STATE OF NEW JERSEY
DEPARTMENT OF CONSERVATION
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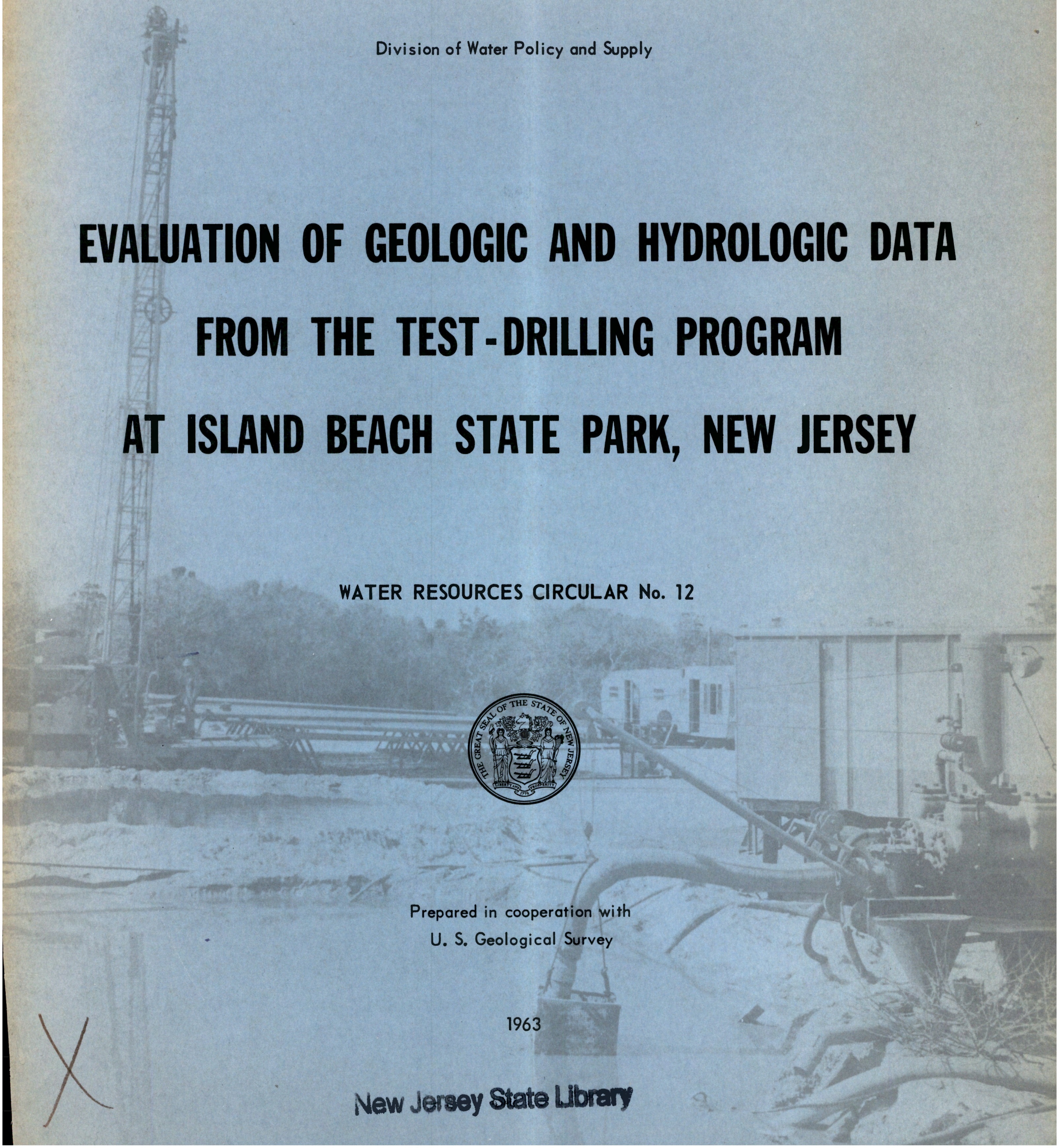
Division of Water Policy and Supply



EVALUATION OF GEOLOGIC AND HYDROLOGIC DATA FROM THE TEST-DRILLING PROGRAM AT ISLAND BEACH STATE PARK, NEW JERSEY

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By
Harold E. Gill, Paul R. Seaber,
John Vecchioli, and Henry R. Anderson

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ABSTRACT

The test-drilling program at Island Beach State Park, N. J. was undertaken to provide geologic and hydrologic information necessary for proper evaluation of the ground-water resources of southern New Jersey. An exploratory borehole was drilled through the entire unconsolidated Coastal Plain sequence. Electric and radioactivity logs were made of the hole, core samples of the materials penetrated were taken and described, and water samples obtained at several horizons were analyzed. These data and the interpretations based on them are presented in this report.

Most of the Coastal Plain formations at Island Beach differ significantly from their updip outcrop counterparts. In general, the sequence at Island Beach reflects a deeper water environment of deposition. The finer grained nature of several of the formations that function as important aquifers updip renders them unfit for development in the Island Beach test-well area.

The aquifer system in the Raritan Formation is the only one capable of furnishing large supplies of fresh water to wells in this area. However, the water becomes increasingly saline toward the base of the formation and extreme care should be taken in the development of water supplies from the upper part of the system to prevent salt-water contamination.

The data presented in this report should be augmented with similar data in other areas before definite conclusions can be reached regarding the geohydrologic framework of the aquifers in the Coastal Plain of New Jersey.

INTRODUCTION

Purpose and Scope

Increased ground-water use in the Coastal Plain of New Jersey has necessitated a thorough understanding of the geology and hydrology of southern New Jersey. The U. S. Geological Survey, in cooperation with the New Jersey Department of Conservation and Economic Development, Division of Water Policy and Supply, has undertaken a drilling program to

(1) define the number, character, and areal extent of the principal aquifers,
(2) determine the chemical quality of water in the various aquifers with special emphasis on present and possible future salt-water contamination,
(3) determine the presence and direction of interaquifer leakage,
(4) expand the observation-well network to monitor the effects of the increased withdrawals.

This report presents geologic and hydrologic data obtained from a test well at Island Beach State Park, Ocean County, N. J., the second under the deep test-well program being conducted as part of the expanded long-range statewide ground-water investigations authorized by the Water Supply Act of 1958. A depth of 3,891 feet was reached by an exploratory borehole, and several observation wells were constructed.

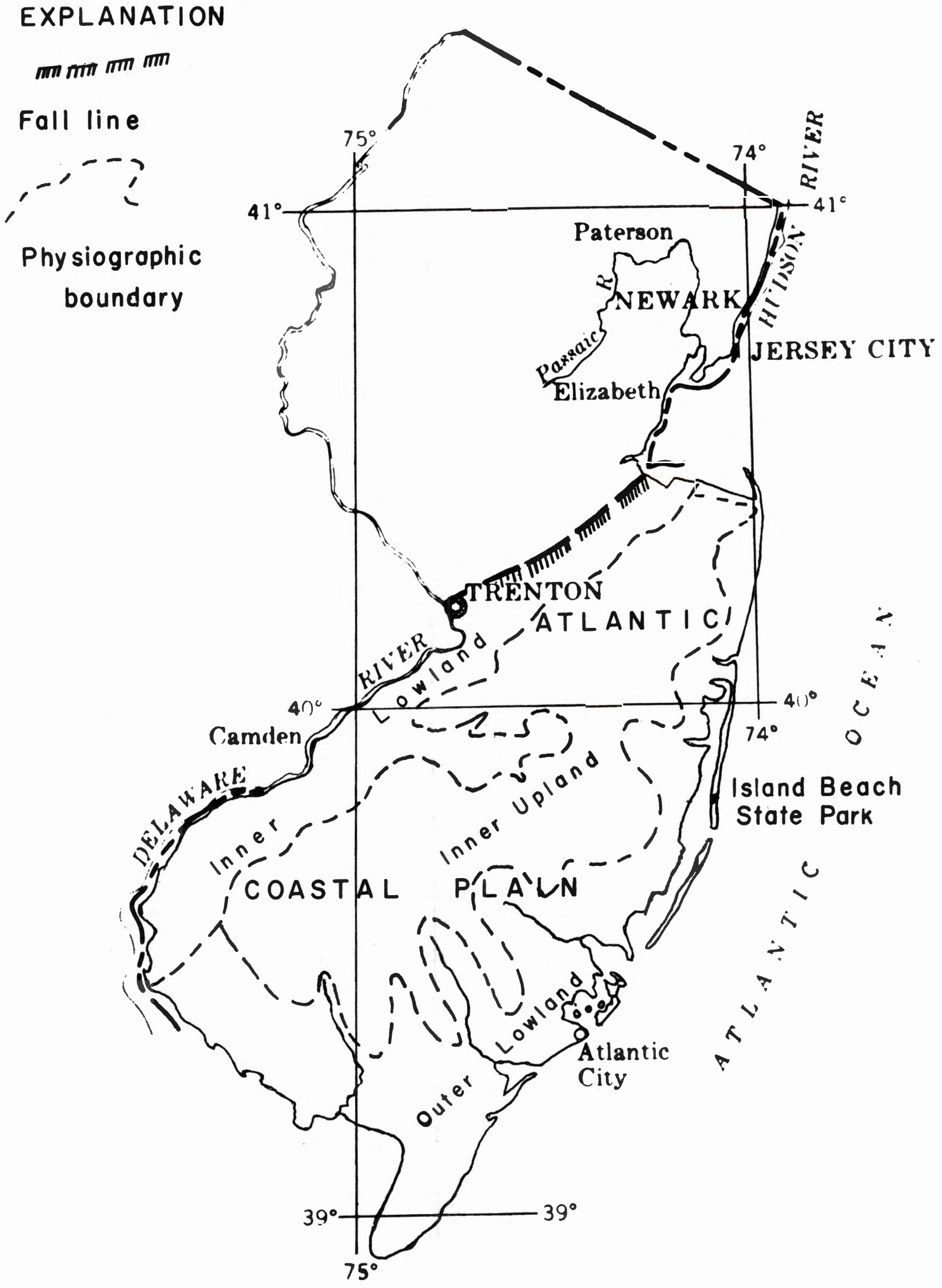


Figure 1. – Map of New Jersey showing the location of the test site.

