Geohydrologic Appraisal of Water Resources of the South Fork, Long Island, New York

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 2073

Prepared in cooperation with the
Suffolk County Water Authority and
Suffolk County Department of Health Services

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By BRONIUS NEMICKAS *and* EDWARD J. KOSZALKA

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UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1982

UNITED STATES DEPARTMENT OF THE INTERIOR

JAMES G. WATT, *Secretary*

GEOLOGICAL SURVEY

Dallas L. Peck, *Director*

Library of Congress Cataloging in Publication Data
Nemickas, Bronius
Geohydrologic appraisal of water resources of the South Fork, Long Island, New York
(Geological Survey Water-Supply Paper 2073)
Bibliography: p. 54
1. Water, Underground—New York (State)—Long Island. 2. Geology—New York (State)—Long Island.
I. Koszalka, Edward J., joint author. II. Suffolk Co., N.Y. Water Authority.
III. Suffolk C., N.Y. Dept. of Health Services. IV. Title. V. Series: United States Geological Survey Water-Supply Paper 2073
GB1025.N7N45 553.7'9'0974721 80-607922

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402

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CONVERSION FACTORS

Inch-pound unit	*Mulitply by*	*To obtain SI unit*
inch (in)	25.4	millimeter (mm)
feet (ft)	0.3048	meter (m)
mile (mi)	1.61	kilometer (km)
square mile (mi^2)	2.59	square kilometer (km^2)
gallon (gal)	3.785	liter (L)
million gallons (Mgal)	3785	cubic meter (m^3)
million gallons per day (Mgal/d)	3785	cubic meter per day (m^3/d)
gallon per minute (gal/min)	0.06309	liter per second (L/s)
gallon per minute per foot (gal/min/ft)	0.207	liter per second per meter ((L/s)/m)
foot per day (ft/d) (m/d)	0.3048	meter per day
square foot per day (ft^2/d)	0.0929	square meter per day (m^2/d)
micromho (μmho)	1.0	microsiemens (μS)

GEOHYDROLOGIC APPRAISAL OF WATER RESOURCES OF THE SOUTH FORK, LONG ISLAND, NEW YORK

By BRONIUS NEMICKAS and EDWARD J. KOSZALKA

ABSTRACT

The ground-water resources of the South Fork of Long Island, N.Y., were investigated from April 1974 to September 1977. The study area encompasses 137 square miles and includes the eastern part of the Town of Southampton and the entire Town of East Hampton.

The South Fork consists of a Paleozoic basement complex that is overlain by Cretaceous and Pleistocene sediments. The surficial material is composed of Late Wisconsinan glacial and glaciofluvial deposits in association with beach and marsh deposits of Recent age. Till underlies most of the eastern part of the South Fork.

Precipitation is the sole source of fresh ground water on the South Fork. Average annual precipitation recorded at Bridgehampton from 1931-76 is 45 inches; about half this amount reaches the ground-water reservoir. It is estimated that overland runoff amounts to 0.5 inches per year, and evapotranspiration is 23 inches per year. Thus, recharge equals approximately 22 inches per year.

Hydraulic conductivity and transmissivity of the Magothy (Cretaceous) and upper glacial (Pleistocene) aquifers on the South Fork were estimated from aquifer tests and specific-capacity data. The average horizontal hydraulic conductivity of the Magothy aquifer is 70 feet per day, and of the upper glacial aquifer 350 feet per day. Transmissivity of the Magothy aquifer on the South Fork ranges from 600 to 24,100 feet squared per day; transmissivity of the upper glacial aquifer ranges from 5,400 feet to 22,700 feet squared per day. No potable water is available from the underlying Lloyd aquifer.

The position of the freshwater to saline-water interface is depicted in maps. In the southern part of the area, the freshwater reservoir follows the Ghyben-Herzberg principle, but in the northern part, the depth to interface is less than expected owing to a greater degree of anisotropy of the geologic units.

Total public-supply pumpage on the South Fork is estimated to be about 3 Mgal/day, (million gallons per day). Public-supply withdrawls in 1976 averaged 2.75 Mgal/day; of this amount, 2.55 Mgal/day was withdrawn from the upper glacial aquifer, and 0.17 Mgal/day from the Magothy aquifer.

Ground water and fresh surface water on the South Fork are generally of suitable quality for drinking and most other uses. However, some substances, for example, iron, chloride, and nitrate, may occur locally in objectionable concentrations.

INTRODUCTION

The eastern end of Long Island, N.Y., is known locally as the South Fork. All water for public supply, irrigation, industrial, and commercial use on South Fork is obtained from ground water. To facilitate proper development of this natural resource and to protect its chemical quality, the ground-water environment and its hydrologic and chemical characteristics must be thoroughly understood.

PURPOSE AND SCOPE

From April 1974 through September 1977, the water resources of the South Fork were investigated to (1) compile and evaluate hydrologic and geologic data relating to availability, occurrence,sources, and movement of ground water; (2) define and evaluate thickness, areal extent, and hydraulic characteristics of the aquifers; (3) delineate the freshwater saline-water interface surrounding the peninsula; and (4) evaluate the chemical quality of ground water within the area. The study was conducted by the U.S. Geological Survey in cooperation with the Suffolk County Water Authority and the Suffolk County Department of Health Services.

LOCATION AND GEOGRAPHY OF THE SOUTH FORK

The South Fork lies within Suffolk County between long 71°50′ and 72°35′ W., and lat 40°50′ and 41°06′ N. It contains 137 square miles and encompasses the Town of East Hampton and the eastern part of the Town of Southampton. The South Fork is bounded on the north by Great Peconic Bay, on the east by Gardiners Bay, on the south by the Atlantic Ocean, and on the west by Shinnecock Bay and Great Peconic Bay. The location and major geographic features of the South Fork are shown in figure 1.

PHYSIOGRAPHY, TOPOGRAPHY, AND GEOLOGY

All of Long Island is in the Atlantic Coastal Plain physiographic province of the United States. The physiographic features of the South Fork may be grouped into five geomorphic units: (1) the Ronkonkoma moraine, (2) kame deposits north of the moraine, (3) the south-sloping outwash plain, (4) the dune, spit, and tombolo complex to the east, and (5) shoreline and barrier beaches. The locations and extent of these features are shown on plate 1.

The moraine of the Ronkonkoma Drift forms an irregular ridge along the north and central parts of the South Fork and reaches a maximum altitude of about 300 feet near Noyack (pl. 1). The moraine is trans-

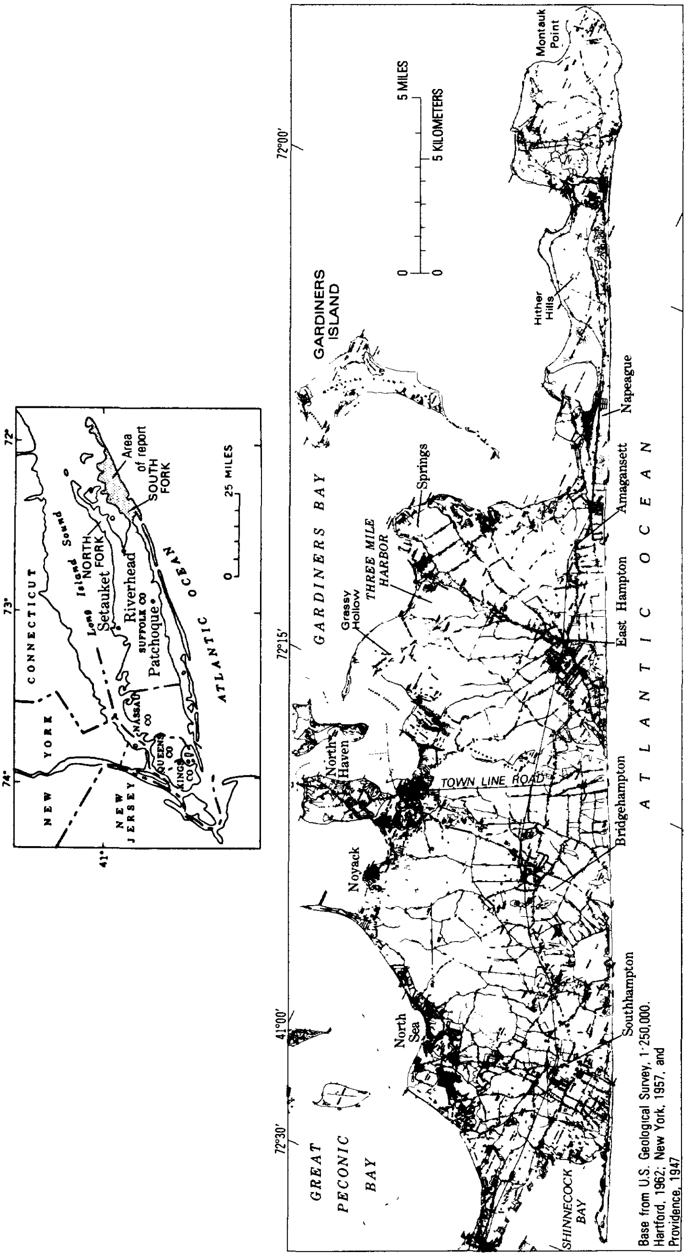

FIGURE 1.—Location and major geographic features of the South Fork, Suffolk County, Long Island, N.Y.

sected in several places by channels having altitudes of 50 feet or less; these channels mark former spillways of the southward flowing glacial-meltwater streams. North of the moraine are kame deposits, particularly at North Haven and Grassy Hollow (fig. 1). These deposits reach a maximum altitude of about 100 feet and mark areas of disintegrated, stagnant ice. An outwash plain slopes southward from the moraine to the shore, barrier beaches, and ocean. This outwash plain reaches a maximum altitude of 150 feet north of Bridgehampton.

East of Amagansett and along the north shore of the South Fork (fig. 1) are spits and tombolo complexes that reach altitudes as high as 20 feet. These are continually formed and reshaped by the westerly longshore drift along the south shore and the easterly currents along the north shore.

POPULATION

Total population of the South Fork in 1970 is estimated to have been 26,776 (Nassau-Suffolk Regional Planning Board, 1976). The populations of the Town of East Hampton and the eastern part of the Town of Southampton as estimated for 1970, 1975, and 1995 are listed in table 1. In 1970 the residential-population density of East Hampton was 0.24 per acre and of the eastern part of Southampton was about 0.40 per acre. The residential-population density in 1995 is predicted to be 0.56 per acre in East Hampton and 0.84 per acre in eastern Southampton.

The above figures and estimates do not include the part-time residents and toursists, which substantially increase the total population and water demands during summer. The number of part-time and summer residents is unknown.

TABLE 1.—*Population estimates for the South Fork, Suffolk County, N.Y.*

[Estimates from Nassau-Suffolk Regional Planning Board, 1976]

Year	Town of East Hampton	Eastern part of Town of Southampton	Total for South Fork
1970	10,980	15,796	26,776
1975	13,053	17,538	30,591
1995	25,637	27,540	53,177

WATER USE

Ground water is the only source of water supply to the residents of the South Fork. Most of the water is obtained from the upper glacial (water-table) aquifer; the rest is obtained from the Magothy (deep) aquifer. At present, seven water companies supply water to various parts of the South Fork; these companies are Suffolk County Water Authority; Bridgehampton Water Company, Milford Lane Associate, Colony Beach Front Association, Panoramic Apartments, Town Point Water Company, and Surfside Water Company. These companies supply about 8,700 service units.

Total public-supply pumpage on the South Fork is estimated to be 3 Mgal/day; in 1976, total public-supply withdrawal was 2.72 Mgal/day. In 1976, 2.55 Mgal/day was withdrawn from the upper glacial aquifer and 0.17 Mgal/day from the Magothy aquifer. Table 2 shows the estimated major withdrawals for public water supply on the South Fork from 1970 to 1976, by aquifer.

The two major aquifers that underlie the South Fork are capable of producing larger quantities of water than are currently being withdrawn. The upper glacial aquifer is the most readily available source for supplying additional water needs in the area. If this source should prove inadequate for a particular need, wells could be drilled to the underlying Magothy aquifer in the central part of South Fork.

METHODS OF INVESTIGATION

An inventory of wells on the South Fork was conducted to locate observation wells for water-level measurements and water-quality sampling and to establish sites for additional wells to complete an observation-well network.

Data on ground-water levels were collected in April and October of 1974, 1975, and 1976 from 206 observation wells screened in the upper

TABLE 2.—*Estimated major public-supply withdrawals on the South Fork, Suffolk County, N.Y., 1970–76*

[Records from New York State Department of Environmental Conservation]

Well owner	Location	Aquifer[1]	Pumpage, in million gallons per day						
			1970	1971	1972	1973	1974	1975	1976
Suffolk County Water Authority.	East Hampton[2]	G	0.63	0.73	0.58	0.86	0.97	1.30	1.49
		M	---	.01	.18	.06	.06	.08	.04
Suffolk County Water Authority	Southampton	G	.77	.61	.57	.47	.49	.53	.57
		M	---	.15	.14	.28	.30	0.13	.13
Suffolk County Water Authority.	Sag Harbor	G	.27	.30	.27	.28	.25	.29	.34
Amagansett Water Company.[3]	Amagansett	G	.24	.33	.24	.47	.26	---	---
Bridgehampton Water Company.	Bridgehampton	G	.09	.09	.13	.14	.14	.12	.12
Montauk Water Company.[4]	Montauk	G	.20	.24	.18	.07	---	---	---
Montauk Air Force Base.	Montauk	G	.03	.03	.03	.03	.03	.03	.03
Total		G	2.23	2.33	2.00	2.18	2.14	2.36	2.55
		M	---	.16	.32	.34	.36	.21	.17

[1]G, upper glacial aquifer; M, Magothy aquifer.
[2]Includes service previously operated by Amagansett and (or) Montauk Water Companies.
[3]Service taken over by Suffolk County Water Authority in May 1974.
[4]Service taken over by Suffolk County Water Authority in May 1973.

glacial aquifer (pl. 2); these data were compiled to make a water-table map (pl. 4). All wells were measured on reference to National Geodetic Vertical Datum (NGVD) of 1929.

The observation-well program entailed drilling 30 water-table wells and 21 wells at the freshwater to saline-water interface to collect geologic information, water-level data, and water-quality data. The drilling was conducted by the U.S. Geological Survey, the Suffolk County Department of Environmental Control, and the Delta Well Company.

Both ground water and surface water of the area were analyzed for physical and chemical properties. Chemical analyses of water samples from 51 wells and 20 stream sites in the area are listed in tables 2 and 3 in the report by Nemickas, Koszalka, and Vaupel (1977); the analyses were made by the U.S. Geological Survey laboratory in Albany, N.Y.

Geophysical logging was done to assist in subsurface geologic mapping, in lithologic differentiation, and in location of the freshwater to saline-water intersurface.

Samples of till were collected for analysis of mineral composition and paritcle-size distribution and to assist in reconstruction of the geologic history.

PREVIOUS INVESTIGATIONS

The geology of the South Fork was first reported by Fuller (1914) who included a surficial geologic map and descriptive information on the Pleistocene units. Information on the subsurface geology of the South Fork was presented by Suter, de Laguna, and Perlmutter (1949). Since these early studies, many other investigations have provided information on the geology and hydrology of the South Fork; one of these is by Perlmutter and DeLuca (1963), who investigated the hydrogeology of the area around the Montauk Point Air Force Base. Holzmacher, McLendon, and Murrel (1968) described the water resources of the South Fork. Jensen and Soren (1974) presented maps describing the hydrology and geology of Suffolk County. Neiter, Nemickas, Koszalka, and Newman (1975) described the Pleistocene deposits of the South Fork, and Berkebile and Anderson (1975) described the hydrogeology of Town of Southampton. The report by Bart and others (1976) contains hydrologic data on the South Fork, and the report by Nemickas, Koszalka, and Vaupel (1977) contains a 1975 water-table map and basic data on hydrogeology of the South Fork.

ACKNOWLEDGMENTS

The authors acknowledge the cooperation and assistance of the Suffolk County Water Authority and Suffolk County Department of Health Services in data collection. Thanks are also extended to State

and municipal officials, Princeton University, well drillers, groundwater consultants, and private individuals who supplied assistance in the field and some of the data on which this report is based.

GEOLOGY

STRATIGRAPHY

The South Fork is underlain by unconsolidated deposits of Cretaceous and Quaternary age that rest unconformably on the Precambrian(?)–Upper Paleozoic(?) basement complexes (fig. 2). The Upper Cretaceous deposits include, in ascending order, (1) the Raritan Formation, which consists of the Lloyd Sand Member and an overlying clay member, (2) the Magothy Formation–Matawan Group, undifferentiated, and (3) the Monmouth Group. Except for the Monmouth Group, which occurs only at the eastern edge of the South Fork, the three units are continuous throughout the study area (fig. 2).

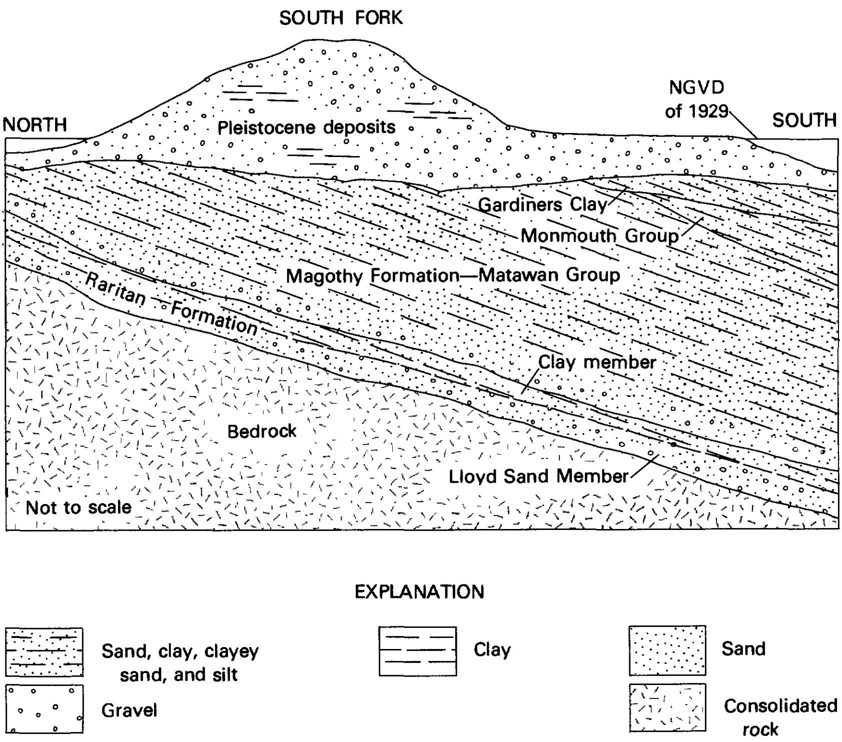

FIGURE 2.—Generalized geologic section of the South Fork, Suffolk County, Long Island, N.Y.

The Cretaceous deposits are overlain by Pleistocene deposits consisting of (1) Gardiners(?) Clay (marine clay), (2) the Montauk Till Member of the Manhasset Formation, (3) the Ronkonkoma drift, and (4) loess (Nieter and others, 1975). The surficial geologic units consist of Pleistocene and Holocene (Recent) deposits (pl. 1). The Holocene units consist of beach and marsh deposits throughout the area, and artificial fill at certain locations. Table 3 summarizes the geologic units and the corresponding hydrogeologic units on the South Fork.

BEDROCK

No wells or test borings on the South Fork have reached bedrock. A map (pl. 5*A*) showing the configuration of the bedrock surface was extrapolated from Jensen and Soren (1974), who used well- and test-boring data from the North Fork and the area west of Shinnecock Canal (fig. 1). The data suggest that the bedrock consists predominantly of gneiss and schist and may be correlative with the bedrock complex of Connecticut. Depth to bedrock increases to the southwest along the length of the South Fork from less than 1,000 feet to more than 1,500 feet below National Geodetic Vertical Datum (pl. 5*A*).

A sample of bedrock from a test boring on the North Fork was dated at 254 ± 9 million years by the potassium-argon (K-Ar) method (Pierce and Taylor, 1975). Bedrock underlying the South Fork is probably of the same age, which would place it in the late Paleozoic era and the middle of the Permian Period. However, this method of radiometric dating may give erroneous results; for example, if the rock unit was reheated during an event, such as the formation of the Atlantic Ocean (approximately 200 million years ago), the escape of argon (Ar) gas at the time of reheating would indicate the rock unit to have originated at this time.

RARITAN FORMATION

The Raritan Formation, of Late Cretaceous age, has been correlated with the Raritan Formation of New Jersey. It is divided into the Lloyd Sand Member, which overlies bedrock, and an unnamed clay member that overlies the Lloyd Sand Member (fig. 2). Only one well on the South Fork has penetrated the Raritan Formation.

