	0.5 mi north of Shiloh on Cohansey Rd. (Rt. 49)	130	Haines & Moore	1961	88	4	Ch-Kw	77- 88	24	48	--	--	4- 6-61	
5	A. R. Brown, Jr. (U.S.G.S. West Branch No. 2)	2.4 mi NE of Shiloh	90	--	--	32	--	Ch-Kw	Dug well	--	26	--	--	7-17-61	U.S.G.S. water level observation well 1953 through 1962)
6	Shoemaker Dairies (No. 1)	2.0 mi east of Shiloh	100	Haines & Moore	1947	81	8	Ch-Kw	61- 81	200	--	--	--	--	
7	Shoemaker Dairies (No. 2)	do.	95	Vance Skinner	1958	85	8	Ch-Kw	--	240	--	--	--	--	
8	Shoemaker Dairies (No. 3)	do.	85	Layne-New York Co.	1949	114	8	Ch-Kw	69- 89	222	36	30	7.4	10- 4-49	

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										Yield (gpm)	Static water level (feet)	Drawdown (feet)	Specific capacity (gpm/ft of drawdown)	Date	
HOPEWELL TOWNSHIP--Continued															
Ho-10	R. E. Daut	2.5 mi east of Shiloh on Beebe Run Rd.	50	Vance Skinner	1948	257	4	PP	237- 257	20	15	11	1.8	9-13-48	QW-52 mg/l chlorides.
11	Wm. E. Tilton, Jr.	0.5 mi NE of Roadstown on Shiloh Rd.	125	Haines & Moore	1956	60	4	Ch-Kw	53- 59	20	41	5	4.0	5- 8-56	
12	D. H. Dilks	Roadstown on Shiloh Rd.	100	Haines & Moore	1958	48	4	Ch-Kw	42- 47	20	31	5	4.0	2-22-58	
13	Perkin-deWilde Nurseries	Roadstown	80	do.	1952	64	6	Ch-Kw	56- 62	60	32	6	10	2-13-53	
14	Howard F. Hewitt	Roadstown	110	do.	1958	56	4	Ch-Kw	50- 55	20	37	--	--	4-18-58	
15	Gorsen & McCormick	0.7 mi SE of Shiloh and 1.5 mi NE of Roadstown	80	Wm. Stothoff Co.	1944	188	6	Ch-Kw	75- 95	90	--	--	--	--	Abandoned
16	Joseph A. Newkirk	1.3 mi east of Roadstown and 1.0 mi south of Shiloh	105	Haines & Moore	1957	56	4	Ch-Kw	50- 55	20	33	6	3.3	12-27-57	
17	Edward Mayhew, Jr.	1.5 mi SE of Shiloh	75	do.	1954	64	4	Ch-Kw	58- 63	20	26	6	3.3	2- 1-54	
18	Ellis Ketchum, Jr.	Lakeside Dr., northwest of Mary-Elmer Lake	57	do.	1954	57	4	Ch-Kw	50- 56	20	28	4	5.0	4- 7-54	
19	Charles Hannon	Kinkle Rd. west of Mary-Elmer Lake	80	do.	1954	81	4	Ch-Kw	74- 80	20	38	8	--	10-20-54	
20	Hopewell Twp. School	1.8 mi SE of Shiloh	85	do.	1956	90	6	Ch-Kw	78- 88	45	33	6	7.5	8-17-56	
21	Calvery Orthodox Presbyterian Church	Hitchner Ave., 2.7 mi SE of Shiloh	115	do.	1960	102	4	Ch-Kw	94- 99	24	74	6	4.0	9-28-60	
22	Clarence H. Fogg, Jr.	Roadstown Rd., 0.1 mi west of Bridgeton City bdy.	50	do.	1958	41	4	Ch-Kw	35- 40	20	13	5	4.0	12- 5-58	
23	Sunny Slope Farms	Bridgeton-Greenwich Rd. and County House Lane	105	do.	1949	110	4	Ch-Kw	102- 108	25	63	5	5.0	1-24-49	
24	do.	do.	90	Wm. Stothoff Co	1944	114	6	Ch-Kw	96- 106	110	55	--	--	3-22-44	Irrigation well.
25	Edmund Schrier	2.5 mi south of Shiloh and 1.6 mi SE of Roadstown	115	Haines & Moore	1957	75	4	Ch-Kw	69- 74	15	51	5	3.0	7-18-57	
26	Harold Ayers (No. 2)	Bowentown	75	do.	1949	86	4	Ch-Kw	98- 104	25	24	--	--	2-26-49	
27	do. (No. 1)	0.8 mi east of Bowentown on County House La.	60	do.	1949	105	4	Ch-Kw	78- 84	25	44	5	5.0	8- 2-49	
28	Cumberland Co. Farm	1.0 mi SE of Bowentown on County House La.	100	Wm. Stothoff Co.	1937	124	8	Ch-Kw	114- 124	115	65	20	5.8	1937	
29	Cumberland Co. Hospital (No. 1)	do.	80	do.	1942	182	6	Ch-Kw	--	90	--	--	--	--	
30	Cumberland Co. Hospital (No. 2)	do.	80	do.	1942	159	8	Ch-Kw	149- 159	150	50	13	12	6-21-63	Driller's log in table 16.
31	Owen Cameron	S. Fayette St. Bridgeton	50	Haines & Moore	1956	54	4	Ch-Kw	47- 53	20	30	5	4.0	5- 9-56	
32	Ben Rizzo	Dutch Neck Rd., 1.2 mi east of Sheppards Mill	40	D'Agostino Well Drilling Co.	1959	335	--	--	--	--	--	--	--	--	Irrigation test well.
33	Wm. W. Loew	0.6 mi north of Dutch Neck Rd. on Bowentown Rd.	82	Haines & Moore	1962	108	4	Ch-Kw	101- 107	20	45	--	--	6- 8-62	
34	George L. Brooks	Lower Dutch Neck Rd.	17	do.	1953	37	4	Ch-Kw	30- 36	25	12	4	6.3	5-25-53	
35	H. J. Ridgeway	do.	55	Robert Peck	1953	66	2	--	--	8	40	--	--	8- 8-53	