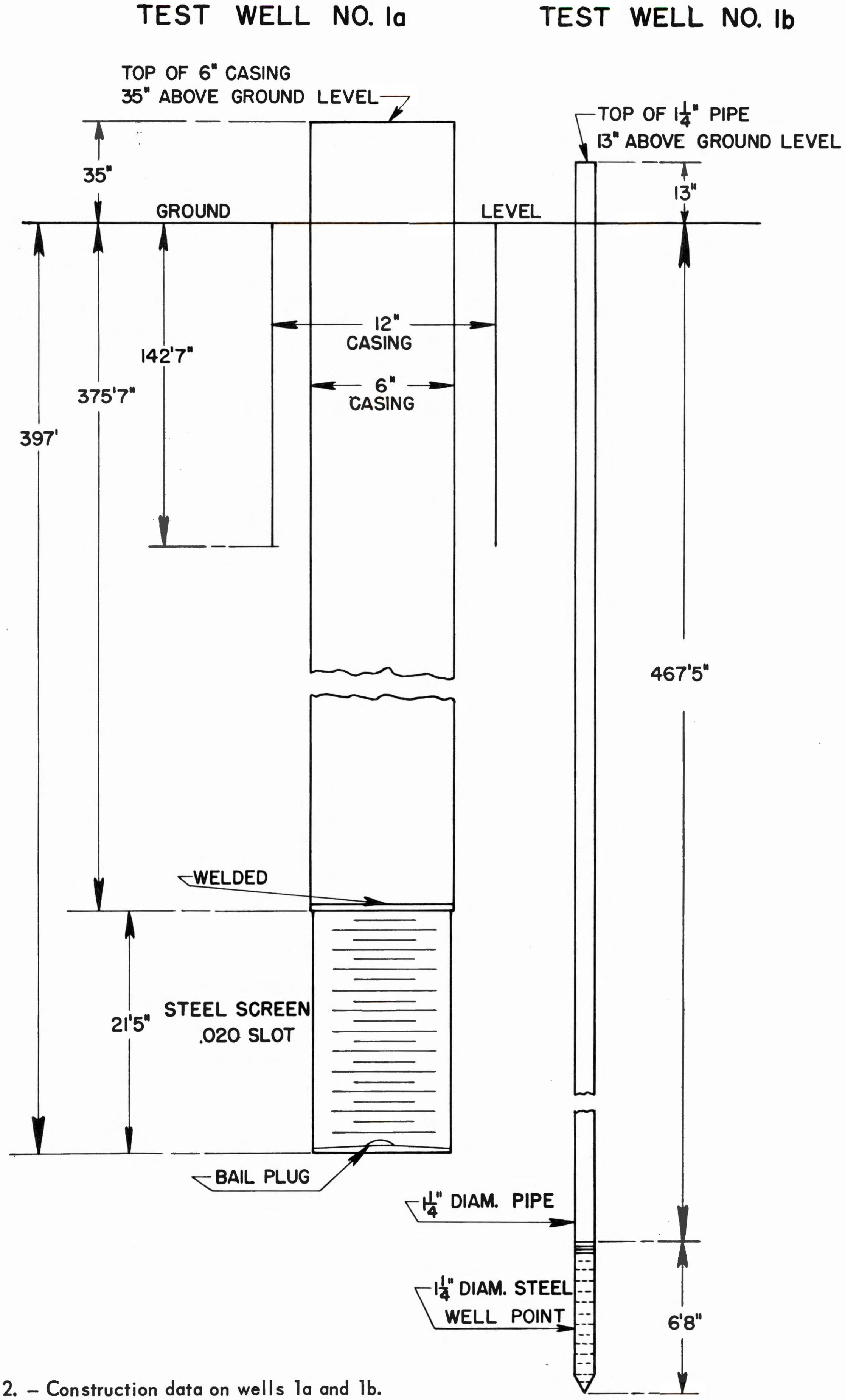


Figure 2. – Construction data on wells 1a and 1b.

The geologic and hydrologic work was under the direct supervision of the writers. The drilling contractor was the A. C. Schultes & Sons Co. of Woodbury, N. J., and the drilling was supervised by James F. Schultes of that company.

Program of Drilling

Drilling by the hydraulic rotary method was begun on April 2, 1962. A 9-inch hole was drilled to a depth of 3,891 feet, which was reached on May 4, 1962. Ditch samples were obtained from the circulated drilling mud at approximately 10-foot intervals.

On May 5 through 7, 1962, electric and radioactivity logs were made in the hole by the Schlumberger Well Surveying Corp. of Fairmont, W. Va. The following logs were run on the test hole: induction-electric log, laterolog-gamma ray-neutron log, sonic log, formation density-caliper log, directional log, and temperature log.

The cores from the Island Beach test well were taken with a 12-inch sidewall, wire-line coring device after the hole had been drilled. A total of 226 cores were taken at irregular intervals based on significant lithologic changes indicated from the various electric and radioactivity logs. The hole remained uncased during the sidewall coring operations except for 140 feet of surface casing. Sidewall coring of test hole 1 below 1,200 feet began on May 7, 1962, and continued on an around-the-clock basis until May 16, 1962. Coring of the lower uncased portion of the test hole resulted in the hole being abandoned after several unsuccessful attempts to recover drilling equipment stuck in the hole. A second test hole was drilled within 50 feet of the first, and the remainder of the cores between 2,700 and 3,891 feet were collected with the sidewall coring device.

Test hole 1, which had caved below 500 feet, was completed with the installation of two shallow observation wells. Construction details are summarized in figure 2. Below the lowermost screen, the hole was filled with a mixture of sand and clay. A 6-inch well with 20 feet of screen was completed at 397 feet and the 1 1/4-inch well with 6 feet of screen was completed at 474 feet. The annular space between the casing and wall of the test hole above the uppermost screen (377 feet) was cemented to the surface, and each of the test wells was developed individually. The sealing of the open hole between the two wells was verified by the different static water levels, quality of water, and negligible drawdown of water level in the 1 1/4-inch well when the 6-inch well was pumped. On July 20, 1962, the 6-inch well was equipped with an automatic water-stage recorder.

Test well 2 was completed to a depth of 2,759 feet. The hole below the screen was filled with a mixture of cement, gravel, sand, and clay. For a distance of 500 feet above 2,700 feet, the annular space between the 6-inch casing and the wall of the test hole was filled with cement. The annular space from the surface to a depth of 142 feet also was cemented. The well was developed and pumped; samples of water were collected, and the well was completed on September 21, 1962. An automatic pressure-stage recorder was installed on the well, which was necessitated by the flowing artesian condition of the well. Well construction is shown in figure 3.

Program of Sampling

Ditch samples were collected during the drilling operations from a baffled trough connected directly to the surface casing at the top of the test hole. A portion of each individual sample was washed in the field laboratory and decanted through a 100-mesh sieve to remove the drilling mud from the cuttings. The sample was ovendried and subsequently examined under the binocular microscope. The color, gross lithologic character, and fossil content of each sample were described by the percentage method. In this system all the material in the sample is described, disregarding obvious cavings. The percentage of the various constituents was estimated by eye.

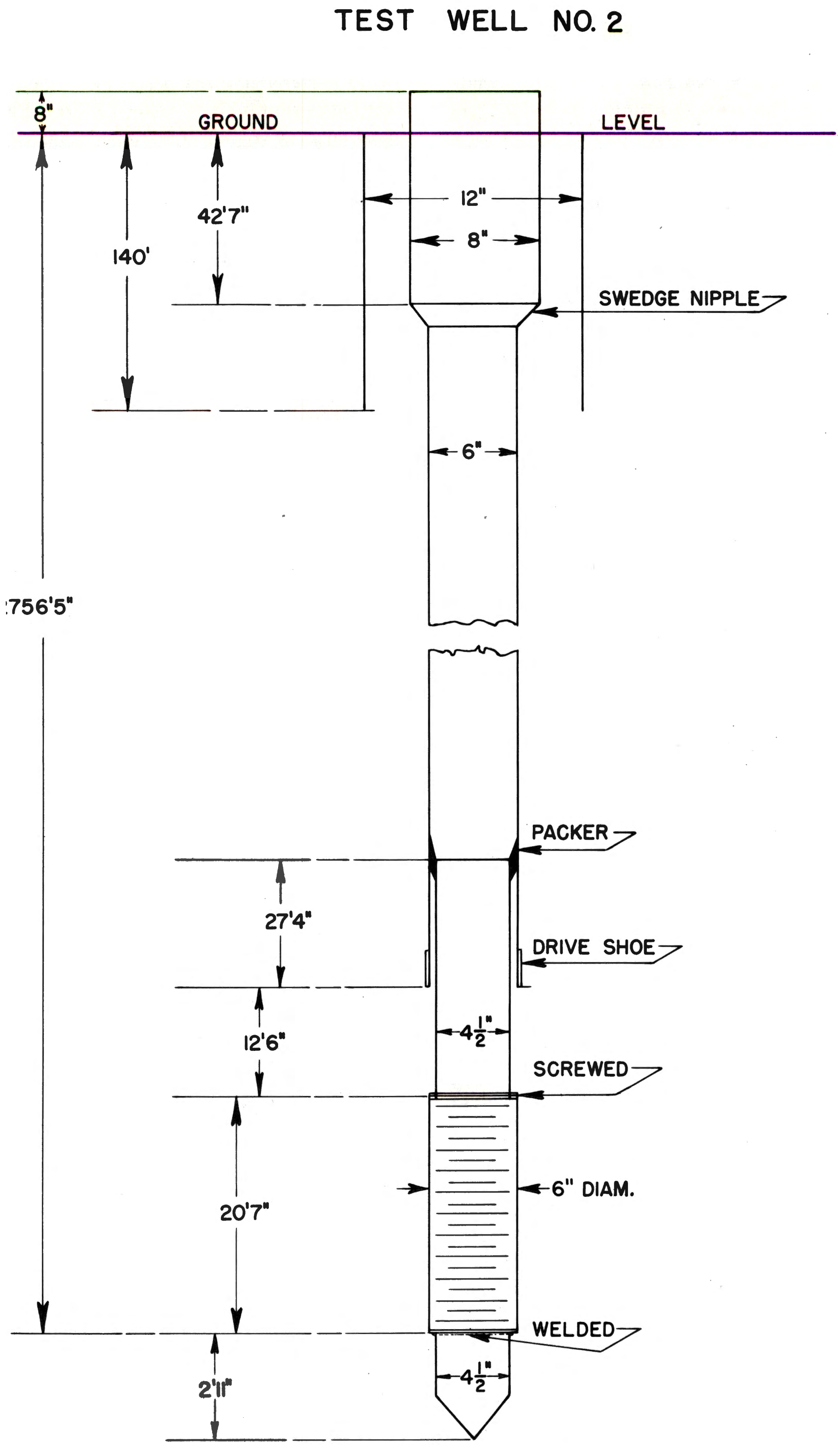


Figure 3. – Construction data on test well 2.