A map showing the altitude of the top of the Lloyd Sand Member in Suffolk County was prepared by Jensen and Soren (1974); its altitude

TABLE 3.—*Summary of geologic and hydrogeologic units on the South Fork, Suffolk County, N.Y.*

System	Series	Geologic Unit	Hydrogeologic unit
Quaternary	Holocene	Recent shore, beach, salt-marsh deposits, and artificail fill.	Upper glacial aquifer.
	Pleistocene	Glaciofluvial deposits. Moraine and outwash deposits (Ronkonkoma Drift) Montauk Till Member of the Manhasset Formation	
		UNCONFORMITY?	
		Gardiners(?) Clay (Marine clay).	Gardiners(?) Clay.
		UNCONFORMITY?	
		Post-Cretaceous(?) deposits.	Upper glacial aquifer.
Cretaceous	Upper Cretaceous	UNCONFORMITY?	
		Monmouth Group.	Monmouth greensand.
		UNCONFORMITY?	
		Magothy Formation–Matawan Group (undifferentiated).	Magothy aquifer.
		UNCONFORMITY	
		Raritan Formation. Clay member.	Raritan clay.
		Lloyd Sand Member.	Lloyd aquifer.
Paleozoic and Precambrian		UNCONFORMITY	
		Bedrock.	Bedrock.

on the South Fork is shown on plate 5*B*. The altitude, extrapolated from well data west of the study area and from the North Fork, decreases to the southwest from about 700 to 1,200 feet below sea level. The Lloyd Sand Member has an estimated thickness of 200 to 300 feet and is thickest in the Southwestern part of the study area. The one well that has penetrated the Lloyd Sand Member is S31037. (See hydrogeologic sec. C–C′, pl. 3.) The lithology was described as a fine, light-gray sand (Holzmacher and others, 1968).

Jensen and Soren (1974) also presented a map showing the altitude of the top of the unnamed clay member of the Raritan Formation in Suffolk County; its altitude on the South Fork is shown on plate 5*C*. The structural contours were extrapolated from data obtained at other areas of eastern Long Island. The top to the clay member decreases in altitude to the southwest from about 600 to 1,000 feet below sea level. The clay member has an estimated thickness of 100–200 feet and is thickest in the southwestern part of the study area.

The name "clay member" is misleading because the composition of this member varies throughout Long Island. Core descriptions of well S31037 (pl. 2) show the "clay member" to consist of dark gray and brown clay with some medium, light-brown sand.

MAGOTHY FORMATION-MATAWAN GROUP

The Magothy Formation–Matawan Group overlies the Raritan Formation and is overlain by the Monmouth Group of Late Cretaceous age (fig. 2). On the South Fork, only one well (S31037, pl. 3, sec. C–C′) has penetrated the full thickness of the Magothy–Matawan unit.

The altitude of the top of the Magothy–Matawan unit on the South Fork is shown on plate 5*D*; its contours differ from those published in Jensen and Soren (1974) in that a deep channel south of Gardiners Island, indicated by recent test holes and wells, is depicted. Test holes west of Three-Mile Harbor and at Hither Hills State Park (fig. 1) show the Magothy-Matawan surface to be more than 325 feet and 348 feet below sea level, respectively. Because the Magothy-Matawan unit was fully penetrated by only one well on the South Fork, its thickness there can only be approximated. The Magothy is thickest (800 feet) in the western part of the study area and thinnest (400 ft) in the channel area south of Gardiners Island (pl. 5*D*).

The Magothy-Matawan unit consists of beds of poorly sorted quartzose sand interbedded with silt and clay. Some of the clay beds are as thick as 40 feet, and many contain lignite. Pyrite and iron oxide concretions are ubiquitous in this formation.

MONMOUTH GROUP

The Monmouth Group, which unconformably overlies the Magothy-Matawan sequence and is unconformably overlain by Pleistocene deposits (fig. 2), is Late Cretaceous in age and has been correlated with the Monmouth Group of New Jersey (Perlmutter and Todd, 1965). This correlation was based on the identification of microfossils within the unit.

The Monmouth Group underlies most of the southern edge of Suffolk County but, in general, is not present on the South Fork (Jensen and Soren, 1974, sheet 1). The approximate areal extent of the Monmouth Group on the South Fork is shown on plate 5*E*.

On the South Fork, the Monmouth Group consists predominatly of glauconitic sand and clay. The glauconite gives the unit a greenish hue; hence, as a hydrogeologic unit, the group has been called the Monmouth greensand (Jensen and Soren, 1974). The glauconite content ranges from 20 to 95 percent of the total mineral content in some beds (Perlmutter and Todd, 1965), and the particles take one of two forms —an accordian shape or a kidney shape. On the South Fork, the kidney shape predominates. The presence of glauconite indicates that the depositional environment was marine with very slow sedimentation, such as current-swept bank tops (Berner, 1971).

Along the southern edge of Suffolk County, the unit contains numerous species of Foraminifera; specimens taken from cores and well cuttings were identified and described by Perlmutter and Todd (1965). No Foraminifera were found in well cuttings from this unit on the South Fork during the present study.

POST-CRETACEOUS(?) DEPOSITS

On some areas of the South Fork, a sand and gravel unit unconformably overlies the Cretaceous deposits and underlies a marine clay called the Gardiners(?) Clay in this report. The unit resembles a glaciofluvial deposit and consists predominantly of fine to coarse, brown sand. It ranges in thinkness from 20 to 140 feet (pl. 3, sec. *D–D′*). The areal extent of this unit is unknown because it was found in only two wells, S59793 and S60177 (pl. 2).

The exact age of this deposit is uncertain. The unit may be Early Wisconsinan, if the Gardiners(?) Clay is an interstadial deposit, or it may be pre-Sangamon if the clay is an interglacial unit.

GARDINERS(?) CLAY

In some areas of the South Fork, a fossiliferous marine clay unconformably overlies the Magothy-Matawan sequence, the Monmouth Group, and (or) some Post-Cretaceous(?) deposits. This marine clay is in turn overlain unconformably by Pleistocene deposits of the Wisconsin Glaciations. In this report the unit is defined as the Gardiners(?) Clay. Previous reports have given varying definitions of its lithology and mode of formation.

Fuller (1914) first defined and described this unit as a fossiliferous clay on Gardiners Island and restricted use of that name to an interglacial period. MacClintock and Richards (1936) visited the Gardiners Island locality and confirmed the presence of interglacial fauna. However, deLaguna (in Suter and others, 1949), although confirming the findings of MacClintock and Richards, found that the clay on Gardiners Island is lacustrine, rather than marine. Upson (1966, 1970) reported that many of the silts and clays on the eastern part of Long Island are lacustrine, and not marine, and are, therefore, glacial rather than interglacial. To compound the problem, an exposure of clay, defined as Gardiners Clay, north of Bridgehampton was studied by Gustavson (1972), who found that the deposition took place during an interglacial period. This exposure no longer exists; however, samples of well cuttings and cores from recent test drilling in the area substantiate the probable presence of the Gardiner's Clay in the subsurface.

A map showing the approximate limit of the Gardiners(?) Clay on the South Fork is shown on plate 5*E*. The altitude of the top of the unit ranges from 37 to 84 feet below sea level, and its thickness ranges from 40 to 60 feet.

The Gardiners(?) Clay consists of a brown to grayish-green sandy clay; the color variation is due to the glauconite content. The fossil content of the unit varies locally.

MONTAUK TILL MEMBER OF THE MANHASSET FORMATION

The Montauk Till Member of the Manhasset Formation underlies some of the northern and eastern areas of the South Fork (fig. 3). The unit is exposed along the bluffs east of the Village of Montauk (figs. 2, 4), and is exposed in gravel pits and landfills. The areal extent of the till (fig. 3) is extrapolated from driller's logs, geophysical logging, and outcrops. The unit is discontinuous and appears to be displaced in some areas (Nieter and others, 1975); it ranges in thickness from 10 feet to more than 50 feet. The Montauk Till Member contains unsorted deposits of boulders, gravels, sands, silts, and clays; it is overlain in most places by stratified glaciofluvial deposits (fig. 5). When

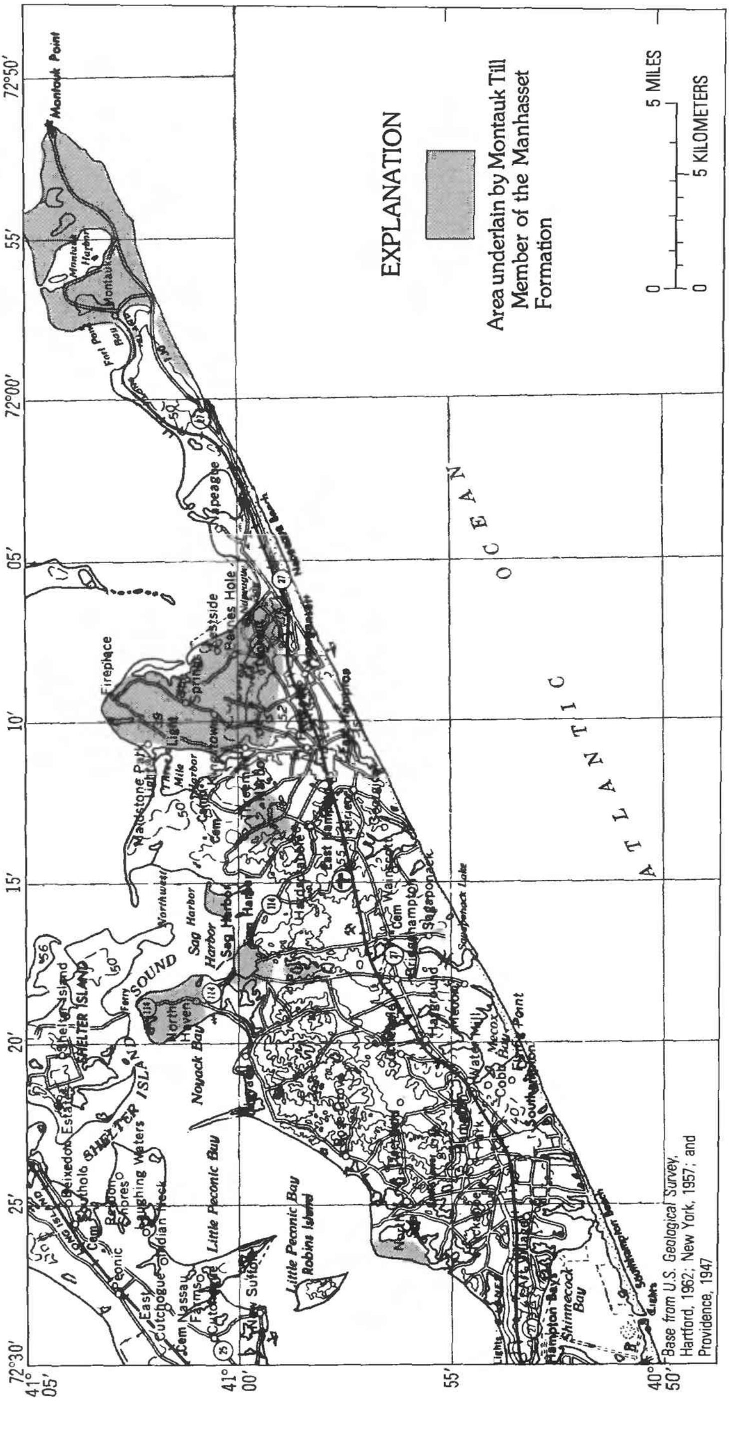

FIGURE 3.—Approximate areal distribution of Montauk Till Member of the Manhasset Formation on the South Fork, Suffolk County, Long Island, N.Y.

FIGURE 4.—Outcrop of Montauk Till Member of the Manhasset Formation east of Village of Montauk, on the South Fork, Suffolk County, Long Island, N.Y.

weathered, the Montauk Till Member takes on a "hoodoo" appearance as seen in figure 6.

Nieter, Nemickas, Koszalka, and Newman (1975) suggested that because the till west of Napeague (fig. 1) differs in composition from that at Montauk, it may also differ in age. They suggested (p. 139) that the till to the west was of late Wisconsinan age; whereas the Montauk Till, Member of the Manhasset Formation, was early Wisconsinan. This could coincide with the lobate model of the Wisconsin Glaciation proposed by Sirkin and Mills (1975). However, the authors believe from petrographic and heavy-mineral analyses described in the following paragraphs that the till west of Napeague is correlative with the Montauk Till Member at Montauk.

Nine samples of till were collected and analyzed for size distribution and heavy-mineral identification. Four samples of the Montauk Till Member were collected at Montauk; the others were collected at exposures west of Napeague. The locations of the sampling sites are shown in figure 7. The samples were collected by driving a 1.5-inch-diameter pipe into freshly exposed till (fig. 6) and were analyzed in a Geological Survey laboratory.

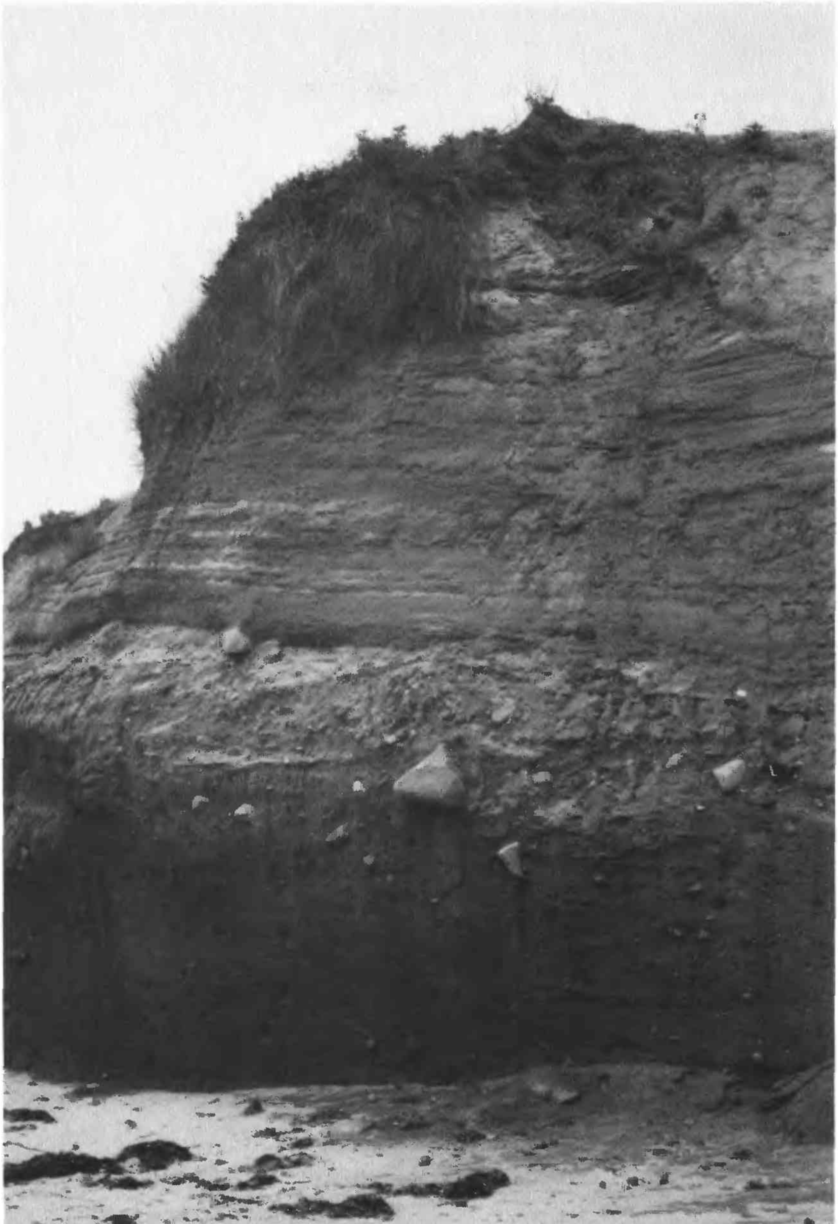

FIGURE 5.—Outcrop of Montauk Till Member of the Manhasset Formation and overlying stratified glaciofluvial deposits on the South Fork, Suffolk County, Long Island, N.Y.

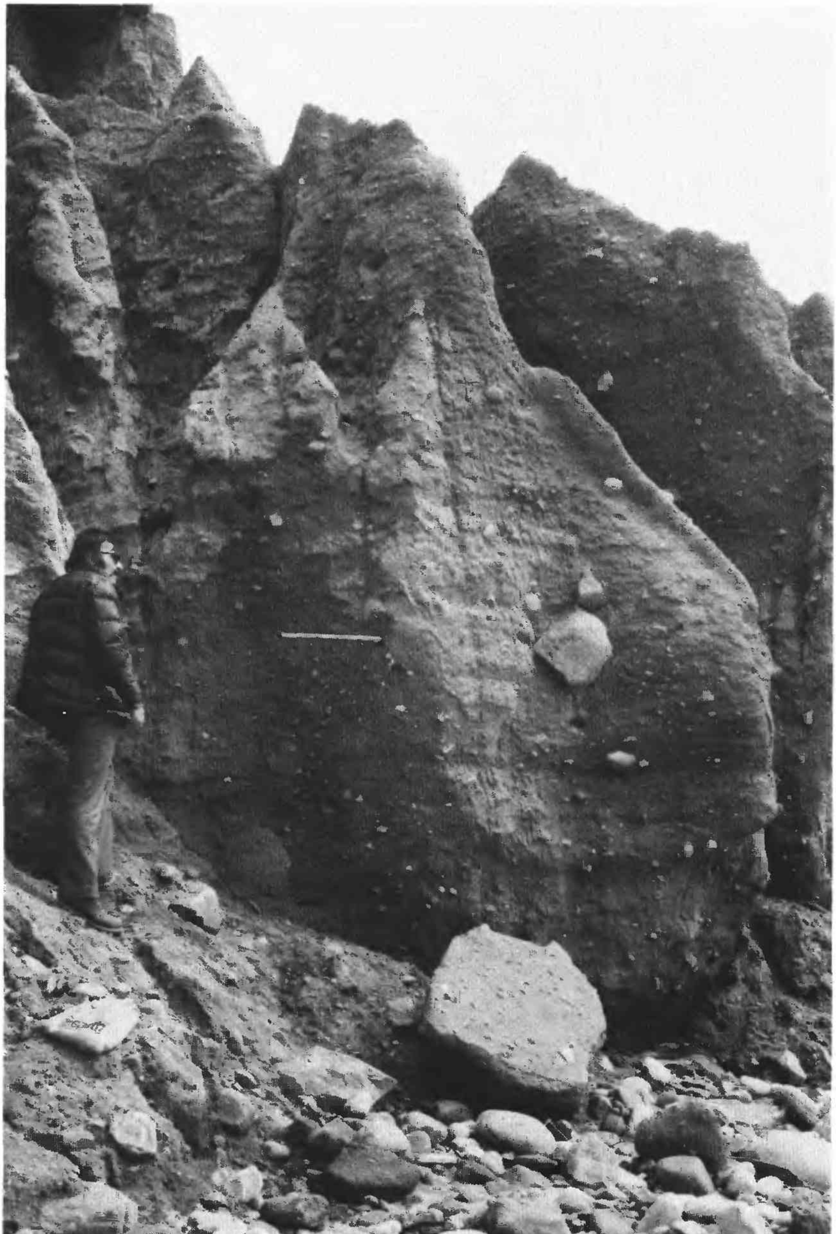

FIGURE 6.—"Hoodoo" appearance on weathered surface of Montauk Till Member of the Manhasset Formation on the South Fork, Suffolk County, Long Island, N.Y.

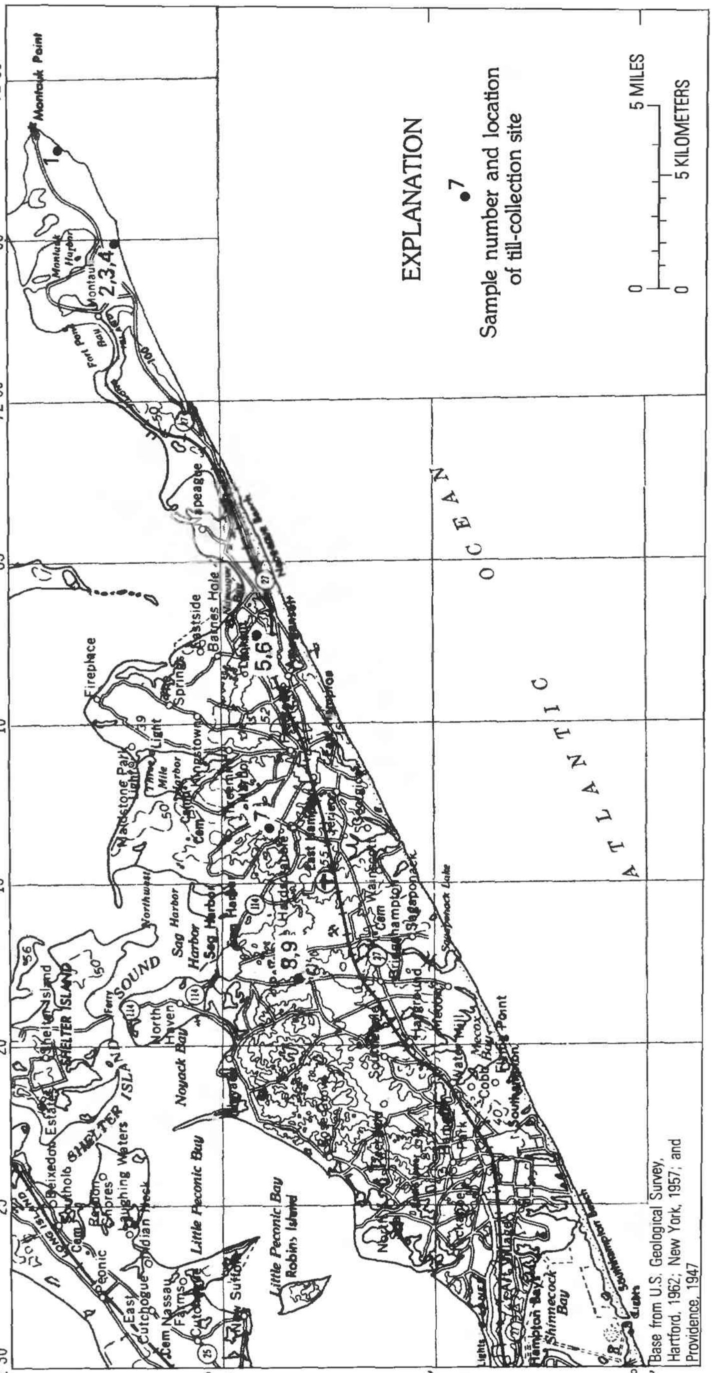

FIGURE 7.—Locations of till-collection sites, Montauk and Napeague vicinity, South Fork, Suffolk County, Long Island, N.Y.