TABLE 14.--RECORDS OF SELECTED WELLS IN CUMBERLAND COUNTY, N.J.--Continued

Aquifer: CM, Cape May Formation
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										Yield (gpm)	Static water level (feet)	Drawdown (feet)	Specific capacity (gpm/ft of drawdown)	Date	
LAWRENCE TOWNSHIP															
La- 1	Seabrook Farms Co.	Ramah Rd., 1.0 mi west of Millville-Cedarville Rd.	85	Haines & Moore	1951	144	4	Ch-Kw	131- 142	20	24	4	5.0	6-25-51	Abandoned.
2	E. W. Baker	Millville-Cedarville Rd. at Centre Grove	75	Gus Hauser	1948	143	3	Ch-Kw	128- 138	--	25	--	--	12-23-48	
3	Louis Bartholomew	do.	70	do.	1952	150	6	Ch-Kw	110- 150	440	11	--	--	11-16-52	Irrigation well.
4	Maple Run Farms (No. 1)	Cedarville-Bridgeton Rd., 1.2 mi NW of Cedar Creek	35	Vance Skinner	1939	75	4	Ch-Kw	65- 75	125	15	16	7.8	11-30-56	Irrigation well.
5	Maple Run Farms (No. 2)	do.	35	do.	1941	75	5	Ch-Kw	55- 75	250	15	12	21	11-30-56	do.
6	Maple Run Farms (No. 3)	do.	35	do.	1943	75	5	Ch-Kw	55- 75	300	15	12	25	--	do.
7	David Sheppard	Sayres Neck Rd. and Sheppard Davis Rd.	15	do.	1953	49	5	Ch-Kw	29- 49	110	5	8	14	4-12-53	Irrigation well equipped with a 500 gpm pump.
8	Laning Brothers	Sayres Neck Rd.	--	do.	1952	127	4	Ch-Kw	--	800?	12	--	--	11-21-56	Irrigation well.
9	Sheppard Farms	Mulford Ave. and N. Main St., Cedarville	--	Owner	--	40	4	Ch-Kw	20- 40	200	7	--	--	--	do.
10	Cedarville Elementary School	East Ave., Cedarville	30	R. Ziegenfuss	1954	60	4	Ch-Kw	55- 60	20	19	26	0.8	2-22-54	
11	Cedar Lake Canning Co.	E. Maple Ave., 0.4 mi east of Main St.	25	Delmarva Drilling Co.	1960	68	17	Ch-Kw	32- 68	800	10	50	16	2-25-60	Concrete casing and screen
12	Clement Pappas	S. Main St., 0.3 mi south of Maple Ave., Cedarville	--	Vance Skinner	1948	100	8	Ch-Kw	--	500	30	20	25	--	Supplies food processing plant.
13	Cedar Brook Farms (Howell Farm)	Jones Island, 2.0 mi SW of Cedarville	7	Delmarva Drilling Co.	1960	74	17	Ch-Kw	48- 74	1,280	6	44	29	3- 1-60	17-inch concrete well for irrigation.
14	Cedar Brook Farms (Cook Farm)	do.		do.	1960	78	17	Ch-Kw	--	1,200	--	--	--	1960	do.
15	Cedar Brook Farms (Cook Farm, No. 1)	do.	10	Vance Skinner	1952	68	5	Ch-Kw	37- 62	200	3	11	18	1-20-52	Irrigation well.
16	Cedarbrook Farms	Jones Island Rd.	10	Delmarva Drilling Co.	1964	56	13	Ch-Kw	12- 56	380	12	32	12	12- 2-64	Concrete irrigation well.
17	do.	do.	10	do.	1964	104	17	Ch-Kw	28- 104	500	9	--	--	12-11-64	do.
18	Bay Point Rod and Gun Club	Bay Point (Delaware Bay Beach)	5	Vance Skinner	1947	405	4	PP	356- 376	--	Flowing	--	--	4-18-63	QW-72 mg/l chlorides.
19	George Sedeyn	Rt. 553, 1.0 mi north of Newport	20	--	1944	125	6	Ch-Kw	--	350	6	--	--	11-29-56	Irrigation well.
MAURICE RIVER TOWNSHIP															
MR- 1	New Jersey Silica Sand Co. (No. 10)	3 miles north of Port Elizabeth along Penna. Reading Seashore RR	30	Haines & Moore	1952	85	8	Ch-Kw	70- 85	165	28	--	--	12-11-52	Sand washing plant.
2	New Jersey Silica Sand Co. (No. 8)	2.7 mi north of Port Elizabeth, 2,700 ft SE of well no. 10	30	do.	1952	115	8	Ch-Kw	68- 83	165	28	7	24	12-10-52	do.
3	New Jersey Silica Sand Co.	700 ft south of well no. 8 and 3,100 ft SE of well no. 10	30	do.	1958	102	6	Ch-Kw	92- 102	90	26	--	--	7- 8-58	Irrigation well for green house.

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										Yield (gpm)	Static water level (feet)	Drawdown (feet)	Specific capacity (gpm/ft of drawdown)	Date	
	MILLVILLE--Continued														
Ml-33	R. Burcham	N. J. Rt. 47 at Manantico Creek	20	Haines & Moore	1953	74	4	CM	67- 73	20	11	4	5.0	9-28-53	
34	E. Martin	Laurel Lake	25	Vance Skinner	1952	98	3	Ch-Kw	93- 98	10	20	--	--	11-27-52	
	SHILOH														
Sh- 1	Florence Bowden	Rt. 77, Shiloh	110	Haines & Moore	1958	75	4	Ch-Kw	69- 74	15	30	5	3.0	11- 4-58	
	STOW CREEK TOWNSHIP														
Sc- 1	Kenneth S. Roberts	0.6 mi south of Cohansey	125	Haines & Moore	1955	90	4	Ch-Kw	50- 56	20	35	5	4	4-25-55	
2	Percy Fogg (USGS West Branch No. 15)	Cohansey Rd. 2.3 mi north of Shiloh	105	--	--	25	36	Ch-Kw	--	--	19	--	--	2-16-54 to 5-23-60	USGS water-level observation well. Static level is the average for a 5-year period.
3	Rollo Davis	0.3 mi west of Cohansey Rd. and 1.9 mi north of Shiloh	125	Haines & Moore	1961	130	6	Ch-Kw	52- 67	60	43	15	4.0	4- 3-61	
4	U.S. Geological Survey (West Branch No. 14)	0.1 mi west of Cohansey Rd. and 1.9 mi north of Shiloh	125	--	1953	58	1¼	Ch-Kw	50- 58	--	41	--	--	1-16-56 5-23-60	USGS water-level observation well. Static level is the average for a 5-year period.
5	Frank W. Irelan	Rt. 49, 1.9 mi NW of Shiloh	100	Haines & Moore	1958	58	4	Ch-Kw	52- 57	20	30	5	4	5- 2-58	
6	David S. Davis	0.8 mi NW of Shiloh	120	do.	1958	75	4	Ch-Kw	70- 75	--	41	--	--	4- -58	
7	F. S. Horner	Kernan Corner, 1.1 mi NW of Roadstown	125	do.	1956	77	4	Ch-Kw	70- 76	12	51	19	0.6	5-22-56	
8	Norman Evans	do.	130	do.	1953	87	4	Ch-Kw	79- 85	7	60	--	--	3-11-53	
9	Leslie G. Fogg	Garrison Corner, 2.0 mi SE of Canton	35	do.	1961	175	4	PP	open hole 147- 175	22	27	100	0.2	12- 5-61	
10	Charles G. Sheppard	Gum Tree Corner, 2.6 mi SE of Canton	45	do.	1957	170	4	PP	open hole 153- 170	8	27	48	0.2	10- 8-57	
11	Morris E. Kernan	0.7 mi west of Roadstown and 2.0 mi SW of Shiloh	120	do.	1960	101	4	Ch-Kw	90- 100	24	49	8	3.0	4- 4-60	
12	W. Harper Ewing	1.0 mi west of Roadstown	120	do.	1958	73	4	Ch-Kw	66- 72	18	52	6	3.0	8- 8-58	
	UPPER DEERFIELD TOWNSHIP														
UD- 1	Seabrook Farms Co.	Griers Lane	130	Delmarva Drilling Co.	1964	106	13	Ch-Kw	46- 106	1,150	38	26	44	3-19-64	Concrete irrigation well.
2	Seabrook Farms Co.	1.0 mi NE of Rt. 77 on Polk Rd.	118	Vance Skinner	1956	164	10	Ch-Kw	126- 161	1,000	26	--	--	7-26-56	Research Farm irrigation well.
3	Francis Lentine	Pindale Dr., 0.2 mi east of Bridgeton-Centerton Rd.	110	Gus Hauser	1952	38	4	Ch-Kw	28- 34	15	17	4	3.8	9-12-52	
4	Alfred A. Kuehn	Deerfield-Seeley Rd.	90	Haines & Moore	1953	55	4	Ch-Kw	48- 54	10	31	13	--	12- 7-53	
5	George Weist	do.	85	do.	1951	64	4	Ch-Kw	58- 64	20	39	10	2	10-12-51	
6	Seabrook Farms No. 1	Seabrook	--	Wm. Stothoff Co.	1934	91	8	Ch-Kw	61- 91	420	37	--	--	5-11-57	Industrial wells.
7	Do. No. 3B	do.	--	Ray Simpkins	1963	185	12	Ch-Kw	155- 185	740	37	--	--	--	do.
8	Do. No. 4	do.	102	--	1937	168	10	Ch-Kw	138- 168	770	36	16	48	4-29-57	do.