A washed and unwashed fraction of the ditch sample was examined under ultraviolet light to detect the presence of hydrocarbons.

The drilling mud was examined at regular intervals to determine the presence of gas. This was done by means of a field "hot-wire" gas-detector instrument. The test for gas in the mud is made by placing a small sample of the mud in a closed-container-type, high speed grinder. After the mud is agitated, the air-gas mixture in the container is drawn into the hot-wire gas-detector chamber by means of a vacuum pump. The combustion of any gas will give a reading on the detecting instrument. None of the tests showed the presence of any gas or oil.

Water was extracted from a sample of the drilling mud collected at the same time that the ditch samples were collected. This was accomplished by use of a Baroid mud-filter press to extract the fluids under pressure. Each of the water samples was analyzed for chloride content to assist in determining the position of the salt-fresh water interface in the various formations.

The core samples were obtained by means of a sidewall coring device designed by the contractor. The core barrel was forced into the wall of the test hole with a penetration of 7 to 12 inches. The core barrel had a maximum diameter of 1 1/4-inches, which reflects the vertical sampling interval of each core. The core was extracted from the split spoon sampler and the contamination of the drilling fluid and mud cake were removed by scraping. A portion of the core was weighed and ovendried to determine moisture content. Fluids were extracted from a number of the cores to assist in determining the salinity of the formation water.

A 100- to 200-gram fraction of the core was washed and decanted through a 100-mesh sieve for microfossil analysis and heavy mineral studies. The washed sample was floated with carbon tetrachloride to concentrate the microfossils. The concentrates were picked for Foraminifera and the specimens were mounted on individual slides for study under the microscope. The heavy minerals were separated from the washed core by means of bromoform, and 174 heavy mineral slides were prepared in the field laboratory to assist in the delineation of formational units.

The unwashed and washed core samples were examined separately under the binocular microscope and the color, gross lithologic character, fossil content, and significant minor mineral constituents were described.

REGIONAL GEOLOGY

Island Beach State Park lies along the Atlantic coast in the New Jersey part of the Atlantic Coastal Plain province. The New Jersey part of the Coastal Plain is largely a region of low relief, consisting of broad plains and gently sloping rounded hills and ridges. It has been divided by Owens and Minard (1960, p. 1) into three physiographic subprovinces (fig. 1): an outer lowland along the Atlantic coast where the elevations rarely exceed 50 feet above sea level, a broad inner upland with elevations ranging up to nearly 400 feet, and a narrow inner lowland along the Delaware River with elevations between 50 and 100 feet. Island Beach State Park is in the outer lowland subprovince and it is the southern part of a large offshore or barrier island separating Barnegat Bay from the Atlantic Ocean.

The formations exposed in the Atlantic Coastal Plain of New Jersey are of Late Cretaceous, Tertiary, and Quaternary age (table 1). They consist of unconsolidated to semiconsolidated deposits of sand, silt, and clay with considerable quantities of gravel. Gravel occurs chiefly in the Quaternary deposits, but minor amounts are associated with quartz sands of Cretaceous and Tertiary age.

Many workers have differentiated and classified the sediments of the Atlantic Coastal Plain in New Jersey. Recently, Owens and Minard (1960, p. 11-14) have prepared summary tables which differentiate and correlate the sediments according to classifications of various workers of Coastal

Table 1. – Physical and water-bearing characteristics of the geologic formations in the Atlantic Coastal Plain of New Jersey

Geologic units									Hydrologic units	
					In outcrop near Trenton		Island Beach State Park			
System	Series	Group	Formation	Previous maximum reported thickness (feet)	Lithology	Average thickness (feet)	Lithology	Thickness (feet)	Coastal Plain	Island Beach State Park
Quaternary	Recent			80	Fine sand, silt, and mud.	0-10	Medium to coarse-grained quartz sand.	74	Water-table aquifer throughout the Coastal Plain. Generally yields small to moderate quantities of water, but the thicker sands are capable of yielding large quantities of water. Generally, where adjacent to saline surface water bodies, contains brackish or saline water with a thin fresh-water lens on top. Locally artesian.	
	Pleistocene		Cape May Formation	200	Heterogeneous mixture of gravel, sand, silt and clay.	less than 50	Very fine to medium-grained quartz sand, and clay.	46		
			Pennsauken Formation				Absent	0		
			Bridgeton Formation							
Tertiary	Pliocene (?)		Beacon Hill Gravel	20	Quartz, gravel, and sand.					
	Miocene (?) and Pliocene (?)		Cohansey Sand	270	Medium to coarse-grained quartz sand. Locally clayey.	200±	Silty clay.	30		Aquiclude
	Miocene		Kirkwood Formation	750	Very fine to medium-grained. Locally clayey, quartz sand, and silt.	60±	Very fine to fine-grained quartz sand, and clay.	250	An aquifer that is a reliable source of moderate to large quantities of water, especially in the southern Coastal Plain. Contains two widespread aquicludes.	An aquifer capable of yielding moderate quantities of water
	Eocene	Rancocas	Manasquan Formation	200	Medium to coarse-grained clayey quartz and glauconite sand, and sandy silt and clay.	40	Very fine to medium-grained clayey glauconite and quartz sand dominant at top, and silt and clay dominant at base.	762	An aquifer that yields small to moderate quantities of water. Locally yields large quantities of water.	An aquifer capable of yielding small quantities of water at the top, grading to an aquiclude at the base.
	Paleocene		Vincentown Formation	460	Fine to coarse-grained clayey quartz sand, and fine-grained clayey quartz and glauconite calcarenite.	55				
			Hornerstown Sand	100	Medium to coarse-grained clayey glauconite sand.	30			An aquitard. Contains several thin water-bearing units capable of yielding small quantities of water.	
Cretaceous	Upper Cretaceous	Monmouth	Red Bank Formation	185	Fine to coarse-grained clayey quartz and glauconite sand.	0-50	Very fine to fine-grained clayey quartz sand, and silt.	28		
			Navesink Formation	70	Medium to coarse-grained clayey glauconite and quartz sand.	20	Clay.	36		
			Mount Laurel Sand	120	Fine to coarse-grained clayey quartz sand.	20	Medium-grained clayey quartz sand.	12	An aquifer that is a widespread reliable source of small to moderate quantities of water. Locally yields large quantities of water.	
		Matawan	Wenonah Formation		Very fine to fine-grained silty quartz sand.	20	Very fine to fine-grained clayey quartz sand, and clayey silt.	116		
			Marshalltown Formation	125	Very fine to medium-grained clayey glauconite and quartz sand.	35	Very fine to medium-grained clayey glauconite and quartz sand, and clayey silt.	244		
			Englishtown Formation	160	Fine to medium-grained quartz sand, Clay-seamed.	45	Absent	0	An aquifer that is a reliable source of moderate to large quantities of water, especially in the northeastern Coastal Plain.	
			Woodbury Clay	255	Clay.	50	Clay and silt.	212	Aquiclude	
			Merchantville Formation		Very fine grained, very clayey quartz sand.	60				
			Magothy Formation	95	Fine-grained quartz sand, and clay.	30	Very fine to medium-grained clayey quartz and glauconite sand, and clay and silt.	260	An aquitard. Contains several thin water-bearing units capable of yielding small to moderate quantities of water. Locally functions as an aquifer in conjunction with the underlying Raritan.	
			Raritan Formation	1,500+	Fine to very coarse-grained quartz sand, and clay	300?	Very fine to coarse-grained quartz sand, and clay.	1,728	An aquifer that is a widespread reliable source of large quantities of water. The water becomes increasingly brackish with downdip position and depth.	
Pre-Cretaceous	Precambrian and early Paleozoic crystalline rocks – metamorphic schist and gneiss and igneous pegmatite and gabbro, and Triassic asalt, sandstone, and shale.						Weathered gneiss (saprolite).	64	Aquiclude	
							Biotite gneiss with pegmatite veins.	---		

Plain stratigraphy in New Jersey. No major changes, except for refinement of various units within the sequence, have been made since the work of Weller (1907, p. 25) on the pre-Miocene stratigraphic sequence and the work of Salisbury and Knapp (1917) on the Quaternary formations.

The sediments in the Coastal Plain province have been divided into 22 mappable units, ranging in age from Late Cretaceous to Recent (table 1). Beds of Early Cretaceous age (Richards, 1945, p. 894-895) and Late Eocene age (Richards, 1956, p. 84) have been reported from the subsurface; these beds do not crop out in the State.