Results of the size analyses are given in table 4 and are plotted on a triangular diagram in figure 8. The nomenclature used in figure 8 is from Shepard (1954). As the plot (fig. 8) indicates, the Montauk samples are slightly more silty or clayey than those from the other sites. A mean-size comparison of the till samples (Nos. 1–4) from Montauk with those from west of Napeague (Nos. 5–9) are plotted as cumulative curves in figure 9. The distribution of the sand-size fraction of the samples from Montauk (Nos. 1–4) and Napeague (Nos. 5–9) are similar, but the Montauk samples (Nos. 1–4) have a greater clay- and silt-size fraction.

TABLE 4.—*Percentage of particle sizes in unconsolidated till samples from the South Fork, Suffolk County, N.Y.*

[Particle-size diameters are in millimeters, all other values are in percent]

Sample Nos.[1]	Clay sizes (<0.004)	Silt sizes (0.004–0.0625)	Sand sizes: Very fine 0.0625–0.125	Sand sizes: Fine 0.125–0.25	Sand sizes: Medium 0.25–0.5	Sand sizes: Coarse 0.5–1	Sand sizes: Very coarse 1–2	Gravel sizes: Very fine 2–4	Gravel sizes: Fine 4–8	Gravel sizes: Medium 8–16	Gravel sizes: Coarse 16–32	Gravel sizes: Very coarse 32–64
1	11.6	14.1	11.5	13.4	21.7	14.2	5.4	4.0	3.9	0	0	0
2	11.0	15.7	11.6	11.0	20.5	14.3	5.8	2.5	3.8	3.7	0	0
3	16.7	21.5	10.0	13.0	11.9	15.0	2.3	1.8	1.5	6.3	0	0
4	16.9	20.4	9.8	10.1	16.4	10.1	4.0	2.3	1.6	8.6	0	0
5	8.4	7.4	5.3	11.5	16.0	19.1	4.7	3.1	3.6	10.5	10.5	0
6	7.9	8.8	7.5	15.1	19.8	23.8	7.2	3.5	3.4	3.1	0	0
7	7.8	11.5	8.4	15.8	16.4	21.2	4.3	2.5	3.6	8.5	0	0
8	4.0	9.4	7.9	13.3	26.9	19.4	8.3	3.5	3.1	4.1	0	0
9	3.6	11.3	7.4	13.8	16.9	21.8	2.8	2.6	2.8	9.2	7.7	0

[1]Samples Nos. 1–4 are from Montauk Point; sample Nos. 5–9 are from west of Napeague. Locations of sample collection sites are shown in figure 7.

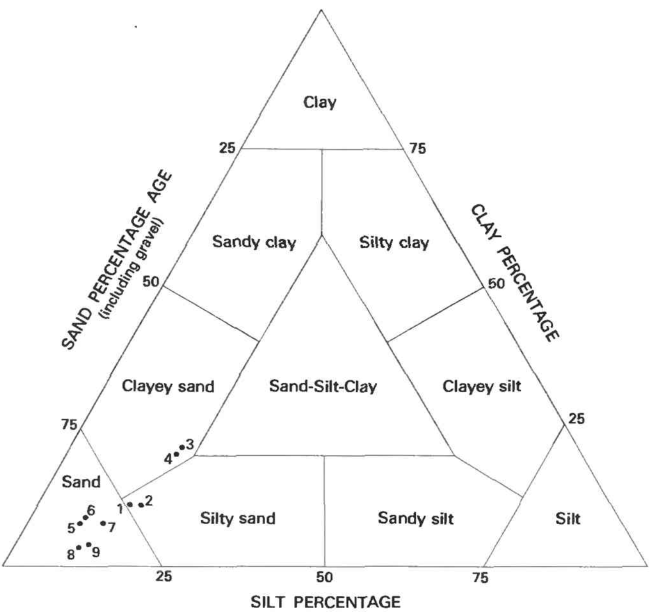

FIGURE 8.—Size analyses of nine till samples from the South Fork, Suffolk County, N.Y.

TABLE 5.—*Number of heavy-mineral grains in a 300-grain count of till samples from the South Fork, Suffolk County, N.Y.*

[All values indicate average number per 100 grains. Leaders (- - -) indicate none detected]

Heavy minerals	Sample-identification number and weight percentage of heavy minerals								
	1 (7.83)	2 (7.14)	3 (8.32)	4 (8.22)	5 (8.03)	6 (8.12)	7 (6.89)	8 (7.79)	9 (7.03)
Pyrite	---	---	1	---	---	---	---	---	---
Magnetite/ilmenite	14	17	12	10	16	14	16	15	15
Hematite	---	---	---	---	---	---	---	---	---
Rutile	1	---	---	---	3	2	2	1	1
Limonite	---	2	<1	1	2	1	1	<1	1
Leucoxene	---	---	---	---	1	---	---	---	---
Dolomite	---	---	---	---	---	---	<1	---	---
Muscovite	8	14	18	18	9	10	11	4	6
Biotite	17	13	16	18	11	15	14	9	11
Anthophyllite	2	---	---	---	---	---	---	---	<1
Tremolite/Actinolite	---	---	---	---	---	---	---	---	---
Hornblende	26	24	25	26	23	26	31	40	36
Enstatite	---	3	1	2	---	---	<1	---	---
Hypersthene	<1	---	---	---	3	3	---	---	---
Augite	---	---	---	---	---	---	---	---	---
Tourmaline	2	1	1	1	1	4	3	<1	2
Zoisite	2	3	3	2	1	---	---	---	---
Clinozoisite	---	1	1	---	1	---	2	<1	1
Epidote	7	6	4	8	6	4	5	7	3
Sillimanite	---	---	---	---	1	---	---	---	---
Staurolite	2	---	---	---	---	---	---	---	1
Garnet	18	14	15	16	18	18	13	22	21
Zircon	1	1	2	---	2	1	1	<1	3
Sphene	<1	<1	---	---	1	1	---	---	---

Results of the heavy-mineral analyses are given in table 5. All samples have a similar mineral composition, with magnetite/ilmenite, muscovite, biotite, hornblende, and garnet forming 85 percent of the heavy-minerals. The grain-size and heavy-mineral analyses indicate that the samples collected from the nine sites are similar and that a possible correlation can be made between them.

MORAINE AND OUTWASH DEPOSITS

Moraine and outwash deposits form most of the surficial deposits of the South Fork (pl. 1). The Ronkonkoma Drift forms moraine deposits that are primarily foreset beds of sand and gravel with occasional lenses of till and clay. Outcrops of till are rare, but they can be found in some gravel pits and landfill sites. Many of the sand and gravel deposits are folded and faulted (fig. 10) as a result of glacial tectonics and slumping.

South of the Ronkonkoma moraine is an outwash plain that slopes gently southward to the ocean where it is continually eroded by wave

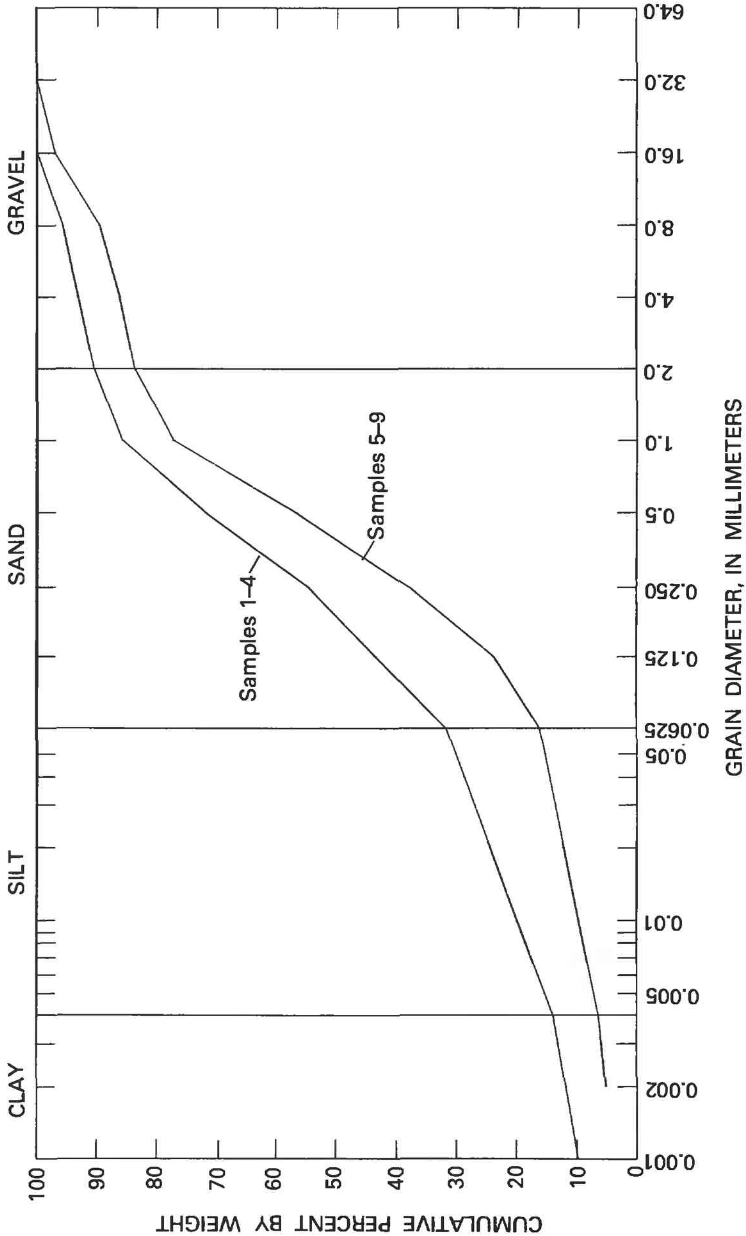

FIGURE 9.—Average cumulative particle-size distribution in till near Montauk and till west of Napeague, South Fork, Suffolk County, Long Island, N.Y.

FIGURE 10.—Moraine outcrop of folded and faulted Ronkonkoma Drift, South Fork, Suffolk County, Long Island, N.Y.

action and by westerly longshore drift. The outwash deposits consist of stratified, fine to coarse, tan sand in which crossbedding is common, and the deposits also contain fine to medium gravel (fig. 11). Clays and silts are virtually absent in the region. Quartz is the predominant mineral; locally, it contains relatively small amounts of alkali feldspar and rock fragments.

The contact between the Ronkonkoma moraine and outwash deposits is almost indiscernible because they are nearly identical in lithologic composition. However, an approximate contact was drawn on plate 1 to separate those deposits which may contain fine-grained material (moraine) from those that do not (outwash). The age of these deposits in unknown; however, Sirkin and Mills (1975) and Nieter, Nemickas, Koszalka, and Newman (1975) suggested that the complex is late Wisconsinan in age.

North of the moraine is an outwash deposit composed of stratified sand and gravel similar to the outwash plain to the south. This outwash

FIGURE 11.—Outcrop of outwash deposits consisting of stratified and crossbedded sands and gravels, South Fork, Suffolk County, Long Island, N.Y.

ranges in thickness from 20 feet to more than 80 feet. On North Haven and Springs peninsulas (fig. 1), the outwash overlies a till and resembles ground moraine; elsewhere, it overlies Cretaceous and post-Cretaceous(?) deposits or Gardiners Clay.

In areas where the moraine was crosscut by meltwater, the two outwash deposits are in contact. No attempt was made to differentiate between the two because their lithologic compositions were indistinguishable; therefore, both deposits were mapped as one unit (pl. 1). However, the outwash north of the moraine is probably a recessional feature; whereas, the outwash plain to the south is contemporaneous with the moraine deposits.

GLACIOFLUVIAL DEPOSITS

Glaciofluvial deposits overlie the outwash deposits north of the moraine as irregularly shaped ridges (pl. 1). These ridges, or kames, consist of stratified, poorly sorted sand and gravel, and, at some locations, they are overlain by a thin ablation till. Numerous kettleholes are associated with these kames in areas such as Grassy Hollow peninsula and vicinity. These kames were deposited by stagnant, disintegrating ice.

RECENT DEPOSITS

Deposits of Holocene age consisting of beach and marsh sediments are found predominantly along the shores of the South Fork. The beach deposits, which consist of a gravelly sand derived from the erosion of the outwash plain and bluffs, are the principal component of the tombolos east of Amagansett (pl. 1). Marsh deposits consisting of mud and peat occur along baymounts, streambeds, and ponds (pl. 1).

GEOLOGIC HISTORY

During the Cretaceous Period (65–136 million years ago) highlands north of Long Island were eroded, and the sediments were transported and were deposited on the gently sloping basement complex. These deposits now form the Raritan Formation and Magothy Formation–Matawan Group undifferentiated. The Monmouth Group was deposited above them from a transgressive sea.

The Tertiary Period (approximately 1.8–65 million years ago) is characterized throughout Long Island by either nondeposition of sediments or deposition followed by erosion. However, a post-Cretaceous(?) deposit underlies the South Fork; its age is uncertain (pl. 3, sec. *D–D′*).

During the Pleistocene Epoch, 1.8 million to 10,000 years ago, much of northern North America was overlain by continental glaciers. Four major glaciations and three corresponding interglaciations were recorded during this time. The names of each and their approximate duration and beginning data are shown in table 6. Recent studies on Long Island indicate the Wisconsinan stage to have contained three substages—early and late glaciations with an interstadial of middle Wisconsinan age (Sirkin and Mills, 1975; Nieter and others, 1975). On the South Fork, the Montauk Till Member of the Manhasset Forma-

TABLE 6.—*Data on major glaciations and corresponding interglaciations on the South Fork, Suffolk County, N.Y.*

[Dates are from Kay, 1931]

Period	Epoch	Glaciation	Interglaciation	Duration, in years	Number of years ago
	Holocene				20,000
		Wisconsin		66,000	86,000
Quaternary			Sangamon	120,000	206,000
		Illinoian		9,000	215,000
	Pleistocene		Yarmouth	300,000	515,000
		Kansan		7,500	522,500
			Aftonian	200,000	722,500
		Nebraskan		7,500	730,000

tion, moraine, and outwash sediments were deposited during the Wisconsin Glaciation. During the previous intervening Wisconsinan interstadial—or Sangamon Interglaciation—the marine clay (Gardiners(?) Clay in this report) was deposited. As the glaciers retreated, melt-water ponded behind the moraine and formed streams flowing through topographic lows. These streams subsequently eroded the moraine and formed north-south trending channels. The locations of these channels are shown in figure 12.

With the final recession of continental glaciers, sea level rose to its present position or higher. As a result of this rise, parts of the glacial deposits were eroded or inundated, or both. Wave action, along with currents and longshore drift, deposited the eroded sediment to form the present beach and dune complex on the South Fork.

HYDROLOGY

HYDROLOGIC SYSTEM

Water is continually being exchanged in a circulatory pattern between the ocean and the atmosphere. In general, the amount of precipitation on the South Fork determines the amount of water available for use in the area. Some of the precipitation on the land evaporates, some is absorbed by plants and is later transpired back to the atmosphere, some flows overland to streams, and some infiltrates to become ground water. Some of the ground water discharges into streams that flow to the ocean; however, most of the ground water discharges directly into the ocean. From the ocean, the water is evaporated back to the atmosphere.

All fresh ground water on the South Fork originates from local precipitation; recharge to the ground-water reservoirs results from infiltration of precipitation through the soil to the water table. The amount of water that reaches the water table varies throughout the year and is controlled by (1) precipitation type, frequency, and intensity; (2) slope of the land surface; (3) geology, soil moisture content, and the amount and kind of vegetal cover; and (4) air temperature. Figure 13 shows the major components of the hydrologic cycle on the South Fork.

PRECIPITATION AND TEMPERATURE

The climate of the South Fork is influenced by the Atlantic Ocean and Long Island Sound; these water bodies prevent the extremes of temperature and precipitation from occurring on Long Island as they occur in the interior of the continent. The climate is characterized by a moderate temperature range and mild winters. On the South Fork, as

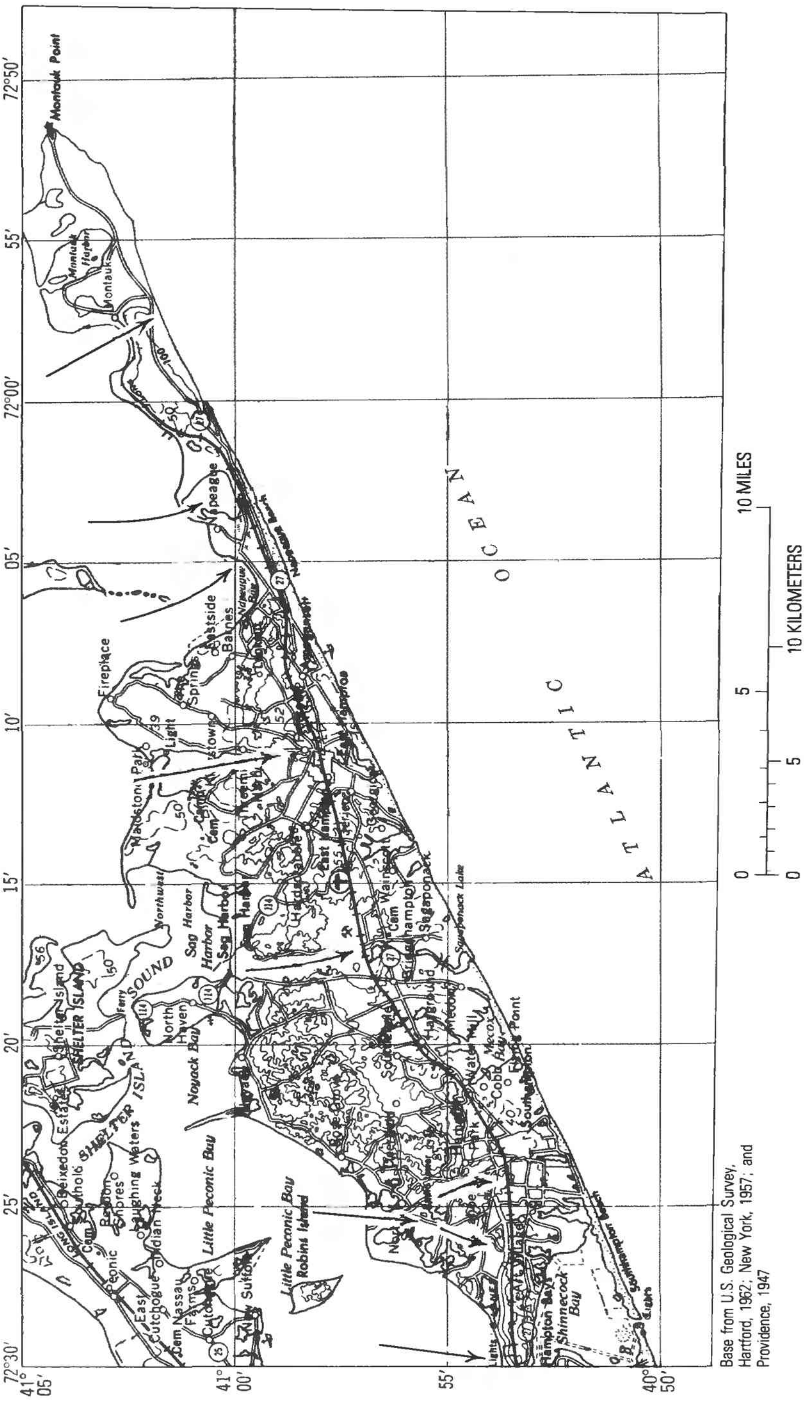

FIGURE 12.—Locations of north-south-trending channels developed during Wisconsinan interstadial, or Sangamon Interglaciation.