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										Yield (gpm)	Static water level (feet)	Drawdown (feet)	Specific capacity (gpm/ft of drawdown)	Date	
UPPER DEERFIELD TOWNSHIP--Continued															
UD- 9	Seabrook Farms No. 5	Seabrook	108	Haines & Moore	1953	174	12	Ch-Kw	144- 168	920	37	16	58	8-28-53	Industrial wells.
10	Do. No. 6	do.	100	Chalky Haines	1938	145	10	Ch-Kw	115- 145	660	--	--	--	3- 9-59	do.
11	Do. No. 7	do.	105	Chalky Haines	1938	144	10	Ch-Kw	114- 144	740	--	--	--	3-17-59	do.
12	Do. No. 8	do.	110	Vance Skinner	1958	180	12	Ch-Kw	127- 172	1,155	34	--	--	--	do.
13	Do. No. 9	do.	99	Chalky Haines	1936	100	8	Ch-Kw	70- 100	220	19	--	--	1-16-57	Irrigation well for greenhouse.
14	Do. No. 10	do.	101	Haines & Moore	1940	145	12	Ch-Kw	121- 145	1,025	--	22	47	1956	Industrial well.
15	Do. No. 11	do.	118	Wm. Stothoff Co.	1943	180	12	Ch-Kw	152- 173	960	35	53	18	1-16-56	do.
16	Do. No. 12	do.	117	do.	1944	172	12	Ch-Kw	147- 172	1,070	--	57	19	3-11-57	do.
17	Do. No. 13	do.	118	do.	1944	183	12	Ch-Kw	155- 180	1,190	39	55	22	4- 4-58	do.
18	Do. No. 14	do.	113	do.	1944	182	12	Ch-Kw	156- 182	1,130	42	77	15	1-22-58	do.
19	Chris Uhland	Seeley Rd., 2.0 mi west of Rt. 77	85	Haines & Moore	1951	110	4	Ch-Kw	102- 108	10	24	--	--	6- 5-51	do.
20	Louis Pizzo	—	115	Delmarva Drilling	1964	156	17	Ch-Kw	16- 156	1,250	32	42	30	3- 3-64	Concrete irrigation well.
21	Seabrook Farms Co.	N. J. Central RR, 0.5 mi west of Rt. 77	105	--	1934	90	8	Ch-Kw	60- 90	250	--	--	--	1963	Irrigation well.
22	F. R. McLeod	Love La., 1.8 mi west of Rt. 77	100	Haines & Moore	1949	108	4	Ch-Kw	100- 106	20	60	10	2	5- 5-49	
23	Do.	do.	90	do.	1959	98	6	Ch-Kw	87- 97	50	55	--	--	9-10-63	Well used by USGS for water level means.
24	Bridgeton Shopping Ctr.	Carlls Corner	90	D'Agostino Well Drilling Co.	1962	135	4	--	--	--	--	--	--	--	Test boring.
25	Woodruff Little League	Woodruff-Gouldtown Rd.	90	do.	1956	72	4	Ch-Kw	60- 70	--	12	--	--	6-25-56	
26	Rev. Boston Turner	0.2 mi east of Deerfield Pike on Laurel Heights Dr.	107	do.	1962	100	3	Ch-Kw	91- 98	--	65	--	--	11- 8-62	
27	Frank Schultz	0.4 mi east of Deerfield Pike on Laurel Heights Dr.	100	Gus Hauser	1952	77	4	Ch-Kw	62- 68	--	50	--	--	9-12-52	
VINELAND															
Vi- 1	Hella Maier	Columbia Ave., 0.1 mi east of N. J. Rt. 47	110	Rudy Skypala	1954	73	2	Ch-Kw	67- 73	7	37	2	3.5	3- 7-54	
2	Alfred Osterman	Arber Ave., 0.2 mi east of N. East Blvd.	120	Gus Hauser	1953	75	4	Ch-Kw	65- 71	11	30	--	--	9-12-53	
3	Louis Pelts	Prospect Ave., 0.1 mi south of Weymouth Rd.	110	do.	1953	55	4	Ch-Kw	45- 51	60	--	--	--	7-10-53	
4	Frank Russo	N. West Blvd., 0.5 mi south of Weymouth Rd.	105	do.	1952	129	5	Ch-Kw	99- 129	165	19	20	8.3	7-29-50	Abandoned irrigation well.
5	Lurex Corp.	N. West Blvd., 1.5 mi south of Weymouth Rd.	85	do.	1952	88	4	Ch-Kw	64 88	160	10	--	--	3-15-52	Industrial well.
6	Angelo Amedie	Vine and Brewster Rd.	95	Rudy Skypala	1954	144	2	Ch-Kw	138- 144	7	14	--	--	6-12-54	Unused well.
7	H. Fassnacht	W. Oak Rd., 0.4 mi west of N. West Blvd.	110	Gus Hauser	1951	70	4	Ch-Kw	60- 66	20	22	--	--	9-29-51	

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										Yield (gpm)	Static water level (feet)	Drawdown (feet)	Specific capacity (gpm/ft of drawdown)	Date	
VINELAND--Continued															
Vi-59	Russell Jordan	Sheridan Ave., 0.2 mi west of Main Rd.	70	Vance Skinner	1954	102	4	Ch-Kw	92- 98	15	16	8	1.9	8-11-54	QW analysis in table 15 indicates polluted water.
60	Stella Emolowich	Rt. 47, 0.7 mi south of Sherman Ave.	95	do.	1954	132	4	Ch-Kw	122- 128	50	45	--	--	8-12-54	
61	Southern Oxygen Co.	S. West Blvd., 1.3 mi south of Sherman Ave.	55	Vance Skinner	1953	100	6	Ch-Kw	88- 100	75	0	5	15	3- 8-53	
62	Van Dyk Bros.	Millville-Mays Landing Rd. west of Snyder Ave.	75	Gus Hauser	1953	95	4	Ch-Kw	85- 95	20	34	--	--	5- 9-53	

Table 15.--Chemical analyses of water from wells in Cumberland County, N. J.
(Results in milligrams per liter except temperature, specific conductance, pH, and color)

Well No.	Water-bearing Formation or Aquifer	Screen Setting (feet below land surface)	Date of Collection	Temperature (°C)	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved Solids	Hardness as $CaCO_3$	Specific Conductance (micromhos at 25°C)	pH	Color	Carbon Dioxide (CO_2)	Remarks
BRIDGETON																							
Br- 1	Cohansey-Kirkwood	77- 97	9-27-63	13	9.5	0.00	0.00	4.0	4.1	5.0	1.2	2	0.0	10	0.1	30	63	26	102	5.0	5	32	
2	Do.	91-111	4- 4-62	--	--	.13	--	--	--	--	--	--	--	15	.0	--	61	10	--	5.2	--	16	Analysis by Booth, Garrett, and Blair.
11	Do.	20- 70	4- 4-62	--	--	.14	--	--	--	--	--	--	--	7.0	.1	--	60	19	--	5.6	--	17	Do.
13	Do.	67- 87	4- 5-62	--	--	.50	--	--	--	--	--	--	--	6.0	--	--	50	14	--	5.5	0	21	Do.
21	Do.	78-102	4- 4-62	--	--	.04	--	--	--	--	--	--	--	4.0	--	--	40	10	--	5.6	--	19	Do.
COMMERCIAL TOWNSHIP																							
Co- 9	Cohansey-Kirkwood	115-125	1- 4-63	13	44	4.0	.03	15	2.4	3.6	1.2	65	--	4.0	.1	.7	104	48	122	7.0	--	10	
DOWNE TOWNSHIP																							
Dn- 3	Piney Point	350-370	1-14-63	--	16	.31	.00	20	5.8	120	7.0	309	5.5	71	1.0	.2	422	74	754	8.1	7	4	USGS water-quality observation well.
4	Do.	378-400	1-14-63	16	13	.31	.00	19	6.6	105	5.0	289	5.5	56	.8	.2	375	75	667	8.2	5	3	Do.
7	Cohansey-Kirkwood	140-150	1-10-63	13	27	5.4	.70	3.6	1.0	1.7	1.0	18	.0	3.2	.0	.3	58	13	47	6.2	3	18	
11	Lower Kirkwood	283-303	2-16-54	--	--	.10	--	12		--	--	122	--	9.0	.1	.2	190	78	--	7.5	0	7	Analysis by N. J. Dept. of Health
FAIRFIELD TOWNSHIP																							
Fa- 3	Cohansey-Kirkwood	95-135	9-19-63	13	8.7	.02	.09	7.6	4.4	4.0	4.0	1	.8	12	.1	37	87	36	145	4.7	5	--	
4	Do.	120-130	12- 4-62	13	12	.06	.03	1.2	.7	1.4	0.8	5	1.7	2.4	.0	.6	33	4	30	5.5	10	25	
19	Mount Laurel-Wenonah?	312	4-17-63	14	38	.80	.00	34	16	270	10	371	12	295	.3	.5	867	151	1,570	8.0	5	6	USGS water-quality observation well.
20	Piney Point	287	4-17-63	13	26	.21	.00	19	6.8	120	5.0	306	1.7	65	1.0	.9	414	76	749	7.8	3	8	Do.
GREENWICH TOWNSHIP																							
Gr- 5	Cape May or Kirkwood	44- 64	10- 1-63	--	--	2.0	--	--	--	--	--	7.4	--	7.5	--	--	77	51	90	5.0	--	--	
7	Do.	27- 39	10- 1-63	14	23	2.5	.03	44	12	92	5.0	52	42	188	.2	3.4	466	117	799	6.4	5	33	
HOPEWELL TOWNSHIP																							
Ho- 1	Cohansey-Kirkwood	45- 50	11-15-62	13	6.7	.48	.19	15	9.2	6.6	11	6	44	17	0.0	42	154	76	259	5.3	5	48	
10	Piney Point	237-257	5-28-62	16	38	.30	.00	13	7.9	127	11	333	.0	52	.4	.7	424	65	667	7.5	4	17	
26	Cohansey-Kirkwood	98-104	7-13-62	13	--	.20	--	--	--	--	--	8.5	--	14	--	--	--	34	--	5.5	--	--	
28	Do.	114-124	4-27-64	--	9.0	.30	.00	2.4	4.3	5.0	--	1.2	16	12	--	--	50	24	--	4.9	1	23	Analysis by Hungerford and Terry
29	Do.	149-159	4-26-48	--	14	3.2	.00	--	--	--	--	--	44	11	--	--	--	26	--	4.2	5	--	Do.
33	Do.	101-107	6- 8-62	13	--	.50	--	--	--	--	--	--	--	--	--	--	--	51	--	6.0	--	--	
LAWRENCE TOWNSHIP																							
La-18	Piney Point	356-376	4-18-63	15	13	.12	.00	19	9.2	135	6.2	334	5.7	72	1.0	1.1	440	86	822	8.0	5	5	USGS water-quality observation well.