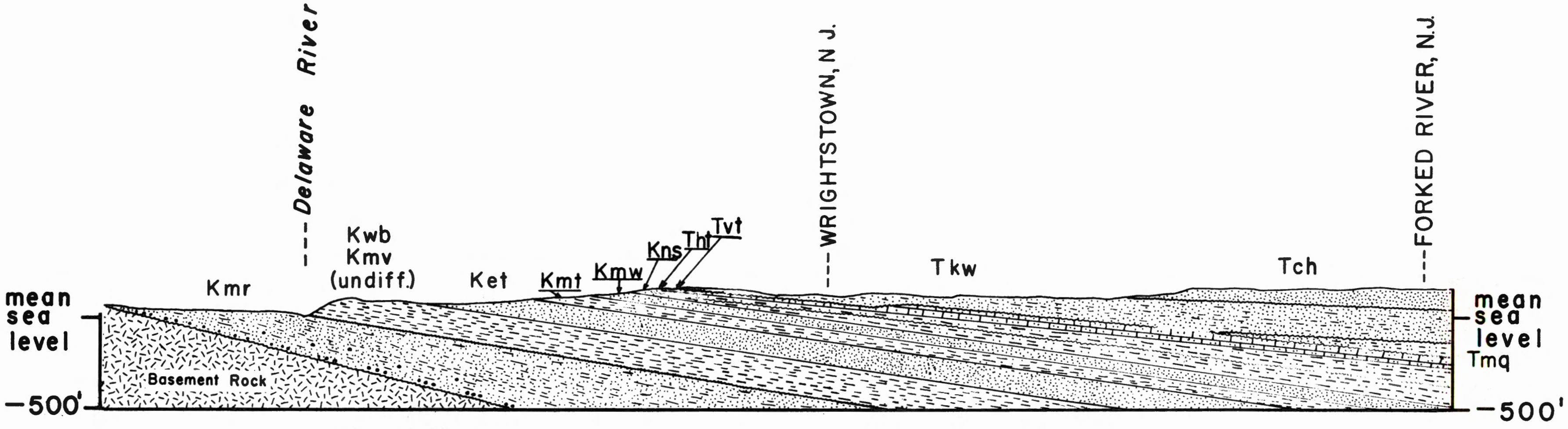
The Upper Cretaceous formations strike about N. 40°-50° E. and dip gently from 35 to more than 60 feet per mile southeastward. The attitude of each formation is remarkably uniform and minor variations are due to slight unconformities. The Tertiary formations strike about N. 50°-70° E. and dip 10 to 45 feet per mile southeastward (Minard and Owens, 1960, p. B184-B186). For the most part, the Quaternary formations consist of nearly flat-lying beds.

The Cretaceous and Tertiary formations form a wedge-shaped prism that lies unconformably upon Precambrian, Paleozoic, and Triassic rocks of the Piedmont province (fig. 4). In their outcrop areas, the Cretaceous and Tertiary formations together range from about 500 to 800 feet in total thickness. These sediments increase in thickness downdip or southeastward, and the tectonic map of the United States (1961) shows them as being about 10,000 feet thick at the extreme tip of southern New Jersey. They extend eastward into a geosyncline having a total thickness of sediments in excess of 15,000 feet about 50 to 60 miles southeast of Island Beach State Park. Farther eastward, toward the edge of the continental shelf, the sediments become considerably thinner. Deposits of Quaternary age, which overlie all the older formations of the area, are present over large areas of the Coastal Plain. They have a wide range in thickness and areal extent.

The entire Coastal Plain sequence indicates several transgressions and regressions of the sea during the period of deposition. The sediments were deposited under relatively stable shelf conditions and were laid down in continental, transitional, and marine environments. The materials that make up these sediments were derived for the most part from highlands north and west of the present Fall Line. In general, the coarser-grained sands occur in the outcrops of the Coastal Plain formations and represent continental, transitional, or shallow-water, or near-shore depositional environments. Southeastward toward the Atlantic coast, the Cretaceous and Tertiary continental and near-shore deposits grade into offshore marine deposits. These deeper water marine deposits are composed mainly of calcareous clays, silts, and glauconite sands. Quartz sands decrease and glauconite sands increase in abundance seaward. The units generally thicken seaward and the thickening is accompanied by an increase in the number of distinct lithologic units present.

The deposits underlying Island Beach reflect all the above-mentioned depositional environments and conditions (table 4). Compared to their outcrop equivalents, the deposits at Island Beach are practically all finer-grained; the marine beds are more glauconitic, calcareous and fossiliferous, thicker, and less quartzose. All these characteristics indicate a deeper-water environment of deposition. It should be emphasized that the correlation of the units encountered during drilling at Island Beach with those of the outcrop area is not based on biostratigraphic time-equivalence, owing to the lack of detailed paleontological work to date. The correlation is strictly a rock-stratigraphic correlation, based mainly on stratigraphic position and lithologic similarities. The outcrop descriptions used for correlation purposes were taken from those given by Owens and Minard in the Columbus Quadrangle (1962) and by Minard and Owens in the New Egypt Quadrangle (1962).

Although a general similarity exists between the deposits encountered at Island Beach and their outcrop equivalents, several striking differences are readily apparent. The basement complex, which underlies the entire sedimentary sequence, consists of a pegmatitic biotite gneiss. The gneiss was encountered at 3,798 feet. The upper 64 feet is highly weathered, and has the appearance of saprolite. The gneiss is probably a correlative of rocks of the Piedmont province



EXPLANATION

Tch	Cohansey Sand
Tkw	Kirkwood Formation
Tmq	Manasquan Formation
Tvt	Vincentown Formation
Tht	Hornerstown Sand
Kns	Navesink Formation
Kmw	Mount Laurel Sand and Wenonah Formation
Kmt	Marshalltown Formation
Ket	Englishtown Formation
Kwb	Woodbury Clay
Kmv	Merchantville Formation
Kmr	Raritan and Magothy Formations

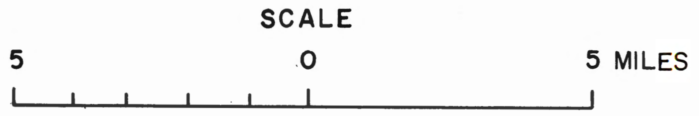


Figure 4. – Cross section of the Atlantic Coastal Plain in New Jersey.

which crop out west of the Fall Line. The Raritan Formation overlying the basement complex lies between 2,070 and 3,798 feet and is similar in its lower 1,000 feet to the continental Raritan Formation in outcrop (table 4). The upper section of about 728 feet appears to have been deposited in a transitional or marine environment. The overlying Magothy Formation has a deeper water aspect than the Magothy exposed in outcrop, being thicker, more glauconitic, and fossiliferous. The overlying Matawan and Monmouth Groups encountered between 1,162 and 1,810 feet also reflect the deeper water environment of deposition. These deposits are thicker, less quartzose, and more glauconitic, calcareous, and fossiliferous than their outcrop equivalents.

At Island Beach, the predominantly quartzose sand beds that are present in the outcrop of the Matawan and Monmouth Groups are either finer-grained (Red Bank Sand and Wenonah Formation), thinner (Mount Laurel Sand), or absent (Englishtown Formation). The overlying Rancocas Group is divided into three formations in the outcrop but could not be subdivided at Island Beach. This unit occurs between 400 and 1,162 feet in the Island Beach well and grades from a glauconite and quartz sand at the top to a basal glauconitic silt and clay unit not present in outcrop. The overlying Kirkwood Formation is similar to its outcrop description except that it is much finer. The Cohansey Sand is present here only as a clay. The Cape May Formation and the 74 feet of beach sand at the top of the section are similar to that described elsewhere along the coast (fig. 5 and table 4).

In summary, the geology of the sedimentary formations encountered at Island Beach reflects a deeper water environment of deposition than the outcrop materials, but it retains the general cyclic aspect of continental deposits overlying and underlying glauconitic marine beds.

GEOHYDROLOGY

Beneath the land surface or the Coastal Plain of New Jersey, a great quantity of fresh ground water is contained in the pore spaces of the unconsolidated rocks. This water is much greater in quantity than all the fresh water contained at any particular instant in the rivers and lakes on the land surface in New Jersey. The source of virtually all this vast quantity of fresh ground water is precipitation that falls on the surface of the Coastal Plain. Part of this ground water is of low mineral content (less than 250 ppm) and of excellent quality for municipal and industrial use. An approximately equal amount of water contained in the materials underlying the emerged Coastal Plain is saline. This saline water occurs in the deeper materials and in a few localized areas adjacent to saline surface waters.

The fresh ground water is moving slowly through this natural underground reservoir system. It moves from areas where infiltration of rainfall is occurring to natural outlets of seepage on the land surface, to the ocean, and to points of artificial discharge.

The quantity in underground storage varies slightly from season to season. It decreases even with normal precipitation during the summer and fall when the use of water by plants is large. It increases during the winter and early spring when vegetal growth is at a minimum.

The Coastal Plain materials differ as to the amounts of water they contain and the rates at which this water can move through the formations and into wells. The quantity of ground water in any one place is determined by the size and number of saturated openings in the materials. In the Coastal Plain, virtually all the water occurs in interstices or voids among the mineral grains composing the unconsolidated rocks. The size of these interstices is important. Water held in minute pores is difficult to remove because of the strong capillary attraction between the rock particles and the water, even though the percentage of voids may be relatively high.

Materials such as gravels and the coarser sands contain a considerable volume of relatively large voids, in some places as much as 30 to 35 percent of the rock mass, and transmit and yield the water readily. They are called *aquifers.* Materials such as clay contain just as much or more void space, but because the openings are smaller, they transmit and yield water very slowly. They are called *aquicludes.* An intermediate group of materials, in terms of capacity to transmit and yield water, are called *aquitards* and they consist of the finer sands and silts.

The coarser beds in the layers of gravel, sand, silt, and clay which underlie the Coastal Plain are thus very favorable for the storage and movement of ground water and they constitute the aquifers of the Coastal Plain. The finer grained materials constitute the confining beds. Except for the outcrop areas, the more permeable beds form artesian aquifers between confining beds of finer grained material. The aquifers and intervening confining beds of lower permeability do not necessarily conform to the mapped geologic formations of the Coastal Plain.