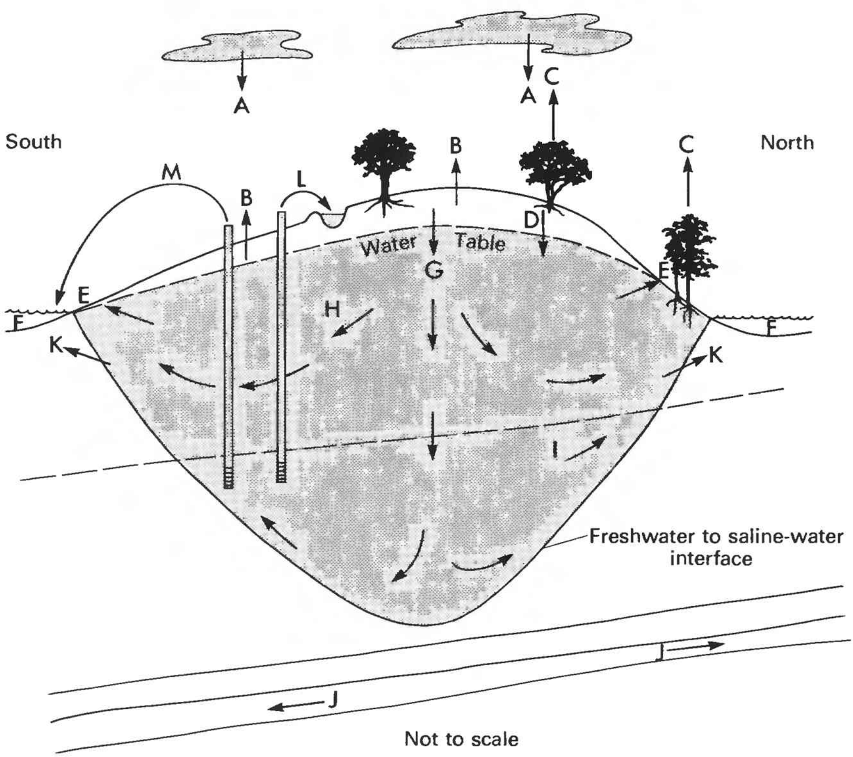

FIGURE 13.—Major components of the hydrologic cycle on the South Fork; (A) precipitation, (B) evaporation, (C) transpiration, (D) unsaturated ground-water flow, (E) seepage from surface, (F) salty water, (G) saturated ground-water flow, (H) glacial aquifer, (I) Magothy aquifer, (J) Lloyd aquifer, (K) dispersion into salty water, (L) deep ground water pumped to surface, and (M) ground water returned to salty water. Arrows show inferred direction of water movement.

on the rest of Long Island, the long-term quantity of precipitation is almost the same during the cool season (October-March) as during the warm season (April-September). However, precipitation is more frequent in the spring than in the fall. Most precipitation on the South Fork is in the form of rain; only 10–20 percent of the winter precipitation is in the form of snow or sleet.

Long-term normal precipitation in Suffolk County is 43 inches per year, according to an analysis by the National Weather Service of the 30-year precipitation records at Bridgehampton, Riverhead, Setauket, and Patchogue (fig. 1). However, recent studies by Suffolk County indicate that this normal could be underestimated by at least 10 percent.

Prevailing winds in Suffolk County during the summer are from the south; northwest winds prevail during the winter. Winds of destructive velocities are generally associated with thunderstorms and have produced small tornadoes, occasional hurricanes, and tropical storms during late summer and early fall. In Suffolk County, winter air temperatures on the north shore are slightly warmer than on the south shore because the prevailing winter northwesterly current is modified by Long Island Sound. During the summer, temperatures on the south shore are cooler than on the north shore as a result of the prevailing southerly ocean breeze and local onshore sea breezes.

The most pronounced interaction between climatic effects of land and adjacent water masses is at Montauk. Temperature data from New York Ocean Science Laboratories Meteorological Research Station at Montauk reveal the moderating influence of the surrounding water. During winter, the Montauk area consistently has the warmest average air temperature on Long Island and also the highest minimum air temperature, which is caused by the counterradiation or returned long-wave radiation (greenhouse effect) produced by a high water-vapor content from the surrounding large water masses. In the early spring, when land surface warms rapidly in response to solar heat, the water surrounding Montauk is still cold. As a result, the lowest average air temperatures on Long Island during April and May are at Montauk.

The precipitation regime of Long Island for 1951–65 was studied by Miller and Frederick (1969), who, from two stations on the South Fork, estimated the mean annual precipitation to be between 45 and 48 inches. This compared closely with the 43 inches per year determined for all of Suffolk County.

The annual precipitation recorded at Bridgehampton from 1931–76 had a maximum 63.71 inches in 1953 to a minimum 30.67 inches in 1965 (fig. 14); the long-term normal annual precipitation from 1931–76 is 45 inches. Mean monthly precipitation at Bridgehampton ranges from a low of 2.8 inches in July to a high of 4.5 inches in November (fig. 15).

Yearly departures and a cumulative departure from the mean annual precipitation are depicted in figures 16 and 17. In general, annual precipitation during 1939–50 and 1962–70 was below mean annual precipitation; during the intervening years, 1950–62, annual precipitation was above the yearly normal.

SURFACE WATER

Surface water on the South Fork consists predominantly of ground-water discharge. The amount of overland runoff from precipitation on Long Island and the South Fork is relatively low because the surficial materials are highly permeable. Overland runoff is probably less than 1 percent of the total precipitation (Franke and McClymonds, 1972, p. F19).

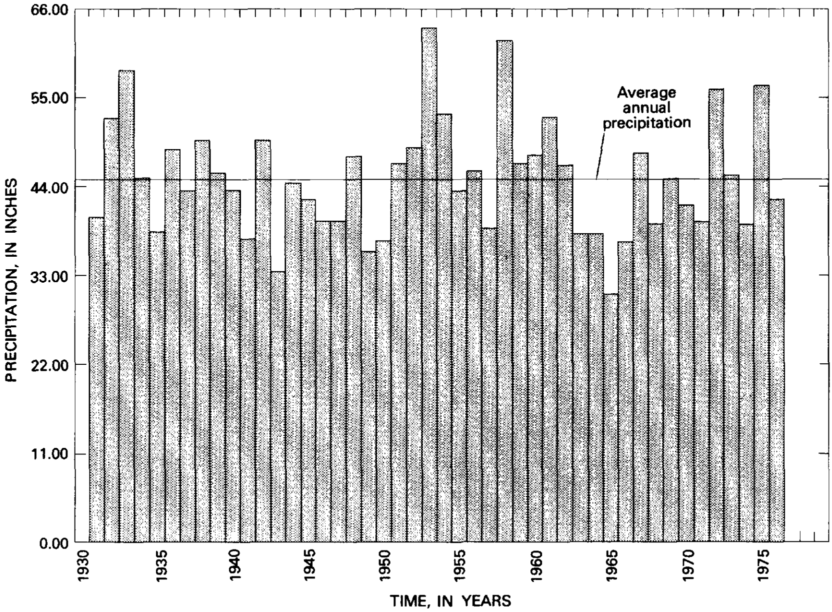

FIGURE 14.—Annual precipitation at Bridgehampton, Suffolk County, Long Island, N.Y., 1931–76.

Stream discharge was measured periodically at 20 sites on the South Fork; the locations of these sites are shown on plate 2. Nemickas, Koszalka, and Vaupel (1977, table 4) have presented discharge measurements for the streams. It is difficult to obtain accurate discharge measurements on streams that flow into the bays and ponds along the south shore because from late fall to early spring, the mouths of these bays and ponds are closed by sand deposits that inhibit surficial freshwater flow into the ocean and cause ponding. Measurements during these periods showed a decrease in velocity and an increase in cross-sectional area, which would give inaccurate discharge values. However, such measurements may be used as approximations.

EVAPOTRANSPIRATION

Evapotranspiration is defined as the natural removal of water through both evaporation and transpiration by plants. This term excludes water removed through irrigation or any other artifical means of providing water to plants. Evapotranspiration cannot be measured directly, and all calculations must be considered as estimates. The most widely accepted estimates of evapotranspiration on the South

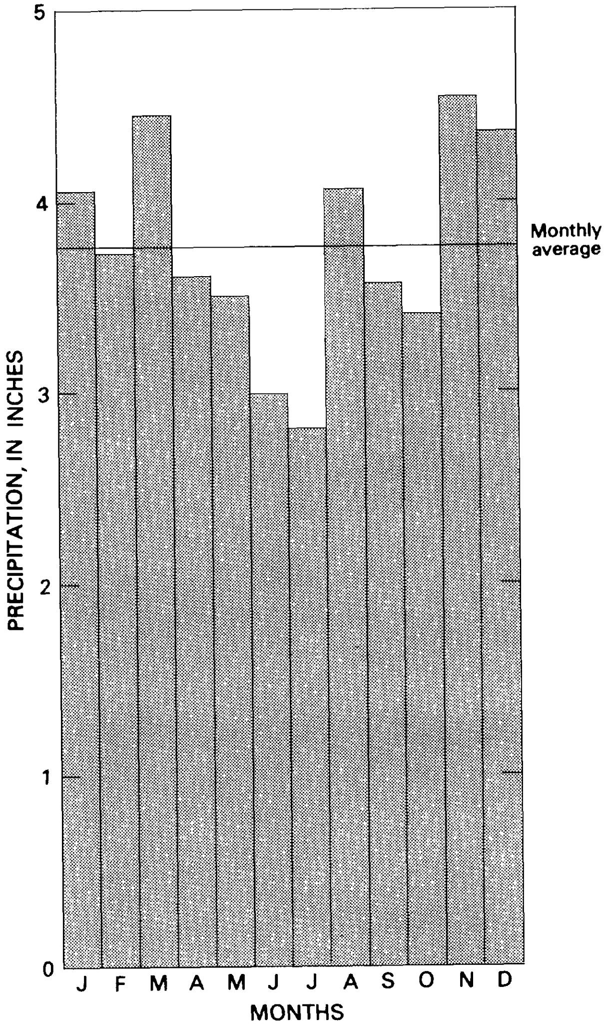

FIGURE 15.—Average monthly precipitation at Bridgehampton, Suffolk County, Long Island, N.Y., 1931-76.

Fork were obtained with the Thornthwaite Water Balance calculations (Bart and others, 1976, p. E24). Annual evapotranspiration, determined from mean weather data from 1930–75 is 23.2 inches (Bart and others, 1976, p. E24). Extremes, determined from available data, are 16.4 inches in 1957 and 24.6 inches in 1959. This represents an annual range of 8.2 inches (Bart and others, 1976, p. E24). The average annual evapotranspiration of 23.2 inches on South Fork, calculated by Bart

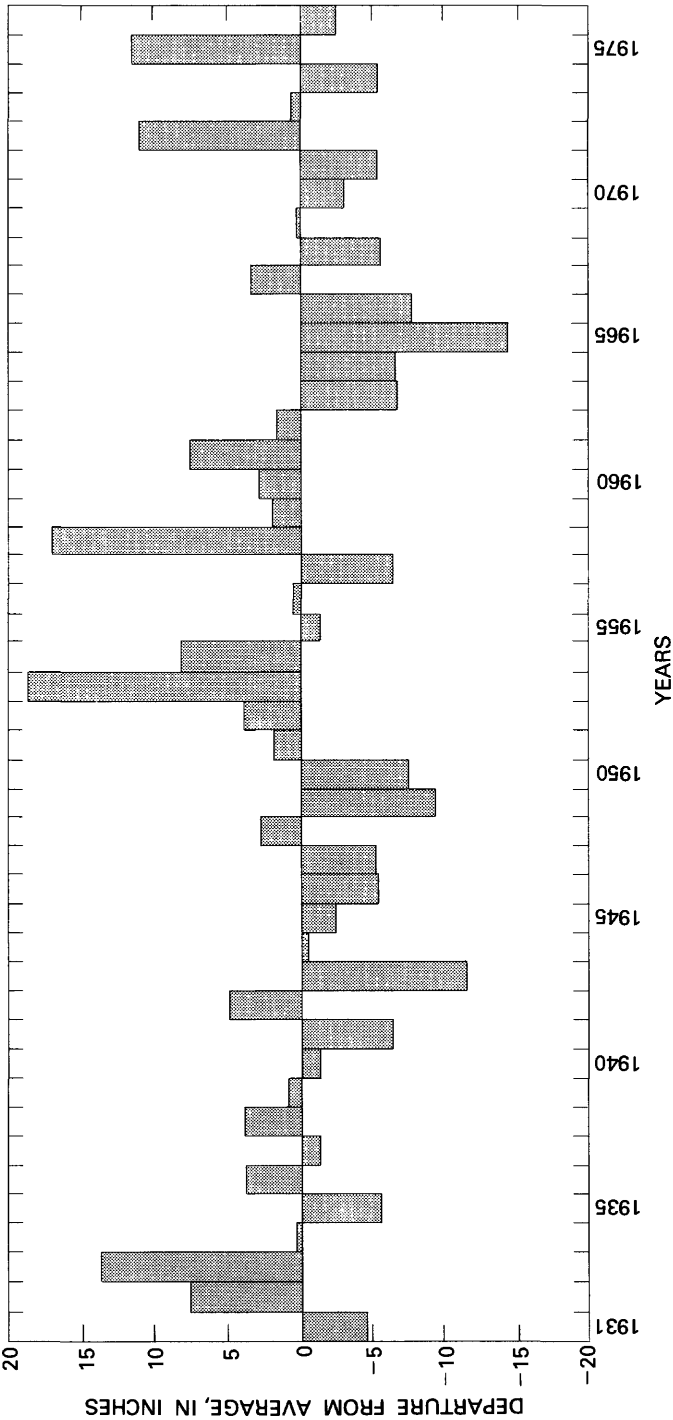

FIGURE 16.—Yearly departures from normal precipitation at Bridgehampton, Suffolk County, Long Island, N.Y. from 1931–76.

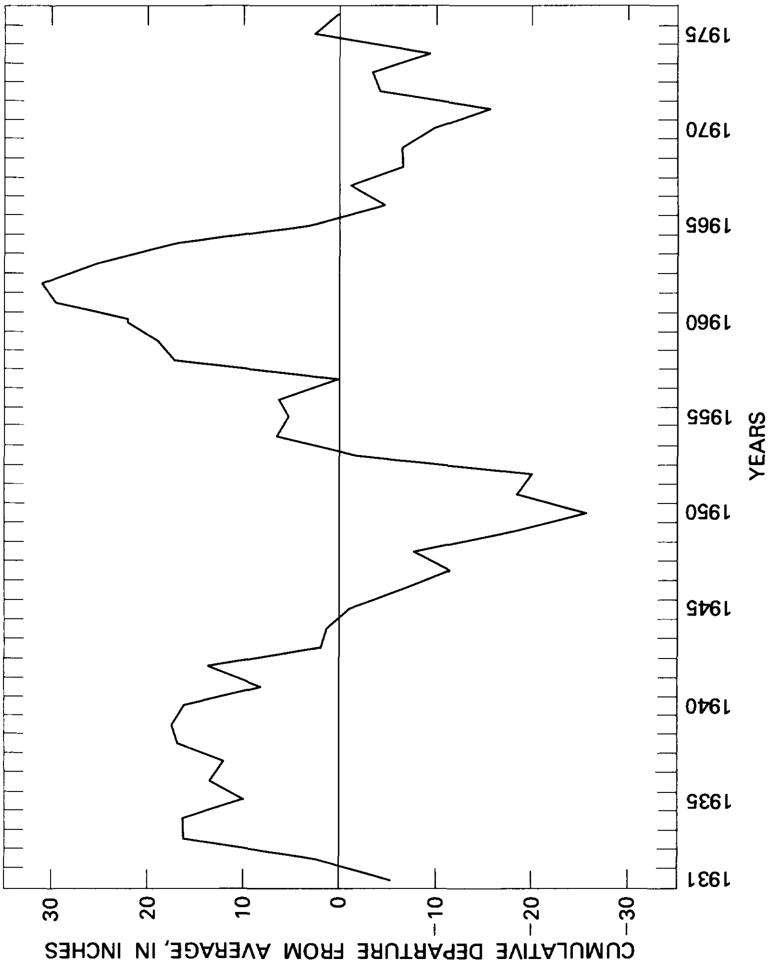

FIGURE 17.—Cumulative departure from mean annual precipitation at Bridgehampton, Suffolk County, Long Island, N.Y., 1931–76.

and others, compares favorably with estimates made elsewhere on Long Island. For example, Vaupel and others (oral commun., 1977), used the method of Thornthwaite and Mather (1957) to calculate evapotranspiration for 1956-73 from average precipitation data recorded at Mineola and Setauket. Air-temperature data from Mineola and an estimated soil-retention value of 2.0 inches was used; the average annual evapotranspiration for 1956–73 was determined to be 21.6 inches, or slightly less than half of the precipitation on Long Island annually.

RECHARGE AND DISCHARGE OF GROUND WATER

Ground water on the South Fork is recharged by infiltration of precipitation through the unsaturated zone to the water table. The amount of water that reaches the water table varies throughout the year and is controlled by (1) precipitation type, frequency, and intensity; (2) slope of the land surface; (3) soil permeability and soil-moisture content; (4) amount and kind of vegetal cover; and (5) air temperature.

Average annual recharge on the South Fork during 1931–76 can be calculated from the following equation:

$$\text{Recharge} = \text{Precipitation} - (\text{Evapotranspiration} + \text{Overland runoff}) \qquad (1)$$

If average annual precipitation at Bridgehampton is 45 inches and annual evapotranspiration is 23 inches, and if average overland runoff is about 0.5 inches per year, then:

$$\text{Recharge} = 45-(23+0.5), \text{ or}$$
$$\text{Recharge} = 22 \text{ inches per year.}$$

Vaupel and others (oral commun., 1977), using the same equation (eq 1), calculated recharge for Long Island during 1956–73 to be 20.5 inches.

When the extremes of 16 inches and 25 inches of evapotranspiration for the South Fork are used in combination with the (1) lowest annual precipitation at Bridgehampton (31 inches in 1965) and (2) an overland runoff value of 0.5 inches per year, recharge to the water table ranges from 6 to 15 inches per year. Similarly, when the maximum annual precipitation at Bridgehampton (64 inches in 1953) is applied to equation (1), recharge to the water table ranges from 39 to 48 inches per year. Also, rates of recharge, precipitation, evapotranspiration, and other factors may vary considerably from place to place— and with time—so that the average value of annual recharge of 22 inches on the South Fork should be considered only a rough approximation.

Ground water on the South Fork is naturally discharged by evapotranspiration, by seepage into streams draining into the ocean and bays, by subsurface outflow into saltwater bodies, and by the flow of coastal springs. Ground water is also discharged by pumping of wells. On the South Fork the latter is negligible because most of the water pumped reenters the ground-water reservoir through cesspools and septic tanks. The only net loss to the system is irrigation pumpage, where some of the water is removed to evapotranspiration.

UPPER GLACIAL AQUIFER

The upper glacial aquifer generally corresponds to the saturated upper part of the highly permeable Pleistocene deposits. It is the major source of water supply for the South Fork. The configuration of the water table (pl. 4) is controlled by the thickness and water-transmitting properties of the aquifer, by the water-transmitting properties of the underlying deposits, by the quantity and location of recharge, and by the location and nature of natural discharge points (streams, springs, and so forth).

Water-level measurements at 206 wells were used to prepare the water-table map for the South Fork (pl. 4). In the western part of the study area is a ground-water mound that in October 1976 had a maximum altitude of 37 feet; water levels as high as 65 feet (fig. 18; pl. 4) have been recorded in this area. These mounds result from local variations in hydraulic conductivity of the geologic units within the region. The authors have found a silty-clayey sand unit (Gardiners(?) Clay), whose top is at about sea level on the South Fork and which decreases the vertical hydraulic conductivity of the upper glacial aquifer. Head measurements made above and below this 60- to 100-foot thick silty-clayey sand differ by more than 25 feet. This silty-clayey sand is in the saturated zone and, by retarding vertical movement of ground water, produces a higher water table in the area. East of this mound, the water table reaches a maximum altitude of 13 feet and slopes downward to sea level at the shore. Smaller water-table mounds have been observed throughout the area: for example, in North Haven, Hither Hills, and Montauk (pl. 4). These water-table mounds have maximum altitudes of less than 4 feet.

Depth to the water table from land surface throughout the South Fork is shown on plate 6. In general, the depth to water increases northward from zero along the south shore to more than 100 feet beneath parts of the Ronkonkoma moraine (fig. 19). From the Ronkonkoma moraine, depth to the water table decreases northward to zero at the north shore. In areas where depth to water is less than 25 feet (fig. 19), the water is within suction limit so that a centrifugal pump

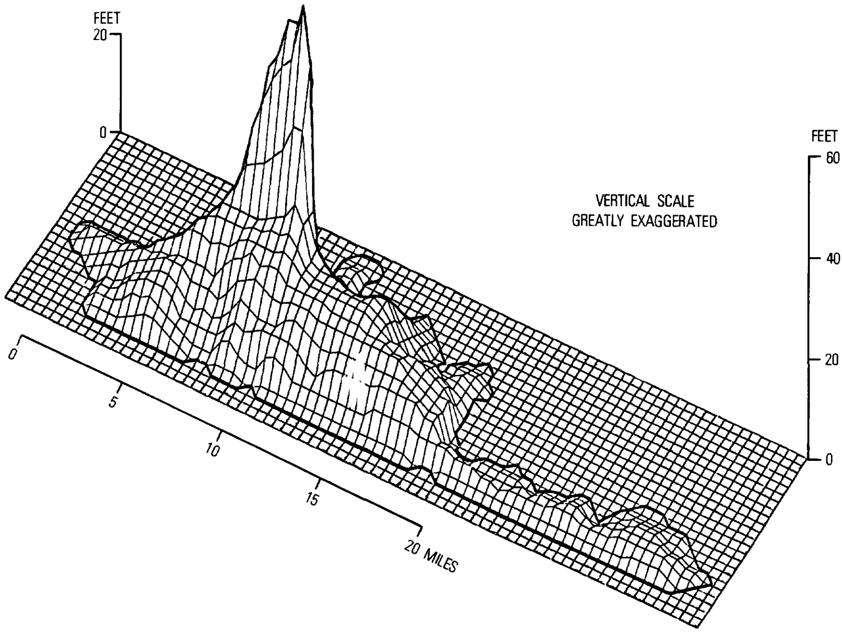

FIGURE 18.—Water-table configuration on the South Fork, Suffolk County, Long Island, N.Y.

can be used in a well. This enables the use of firewells[1] and eliminates the need for fire hydrants. Firewells are placed at strategic locations throughout Long Island, and, during a fire emergency, water is pumped directly from the nearest firewell. Because water levels in firewells must be within the suction limit, they can be placed only in areas where depth to water from land surface is less than 25 feet.