Table 13.--Chemical analyses of water from wells in Cumberland County, N. J.--Continued

(Results in milligrams per liter except temperature, specific conductance, pH, and color)

Well No.	Water-bearing Formation or Aquifer	Screen Setting (feet below land surface)	Date of Collection	Temperature (°C)	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved Solids	Hardness as $CaCO_3$	Specific Conductance (micromhos at 25°C)	pH	Color	Carbon Dioxide (CO_2)	Remarks
MAURICE RIVER TOWNSHIP																							
MR-10	Cape May	78	1-29-63	13	8.3	1.5	.25	0.8	1.0	2.4	0.2	5	2.1	5.0	0.0	0.0	22	8	34	5.4	2	30	
13	Lower Kirkwood	264-274	1- 9-63	13	71	.00	.00	24	4.1	2.6	2.4	89	8.4	3.8	.1	.5	167	81	177	8.1	2	1	
16	Do.	245-265	1- 8-63	14	44	1.8	.00	17	1.5	4.8	2.0	58	8.0	3.0	.2	.4	122	50	131	6.8	20	15	
19	Do.	262-270	11-29-63	14	47	1.2	.07	22	2.2	10	3.0	94	9.0	2.7	.2	.2	153	64	175	7.7	25	--	
20	Do.	242-269	1- 8-63	13	58	1.2	.09	22	3.2	9.6	3.2	91	12	2.4	.2	.5	165	68	165	7.4	5	6	
22	Do.	295-315	1- 8-63	14	62	.10	.00	22	4.1	5.5	2.8	85	8.1	4.2	.1	.2	156	75	177	7.9	2	2	USGS water-quality obs. well since 1956.
MILLVILLE																							
Ml- 3	Cohansey-Kirkwood	118-150	9- '57	--	--	.50	--	--	--	--	--	6	--	5.0	--	--	40	19	--	5.5	--	31	Source of analysis, A. C. Schultes & Sons.
11	Kirkwood	160-180	5-22-63	13	20	1.7	.00	7.2	1.0	3.0	1.0	24	86	3.0	--	--	70	24	--	6.2	0	22	Analysis by Booth, Garrett and Blair.
12	Lower Kirkwood	245-280	5-14-63	14	28	1.4	.03	9.6	1.5	5.5	0.8	36	9.6	3.4	.0	.8	86	31	90	6.1	15	43	
16	Cohansey-Kirkwood	105-136	2-25-63	--	12	--	--	1.6	.5	--	--	0	15	3.0	--	--	30	6	50	4.3	--	--	Analysis by Betz Labs.
22	Lower Kirkwood	335-365	7-16-63	13	42	1.9	.00	13	1.5	3	1.0	44	7.8	3.0	--	--	112	40	--	6.6	0	17	Analysis by Booth, Garrett and Blair.
23	Cohansey-Kirkwood	161-191	8- 3-64	13	8.8	.00	.00	1.6	.5	1.5	0.5	6	1.4	2.9	.0	.5	19	7	24	6.3	5	5	
25	Lower Kirkwood	320-350	6-25-63	--	23	1.4	.00	2.4	1.0	6.0	2.0	13	11	5.0	--	--	72	10	--	5.8	--	31	
27	Cohansey-Kirkwood	95-101	11-28-54	--	7.0	.9	--	1.6	1.0	4.1		8.5	.0	7.0	--	--	26	9	--	59	7	18	Analysis by Hungerford and Terry.
33	Cape May	67-73	9-28-53	--	20	1.8	--	6.4	2.9	14		40	16	6.0	--	--	87	28	--	6.7	5	13	Do.
STOW CREEK TOWNSHIP																							
SC- 6	Cohansey-Kirkwood	70- 75	8- 7-62	14	--	.30	--	--	--	--	--	8	--	37	--	--	--	119	--	5.5	--	40	
9	Piney Point	147-175	4-16-63	14	58	.99	.00	11	1.7	46	5.5	164	0.2	4.8	0.3	0.6	209	35	292	7.9	3	3	
12	Cohansey-Kirkwood	66- 72	8- 7-62	16	--	.00	--	--	--	--	--	11	--	15	--	--	--	17	--	5.7	--	35	
VINELAND																							
Vi- 6	Cohansey-Kirkwood	138-144	1-26-63	--	--	4.0	--	--	--	--	--	17	--	15	--	--	23	--	35	6.2	---	17	
8	Do.	150-170	5-17-54	--	9.0	.70	--	0.4	0.5	3.0	--	2.4	2.0	5.0	--	--	--	4	--	5.1	1	34	Analysis by Hungerford and Terry.
15	Do.	145-175	10- 2-63	13	8.8	.02	.00	5.2	0.7	4.0	.8	4	.0	6.4	.1	15	43	16	71	5.0	5	63	
19	Do.	112-124	3- 3-55	--	7.0	.10	--	2.4	3.6	0.5	--	1.2	.0	15	--	--	--	21	--	4.9	--	26	Analysis by Hungerford and Terry.
23	Do.	83-103	11- 1-56	--	8.0	.10	--	10	--	--	--	--	.0	46	--	--	--	36	--	4.2	1	20	Do.
26	Do.	110-130	1-30-56	--	11	1.8	.05	9.6	9.1	--	--	2	.0	39	--	--	--	62	--	5.0	1	34	Do.
30	Do.	36- 43	1- 7-63	12	6.7	1.0	.10	9.2	5.6	7.8	2.6	17	.0	13	.1	45	125	46	190	5.9	3	40	
36	Do.	90-100	7- 7-49	--	5.0	15	.10	--	--	--	--	292	56	30	--	--	--	132	--	6.5	8	95	"Had a chemical odor" Analysis by Hungerford and Terry.
37	Do.	132-162	10- 2-63	13	9.2	.00	.00	4.8	3.4	7.5	1.5	3	.0	10	.1	33	73	26	117	5.0	3	48	
45	Do.	140-170	1965	13	6.2	.08	.00	2.0	1.7	5.0	1.1	4	.0	6.8	.0	16	39	12	62	6.4	3	--	
57	Do.	119-125	1- 7-63	13	7.6	1.9	.06	5.2	3.6	7.8	.5	13	.0	8.0	.1	30	90	28	122	5.9	2	26	Alum. 0.1 ppm.
58	Do.	26- 30	1-10-63	14	3.2	5.3	.56	31	35	140	6.5	270	.0	250	.0	.0	742	222	1,460	5.2	10	--	Alum. 4.9 ppm.
59	Do.	92- 98	1-10-63	14	6.9	.39	.05	6.8	8.3	9.5	2.2	3	.0	12	.1	65	134	51	200	5.2	3	30	Alum. 0.1 ppm.