Several of the Coastal Plain formations contain aquifers capable of yielding moderate (50 to 200 gpm [gallons per minute]) to large (over 200 gpm) quantities of water to wells. In order of their occurrence from the Fall Line toward the southeast – that is, from oldest to youngest – the aquifers are the permeable sands in the Raritan and Magothy Formations, the Englishtown Formation, the Wenonah Formation and Mount Laurel Sand, the Vincentown Formation, the Kirkwood Formation, and the Cohansey Sand. The overlying irregular and discontinuous veneer of Quaternary sands and gravels serves to receive recharge from precipitation, but is generally not thick enough to yield large quantities of water directly to wells.

On the basis of developed capacity and potential capacity to yield water, the Raritan aquifer system is one of the most important hydrologic units in the New Jersey Coastal Plain.

The Raritan aquifer system contains the principal body of fresh confined ground water at Island Beach. The formation is 1,728 feet thick and occurs from 2,070 to 3,798 feet below land surface. The Raritan Formation at Island Beach is composed of alternating layers of sand, silt, and clay, with a few thin layers of gravel. The sediments composing the mineral framework of the Raritan aquifers range from fine to very coarse sand and granules. The texture of the sediments in the Raritan aquifers was much coarser than any of the overlying confined aquifers encountered in the Island Beach test well. The coarse texture of the Raritan sands indicates a much higher permeability for the aquifer system than the overlying Kirkwood. Yields of 200 to 500 gpm, or more, can be expected from properly constructed large-diameter wells in the Raritan aquifer system of this area.

The Raritan aquifer system contains varying degrees of salt-water contamination. The deep test well (2,756 feet) at Island Beach yielded water with a chloride concentration of 670 ppm (parts per million). Data obtained from the electric-induction log illustrated on figure 5 and chloride determinations on fluids extracted from the cores indicate that the chloride content of the water above 2,750 feet decreases gradually. Toward the top of the aquifer system, the chloride content of the water is probably not more than several tens of parts per million. Below 2,750 feet, there is a gradual increase in the chloride content of the water to a concentration probably approaching that of sea water toward the base of the aquifer system.

The information obtained on the Raritan aquifer system at Island Beach indicates several important hydrologic features. The most significant is the occurrence of an upper fresh-water zone which apparently extends farther down dip (southeast) than the Island Beach test well. Secondly, the static water levels in the Raritan observation well are somewhat higher than anticipated; during the fall of 1962 they ranged from 25.6 to 28.3 feet above mean sea level. Tidal loading accounts for the major part of the water-level change in the aquifer. Of all the aquifers measured at Island Beach, the Raritan aquifer system had the highest head above mean sea level (static water level).

An analysis of water taken from the Raritan observation well is given in table 2. The water in the aquifer is high in dissolved solids (1,430 ppm) and moderately hard. Iron and chloride exceed the maximum U. S. Public Health Service standards for potable water supplies. Chemical analysis of the water indicates that the quality of water in the aquifer is affected principally by

Table 2: – Chemical analyses, in parts per million, of water from test wells at Island Beach State Park

(Analyses by U. S. Geological Survey)

Well no.	1a	1b	2
Aquifer	Kirkwood Formation	Rancocas Group	Raritan Formation
Date of Collection	9-21-62	9-17-62	9-21-62
Temperature (°F)	62	62	86
Silica (SiO_2)	29	34	16
Iron (Fe)	1.7	.87	1.8
Calcium (Ca)	16	4.8	31
Magnesium (Mg)	1.5	1.9	6.1
Sodium (Na)	12	74	485
Potassium (K)	4.2	7.3	8.2
Bicarbonate (HCO_3)	70	192	188
Sulfate (SO_4)	12	16	2.5
Chloride (Cl)	7.0	8.2	670
Fluoride (F)	.1	1.2	1.0
Nitrate (NO_3)	.4	.0	.2
Residue on evaporation at 180°C	115	238	1,430
Hardness as $CaCO_3$			
Calcium, Magnesium	46	20	103
Noncarbonate	0	0	0
Specific conductance (micrombos at 25°C)	179	365	2,750
pH	7.4	7.4	7.3

contamination from a salt-water source, and can be classified as a sodium-chloride water. Whether the salt-water source is the ocean or a residual body of interstitial salt water is still conjectural.

The future development of the Raritan aquifer system in this area is limited by the salt-water contamination of the basal part of the formation (below 2,700 feet). Supplies developed from the upper fresh-water zone still appear to be feasible, but care should be taken to prevent upward vertical leakage from the lower salt-water body.

The temperature of the water in the Raritan aquifer system may be the most objectionable feature for its future use. The temperature of the water from the Raritan well at Island Beach reached 87° Fahrenheit at a yield of 40 gpm. The temperature log obtained during the geophysical logging of the well indicated a formation temperature of about 96° Fahrenheit. Larger yields from a well at this depth will show an increase in water temperature to that approaching the natural aquifer temperature.

The aquifer in the Englishtown Formation, which is a major aquifer system overlying the Raritan Formation in parts of Ocean and Monmouth Counties, is absent at Island Beach. The geologic information obtained from the Island Beach test well substantiated the preliminary conclusions as to the southern extent of the Englishtown Formation (Seaber, 1962).

The Mount Laurel Sand is represented by a thin section of marine sand in the Island Beach test well. The water-bearing zone occurs between 1,226 and 1,238 feet below land surface. The thinness of this zone sharply limits its consideration as a major source of water for industrial or municipal supplies. The Mount Laurel Sand, as part of the stratigraphic sequence from the middle of the Rancocas group to the base of the Marshalltown Formation, functions as an aquitard in the Island Beach area (fig. 5).

Several minor water-bearing zones are present in the Rancocas Group in the Island Beach test hole (fig. 5). These zones are thin and of low permeability at Island Beach; however, in other areas they are capable of yielding large supplies for municipal and industrial purposes.

The uppermost zone of the Rancocas Group was tapped with a 1 1/4-inch well point in test hole 1. The head (static water level) in this well, based on numerous manual measurements, has ranged from 0.16 to 0.40 foot higher than simultaneous measurements in the Kirkwood well. Although there is a separation of the water-bearing zones at Island Beach, the indication is that regionally the two zones probably act as a single aquifer system.

The chemical quality (table 2) of the water in the upper Rancocas sand was found to be good. The water is soft, low in chloride (8.2 ppm) and dissolved-solids content (238 ppm), and can be classified as a sodium-bicarbonate water.

The Kirkwood Formation contains the uppermost body of fresh confined ground water at Island Beach. The formation is 250 feet thick and occurs between 150 and 400 feet below the land surface at the test-well site. The sediments composing the mineral framework of the aquifer range from very fine to fine sand; the coarsest material occurs in the lowermost 88 feet of the formation.

The fine texture of the sands in the Kirkwood Formation at Island Beach indicates that the permeability of the aquifer is considerably lower here than that for other areas on the barrier islands to the south. Conditions similar to those at the test-well site were reported for the well at the Island Beach bathing area 3 miles north. Hence, although large supplies of water have been developed from the Kirkwood Formation in other areas of the Coastal Plain, the aquifer at Island Beach is capable of yielding only moderate (50 to 200 gpm) supplies of water to large-diameter wells which are constructed with a maximum length of screen, gravel-packed, and are properly developed.

The island Beach Kirkwood observation well is strategically located between major areas of

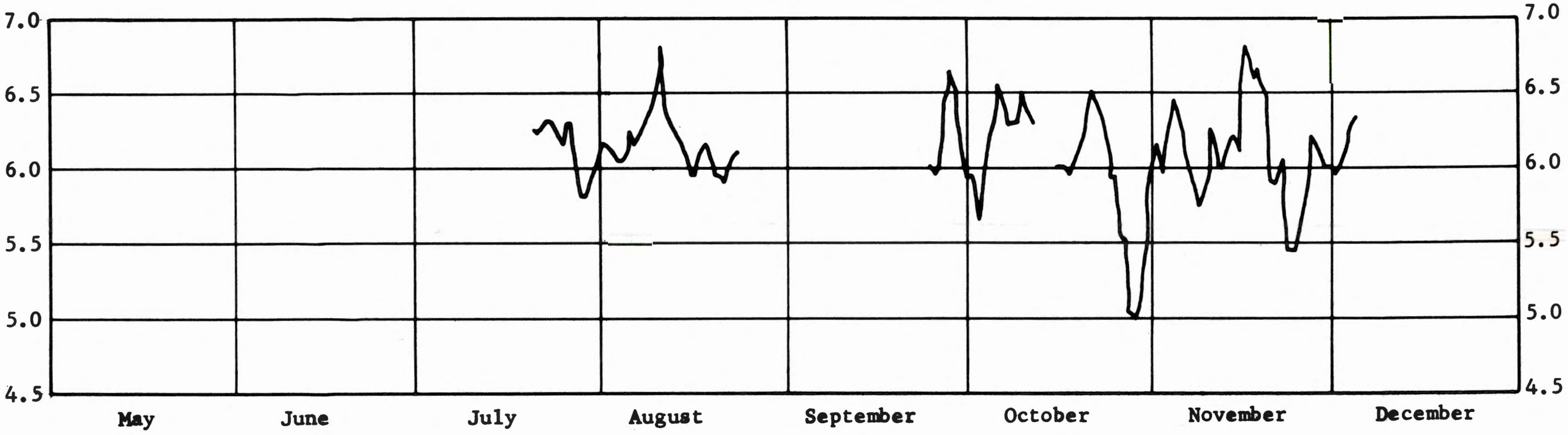


Figure 6. – Hydrograph of the aquifer in the Kirkwood Formation at Island Beach.

pumpage in the aquifer. As such, it is ideally situated to be sensitive to any major regional water-level changes. Figure 6 is a hydrograph of the Kirkwood well at Island Beach from July to December 1962. The water level in the well responds to tidal changes in the Atlantic Ocean. During the short period of record, the water level has fluctuated within a range of about 1.8 feet, the major part of this fluctuation being the result of tidal loading. No significant increase or decrease in water level in the aquifer occurred during the period, and the average water level has been about 6 feet above mean sea level.