The lower boundary of the freshwater-bearing zone of the upper glacial aquifer near the shore is the freshwater/saline-water interface and, further inland, it is the top of the Magothy aquifer. The approximate thickness of the freshwater-bearing zone in the upper glacial aquifer across the South Fork is shown on plate 7. Where Gardiners(?) Clay is present in the freshwater zone, it delinates the lower boundary of the upper glacial aquifer. The hydrogeologic sections of plate 3 show the relationship of the upper glacial aquifer to the frewhwater/saline-water interface, to the Magothy aquifer, and to the Gardiners(?) Clay.

Synoptic water-level measurements made on the South Fork from 1974 to 1977 and long-term records of a few observation wells indicate that the water table generally rises from the end of October to the end of

[1]Firewell—A shallow well screened in the water table whose water is used to extinguish fires.

April, when vegetation is dormant and evapotranspiration is thus at its lowest. The water table generally begins to decline in May and reaches its lowest levels in early October. The maximum seasonal water-table fluctuation on the South Fork is less than 4 feet. The largest observed water level fluctuations are in areas where the water table is high (recharge areas) near the east-west centerline of the South Fork (topographic high). Seasonal fluctuations observed north and south of the topographic highs are less than 2 feet. Water levels in wells near or on the shore are influenced by the oceanic tides and show corresponding fluctuations of about 1 foot.

The U.S. Geological Survey has monitored several observation wells over the past 25 years on the South Fork; the 25-year hydrographs for six of these wells are given in figures 19–24. The water levels coincide in terms of periodicity of water-level fluctuations but differ in magnitude of change.

Water-level fluctuations in response to variations in precipitation is shown in figure 25. The hydrograph for well S8833 is typical for most wells during the period 1950–76. Figure 25 shows that an increase or decrease in the amount of precipitation causes a corresponding rise or decline in water levels. This is exemplified during the drought of 1962–66 and during the recovery of the following years where water levels first declined and then rose. There also appears to be a 1 year lag for the water levels to respond to the annual precipitation. The smallest amount of precipitation occurred in 1965, but the lowest water level recorded was in 1966.

MAGOTHY AQUIFER

The Magothy aquifer is the deepest freshwater-bearing zone on the South Fork. In some areas on the South Fork, the upper part is in direct contact with the upper glacial aquifer and is under water-table conditions. In most areas, however, the Magothy aquifer is overlain by units of lower permeability and is under artesian conditions. The difference in coarseness of the deposits is the major criterion for differentiating the two aquifers. In the study area, the average horizontal hydraulic conductivity of the Magothy aquifer is 70 ft/day, whereas that of the upper glacial aquifer is 350 ft/day.

The upper boundary of the freshwater-bearing zone of the Magothy aquifer is the base of the upper glacial aquifer; the lower limit is the freshwater/saline-water interface. The hydrogeologic sections of plate 3 show the relationship of the Magothy aquifer to the freshwater/saline-water interface and to the upper glacial aquifer. Thickness of the freshwater-bearing zone in the Magothy aquifer, shown on plate 8, ranges from zero near the shores to more than 400 feet near the center of the South Fork.

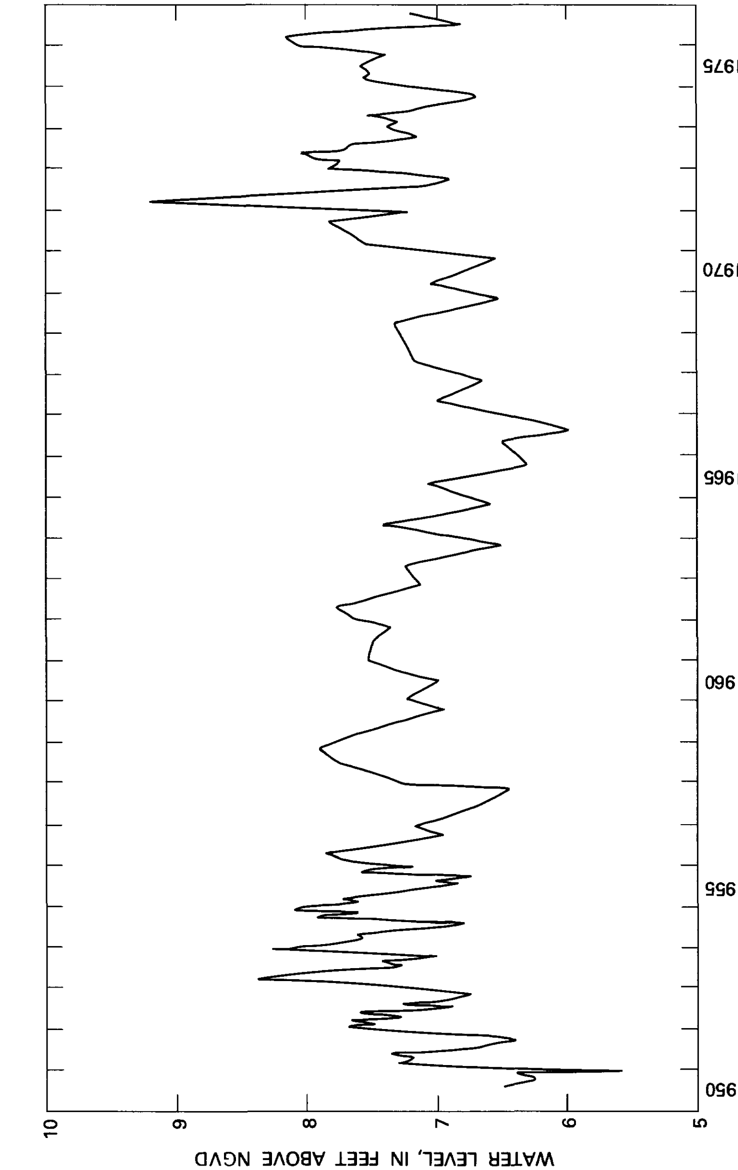

FIGURE 19.—Twenty-five year hydrographs for well S8831.

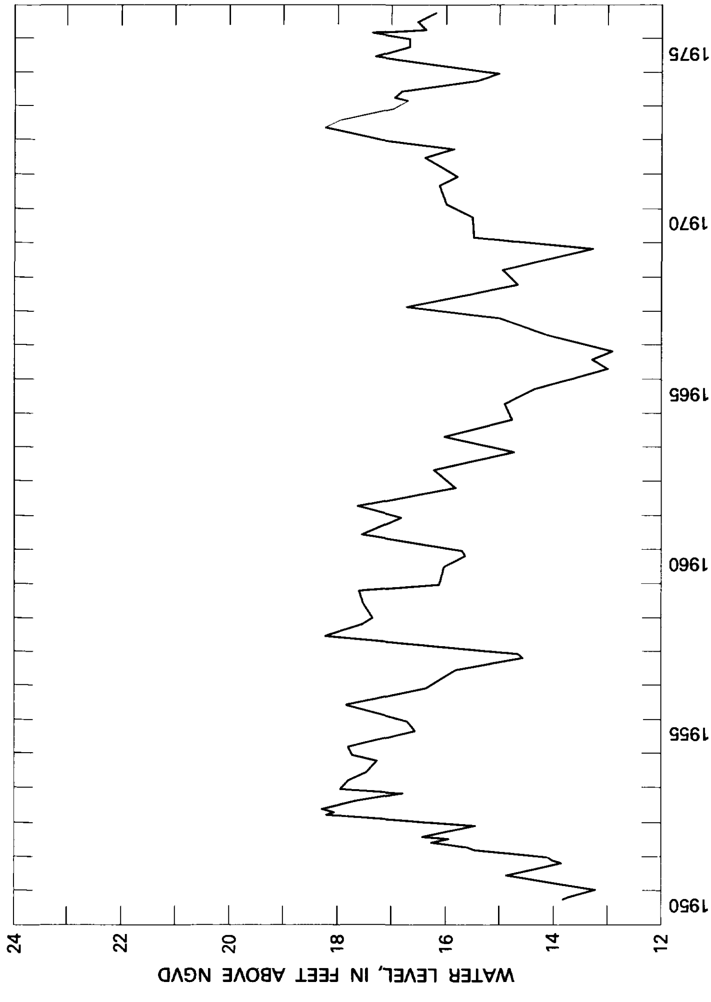

FIGURE 20.—Twenty-five year hydrograph for well S8833.

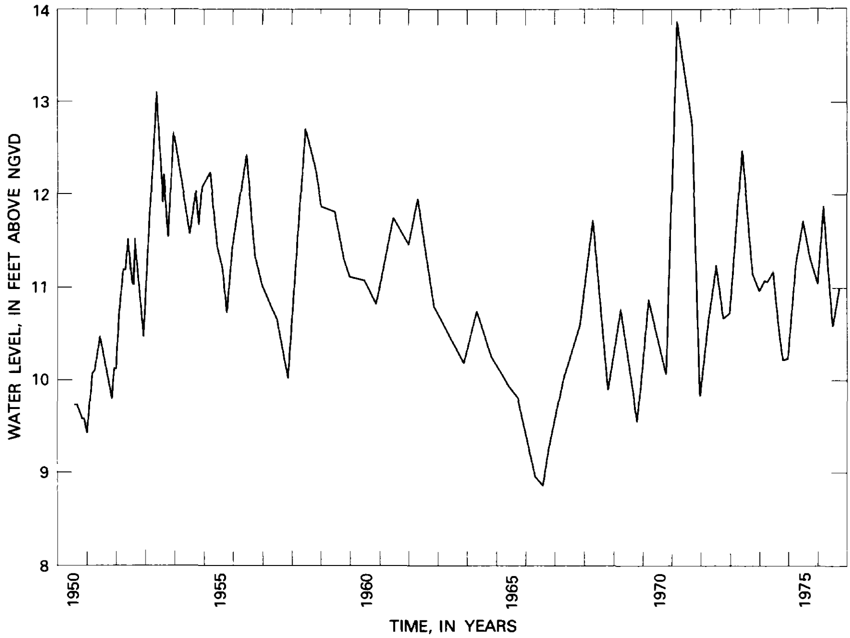

FIGURE 21.—Twenty-five year hydrograph for well S8838.

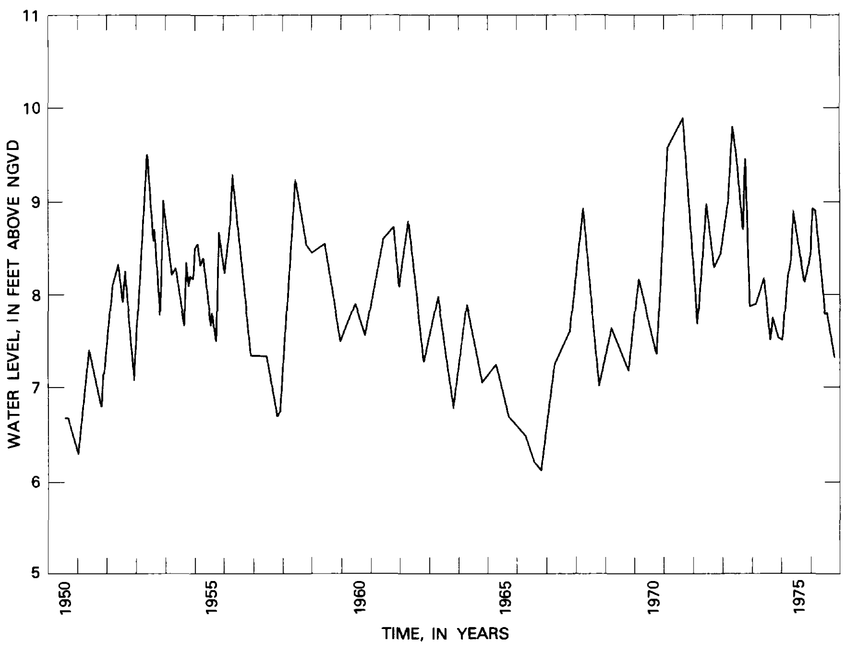

FIGURE 22.—Twenty-five year hydrograph for well S8839.

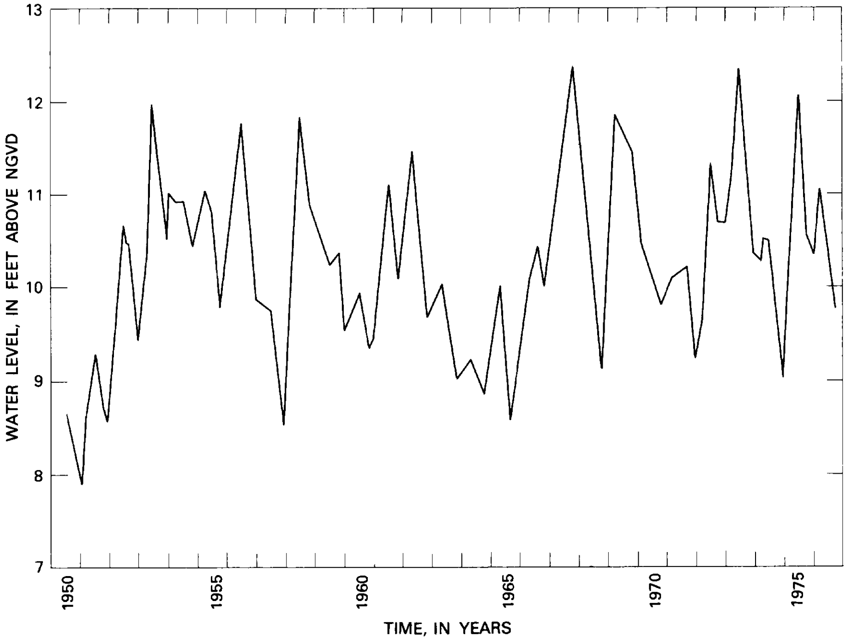

FIGURE 23.—Twenty-five year hydrograph for well S8843.

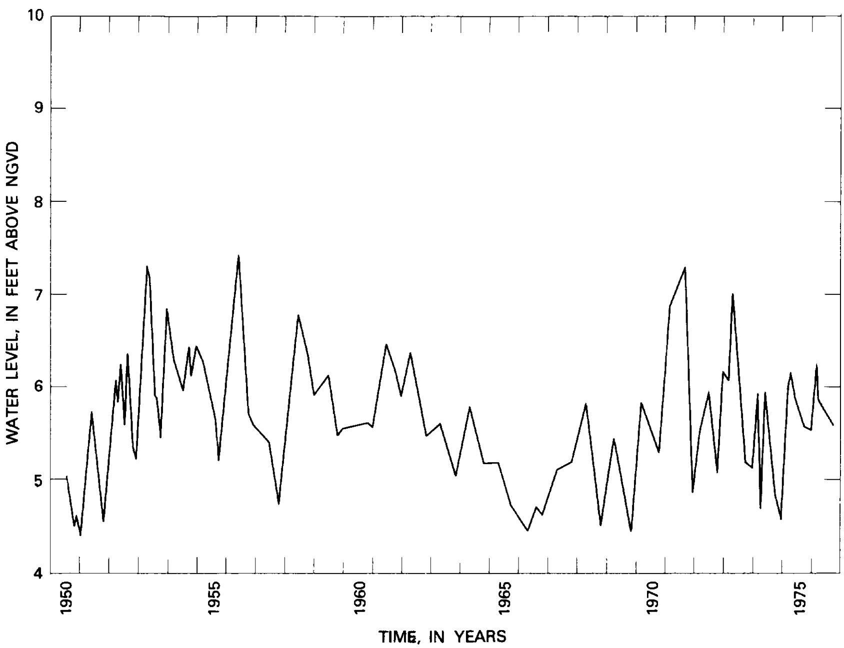

FIGURE 24.—Twenty-five year hydrograph for well S8844.

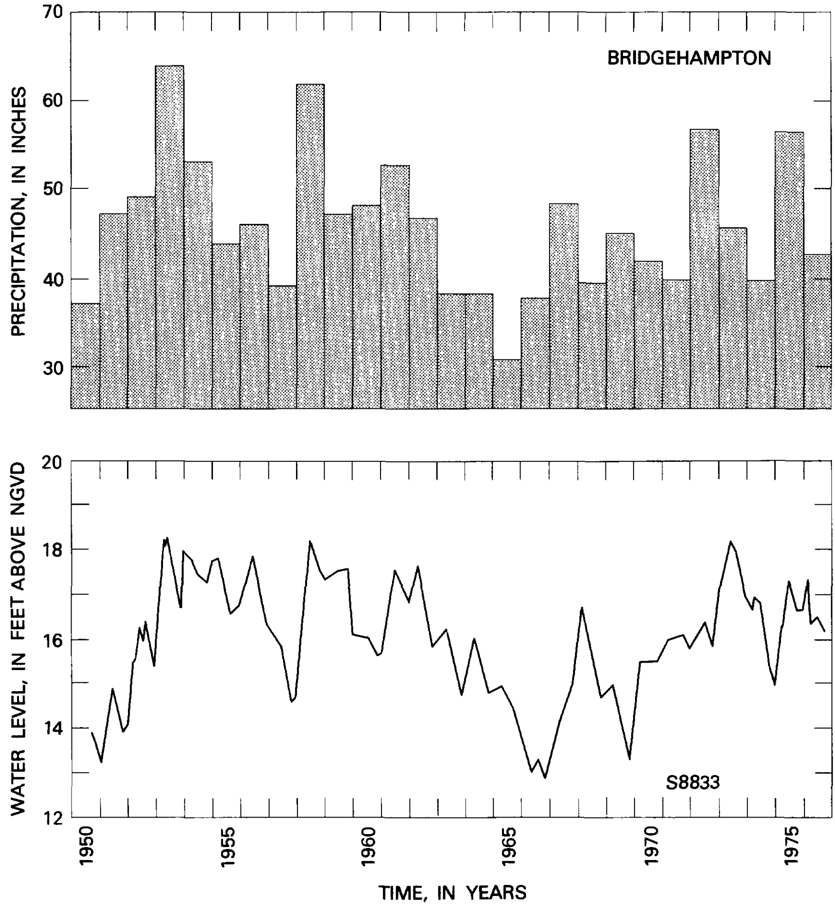

FIGURE 25.—Effects of annual precipitation on water-level fluctuations of well S8833 from 1950–76.

LLOYD AQUIFER

No data on the South Fork part of the Lloyd aquifer are available. No wells penetrate the full thickness of the Lloyd aquifer, but it is assumed to underlie the entire study area. Bedrock marks the lower limit of this deep artesian aquifer; the upper limit is the base of the unnamed clay member of the Raritan formation (pl. 1), but the altitude of this surface has not been defined because no data are available.

In all parts of the South Fork, saline water extends into the Magothy aquifer and, in many areas, into the upper glacial aquifer as well. Hence, it is improbable that the Lloyd aquifer contains freshwater, and it cannot be considered as a potential freshwater supply.

HYDRAULIC CHARACTERISTICS OF MAJOR AQUIFERS

Hydraulic conductivity and transmissivity of the Magothy and upper glacial aquifers were estimated from aquifer tests and from specific-capacity data as described by Theis, Brown, and Meyer (1954).

Hydraulic conductivity at seven wells in the Magothy aquifer ranged from 31 ft/day to 134 ft/day and averaged 82 ft/day (Fetter, 1971). The Magothy aquifer contains layers of clay, sandy clay, and silty clay, which have lower hydraulic conductivity than the more permeable zones on the unit. When the zones of lower hydraulic conductivity are included, the average hydraulic conductivity of the Magothy aquifer becomes lower, about 70 ft/day (Fetter, 1971). Aquifer tests in the Magothy aquifer on the South Fork indicate that transmissivity ranges from 607 ft^2/day to 24,064 ft^2/day (Fetter, 1971).

In the upper glacial aquifer, horizontal hydraulic conductivity at 10 wells on the South Fork ranged from 200 ft/day to 750 ft/day (table 7); about 70 percent of these values were between 280 ft/day and 400 ft/day. The average horizontal hydraulic conductivity of the upper glacial aquifer on the South Fork is 350 ft/day. In an earlier study, Fetter (1971) found the horizontal hydraulic conductivity of the upper glacial aquifer on South Fork to range from 43 ft/day to 435 ft/day; about 60 percent of his values were between 120 ft/day to 187 ft/day. The average of 18 determinations of hydraulic conductivity by Fetter (1971) is 159 ft/day. Values obtained in the present study by the same method are higher than Fetter's because transmissivity of the aquifer over the entire region was estimated from the hydraulic conductivity of the screened part of the aquifer; whereas, Fetter's vaules were based on the entire thickness of the aquifer and not the screen zone.

TABLE 7.—*Horizontal hydraulic conductivity and transmissivity of upper glacial aquifer on the South Fork, Suffolk County, N.Y.*

Well No.	Hydraulic conductivity (ft/day)	Transmissivity (ft^2/day)
S24323	200	6,000
S28928	215	5,400
S2405	280	8,400
S2415	310	9,400
S17474	320	6,400
S1340	335	6,700
S38917	350	10,000
S7570	360	9,000
S1341	400	8,000
S14192	750	22,700

The transmissivity of the screen zones of the 10 wells (table 7) ranged from 5,400 ft^2/day to 22,700 ft^2/day. If the highest and lowest values are eliminated, the range is from 6,000 ft^2/day to 10,000 ft^2/day.