CONTENTS (APPENDIX)

TABLE 16

SELECTED LOGS OF WELLS IN CUMBERLAND COUNTY, N.J.

Well Number	Owner and Owner's Well Number	Total Depth Drilled (feet)	Appendix Page
Br- 3	Bridgeton, Layne TW 1 (1939)	1,651	1
Br-17	Bridgeton, Well No. 2	102	2
Co- 4	H. King, Coverly Farm Irrigation Well	213	3
Dn- 1	Pennsylvania Glass Sand Corp.	605+	4
Dn-11	Fortescue Realty Company, No. 3	303	5
Dr- 2	Joe Sparacio, Sr.	84	5
Fa- 3	Seabrook Farms - Buckshutem Irr. Well	151	6
Fa- 4	Fairton Public School	130	6
Fa-12	Cedarbrook Farms, Conc. Irr. Well	165	7
Gr- 5	Greenwich Elementary School	64	7
Ho- 2	Burpee Seed Company, TW No. 1	125	8
Ho-10	Ronald E. Daut	257	8
Ho-20	Hopewell Township School	90	8
Ho-30	Cumberland County Hospital	159	9
La-11	Cedar Lake Canning Company	68	9
La-18	Bay Point Rod and Gun Club	405	10
Ml-22	City of Millville, Layne TW No. 3	380	10
Ml-25	City of Millville, Layne TW No. 2	738	11
MR- 2	N. J. Silica Sand Company, No. 8	115	13
MR-12	Leesburg State Prison Farm	238	13
MR-17	American Clam Company, Inc.	270	14
MR-19 & 20	East Point Water Assoc. and E. Dorr	270	15
Sc- 3	Rollo Davis	130	15
Sc- 9	Leslie G. Fogg	175	15
UD- 2	Seabrook Farms Co, Res. Farm Irr. Well	164	16
UD-18	Seabrook Farms Co, No. 14	184	16
UD-24	Bridgeton Shopping Center	135	17
Vi-10	City of Vineland, No. 8	200	17
Vi-15	City of Vineland, No. 6	203	18
Vi-45	City of Vineland, No. 7	208	18
Vi-51	J. Martino, Irr. Well	220	19
Vi-62	Van Dyk Brothers	95	20

Table 16.-- Selected Logs of Wells in Cumberland County, N.J.

Well Br 3: City of Bridgeton, Layne Test Well 1 (1939)
Location : Cumberland Ave., Bridgeton
Remarks : Driller's log by Layne-New York Co., Inc.
Altitude : 80 feet

	Thickness (feet)	Depth (feet)
Sand, brown and coarse gravel	24	24
Clay, yellow	3	27
Sand, brown, coarse and some gravel	21	48
Clay, blue	13	61
Sand, yellow, fine	6	67
Sand, yellow, coarse and fine gravel	8	75
Sand, yellow, coarse	26	101
Mud, soft, black	38	139
Sand, gray, medium coarse	25	164
Clay, blue, soft	66	230
Marl, black, clay and shells	48	278
Sand, black, fine shells and thin clay streaks	17	295
Clay or marl black, soft, shells	60	355
Marl, black	19	374
Clay, blue; streaks of hardpan	26	400
Clay, blue, tough	51	451
Clay, blue, tough; streaks of hardpan	10	461
Clay, blue, soft	20	481
Clay, blue, tough	119	600
Clay, blue, tough; soft streaks	107	707
Marl, black; shells and clay	42	749
Marl, black, soft; (contains) shells, fine sand and clay	31	780
Clay, blue, tough; streaks of marl	28	808
Clay, black, and streaks of marl	95	903
Boulder		at 903
Clay, hard	31	934
Clay, sandy	5	939
Clay, sandy, hard; marl	26	965
Boulders	2	967
Clay, marl and boulders	58	1,025
Clay, sandy	18	1,043
Sand, black, fine; hard	51	1,094
Clay, tough and hard	56	1,150
Clay, red, tough	50	1,200
Clay, hard	40	1,240
Clay, red and gray, tough and hard	80	1,320
Clay, tough	15	1,335

Table 16.--Selected Logs of Wells in Cumberland County, N.J.

Well Br-3, City of Bridgeton, Layne Test Well 1 (1939)--Continued

	Thickness (feet)	Depth (feet)
Clay, sandy	35	1,370
Clay, sandy, tough streaks	21	1,391
Clay, sandy and streaks of conglomerate, some gravel (tough streaks all along)	34	1,425
Clay, with soft streaks	45	1,470
Clay, red, tough	50	1,520
Clay, sandy; tough streaks	20	1,540
Clay, sandy and quicksand	60	1,600
Quicksand, red,	5	1,605
Rock	2	1,607
Streaks of sandy clay with tough streaks & streaks of rock	44	1,651

Well Br 17: City of Bridgeton, Well 2.
Location: Approximately 50 feet west of S. East Ave. and 200 yards north of Rocaps Run.
Remarks: Log obtained from files of N.J. Bureau of Geology and Topography.
Altitude: 28 feet.

	Thickness (feet)	Depth (feet)
Gravel and sand	10	10
Sand and yellow stone	4	14
Clay, yellow, hard	4	18
Sand, brown, medium-grained	2	20
Clay, hard with sand	2	22
Clay, yellow, hard; with yellow sandstone	5	27
Clay, yellow, hard; medium-grained sand	7	34
Clay and sandstone, yellow	5	39
Sand with some clay	3	42
Sand, light-yellow fine-grained	7	49
Sand, light-brown, medium-grained	7	56
Sand, dark-yellow; with coarse stones	2	58
Sandstone, light-and dark-yellow, medium grained	7	65
Sand and clay, light-yellow	3	68
Clay, white, hard	1	69
Clay, sand, yellow, sandstone	4	73
Sand, yellow, medium	3	76
Sandstone, light-brown, medium-grained sand	4	80
Sand, yellow to light-brown, medium-grained	6	86

Table 16.--Selected Logs of Wells in Cumberland County, N. J.

Well Br-17, City of Bridgeton, Well 2--Continued

	Thickness (feet)	Depth (feet)
Clay; medium-grained brown sand	1	87
Sand, light-yellow to light-brown, medium-grained	6	93
Sand, dark-brown, coarse-grained	2	95
Sand, black	2	97
Clay, black; sand	5	102

Well Co-4: Henry King, Coverly Farm irrigation well.
Location : Dragston Road, approximately 2.0 miles east of Dividing Creek.
Remarks: This is a composite log adapted from the driller's log by V. Skinner and a gamma-ray log of the well.
Altitude: 15 feet.

	Thickness (feet)	Depth (feet)
Stones	16	16
Sand, cemented, fine-grained	15	31
Sand, loose, fine-grained	5	36
Sand, cemented, and thin layers of clay	14	50
Sand, black, fine-grained	40	92
Clay, black, hard	40	132
Sand and fine gravel	25	157
Sand, cemented, fine-grained	25	182
Gravel, medium-grained	31	213
Hardpan		at 213

Table 16.--Selected logs of wells in Cumberland County, N. J.