An analysis of water taken from the Kirkwood observation well is given in table 2. Water in the aquifer is low in dissolved solids (115 ppm) and soft, and can be classified as a calcium-bicarbonate water. Water from the Kirkwood aquifer has the lowest dissolved-solids content of the confined water-bearing zones sampled at Island Beach.

The Cohansey Sand overlies the Kirkwood Formation throughout most of the Coastal Plain of New Jersey. The Cohansey compares favorably with the Raritan and Magothy in its ability to store and transmit water, but it is virtually undeveloped. In the Island Beach test well the Cohansey Sand is represented by a 30-foot section of clay and functions as an aquiclude, protecting the underlying aquifer in the Kirkwood Formation from the unconfined salt water above.

The uppermost body of fresh ground water at Island Beach is a zone of unconfined water within the beach complex which is replenished directly by precipitation. The topography and the permeable nature of the sediments which blanket the barrier island are such that there is virtually no immediate overland runoff of precipitation. Part of the water that sinks into the ground is discharged by evaporation to the atmosphere. Most of the remainder percolates down to the water table and is temporarily stored in the ground-water reservoir. The ground water moves from the high-level recharge area near the sand dunes along the beach and is discharged as underflow to the Atlantic Ocean and Barnegat Bay (fig. 1).

The unconfined aquifer on the barrier island is surrounded by salt water from the Atlantic Ocean and Barnegat Bay. In this area, the water-bearing zone is underlain by an extensive confining layer. The zone of saturation (area beneath the water table) contains fresh water floating on salt water, owing to a difference in fluid density. The fresh water lens is about 10 feet thick in the central part of the barrier island and tapers toward the ocean and bay.

The barrier island is only a few feet above sea level. During hurricanes and extra tropical storms, parts of the barrier island are inundated with salt water. During and after such periods, salt water is able to percolate to the water table; once this occurs, a long period of time is required for natural flushing of the salt water by the slow movement of fresh water in the ground-water reservoir.

A hydrograph of the water-table well at Island Beach, showing the magnitude of the water-level fluctuations and its response to precipitation during the late spring, summer, and fall of 1962, is shown in figure 7. The water table has fluctuated a maximum of 1.8 feet during this period. The aquifer responds almost immediately to precipitation.

The quality of the water in the unconfined aquifer is the greatest single factor limiting its extensive development. Large supplies could easily be obtained if water quality were not of primary importance. The presence of swamp gases is a secondary deterrent in the use of water from the aquifer.

The future development of this aquifer is sharply limited as a result of the proximity of a salt-water contaminant. Small supplies of water from shallow wells tapping the fresh-water zone can be assured of a safe quality most of the time. Periods of severe salt-water flooding render the aquifer unfit for most uses for periods of several weeks or months, until the salt water is flushed from the upper part of the unconfined aquifer.

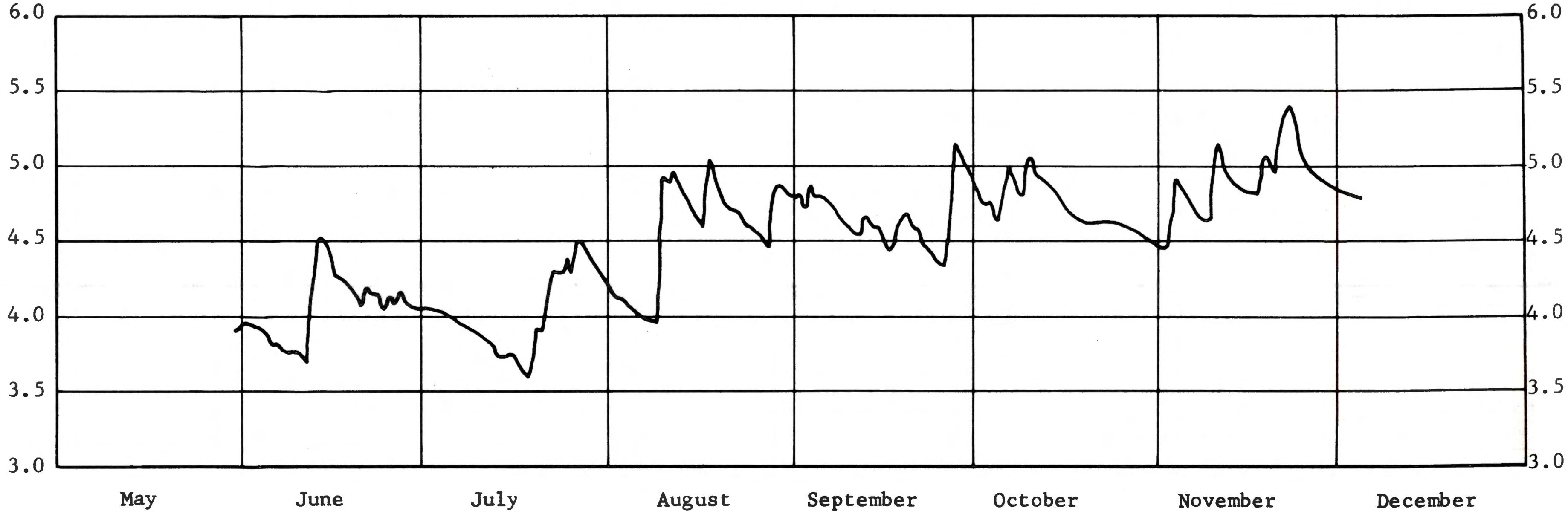


Figure 7. – Hydrograph of the unconfined aquifer at Island Beach.

SUMMARY AND SUGGESTIONS FOR FURTHER WORK

The Island Beach test-drilling program has emphasized several deficiencies in our understanding of the hydrogeologic framework of the New Jersey Coastal Plain.

The test well showed that several major differences exist in the character of the sediments between the outcrop areas of the various formations and the Island Beach area. The most notable of these differences are (1) the absence of the sand (aquifer) in the Englishtown Formation, (2) the limited thickness of the Mount Laurel Sand, such that its development as a source of water supply is not feasible, (3) the finer character of the mineral framework of the Kirkwood aquifer, and (4) the absence of any water-bearing zone in the Cohansey Sand. Precise correlation of all the units in the Island Beach test well with the outcrop area will have to be postponed until additional data are obtained from a test well located midway between the outcrop area and Island Beach. This will make possible a more complete description of the framework of the various aquifer systems.

Our understanding of the Raritan aquifer system should be greatly expanded. The test well at Island Beach indicated the presence of a fresh-water zone at the top of the aquifer system. There is a gradual increase in the chloride content of the water in the Raritan aquifer system with depth. The water at the base of the Raritan Formation probably approaches a chloride content similar to that of sea water. Before maximum development of the Raritan aquifer system can be reached, we need to understand more completely the interrelation of the various aquifers within the system. The extent of the interconnection between the Raritan aquifers will be of major importance in controlling the movement of the main salt-water body. The primary source of the salt water will also affect the movement of the salt-water body.

The information obtained to date from the test-drilling program has supplied much valuable information essential for a more complete understanding of the hydrogeologic framework of the New Jersey Coastal Plain.

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Table 3 – Depths, in feet below land surface, at which cores were obtained

96
100
120
146
150
171
175
196
200
256
260
280
305
338
342
375
400
421
425
458
471
475
496
500
506
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518
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576
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626
630
656
660
696
700
736
740
776
780
782
796
800
826
830
840
860
876
880
900
920
950
975
996
1,000
1,025
1,050
1,060
1,075
1,100
1,130
1,134
1,136
1,140
1,148
1,161
1,165
1,176
1,180
1,196
1,200
1,201
1,205
1,220
1,226
1,230
1,255
1,275
1,296
1,300
1,321
1,325
1,346
1,350
1,371
1,375
1,396
1,400
1,419
1,423
1,426
1,430
1,449
1,453
1,456
1,460
1,464
1,468
1,488
1,500
1,550
1,554
1,596
1,600
1,616
1,620
1,636
1,640
1,656
1,660
1,680
1,700
1,740
1,754
1,758
1,770
1,780
1,800
1,801
1,805
1,830
1,834
1,860
1,864
1,890
1,894
1,910
1,914
1,946
1,950
1,980
1,984
1,990
2,000
2,004
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2,080
2,100
2,150
2,180
2,200
2,220
2,250
2,300
2,735
2,746
2,796
2,800
2,836
2,840
2,856
2,860
2,875
2,896
2,900
2,910
2,916
2,920
2,946
2,950
2,976
2,980
3,030
3,066
3,070
3,096
3,100
3,106
3,146
3,150
3,176
3,180
3,196
3,200
3,246
3,250
3,296
3,300
3,316
3,320
3,346
3,350
3,366
3,370
3,396
3,400
3,435
3,456
3,460
3,496
3,500
3,530
3,548
3,696
3,700
3,715
3,730
3,740
3,746
3,750
3,760
3,766
3,780
3,786
3,796
3,800
3,806
3,810
3,816
3,820
3,826
3,830
3,836
3,840
3,850
3,876 - 3,885