Fetter (1971) estimated the specific yield of the upper glacial aquifer on the South Fork to be 0.21; Warren, de Laguna, and Lusczynski (1968) calculated the specific yield in western Suffolk County to be 0.24. Crandell (1963) estimated specific yield in the Town of Southold, on the North Fork, to be from 0.18 to 0.28. These values suggest that the specific yield of the upper glacial aquifer on the South Fork is in the range of 0.20–0.30 because the lithology of this unit is fairly uniform throughout Long Island.

WATER QUALITY

The chemical quality of water is for many purposes, just as important as its availability. In its natural state, all water contains minerals in varying proportions as a result of its having leached soluble material from the atmosphere, soil, and rocks through which it moves. Factors affecting the chemical quality of ground water are the chemical composition of material with which it comes in contact, the duration of contact, and the water temperature and pressure.

The ground water and the fresh surface water on the South Fork are for the most part potable, although some constituents, such as iron, chloride, and nitrate, may occur in objectionable concentrations. Water-quality data on the upper glacial aquifer and the 20 streams that discharge from it were presented by Nemickas, Koszalka, and Vaupel (1977). The source and significance of dissolved-mineral concentrations and physical properties of ground water on the South Fork are given in table 8.

Statistical data on the chemical constituents and properties of water from 47 wells collected from the upper glacial aquifer in October 1976 are shown in table 9. Most analyses indicate the water to be of good quality. For comparison, the proposed U.S. Environmental Protection Agency's National Interim Primary Drinking Water Standards (1975) and the State of New York (1964) drinking water standards are listed in table 10.

Water quality of the Magothy aquifer on the South Fork was presented by Fetter (1971, table 14) analyses of samples from 6 wells is shown in table 11.

FRESHWATER TO SALINE-WATER RELATIONSHIP

Fresh water has a lower density than salt water and tends to "float" on top of salt water. On the southern half of the South Fork, the fresh water to saline-water relationship is generally in accord with the

TABLE 8.—*Source and significance of dissolved mineral constituents and physical properties of ground water on the South Fork, Suffolk County, N.Y.*

[This table is modified from one by Gallaher and Price (1966). Abbreviation: mg/L, milligrams per liter]

Constituent or physical property	Source or cause	Significance
Silica (SiO_2)	Dissolved from almost all rocks and soils, usually in small amounts from 1–30 mg/L. High concentrations—as much as 100 mg/L—generally occur in highly alkaline waters.	Forms hard scale in pipes and boilers. Carried over in steam of high-pressure boilers to form deposits on blades of steam turbines. Inhibits deterioration of zeolite-type water softeners.
Iron (Fe)	Dissolved from almost all rocks and soils. May also be derived from iron pipes, pumps, and other equipment. More than 1 or 2 mg/L of soluble iron in surface water usually indicates acid wastes from mine drainage or other sources.	On exposure to air, iron in ground water oxidizes to reddish-brown sediment. Content of more than about 0.3 mg/L stains laundry and utensils reddish brown. Objectionable for food processing, beverages, dyeing, bleaching, ice manufacture, brewing, and other processes. The U.S. Public Health Service (1962) recommends, in its water-quality standards, that iron and manganese together should not exceed 0.3 mg/L, larger quantities cause unpleasant taste and favor growth of iron bacteria.
Manganese (Mn)	Dissolved from some rocks and soils. Not as common as iron. Large quantities often associated with high iron content and with acid waters.	Same objectionable features as iron. Causes dark-brown or black stain. Federal standards recommend that iron and manganese together should not exceed 0.3 mg/L.
Calcium (Ca) and magnesium (Mg).	Dissolved from almost all soils and rocks, especially limestone, dolomite, and gypsum. Calcium and magnesium are found in large quantities in some brines. Large quantities of magnesium are present in sea water.	Cause most of the hardness and scale-forming properties of water; soap consuming (see hardness). Water with low calcium and magnesium contents desired for electroplating, tanning, dyeing, and textile manufacturing.
Sodium (Na) and potassium (K).	Dissolved from almost all rocks and soils. Found also in ancient brines, sea water, some industrial brines, and sewage.	Large amounts, in combination with chloride, give a salty taste. Moderate quantities have little effect on the usefulness of water for most purposes. Sodium salts may cause foaming in steam boilers, and a high sodium ratio may limit the use of water for irrigation.
Bicarbonate (HCO_3) and carbonate (CO_3).	Action of carbon dioxide in water on carbonate rocks such as limestone and dolomite.	Bicarbonate and carbonate produce alkalinity. Bicarbonates of calcium and magnesium decompose in steam boilers and hot-water facilities to form scale and release corrosive carbon dioxide gas. In combination with calcium and magnesium cause carbonate hardness.
Sulfate (SO_4)	Dissolved from rocks and soils containing gypsum, iron sulfides, and other sulfur compounds. Usually present in mine waters and in some industrial wastes.	Sulfate in water containing calcium forms hard scale in steam boilers. In large amounts, sulfate in combination with other ions gives bitter taste to water. Some calcium sulfate is considered beneficial in the brewing process. Federal standards recommend that the sulfate content should not exceed 250 mg/L.
Chloride (Cl)	Dissolved from rocks and soils. Present in sewage. Found in large amounts in ancient brines, sea water, and industrial brines.	In large amounts in combination with sodium gives salty taste to drinking water. In large quantities increases the corrosiveness of water. Federal standards recommend that chloride content should not exceed 250 mg/L.

TABLE 8.—*Source and significance of dissolved mineral constituents and physical properties of ground water on South Fork*—Continued

Constituent or physical property	Source or cause	Significance
Fluoride (F)	Dissolved in small to minute quantities from most rocks and soils.	Fluoride in drinking water reduces the incidence of tooth decay when the water is consumed during the period of calcification. However, it may cause mottling of the teeth depending on the concentration of fluoride, age of the child, amount of drinking water consumed, and susceptibility of the individual.
Nitrate (NO_3)	Decaying organic matter, sewage, and soil nitrates.	Concentrations much greater than the local average may suggest pollution. There is evidence that more than about 45 mg/L of nitrate may cause a type of methemoglobinemia in infants, sometimes fatal. Nitrate has shown to be helpful in reducing intercrystalline cracking of boiler steel. It encourages growth of algae and other organisims which produce undesirable tastes and odors.
Dissolved solids	Chiefly mineral constituents dissolved from rocks and soils. Includes any organic matter and some water of crystallization.	Federal standards recommend that dissolved solids should not exceed 500 mg/L. Water becomes unsuitable for many purposes when it contains more than 1,000 mg/L of dissolved solids.
Hardness as $CaCO_3$	Nearly all the hardness in most waters is due to calcium and magnesium. All metallic cations other than the alkali metals also cause hardness.	Consumes soap before a lather will form. Deposits soap curd on bathtubs. Hard water forms scale in boilers, water heaters, and pipes. Hardness equivalent to the bicarbonate and carbonate is called carbonate hardness. Any hardness in excess of this is called noncarbonate hardness. Waters of hardness up to 60 mg/L are considered soft; 61–120 mg/L, moderately hard; 121–200 mg/L, hard; more than 200 mg/L, very hard.
Specific conductance (μmho/cm at 25°C)	Mineral content of the water.	Specific conductance is a measure of the capacity of water to conduct an electric current; varies with concentration and degree of ionization of the constituents. Varies with temperature, reported at 25°C.
Hydrogen-ion concentration (pH)	Acids, acid-generating salts, and free carbon dioxide lower the pH. Carbonates, bicarbonates, hydroxide, silicates, and borates raise the pH.	pH of 7.0 indicates neutrality of a solution. Values higher than 7.0 denote increasing alkalinity; values lower than 7.0 indicate increasing acidity. The pH is a measure of hydrogen-ion activity. The corrosive properties of water generally increase with decreasing pH; however, excessively alkaline water may also attack metals.

TABLE 8.—*Source and significance of dissolved mineral constituents and physical properties of ground water on the South Fork*—Continued

Constituent or physical property	Source or cause	Significance
Temperature	Shallow wells show some seasonal fluctuation in water temperature. Ground water from moderate depths usually is nearly constant in temperature, which is near the mean annual air temperature of the area. In very deep wells the water temperature generally increases on the average about 1°C with each 100-ft increment of depth. Seasonal fluctuations in temperatures of surface water are comparatively large—depending on the depth of water—but do not reach the extremes of air temperature.	Affects the usefulness of water for many purposes. For most uses, a water of uniformly low temperature is desired.

TABLE 9.—*Chemical quality of water in upper glacial aquifer, South Fork, Suffolk County, N.Y., October 1976*

[All concentrations are in milligrams per liter]

Constituent or property	Concentration or value				
	Minimum	10th percentile	Medium	90th percentile	Maximum
Silica (SiO_2)	1.1	6.8	9.6	16.0	24.0
Iron (Fe)	.08	.18	.47	1.5	23.0
Manganese (Mn)	0	.10	.20	.11	.62
Calcium (Ca)	.7	1.2	4.0	33.0	64.0
Magnesium (Mg)	.7	1.3	2.6	7.4	9.4
Potassium (K)	.2	.5	1.0	6.6	16.0
Sodium (Na)	4.9	6.0	9.2	26.0	52.0
Bicarbonate (HCO_3)	12	14	18	28	65
Sulfate (SO_4)	.6	3.3	6.2	77.0	140.0
Chloride (Cl)	6.9	9.0	19.0	40.0	82.0
Fluoride (F)	0	0	0	0.1	0.1
Nitrate (NO_3)	0	.01	.62	5.80	11.0
Phosphate (PO_4)	.01	.01	.01	.03	.10
Dissolved oxygen	.3	.7	6.7	9.6	10.9
Dissolved solids	26	43	77	212	275
Noncarbonate hardness	0	0	6	100	180
Total hardness (as $CaCO_3$)	5	10	23	110	200
pH	5.5	5.6	6.0	6.5	6.8
Specific conductance (μmho/cm at 25°C)	48	65	155	375	540

TABLE 10.—*Recommended drinking-water standards for selected chemical constituents*

[All concentrations are in milligrams per liter. Leaders indicate not standard]

Chemical Constituents	Maximum concentration	
	U.S. Environmental Protection Agency (1975)	State of New York (1964)
Chloride (Cl)	---	250
Fluoride (F)	1.4–2.4	1.5
Iron (Fe)	---	.3
Manganese (Mn)	---	.3
Nitrogen (NO_3+ NO_2)	10	10
Sulfate (SO_4)	---	250

TABLE 11.—*Chemical quality of water in Magothy aquifer, South Fork, Suffolk County, N.Y.*

[This table is modified from one by Fetter (1971). All concentrations are in milligrams per liter]

Constituent or property	Concentration or value		
	Minimum	Mean	Maximum
Iron (Fe)	0.04	0.49	2.2
Manganese (Mn)	.05	.05	.05
Nitrate (NO_3)	.02	.47	2.0
Chloride (Cl)	8.0	13.0	19.0
Hardness (as $CaCO_3$)	10	23	42
Alkalinity (as $CaCO_3$)	8	15	24
Dissolved Solids	20	67	106
pH	5.8	6.1	6.4

Ghyben-Herzberg principle, depicted in figure 26. According to this principle, the deposits are filled with fresh water to the depth at which the fresh water head is balanced by the head of the saline water. Under steady state (equilibrium) conditions, the depth of fresh water below sea level is proportional to the fresh water head above sea level and is dependent on the density of both the fresh and saline-water. This relationship is expressed by the equation:

$$h = \frac{t}{G-1} \qquad (2)$$

where:

h = depth of fresh water below sea level;
t = height of fresh water above sea level; and
G = density of saline-water as compared to the assumed density of fresh water.

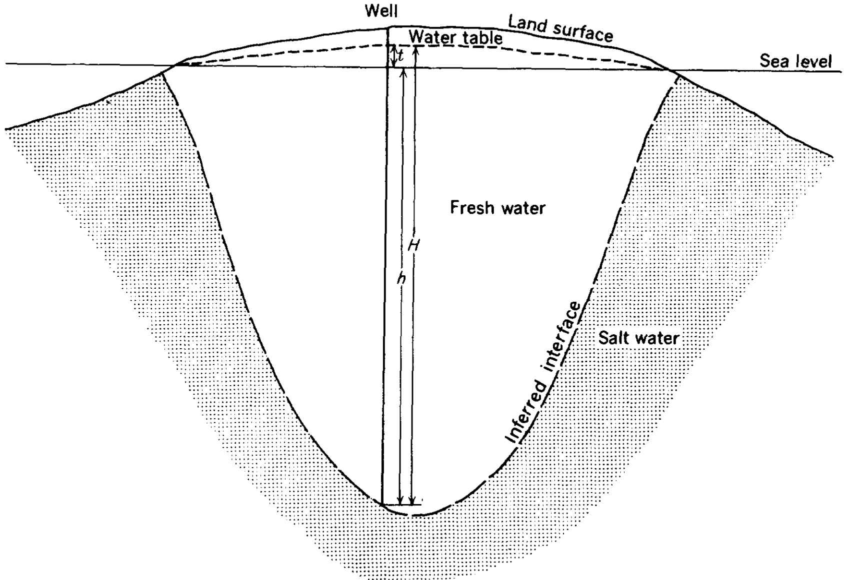

FIGURE 26.—Idealized cross section of an island showing relation of fresh water to saline water according to the Ghyben-Herzberg principle. (From Petitt and Winslow, 1957, pl. 8).

The average density of seawater is 1.025; when this value is applied to the equation, results indicate that freshwater would extend 40 feet below sea level for each foot of freshwater head above sea level.

The zone of diffusion or zone of water that is a mixture of fresh water and saline water, is assumed to be negligble in thickness in the Ghyben-Herzberg hydrostatic model. Although the assumption of hydrostatic equilibrium is not entirely valid, the 40 to 1 ratio of fresh water below sea level to fresh water above sea level is approximately correct in many areas on the southern half of the South Fork. Plate 9 depicts the position of the lower limit of fresh water on the South Fork.

Ground water on the South Fork occurs under dynamic conditions in which fresh water is constantly moving toward and discharging from the edge of the interface. Hydraulic conductivity, saturated thickness, and specific yield are physical properties that determine capacity of the ground-water reservoir to transmit and store water. These properties, together with rates and distribution of recharge and discharge, control the altitude of the water table, the shape of the freshwater lens (fig. 27, and the depth below sea level to the freshwater/saline-water boundary. Because the aquifer materials on the South Fork are generally layered horizontally, hydraulic conductivity is lower in the vertical direction

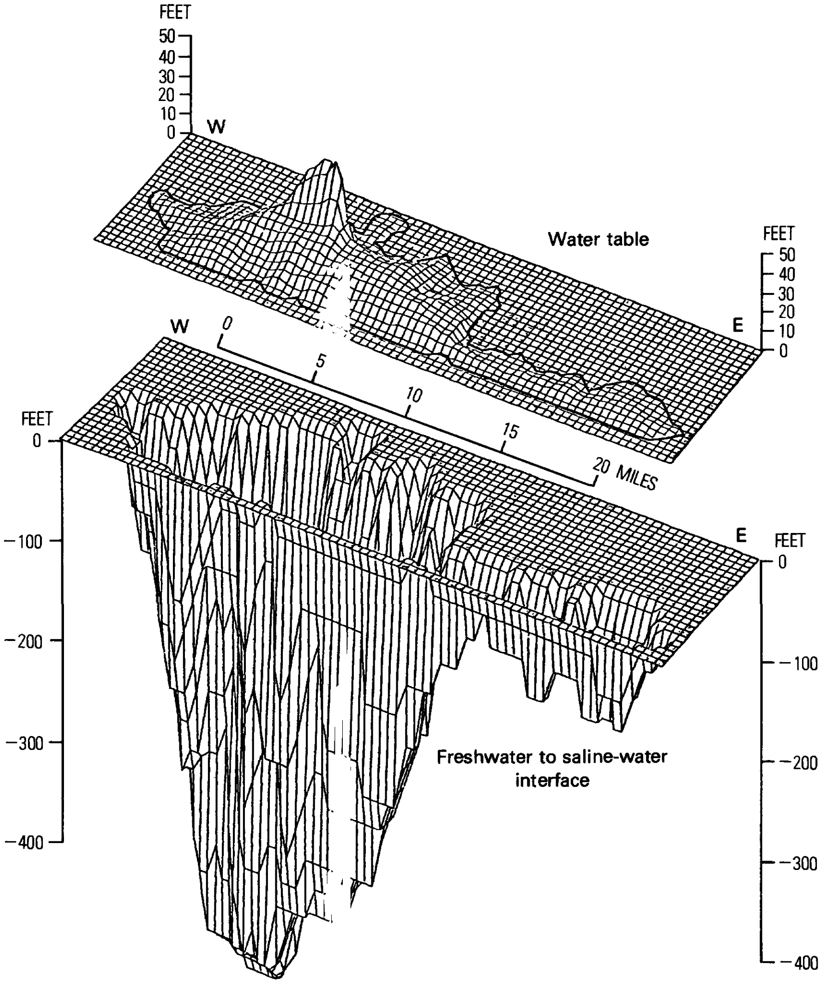

FIGURE 27.—Freshwater lens on the South Fork, Suffolk County, Long Island, N.Y.

than in the horizontal. This difference, termed anisotropy, results in a flattening of the freshwater lens so that it is thinner than it would be if the aquifer were isotropic.

The high degree of anisotropy (lower vertical hydraulic conductivity) of the aquifer in the northern half of the South Fork causes the freshwater/saline-water interface to be at a higher altitude than the Ghyben-Herzberg relationship would indicate (pl. 9). Burns, Frimpter, and Willey (1975) showed by a digital simulation model that the position of the interface is a function of the ratio of vertical to horizontal hydraulic conductivity. Figure 28 depicts this relationship. The ratio of vertical to horizontal hydraulic conductivity varies from place to place on the South Fork. In the northern part, the ration approaches 1 to 100, whereas in the southern part it approaches 1 to 1.

The Montauk Point area has a relatively thin body of fresh ground water. (See pl. 3, sec. *B–B′*). Although perched fresh water is common at shallow depths below land surface (5–35 feet) the major source of fresh water is an artesian aquifer of Pleistocene age consisting of sand and gravel units below the clays, silts, and tills.

The movement of ground water in the South Fork is radially outward from the areas of high water-table altitude. The major ground-water divide trends east-west through these areas; from the divide, ground water moves to the surrounding saltwater bodies along flow lines whose directions are normal to the water-table contours. The direction of horizontal movement is shown by arrows in figure 29. The direction and rate of flow are controlled by the hydraulic gradient and the volume and permeability of the material through which the water moves.

Geologic evidence on the South Fork indicates that the upper glacial aquifer is in direct contact with the ocean or bay floor at the shore and extends seaward, in contact with sea water, for some distance offshore. Wherever a saltwater body is in contact with an aquifer, saline water will enter the aquifer if the freshwater head is lower than the saline-water head. Where the freshwater head is greater, fresh water will flow outward so that no saline water can enter the aquifer.

Saline-water encroachment may also occur by upward or downward movement of saline water from other aquifers. For example, in the Magothy aquifer, which contains both saline water and fresh water on the South Fork, the reduction of freshwater head by excessive pumping may reverse the vertical hydraulic gradient in the vicinity of the stress and cause saline water from underlying adjacent strata to move into the fresh ground water, as illustrated in figure 30.

On the South Fork, the zone of diffusion between fresh water and saline water is relatively narrow, from 20 to 60 feet, which may suggest that saline-water encroachment began suddenly, in response to stresses, such as pumping. It is also possible, however, that the saline water may have been advancing toward the stressed area for many decades. Saline-water encroachment may occur not only laterally, from the shore, but from below, by vertical coning, as depicted in figure 30. Heavy withdrawals at a single location may lower the head in the freshwater aquifer sufficiently to cause upward leakage of saline water from another aquifer.