Well Dn 1: Pennsylvania Glass Sand Corp.
Location : 2.7 miles north of Dividing Creek and 3.4 miles northeast of Newport, N.J.
Remarks : This is a composite log adapted from the driller's log, electric and gamma-ray logs, and a field description of rotary ditch samples from the well.
Altitude: 48 feet

	Thickness (feet)	Depth (feet)
Clay, white, hard; with lenses of sand	10	10
Sand, orange, mostly fine grained; contains some yellow clay and weathered chert	11	21
Clay, blue and gray, sandy	17	38
Sand, yellowish-brown, fine to very coarse grained; clear and brown iron stained quartz; with thin clay lenses	48	86
Sand, gray, medium to coarse-grained, well sorted; a few thin clay lenses.....	44	170
Clay, olive-gray and brownish-gray, micaceous and sandy; sand is very fine grained; samples contained up to 1-inch pieces of lignite and one very small shark's tooth noted in 190-200 foot sample.....	45	214
Clay, olive-gray and bluish-gray, sandy, micaceous; contains broken shell fragments, lignite and some sand lenses	50	265
Sand, gray, fine to coarse grained quartz; contains numerous mica plates and shell fragments	15	280
Rock (3 inches)		at 280
Clay, brownish-gray, touch; fine-grained sand lenses; shell fragments	12	292
Sand, light-gray, medium- to coarse-grained, well-sorted; shell fragments	31	323
Clay, olive-gray and dark-gray, silty to sandy, micaceous; contains numerous shell fragments.....	33	356
Clay, gray, sandy, micaceous; lesser number of shells.	42	398
Clay, brownish-gray, silty, micaceous; has embedded thin shell fragments	17	415
Clay, gray, silty, micaceous; shell fragments	45	460
Clay, olive-gray, silty, micaceous, and tough	52	512
Rock (6 inches)		at 512
Clay, olive-gray, silty, kicaceous, and hard	23	535
Clay, olive-gray, silty, micaceous; a few shell fragments; trace of very fine grained glauconite....	70	605
Clay, olive gray, silty	?	?

Table 16.--Selected Logs of Wells in Cumberland County, N.J.

Well Dn 11: Fortescue Realty Company, No. 3
Location: Fortescue, N. J.
Remarks: Log by Gus Hauser, driller.
Altitude: 5 feet

	Thickness (feet)	Depth (feet)
Sand, yellow	20	20
Clay, gray	30	50
Sand, gray, loamy	20	70
Sand, gray and a mixture of clay	80	150
Sand, gray, loamy	40	190
Sand, gray	50	240
Sand, gray, loamy	20	260
Sand, gray; with shells and a mixture of clay	20	280
Sand, gray, clean	20	300
Clay, brown	3	303

Well Dr 2: Joe Sparacio, Sr.
Location : North side of Parvin Mill Rd., 1.3 miles northwest of Rosenhayn
Remarks : Driller's log by D'Agostino Well Drilling Co.
Altitude : 105 feet

	Thickness (feet)	Depth (feet)
Gravel	27	27
Sand, coarse	20	47
Sand, coarse; contains ironstone	5	52
Clay, sandy	10	62
Sand, medium-grained, dark	10	72
Sand, medium-grained, brown and red	12	84

Table 16.--Selected logs of wells in Cumberland County, N.J.

Well Fa-3: Seabrook Farms Co., Buckshutem Division irrigation well.
Location : 4.6 miles east of Fairton and 0.3 mile north of Millville-Fairton Rd.
Remarks : Driller's log by Vance Skinner.
altitude : 73 feet

	Thickness (feet)	Depth (feet)
Sand and gravel	7	7
Clay, yellow and blue	23	30
Gravel, yellow and white	14	44
Sand, white	8	52
Sand and clay, muddy	20	72
Gravel	6	78
Clay	1	79
Gravel, medium- to coarse-grained	55	134
Sand, muddy	5	139
Clay, black	12	151

Well Fa-4: Fairton Public School
Location : North side of Rahmah Road and 0.1 mile east of Route 553, Fairton, N.J.
Remarks : This is a composite log adapted from the drillers' log, sample descriptions, and a gamma-ray log of the well.
Altitude : 30 feet

	Thickness (feet)	Depth (feet)
Sand and gravel, dirty brown; contains pebbles to 1-inch diameter	10	10
Sand, yellowish-orange, fine to coarse-grained clean	10	20
Clay, mottled gray and orange, silty	4	24
Sand, orange, fine- to medium-grained	5	29
Clay, mottled gray and orange, silty	6	35
Sand, orange, fine-grained, well-sorted	12	47
Sand, orange, fine-grained; with gray sandy clay	15	62
Clay, grayish-green, finely micaceous, tough	26	88
Clay, gray and fine-grained sand	16	104
Sand, olive-brown, fine- to medium-grained, well-sorted, and clean	14	118
Gravel, and coarse-grained sand; clear and iron stained quartz grains	12	130

Table 16.--Selected Logs of Wells in Cumberland County, N.J.

Well Fa-12: Cedarbrook Farms, concrete irrigation well
Location : 0.4 mile west of New England, Cross Roads and 1.0 mile southwest of Fairton.
Remarks : This is a composite log adapted from the driller's log by Delmarva Drilling Co., and an electric log of the well.
Altitude : 22 feet.

	Thickness (feet)	Depth (feet)
Topsoil	1	1
Clay, orange and gray; contains gravel	7	8
Gravel and layers of sandy clay	13	21
Sand, brown, fine to medium-grained; iron ore	8	29
Sand, brown; clay layers	2	31
Clay, orange and gray	4	35
Sand, gray, fine- to medium-grained; clay layers	8	43
Clay, orange, gray, yellow, and blue; iron ore at 45 ft.	6	49
Clay, bluish-green, sandy	13	62
Clay, blue, and sand layers	28	90
Sand, white, and soft blue clay	6	96
Sand, brown and gray, soft; contains cemented iron ore	16	112
Sand, gray, fine- to medium-grained	5	117
Sand, orange, fine-grained	10	127
Sand, blue, fine- to coarse-grained, soft	4	131
Sand, blue, medium to coarse-grained; hard brown clay.	6	137
Clay, blue and brown	5	142
Clay, brown, and sand	11	153
Mud with sand stringers	12	165

Well Gr-5: Greenwich Elementary School
Location : Greenwich
Remarks : Driller's log by R. D'Agostino
Altitude : 15 feet

	Thickness (feet)	Depth (feet)
Topsoil	6	6
Clay, white	3	9
Sand, black and muddy	53	64

Table 16.--Selected Logs of Wells in Cumberland County, N.J.

Well Ho-2: Burpee Seed Company, Test Well No. 1.
Location : 2.3 miles NE of Shiloh and 1.0 miles west of Seeley
Remarks : Driller's log by Ray Simpkins
Altitude : 100 feet

	Thickness (feet)	Depth (feet)
Sand and gravel, clayey	25	25
Water		at 25
Sand, medium-grained	10	35
Sand, coarse-grained, ironstained	10	45
Sand, brownish-orange, fine-grained	10	55
Sand, brownish-orange, fine-grained, clayey	12	67
Clay, black, silty, micaceous	58	125

Well Ho-10: Ronald E. Daut.
Location : West side of Beebe Run Road and 0.2 mile north of Sewell Road.
Remarks : Driller's log by Milton Shephard
Altitude : 50 feet

	Thickness (feet)	Depth (feet)
Sand, buff	14	14
Jerseystone	6	20
Sand, buff, fine-grained; occasional clay shelfs	10	30
Sand, buff, fine-grained	8	38
Sand and gravel, white and buff, clean	28	66
Jerseystone	7	73
Clay, black, hard; contains some sand	18	91
Sand, cemented, gray		at 91
Clay, blue to gray	129	220
Sand, gray to black, poorly water-bearing	37	257

Well Ho-20: Hopewell Township School
Location: East side of Bowentown Rd. and 0.3 mile south of Rte. 49
Remarks : Driller's log by Haines and Moore
Altitude: 85 feet

	Thickness (feet)	Depth (feet)
Sand and gravel	30	30
Clay, white	8	38
Sand, fine and yellow clay	12	50
Sand, medium	9	59
Clay, black, soft	11	70
Sand, medium- to coarse-grained	20	90

Table 16.--Selected Logs of Wells in Cumberland County, N.J.

Well Ho-30: Cumberland County Hospital
Location : East side of Countyhouse Land and 1.6 miles southwest of Bridgeton
Remarks : Log compiled from sample descriptions by M. E. Johnson, former N. J. State Geologist and driller's log by Wm. Stothoff Co.
Altitude : 80 feet.