Table 4 – Composite Geologic and Lithologic Log

Description	Thickness (feet)	Depth (feet)
Quaternary:		
Beach Complex:		
Sand, quartz, pale-grayish-orange, 10 YR 7/3, medium to coarse-grained, well-sorted, micaceous, fossiliferous	74	74
Cape May Formation:		
Clay, medium-gray N 5, pebbly, micaceous	11	85
Sand, quartz, very light-gray, N8, medium-grained, lignitic	5	90
Sand, quartz, dark-gray N 3, very fine to fine-grained, well-sorted extremely lignitic, micaceous	9	99
Sand, quartz, olive-gray, 5 Y 3/1, very fine to fine-grained, fairly well-sorted, silty, micaceous, lignitic	11	110
Clay, dark-gray, N 3, silty, sandy, micaceous, lignitic, fossiliferous, calcareous, sparingly glauconitic	10	120
Tertiary:		
Cohansey Sand:		
Clay, light-olive-gray, 5 Y 6/1, silty, lignitic	30	150
Kirkwood Formation:		
Sand, quartz, light-gray, N 7, to medium-dark-gray, N 4, very fine to fine-grained, well-sorted, silty, sparingly micaceous, lignitic, interbedded with clay, dark-gray, N 3, micaceous, lignitic	96	246
Clay, olive-gray, 5 Y 3/1, silty, micaceous, lignitic	24	270
Clay, olive-gray 5 Y 3/1, silty, micaceous, lignitic, interbedded with sand, quartz, yellowish-gray, 5 Y 8/1, very fine-grained, well sorted	32	302
Clay, brownish-black, 5 YR 2/1, quartz and glauconite, sandy, micaceous, lignitic	10	312
Sand, quartz, olive-gray, 5 Y 4/1, very fine to fine-grained, fairly well sorted, silty, micaceous, lignitic	30	342
Clay, medium dark gray, N 4, silty, micaceous, lignitic	8	350
Sand, quartz, light-olive-gray, 5 Y 6/1, fine-grained, well-sorted, micaceous, sparingly fossiliferous, lignitic, sparingly glauconitic	50	400
Rancocas Group (undifferentiated):		
Clay, dark-greenish-gray, 5 GY 4/1, quartz and glauconite, sandy, micaceous, fossiliferous; contains pyrite	20	420
Sand, quartz, olive-gray, 5 Y 4/1, very fine-grained, well-sorted, silty, micaceous, sparingly glauconitic, lignitic, contains pyrite	45	465
Sand, quartz, greenish black, 5 GY 2/1, very fine to medium grained, poorly sorted, clayey, micaceous, very glauconitic	9	474
Sand, quartz, olive-gray, 5 Y 4/1, very fine grained, well-sorted, silty, micaceous, sparingly glauconitic	21	495
Sand, glauconite, olive-gray, 5 Y 3/1, very fine to medium-grained, poorly sorted, clayey, micaceous, calcareous	7	502
Clay, light-olive-gray, 5 Y 6/1, silty, sparingly micaceous, glauconitic	10	512
Sand, quartz, olive-gray, 5 Y 4/1, fine-grained, fairly well-sorted, silty, micaceous, calcareous, glauconitic	28	540

Table 4 – Composite Geologic and Lithologic Log – Continued

Description	Thickness (feet)	Depth (feet)
Tertiary – Continued:		
Rancocas Group (undifferentiated) – Continued:		
Sand, glauconite, greenish-black, 5 GY 2/1, fine-grained, poorly sorted, sparingly micaceous	32	572
Silt, olive-gray, 5 Y 4/1, clayey, micaceous, sparingly fossiliferous, sparingly glauconitic	12	584
Sand, glauconite, olive-gray, 5 Y 3/1, very fine to medium-grained, poorly sorted, clayey, calcareous, fossiliferous, sparingly quartzose	40	624
Silt, olive-gray, 5 Y 4/1, clayey, micaceous, lignitic, sparingly glauconitic	14	638
Sand, glauconite, olive-black, 5 Y 2/1, very fine-grained, well-sorted, silty, fossiliferous, sparingly micaceous, sparingly calcareous, sparingly quartzose	92	730
Sand, glauconite, olive-gray, 5 Y 4/1, fine-grained, fairly well-sorted, clayey, very quartzose, fossiliferous, calcareous	28	758
Sand, glauconite and quartz, dark-greenish-gray, 5 GY 4/1, fine-grained, well-sorted, silty, fossiliferous, calcareous, sparingly micaceous	34	792
Clay, greenish-gray, 5 GY 5/1, very fossiliferous, very calcareous, sparingly glauconitic	13	805
Silt, greenish-gray, 5 GY 6/1, glauconite and quartz, sandy, very fossiliferous, very calcareous	40	845
Clay, greenish-gray, 5 GY 6/1, very calcareous, very fossiliferous, sparingly glauconitic	45	890
Clay, light greenish-gray, 5 GY 7/1, extremely fossiliferous, extremely calcareous, sparingly glauconitic	18	908
Silt, olive-gray, 5 Y 4/1, clayey, lignitic, micaceous, sparingly glauconitic	14	922
Clay, mottled, pale-green, 5 G 8/2, and grayish-green, 5 G 5/2, silty, extremely fossiliferous, very calcareous, sparingly glauconitic	62	984
Clay, dark-greenish-gray, 5 GY 4/1, fossiliferous, calcareous, micaceous, sparingly glauconitic, sparingly lignitic	136	1,120
Silt, olive-gray, 5 Y 3/1, quartz and glauconite, sandy, micaceous, calcareous, fossiliferous; contains pyrite	42	1,162
Cretaceous:		
Red Bank Sand:		
Sand, quartz, olive-gray, 5 Y 4/1, fine-grained, well-sorted, glauconitic, micaceous, lignitic	6	1,168
Sand, quartz, olive-black, 5 Y 2/1, very fine-grained, well-sorted, clayey, micaceous, lignitic	10	1,178
Silt, dark-greenish-gray, 5 GY 4/1, micaceous, fossiliferous, calcareous, glauconitic	12	1,190
Navesink Formation:		
Clay, olive-gray, 5 Y 3/1, calcareous, fossiliferous, micaceous, glauconitic	8	1,198
Clay, greenish-black, 5 GY 2/1, glauconite, sandy, micaceous, calcareous, fossiliferous	3	1,201

Table 4 – Composite Geologic and Lithologic Log – Continued

Description	Thickness (feet)	Depth (feet)
Cretaceous – Continued:		
Navesink Formation:		
Clay, olive-gray, 5 Y 3/1, calcareous, fossiliferous, micaceous, glauconitic; contains pyrite	9	1,210
Clay, dark-greenish-gray, 5 GY 4/1, calcareous, fossiliferous, micaceous, glauconitic; contains pyrite	16	1,226
Mount Laurel Sand:		
Sand, quartz, moderate olive-brown, 5 Y 4/4, medium-grained, well-sorted, glauconitic, calcareous; contains laminae of clay, grayish-black, N 2, micaceous, lignitic	12	1,238
Wenonah Formation:		
Silt, greenish-black, 5 GY 2/1, clayey, micaceous, calcareous, sparingly glauconitic	22	1,260
Sand, quartz, greenish-black, 5 GY 2/1, fine-grained, fairly well-sorted, silty, micaceous, calcareous, glauconitic, lignitic	44	1,304
Sand, quartz, olive-gray, 5 Y 4/1, very fine-grained, poorly sorted, clayey, micaceous, calcareous, fossiliferous, glauconitic, lignitic	26	1,330
Sand, quartz, dark-gray, N 3, very fine-grained, fairly well-sorted, clayey, very micaceous, fossiliferous, calcareous, glauconitic, lignitic	24	1,354
Marshalltown Formation:		
Clay, olive-black, 5 Y 2/1, sandy, very fossiliferous, micaceous, calcareous, sparingly glauconitic; contains pyrite	38	1,392
Sand, quartz and glauconite, greenish-black, 5 GY 2/1, very fine to fine-grained, fairly well-sorted, clayey, micaceous, calcareous, fossiliferous, sparingly lignitic; contains pyrite	26	1,418
Sand, quartz, dark-gray, N 3, very fine-grained, fairly well-sorted, clayey, micaceous, fossiliferous, calcareous, glauconitic, lignitic; contains pyrite	7	1,425
Sand, quartz and glauconite, dark-greenish-gray, 5 GY 4/1, very fine-grained, fairly well-sorted, clayey, micaceous, fossiliferous, calcareous; contains pyrite	9	1,434
Sand, glauconite, dark-greenish-gray, 5 GY 4/1, very fine-grained, fairly well-sorted, clayey, micaceous, calcareous, fossiliferous, quartzose	23	1,457
Limestone, light-greenish-gray, 5 GY 8/1, glauconitic	4	1,461
Sand, quartz, dark-gray, N 3, very fine-grained, fairly well-sorted, clayey, very micaceous, calcareous, fossiliferous, glauconitic, lignitic	23	1,484
Sand, glauconite, greenish-black, 5 GY 2/1, very fine-grained, well-sorted, silty, micaceous, calcareous, fossiliferous, quartzose	11	1,495
Silt, medium-dark-gray, N 4, clayey, micaceous, calcareous, fossiliferous, glauconitic, lignitic; contains pyrite	17	1,512
Sand, glauconite, dark-greenish-gray, 5 GY 4/1, very fine-grained, well-sorted, silty, micaceous, calcareous, fossiliferous, quartzose, interbedded with silt, dark-gray, N 3, glauconite sandy, very micaceous, calcareous, fossiliferous	40	1,552