In areas where saline-water encroachment from an overlying or underlying source is likely, proper well spacing and well depth are of extreme importance. For example, if shallow wells are used to avoid

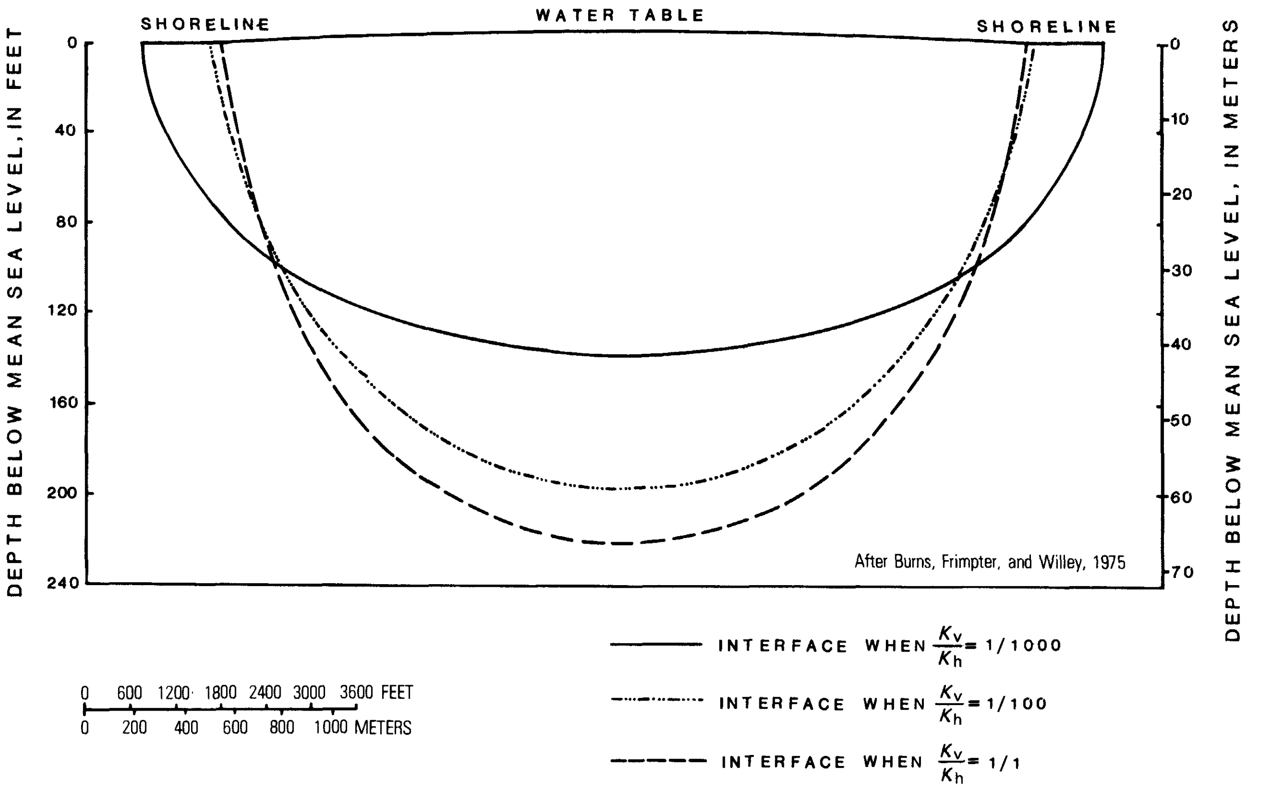

FIGURE 28.—Position of the freshwater/saline-water interface in relation to selected ratios of horizontal to vertical hydraulic conductivity. (From Burns and other, 1975, p.18).

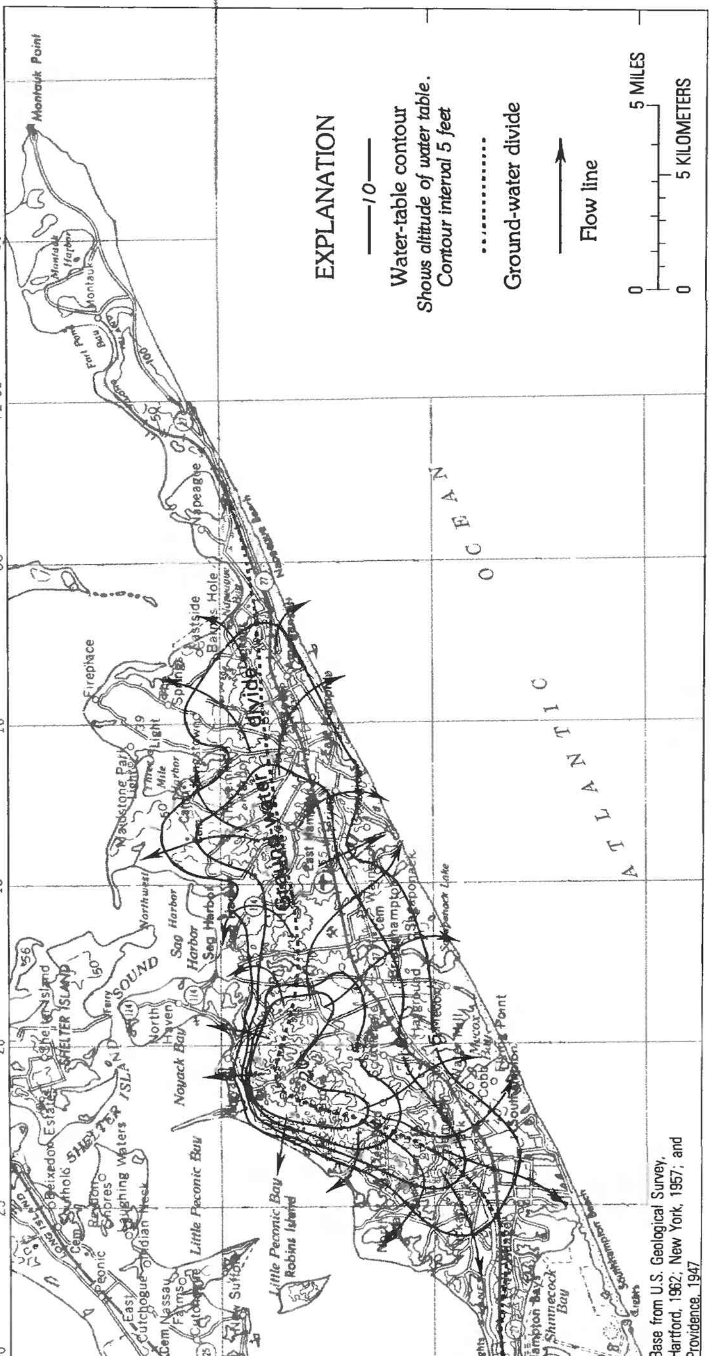

FIGURE 29.—Direction of horizontal movement of ground water on the South Fork, Suffolk County, N.Y.

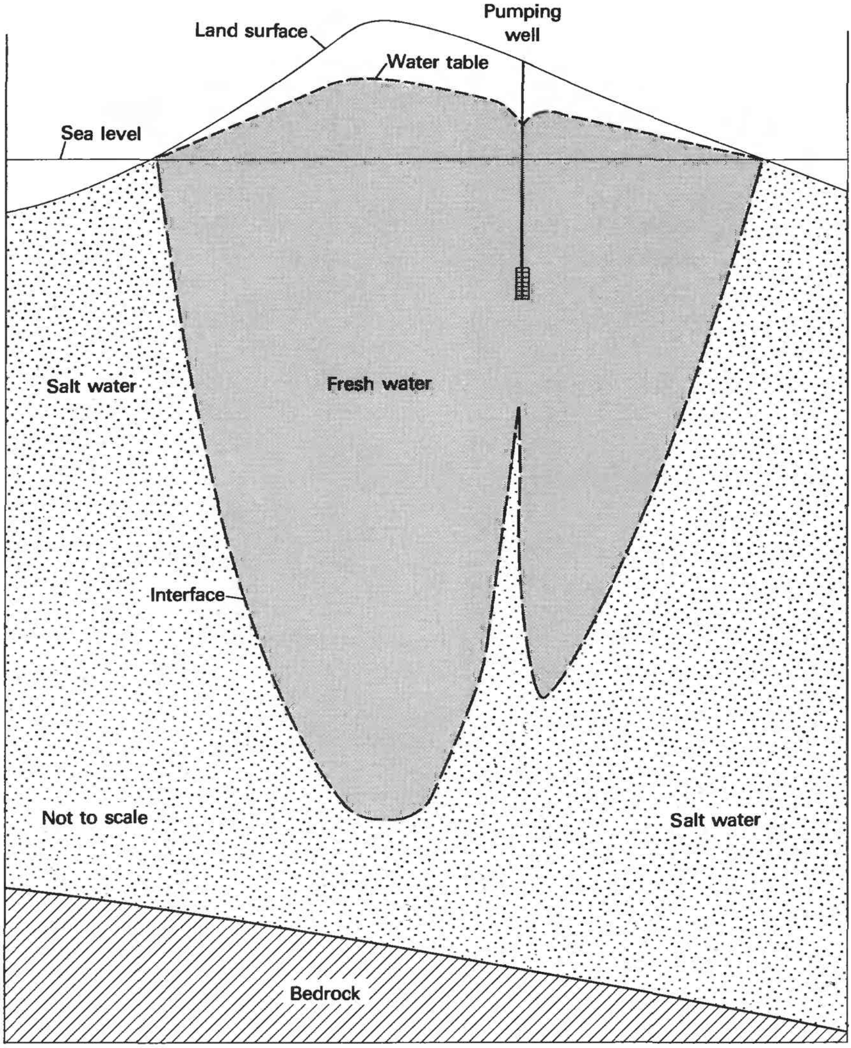

FIGURE 30.—Vertical leakage of saline water in response to pumping.

pumping saline-water and the freshwater supply becomes contaminated from septic-tank effluents installation of sanitary sewers would be necessary. Sanitary sewers piping waste water to the ocean would cause the water table to decline, and this would increase the potential for saline-water intrusion, which, in turn, could necessitate the treatment of all waste water for recycling back to the water table—an expensive and complex operation. To avoid this water-management dilemma, the location of the freshwater/saline-water interface must first be known, then the maximum allowable withdrawals at key locations must be established and the most suitable sites for public-supply wells determined.

SUMMARY AND CONCLUSIONS

The South Fork consists of a Paleozoic basement complex overlain by Cretaceous and Pleistocene deposits. The surficial material consists of late Wisconsinan glacial and glaciofluvial deposits in association with recent beach and marsh deposits.

Precipitation is the source of all ground water on the South Fork. It is estimated that of the total normal annual precipitation of about 45 inches per year, 22 inches per year reaches the ground-water reservoir. Overland runoff is estimated to be 0.5 inches per year, and evapotranspiration is calculated to be 23 inches per year.

The two major aquifers that underlie the South Fork are capable of producing many times more than the 3Mgal/day currently being withdrawn for public supply if careful attention is given to location, depth, and pumping rate of the wells. The water-table aquifer (upper glacial aquifer) is the most readily available source for supplying additional water needs in the area. If this source proves to be inadequate for a particular need, wells can be drilled to the underlying Magothy aquifer in the central part of South Fork. The depth to be drilled to tap this supply at any location can be determined from the structure contour map (pl. 5*D*).

Hydraulic conductivity and transmissivity of the Magothy and upper glacial aquifers were estimated from aquifer tests and specific-capacity data. The average horizontal hydraulic conductivity of the Magothy aquifer is 70 ft/day; that of the upper glacial aquifer is 350/day. Transmissivity of the Magothy aquifer ranges from 607 ft^2/day to 24,064 ft^2/day. The transmissivity of the upper glacial aquifer ranges from 5,350 ft^2/day to 22,725 ft^2/day.

The interface between fresh water and saline water (shown in fig. 26) is assumed to be a thin zone, but test drilling has shown that this is not a sharp boundary but ranges from 20 to 60 feet in width. In the southern part of the area, the configuration of the freshwater reservoir can be approximated from the Ghyben-Herzberg hydrostatic model. In the northern part, however, the calculated depth to the interface is greater than the observed depth owing to increased anisotropy in the geologic units.

With the exception of locally elevated concentrations of iron, chloride, and nitrate, the chemical quality of the fresh gound water is of suitable quality for drinking and most other uses.

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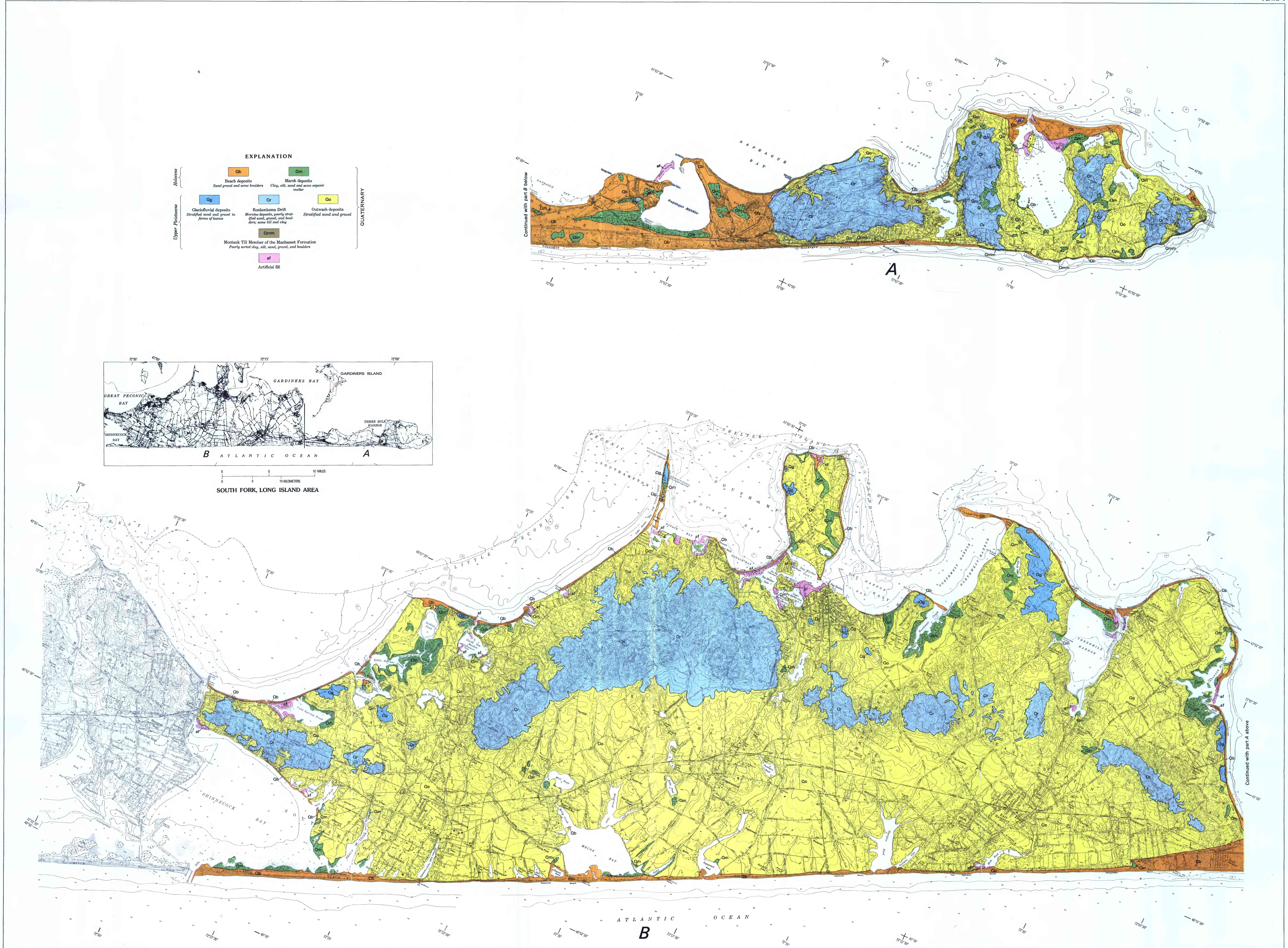
☆ U.S. GOVERNMENT PRINTING OFFICE: 1981—781-617



Base from U.S. Geological Survey, 1:62,500:
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Gardiners Island West, 1956; Greenport, 1956;
Mattituck, 1956; Montauk Point, 1956; Napeague Beach,
1956; Quogue, 1956; Sag Harbor, 1956;
Shinnecock Inlet, 1955; Southampton, 1956;
Southold, 1956

APPROXIMATE MEAN DECLINATION, 1961

SCALE 1:48 000
1 ½ 0 1 2 3 MILES
1 .5 0 1 2 3 KILOMETERS
CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Geology by Bronius Nemickas and Edward J. Koszalka

GENERALIZED SURFICIAL GEOLOGY OF THE SOUTH FORK, SUFFOLK COUNTY, LONG ISLAND, NEW YORK

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
SUFFOLK COUNTY DEPARTMENT OF HEALTH SERVICES AND
SUFFOLK COUNTY WATER AUTHORITY

WATER-SUPPLY PAPER 2073
PLATE 2

EXPLANATION

58961
Observation well

9470
Public water-supply well

59793
Freshwater to saline-water interface test hole

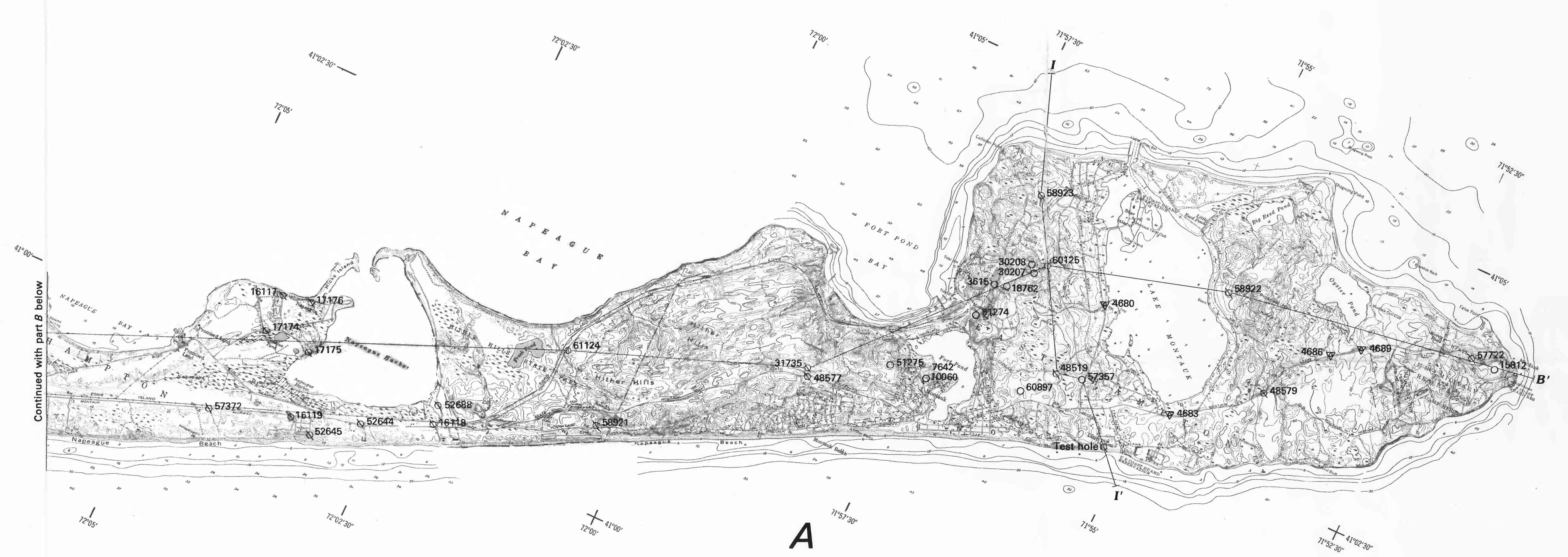
8831
Water-quality observation well

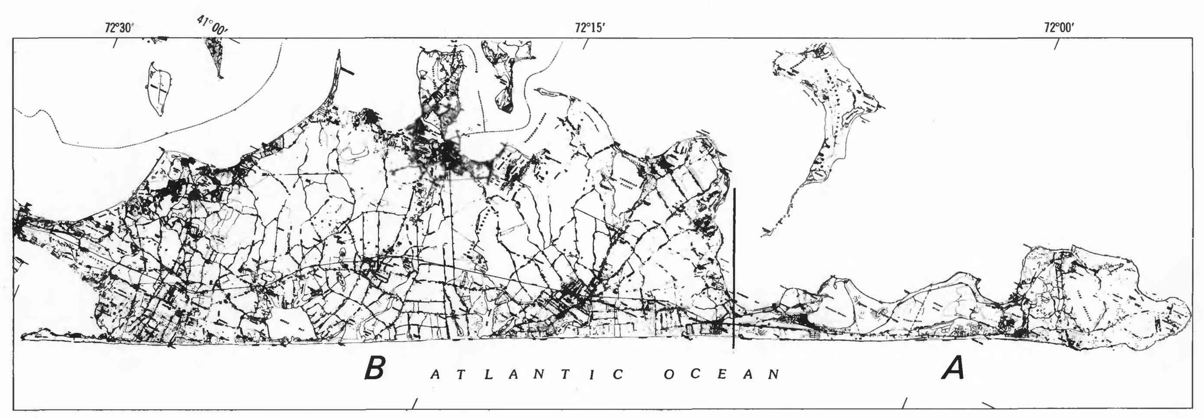
NOTE.—Number is well number; all well numbers are preceded by S (for Suffolk County)

4590
Streamflow-measure site; number is station identification number; all station numbers are preceded by 0130

D ——— D'
Hydrogeologic section

Sections shown on Plate 3





SOUTH FORK, LONG ISLAND AREA

Base from U.S. Geological Survey, 1:62,500:
East Hampton, 1956; Gardiners Island East, 1956;
Gardiners Island West, 1956; Greenport, 1956;
Mattituck, 1956; Montauk Point, 1956; Napeague Beach, 1956; Quogue, 1956; Sag Harbor, 1956;
Shinnecock Inlet, 1955; Southampton, 1956;
Southhold, 1956