	Thickness (feet)	Depth (feet)
No record	5	5
Sand, deep-yellow, fine- to coarse-grained, slightly clayey	15	20
Clay, deep-yellow, sandy	10	30
Sand, yellow-brown, fine-grained, clayey	20	50
Sand, deep-yellow, mostly fine-grained	18	68
Clay, gray and fine sand	17	85
Sand, deep-yellow, fine-to medium-grained, slightly clayey	10	95
Sand, salmon colored, fine to coarse	25	120
Sand, deep-yellow, fine to coarse, slightly clayey	7	127
Sand, deep-yellow, very fine- to fine-grained	5	132
Sand, light grayish-brown, very fine- to fine-grained	4	136
Sand, yellow, very fine- to fine-grained	8	144
Sand, yellowish-brown, very fine to moderately coarse	9	153
Sand, with just a little dark gray clay	3	156
Sand, gray, medium to coarse with a little pea-gravel, and thin streaks of clay	3	159
Clay, blue		at 159

Well La-11: Cedar Lake Canning Co.
Location : Cedarville, N.J.
Remarks : Log obtained from N.J. State Geologist
Altitude : 25 feet

	Thickness (feet)	Depth (feet)
Sand, medium- to very coarse-grained quartz, gravel and quartzite	10	10
Sand, yellowish, fine- to very coarse-grained quartz with some pea gravel; sandstone fragments	20	30
Sand, yellowish, fine- to very coarse-grained quartz, with larger amounts of pea gravel; sandstone fragments	30	60
Sand, very coarse to pea gravel with numerous sandstone fragments; contains small pieces of gray clay	8	68

Table 16.--Selected Logs of Wells in Cumberland County, N.J.

Well La-18: Bay Point Rod and Gun Club
Location : Bay Point
Remarks : Driller's log by Vance Skinner
Altitude : 5 feet

	Thickness (feet)	Depth (feet)
Marsh	17	17
Sand, white, clean	43	60
Sand, yellow	20	80
Clay, black, sandy	4	84
Sand, black, clean	10	94
Hardpan, black	10	104
Sand	2	106
Sand, cemented; shells	8	114
Sand, cemented; marl and clay	24	138
Rock	2	140
Sand, cemented; shells	10	150
Sand, cemented	35	185
Sand, cemented; shells	30	215
Hard black bottom (clay?) and organic material; layers of shells	125	340
Sand, black, fine, cemented	20	360
Sand, coarse; cemented with clay	45	405

Well Ml-22: City of Millville, Layne test well 3 (1963)
Location : Municipal Airport
Remarks : This is a composite log adapted from the driller s log, an electric log, and a description of rotary ditch samples from the well.
Altitude : 62 feet

	Thickness (feet)	Depth (feet)
Sand and gravel, brownish-orange, fine to very coarse grained 1" diameter pebbles; contains poorly preserved non-clacareous fossil fragments	20	20
Clay, brown, yellow, pink, and white, silty	5	25
Sand, yellowish-orange, medium- to coarse-grained; pieces of ironstone and streaks of gray clay	22	47
Sand, brownish-orange, clayey	12	59
Clay, orange, white and gray, sandy; contains pieces of ironstone	34	93
Sand, brownish-orange, clayey, fine- to coarse-grained	8	101
Sand, gray, fine- to coarse-grained	14	115
Sand and gravel, yellowish-orange, fine-grained to gravel size; contains streaks of white and yellow clay	26	141
Clay, yellow and light-gray, sandy; contains pieces of ironstone	14	155
Sand and gravel, yellowish-orange, fine- to very coarse grained; pieces of ironstone; streaks of black and yellow clay. Contains pebbles up to 1" diameter	30	185

Table 16.--Selected Logs of Wells in Cumberland County, N.J.

Well Ml-22: City of Millville, Layne test well 3 (1963)-Continued

	Thickness (feet)	Depth (feet)
Clay, blue, sandy	16	201
Sand, orange, clayey, fine- to medium-grained; contains sandstone and a large amount of dark bluish-gray clay	21	222
Clay, dark bluish-gray, sandy, lignitic	23	245
Clay, gray, sandy, lignitic	8	253
Sand, orangish-gray, fine- to coarse-grained, clayey, lignitic	13	266
Clay, dark-gray, silty to sandy, micaceous; sand is mostly fine-grained quartz; sample contains approximately 30% broken shells	22	288
Clay, dark bluish-gray and brown; silty, micaceous, tough	22	310
Sand, gray, clayey, fine- to coarse-grained; shells	22	332
Sand, gray, fine- to coarse-grained, poorly sorted; lesser number of shells	18	350
Sand and gravel, gray, mostly very coarse-grained	16	366
Clay, brown and dark-gray, silty, and tough	14	380

Well Ml-25: City of Millville, Layne test well 2 (1963)
Location : Orange Street, south Millville
Remarks : This is a composite log adapted from the driller's log, electric, and gamma-ray logs and field description of ditch samples from the well.
Altitude : 22 feet

	Thickness (feet)	Depth (feet)
Sand, yellowish-brown, fine- to medium-grained	13	13
Clay, bluish-gray, silty, tough, micaceous	5	18
Sand, grayish-orange, medium- to coarse-grained	10	28
Sand, dark orange, mostly coarse-grained; some gray, silty, micaceous clay	20	48
Clay, bluish-gray, sandy	10	58
Sand, brown, mostly coarse-grained; streaks of gray sandy clay	30	88
Clay, gray, sandy	30	118
Sand, gray, fine-grained to coarse gravel size, poorly sorted	10	128
Sand, gray, fine- to coarse-grained, poorly sorted; contains a few ironstone fragments	20	148
Sand, gray, clayey, fine- to coarse-grained	20	168
Clay, gray, sandy, micaceous; sample contained large piece of lignite	10	178

Table 16.--Selected Logs of Wells in Cumberland County, N.J.

Well M1-25: City of Millville, Layne test well 2 (1963)-Continued

	Thickness (feet)	Depth (feet)
Sand, gray, fine- to coarse-grained	11	189
Clay, gray, silty to sandy, micaceous, and lignitic; very fine grained quartz	22	211
Clay, gray, sandy	11	222
Clay, gray, hard; streaks of sand	22	244
Sand, gray, clayey, fine- to coarse-grained; streaks of gray silty, micaceous clay	54	298
Clay, gray, silty, very micaceous. Sample contains numerous ½" to 1" diameter smooth round pebbles	20	318
Sand, gray, medium- to coarse-grained	18	336
Clay, dark gray, sandy, lignitic; streaks of tough, silty, micaceous brown clay	24	360
Clay, dark gray and brown, silty, very micaceous	10	370
Clay, dark brown, silty to sandy, very micaceous and lignitic; pieces appear to be laminated with thin, very fine-grained sand lenses	20	390
Sand, dark olive green, silty, very fine to coarse quartz grains. Sample contains pieces of very dark green sandy clay, mumerous calcareous shell fragments, ¼" mica plates, and large pieces of lignite	33	423
Clay, gray and brown, silty, micaceous, and very fossiliferous	45	468
Clay, dark greenish-gray, sandy, silt to fine-grained quartz, micaceous, and lignitic	9	477
Hardpan. "took 2 hours to drill 18 inches."	1.5	478.5
Sand, dark greenish-gray, fine-grained, micaceous and lignitic well sorted	18.5	497
Clay, dark greenish-gray, silty to sandy, micaceous, and slightly fossiliferous	12	510
Clay, dark-gray, silty, micaceous, and fossiliferous	40	450
Sand, gray, silty to fine-grained, fossiliferous, and micaceous	20	560
Clay, greenish-black, silty, micaceous, fossiliferous; sample contains very fine-grained glaucontie and pieces of bright bluish-green clay. One well-preserved shark's tooth	20	580
Clay, greenish-black, sandy, glauconitic, micaceous, and fossiliferous	30	610
Clay, olive-green, sandy, micaceous, and glauconitic; sample contains a few shell fragments	52	662
Sand, gray quartz and iron-stained glauconite, mostly medium-grained; shell fragments and chips of bright green clay	18	680
Clay, greenish-gray, sandy, glauconitic; a few shell fragments	24	704
Sand, brownish-green to greenish-gray, clayey, fine- to medium-grained, very glauconitic; few shell fragments; sharks' teeth.	34	738

Table 16.--Selected Logs of Wells in Cumberland County, N.J.