Table 4 – Composite Geologic and Lithologic Log – Continued

Description	Thickness (feet)	Depth (feet)
Cretaceous – Continued:		
Marshalltown Formation – Continued:		
Silt, greenish-gray, 5 GY 6/1, glauconite, sandy, very fossiliferous, very calcareous, micaceous	12	1,564
Sand, glauconite, dark-greenish-gray, 5 GY 4/1, very fine to medium-grained, poorly sorted, silty, very fossiliferous, very calcareous, quartzose	34	1,598
Woodbury Clay and Merchantville Formation:		
Silt, dusky-green, 5 G 3/2, glauconite sandy, calcareous, fossiliferous; contains pyrite	10	1,608
Clay, dark-greenish-gray, 5 GY 4/1, glauconite and quartz sandy, very fossiliferous, very calcareous, micaceous	20	1,628
Clay, olive-gray 5 Y 3/1, very fossiliferous, very calcareous, micaceous, sparingly glauconitic; contains pyrite	36	1,664
Clay, medium-gray, N 4, glauconite sandy, very fossiliferous, very calcareous, micaceous	31	1,695
Silt, medium-dark-gray, N 4, clayey, very fossiliferous, very calcareous, micaceous, sparingly glauconitic; contains pyrite	59	1,754
Clay, medium-gray, N 5, very fossiliferous, very calcareous, micaceous, sparingly glauconitic; contains pyrite	24	1,778
Silt, dark-gray, N 3, clayey, calcareous, fossiliferous, micaceous, lignitic, sparingly glauconitic; contains siderite nodules	14	1,792
Clay, medium-dark-gray, N 4, glauconite sandy, very calcareous, very fossiliferous, micaceous; contains pyrite	18	1,810
Magothy Formation:		
Sand, quartz, yellowish-gray, 5 Y 8/1, fine-grained, very well-sorted, micaceous; contains laminae of lignite with pyrite	28	1,838
Silt, olive-gray, 5 Y 4/1 to medium-dark-gray, N 4, clayey, quartz and glauconite sandy, micaceous, calcareous, fossiliferous; contains pyrite	50	1,888
Clay, dark-gray, N 3, silty, micaceous, interbedded with sand, quartz, yellowish-gray, 5 Y 9/1, very fine to fine-grained, well-sorted, glauconitic, lignitic; contains siderite nodules	42	1,930
Clay, dark-greenish-gray, 5 GY 4/1, micaceous, calcareous, fossiliferous, interbedded with sand, glauconite, dark-greenish-gray, 5 GY 4/1, very fine to medium-grained, poorly sorted, clayey, quartzose, calcareous, fossiliferous, micaceous. Layers of limestone, light-greenish-gray, 5 GY 8/1, micaceous, fossiliferous, occur at 1,943-1,946, 1,948-1,950, 1,955-1,957, and 1,962-1,964 ft	35	1,965
Sand, quartz, light-gray, N 7, very fine to fine-grained, well-sorted, silty, micaceous, lignitic, sparingly calcareous	21	1,986
Silt, olive-gray, 5 Y 4/1, clayey, calcareous, fossiliferous, micaceous, glauconitic, lignitic; contains pyrite	34	2,020
Silt, light-olive-gray, 5 Y 6/1, micaceous, calcareous, fossiliferous	50	2,070
Raritan Formation:		
Sand, quartz, grayish-orange, 10 YR 7/4, medium-grained, well-sorted, calcarous, glauconitic; contains laminae of white clay	22	2,092
Silt, medium-dark-gray, N 4, clayey, very micaceous, lignitic, calcareous, fossiliferous	76	2,168

Table 4 – Composite Geologic and Lithologic Log – Continued

Description	Thickness (feet)	Depth (feet)
Cretaceous – Continued:		
Raritan Formation – Continued:		
Limestone, light-greenish-gray, 5 GY 8/1, fossiliferous, micaceous	4	2,172
Sand, quartz and glauconite, greenish-gray, 5 GY 5/1, very fine to medium-grained, poorly sorted, clayey, very fossiliferous, very calcareous, micaceous	24	2,196
Silt, light-olive-gray, 5 Y 6/1, clayey, very calcareous, very fossiliferous, micaceous, lignitic, glauconitic	18	2,214
Sand, quartz and glauconite, olive-gray, 5 Y 3/1, very fine to medium-grained, poorly sorted, clayey, very calcareous, fossiliferous, micaceous, lignitic; contains pyrite	30	2,244
Silt, dark-greenish-gray, 5 GY 4/1, glauconite and quartz sandy, very calcareous, very fossiliferous, micaceous; contains siderite nodules	126	2,370
Sand, quartz, yellowish-gray, 5 Y 7/2, mostly coarse-grained. Layers of silt, olive-gray, 5 Y 4/1, glauconite and quartz sandy, calcareous, fossiliferous, micaceous at 2,418-2,421, 2,456-2,459, and 2,471-2,476.	135	2,505
Clay, light-greenish-gray, 5 GY 8/1, quartz and glauconite sandy, silty, calcareous, fossiliferous	17	2,522
Sand, quartz, yellowish-gray 5 Y 7/2, mostly medium-grained; contains thin layers of light-greenish-gray clay and olive-gray silt similar to those above	72	2,594
Clay, medium-light-gray, N 6, to greenish-gray, 5 GY 6/1, silty, sparingly calcareous, sparingly glauconitic	30	2,624
Sand, quartz, yellowish-gray, 5 Y 7/2, mostly coarse-grained	28	2,652
Clay, light-gray, N 7, silty, calcareous, fossiliferous, micaceous, sparingly glauconitic; contains thin layers of shale, black, carbonaceous, micaceous; contains pyrite	64	2,716
Sand, quartz, medium-light-gray, N 6, fine to medium-grained, fairly well-sorted, lignitic, sparingly micaceous, sparingly calcareous; contains siderite nodules and pyrite	42	2,758
Clay, light-gray, N 7, silty, calcareous, fossiliferous, micaceous, sparingly glauconitic, interbedded with sand, quartz, light-gray, mostly medium grained	36	2,794
Clay, light-gray, N 7, silty, micaceous, sparingly lignitic; contains siderite nodules	40	2,834
Sand, quartz, light-gray, N 7, very fine to fine-grained, well-sorted, micaceous, lignitic; contains siderite nodules	12	2,846
Sand, quartz, very-light-gray, N 8, very fine-grained, well-sorted, micaceous, lignitic, interbedded with clay, dark-gray, N 3, micaceous, very lignitic, sparingly calcareous	44	2,890
Sand, quartz, medium-light-gray, N 6, finely laminated in all sizes, micaceous, lignitic; contains siderite nodules and pyrite	24	2,914
Sand, quartz, light-gray, N 7, fine-grained, fairly well-sorted, clayey, micaceous; contains siderite nodules	34	2,948
Sand, quartz, light-gray, N 7, medium to coarse-grained, poorly sorted, micaceous	27	2,975

Table 4 – Composite Geologic and Lithologic Log – Continued

Description	Thickness (feet)	Depth (feet)
Cretaceous – Continued:		
Raritan Formation – Continued:		
Clay, light-gray, N 7, micaceous; contains siderite nodules, interbedded with sand, quartz, light-brownish-gray, 5 YR 6/1, medium to very coarse-grained, fairly well-sorted, sparingly lignitic; contains pyrite	33	3,008
Sand, quartz, yellowish-gray, 5 Y 8/1, fine-grained, very well-sorted, lignitic, sparingly micaceous; interbedded with clay medium-gray, N 5, micaceous, lignitic, sparingly calcareous	38	3,046
Clay, medium-dark-gray, N 4, micaceous, lignitic, interbedded with sand, quartz, medium-gray, N 5, very fine to fine-grained, well-sorted, micaceous, lignitic, sparingly calcareous	40	3,086
Sand, quartz, medium-light-gray, N 6, fine to medium-grained, well-sorted, micaceous, lignitic, very sparingly calcareous; contains siderite nodules	16	3,102
Clay, light-gray, N 7, micaceous; contains siderite nodules and limonite stains	64	3,166
Sand, quartz, medium-light-gray N 6, medium-grained, well-sorted, micaceous, lignitic, sparingly calcareous; contains siderite	26	3,192
Clay, light-gray, N 7 to dark-gray N 3, slightly micaceous, lignitic; contains siderite nodules and pyrite, mottled with clay, dusky-red, 5 R 3/4, sparingly micaceous, sparingly calcareous; contains siderite nodules	192	3,384
Sand, quartz, light-gray, N 7, very fine to fine-grained, fairly well-sorted, micaceous, sparingly lignitic, sparingly calcareous, interbedded with sand, quartz, very light-gray, N 8, fine-grained, very well-sorted, sparingly micaceous, sparingly lignitic; contains siderite nodules	60	3,444
Clay, light-olive-gray, 5 Y 6/1 to olive-gray, 5 Y 4/1, micaceous, lignitic	42	3,486
Sand, quartz, very light-gray, N 8, very fine to very coarse-grained, poorly sorted, micaceous, lignitic, sparingly calcareous	13	3,499
Clay, mottled light-gray, N 7 and dusky-red, 5 R 3/4, sparingly micaceous, sparingly lignitic; contains siderite nodules and pyrite	13	3,512
Sand, quartz, very light-gray, N 8, very fine to coarse-grained, poorly sorted, micaceous, lignitic, interbedded with clay, medium-light-gray, N 6, calcareous, micaceous	31	3,543
Shale, black, carbonaceous, micaceous; contains pyrite	3	3,546
Sand, quartz, very light-gray, N 8, medium-grained, fairly well sorted, micaceous, very lignitic; quartz grains coated with white clay	98	3,644
Shale, black, carbonaceous, micaceous; contains pyrite	3	3,647
Sand, quartz, medium-gray, N 5, very fine to fine-grained, well-sorted, micaceous, lignitic, calcareous, interbedded with clay, light-gray, N 7 to medium-dark-gray, N 4, micaceous, lignitic, sparingly calcareous	85	3,732
Clay, light-gray, N 7, sparingly micaceous; contains siderite nodules and limonite streaks	10	3,742

Table 4 – Composite Geologic and Lithologic Log – Continued

Description	Thickness (feet)	Depth (feet)
Cretaceous – Continued:		
Raritan Formation – Continued:		
Sand, quartz, medium-gray, N 6, very fine to fine-grained, well-sorted, micaceous, lignitic, calcareous, interbedded with clay, light-gray, N 7, micaceous, sparingly lignitic; contains siderite nodules	36	3,778
Clay, multicolored in shades of light-gray, N 7, medium light-gray, N 6, and dusky-red, 5 R 3/4, sparingly micaceous; contains siderite nodules, limonite and hematite	20	3,798
Early Paleozoic or Precambrian:		
Biotite Gneiss:		
Biotite gneiss, highly weathered	64	3,862
Biotite gneiss, unweathered	29	3,891

Radioactivity and Electric logs to a depth of 3891 feet and cores to a depth of 2300 feet are from test hole 1. The cores below 2300 feet are from test hole 2.

Figure 5. – Composite log of test holes 1 and 2 at Island Beach State Park.