Well Mr-2: New Jersey Silica Sand Co., Wash Plant No. 8
Location : Approximately 2.7 miles north of Port Elizabeth and 2.4 miles southwest of Cumberland
Remarks : Drillers' log by Haines and Moore
Altitude : 30 feet

	Thickness (feet)	Depth (feet)
Sand, fine- to medium-grained	25	25
Clay, black	9	34
Gravel and coarse-grained sand	11	45
Sand, medium- to coarse-grained	35	70
Sand, coarse-grained	11	81
Sand, brown, medium-grained	4	85
Clay, black	18	103
Sand, black, fine-grained	6	109
Clay, black	6	115

Well Mr-12: Leesburg State Prison Farm
Location : East side of Route 47, 1.4 miles north of Delmont, N.J.
Remarks : This is a composite log adapted from the drillers' log, and sample descriptions by M.E. Johnson, former N.J. State Geologist
Altitude : 15 feet

	Thickness (feet)	Depth (feet)
Fill	5	5
Sand, buff to white, clayey; fine- to medium-grained quartz; contains a few pebbles and shell fragments at 15 feet	24	29
Clay, greenish-gray; contains a few pebbles	9	38
Sand	4	42
Clay, deep-yellow, silty	12	54
Sand, gray, clayey, fine-grained	32	86
Sand, pink, clayey, fine-grained; contains a few shell fragments	4	90
Sand, pinkish-gray, slightly clayey, very fine- to fine-grained	25	115
Sand, gray, clayey, very fine-grained micaceous (Driller calls it green marl)	9	124
Clay, gray, silty, hard	21	145
Clay, gray, sandy, contains many shell fragments, and fine burnt wood	14	159
Sand, gray, clayey, fossiliferous	13	172

Table 16.--Selected Logs of Wells in Cumberland County, N.J.

Well Mr-12: Leesburg State Prison Farm (Continued)

	Thickness (feet)	Depth (feet)
Clay, dark-gray, sandy, hard; contains many shell fragments and small gravel	22	194
Clay, gray, silty, fossiliferous	21	215
Clay, gray, sandy, highly fossiliferous	10	225
Clay, dark-gray, sandy, hard, fossiliferous	9	234
Sand, light-gray, clayey, fossiliferous	28	262
Sand, medium to coarse-grained; water	21	283
Clay, greenish blue, and shells		at 283

Well Mr-17: American Clam Company Inc.
Location : East bank of the Maurice River, 1.0 miles south of Port Norris.
Remarks : This is a composite log adapted from the drillers' logs, sample descriptions, gamma-ray log of this well and driller/s logs of nearby wells on the same property.
Altitude : 5 feet

	Thickness (feet)	Depth (feet)
Fill	2	2
Clay, black	61	63
Gravel and stones	7	70
Sand, gray, fine-grained, cemented layers of clay	45	115
Sand, gray, coarse-grained, water-bearing	55	170
Clay, black and brown, silty, and micaceous	12	182
Sand, Gray, medium- to coarse-grained, a few gray clay balls and many finely broken shell fragments	8	190
Sand, gray, clayey, medium- to very coarse-grained, contains many well-preserved shells	20	210
Sand, gray, clayey, fine- to very coarse-grained bits of hard gray, micaceous lignitic clay; contains a few shell fragments	25	235
Sand, gray, coarse-grained to gravel size, well sorted	35	270
Clay, black		at 270

Table 16.--Selected Logs of Wells in Cumberland County, N.J.

Wells Mr-19 and Mr-20: East Point Water Association and E. Dorr
Location : East Point Beach
Remarks : This is a composite log adapted from a gamma-ray log of the East Point Water Association well and drillers' logs of both wells.
Altitude : 7 feet

	Thickness (feet)	Depth (feet)
Sand, coarse-grained	12	12
Clay, yellow	8	20
Sand and gravel up to egg size	22	42
Clay, dark gray, sandy, wood (lignite)	33	75
Sand, gray, coarse-grained	29	104
Clay, dark-gray	6	110
Clay and fine-grained gray sand mixed with mica	14	124
Clay, gray; hard and soft layers	18	142
Sand, gray, muddy; some shells	18	160
Sand, gray, clayey, fine-grained	17	177
Clay, dark-brown and gray, hard	37	214
Sand, gray, shells; organic material and occasional hardpan of gray clay	24	238
Clay, bluish-gray; organic material	8	246
Sand and gravel, gray, clean	24	270

Well SC-3: Rollo Davis
Location : 1.2 miles east of Marlboro and 0.3 mile west of Shiloh-Cohansey Road.
Remarks : Driller's log by Haines and Moore
Altitude : 125 feet

	Thickness (feet)	Depth (feet)
Sand, fine-grained	57	57
Clay, Yellow	4	61
Sand, fine-grained	8	69
Clay, black	61	130

Well SC-9: Leslie G. Fogg
Location : Garrison Corner, Stow Creek Twp.
Remarks : Driller's log by Haines and Moore
Altitude : 35 feet

	Thickness (feet)	Depth (feet)
Pit	6	6
Sand and gravel	14	20
Clay, black	125	145
Marl and fine-grained sand	30	175

Table 16.--Selected Logs of Wells in Cumberland County, N.J.

Well Vi-10 City of Vineland, Owner's well No. 8 (Continued)

	Thickness (feet)	Depth (feet)
Clay, tough, yellow, red and white; and dark orange to brown fine-grained sand with lignite	10	120
Clay, tough, gray, yellow, and white	6	126
Sand and gravel, brown to grayish-orange, fine - to coarse-grained	14	140
Sand and gravel, clean, reddish brown to yellowish-orange with streaks of clay near the bottom	38	178
Sand, reddish-brown, streaks of clay	8	186
Clay, dark-gray, sandy,micaceous	14	200

Well Vi-15: City of Vineland; well No. 6
Location : Valley Ave. and Oak Road
Remarks : Driller's log by Layne-New York Co., Inc.
Altitude : 98 feet

	Thickness (feet)	Depth (feet)
Top soil	2	2
Sand, coarse-grained and gravel	48	50
Clay, sandy and gravel	10	60
Clay, sandy and sand streaks	20	80
Clay, red, sandy	5	85
Sand, gravel and some clay	25	110
Clay, blue, tough	13	123
Sand, with some yellow clay streaks	12	135
Sand, coarse-grained	40	175
Clay, blue	5	180
Clay, and sand streaks	23	203

Well Vi-45: City of Vineland, Owner's well No. 7
Location : 780 feet south of Magnolia Rd. and 2,000 feet west of Spring Rd.
Remarks : This is a composite log adapted from the driller's log, electric and gamma-ray logs, and field descriptions of rotary ditch samples of a test well and the owner's well No. 7 drilled by Layne-New York Co., Inc. at the same location.
Altitude : 105 feet

	Thickness (feet)	Depth (feet)
Clay, sandy, yellow, white and dark brown	26	26
Sand, clayey, dirty yellow, mostly fine-grained	18	44

Table 16.-- Selected Logs of Wells in Cumberland County, N.J.

Well Vi-45: City of Vineland, Owner's well No. 7 (Continued)

	Thickness (feet)	Depth (feet)
Sand, light yellow, fine- to coarse-grained contained small ironstone fragments	32	76
Clay, sandy, light orange, yellow and white	14	90
Clay, mottled orange and light gray, silty	10	100
Sand and gravel, very clayey, brown and orange	30	130
Sand and gravel, brownish orange to light grayish-orange, contains some sandy clay streaks	56	186
Clay, black, silty, micaceous; contains embedded pebbles	22	208

Well Vi-51: J. Martino, Irrigation well
Location : Southwest corner of the intersection of Union Road and Trenton Ave., E. Vineland
Remarks : Driller's log by L. Varesio
Altitude : 85 feet

	Thickness (feet)	Depth (feet)
Sand and clay, buff	40	40
Clay, buff	10	50
Sand, cemented in buff clay	20	70
Clay, buff, hard	10	80
Sand, buff, cemented	10	90
Sand, fine-grained	3	93
Ironstone	2	95
Clay, buff and gray, hard	47	142
Gravel, gray	8	150
Clay and sand, gray	9	159
Sand, gray	9	168
Clay, gray	17	185
Sand and clay, gray	35	220

Table 16.--Selected Logs of Wells in Cumberland County, N.J.

Well Vi-62: Van Dyk Brothers
Location : East Broad Street, Millville
Altitude : 75 feet

	Thickness (feet)	Depth (feet)
Gravel, hard and dry; layers of "Jerseystone".....	16	16
Sand, yellow, fine-grained layers of "Jerseystone"...	18	34
Yellow mud	26	60
Clay, yellow and orange	12	72
Sand, yellow and orange, fine-grained; quite a bit of "Jerseystone"; water-bearing	23	95
Clay, orange, hard		at 95