SCALE 1:48 000

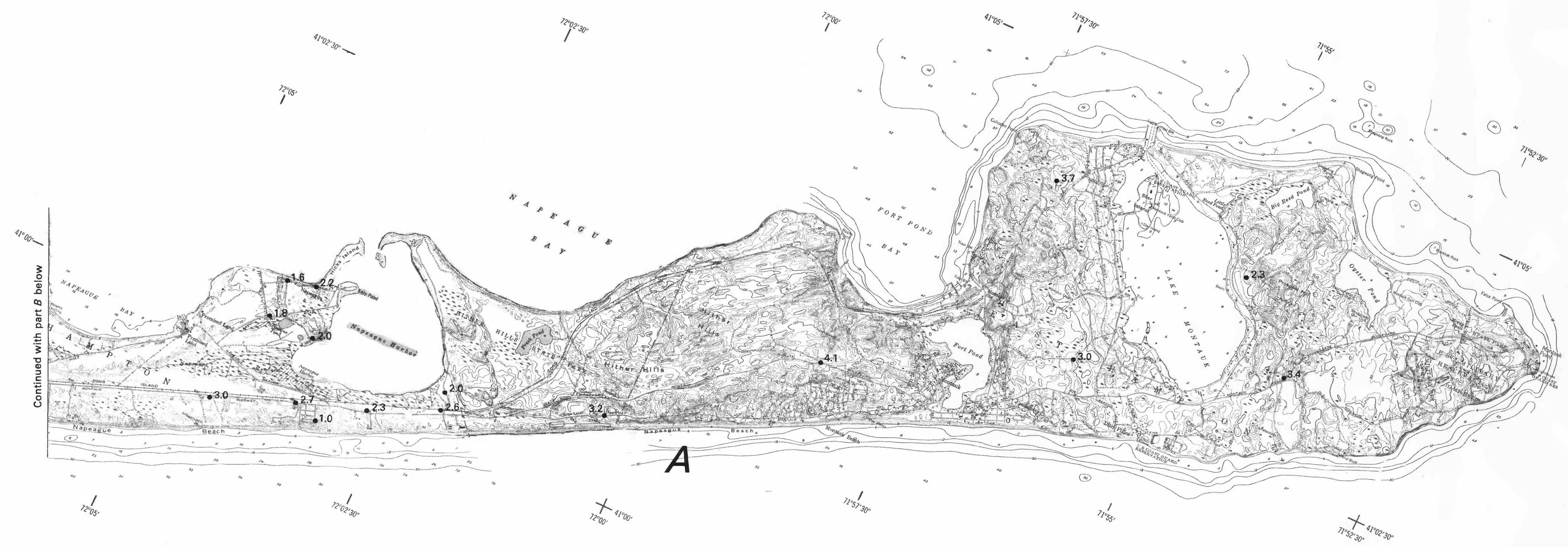
CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Hydrology by Nemickas and Koszalka, 1977

MAP SHOWING LOCATION OF WELLS, STREAMFLOW-MEASUREMENT SITES, AND HYDROGEOLOGIC SECTIONS ON THE SOUTH FORK, SUFFOLK COUNTY, LONG ISLAND, NEW YORK

HYDROGEOLOGIC SECTIONS, SOUTH FORK, SUFFOLK COUNTY, LONG ISLAND, NEW YORK

PREPARED IN COOPERATION WITH THE
SUFFOLK COUNTY DEPARTMENT OF HEALTH SERVICES AND
SUFFOLK COUNTY WATER AUTHORITY

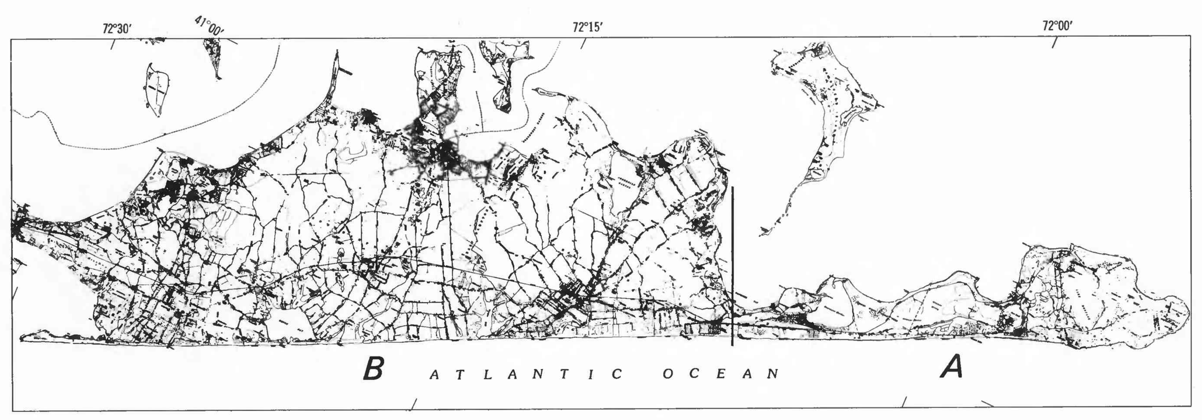


EXPLANATION

•14.2
Observation well; number is altitude of water level, in feet above National Geodetic Vertical Datum of 1929

——15——
Water table contour, shows altitude of water table. Dashed where approximately located. Contour interval 5 feet

Area of high water levels



SOUTH FORK, LONG ISLAND AREA

Base from U.S. Geological Survey, 1:62,500:
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Gardiners Island West, 1956; Greenport, 1956;
Mattituck, 1956; Montauk Point, 1956; Napeague Beach,
1956; Quogue, 1956; Sag Harbor, 1956;
Shinnecock Inlet, 1955; Southampton, 1956;
Southhold, 1956

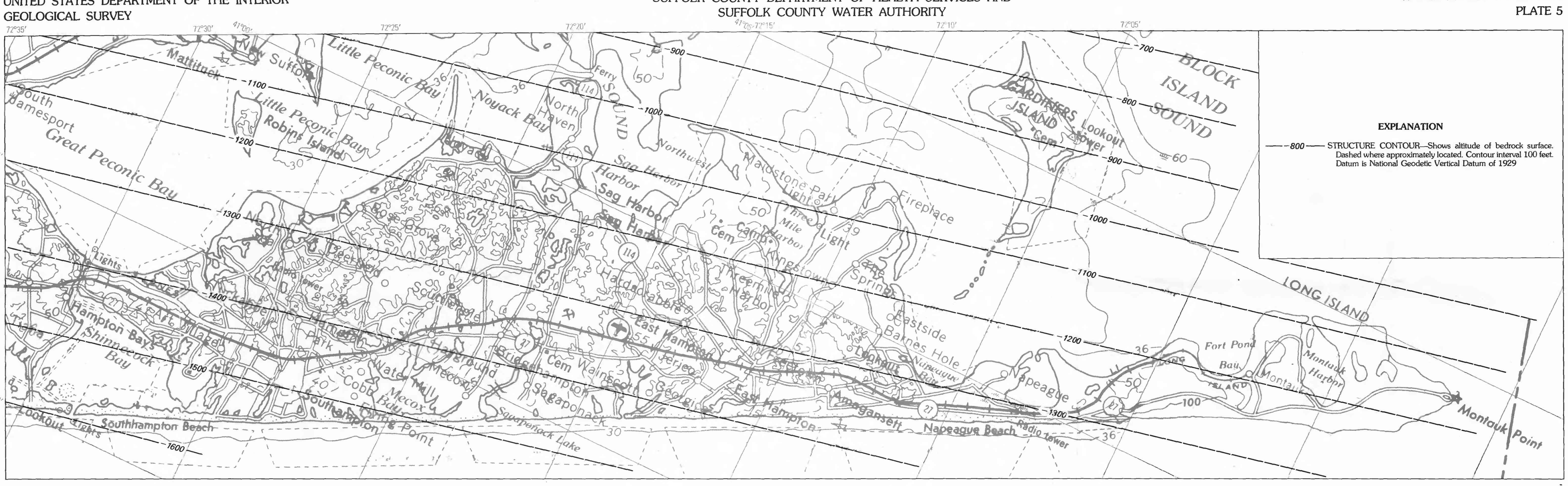
SCALE 1:48 000
1 ½ 0 1 2 3 MILES
1 .5 0 1 2 3 KILOMETERS

CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Hydrology by Nemickas and Koszalka, 1977

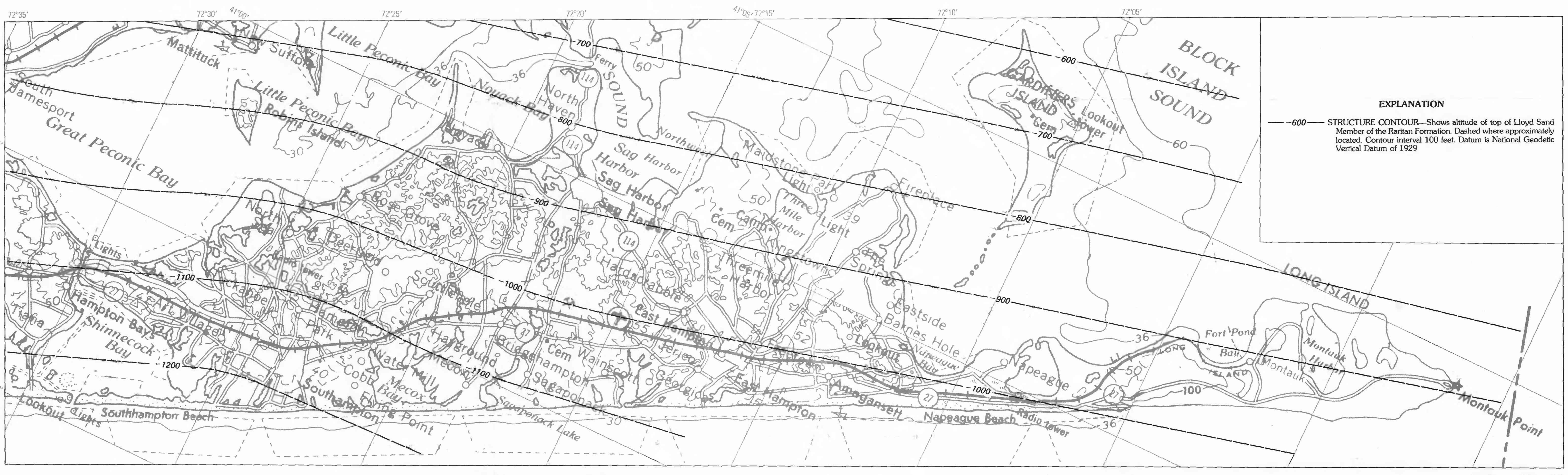
MAP SHOWING WATER TABLE ALTITUDE ON THE SOUTH FORK, SUFFOLK COUNTY, LONG ISLAND, NEW YORK, OCTOBER 1976

PREPARED IN COOPERATION WITH THE
SUFFOLK COUNTY DEPARTMENT OF HEALTH SERVICES AND
SUFFOLK COUNTY WATER AUTHORITY



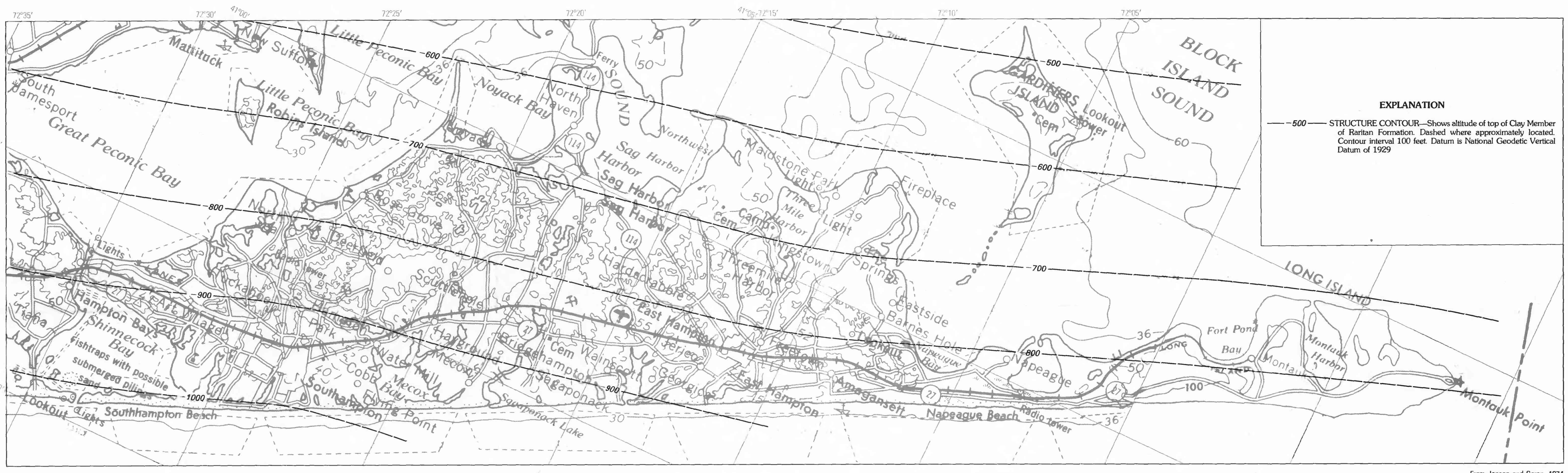
A.—MAP SHOWING ALTITUDE OF BEDROCK SURFACE

From Jensen and Soren, 1974
Sheet 1



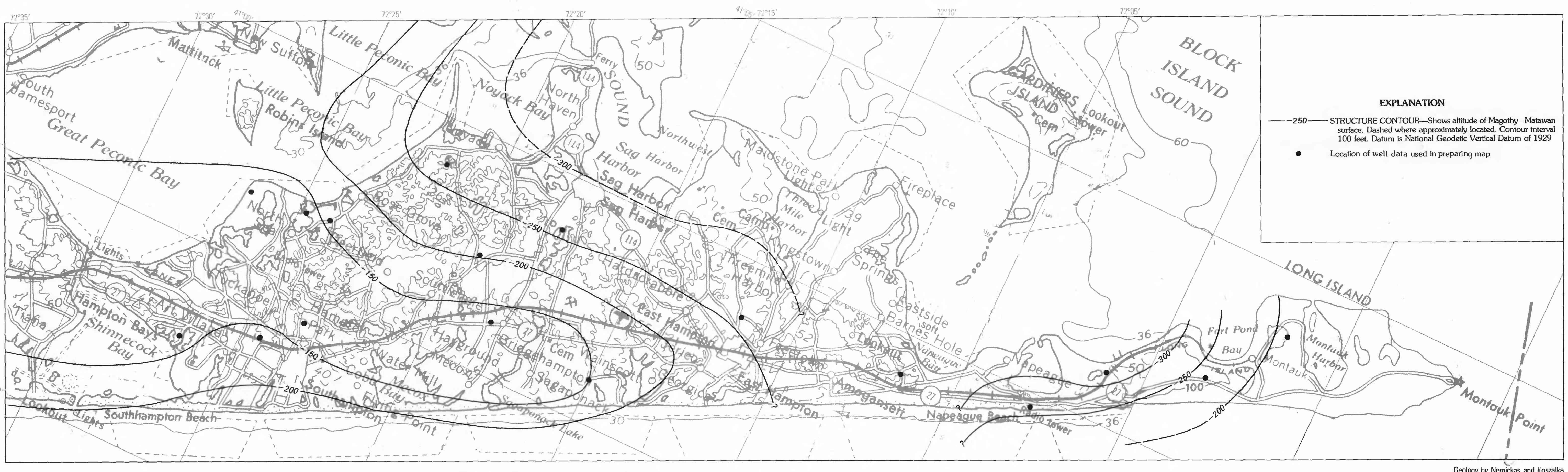
B.—MAP SHOWING ALTITUDE OF TOP OF LLOYD SAND MEMBER OF RARITAN FORMATION

From Jensen and Soren, 1974
Sheet 1



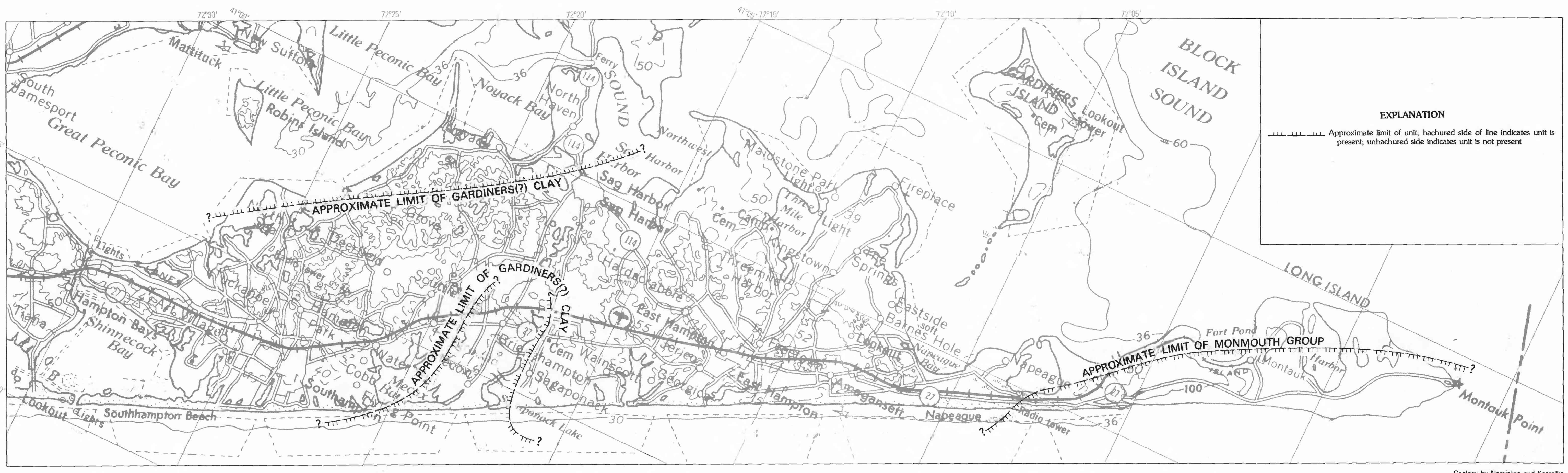
C.—MAP SHOWING ALTITUDE OF TOP OF CLAY MEMBER OF RARITAN FORMATION

From Jensen and Soren, 1974
Sheet 1



D.—MAP SHOWING ALTITUDE OF TOP OF MAGOTHY FORMATION–MATAWA GROUP

Geology by Nemickas and Koszalka



Base from U.S. Geological Survey, 1:250,000:
Hartford, 1962; New York, 1957, and
Providence, 1947

E.—MAP SHOWING APPROXIMATE AREAL EXTENT OF MONMOUTH GROUP AND GARDINERS(?) CLAY

Geology by Nemickas and Koszalka

SCALE 1:125 000

2 0 2 4 6 8 MILES

2 0 2 4 6 8 KILOMETERS

CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

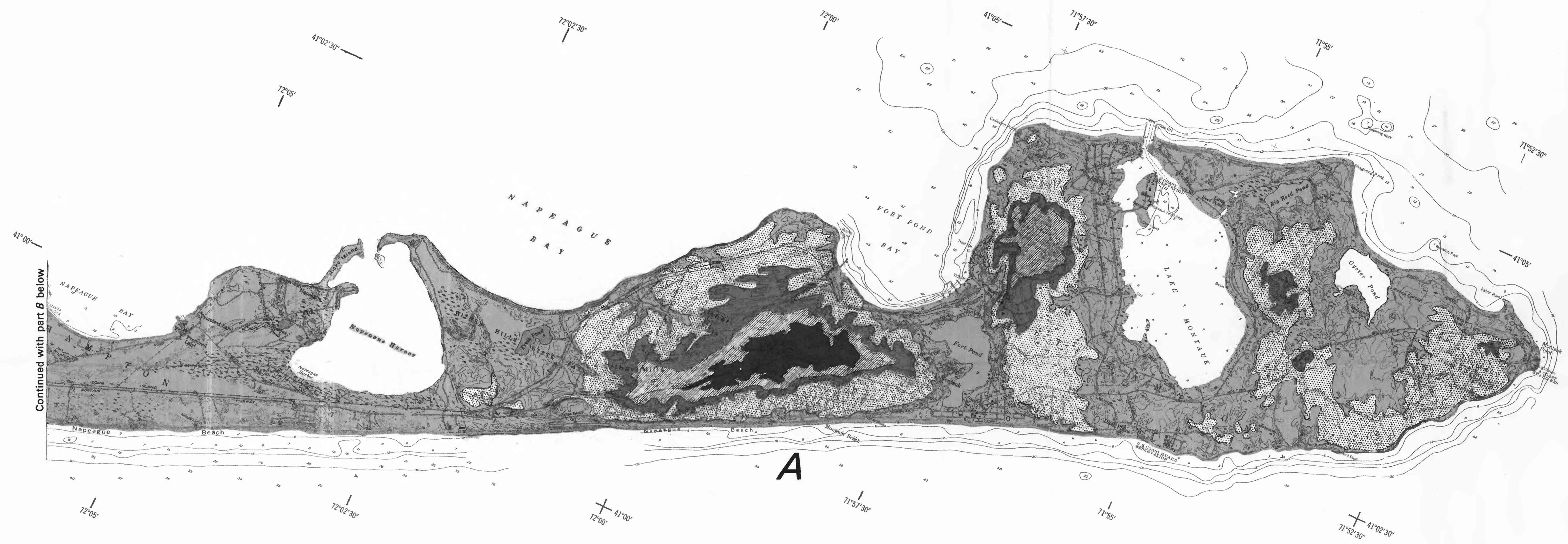
MAPS SHOWING ALTITUDES OF TOP SURFACES OF SEVERAL FORMATIONS AND THEIR MEMBERS AND THE AREAL EXTENT OF THE MONMOUTH GROUP AND GARDINERS(?) CLAY ON THE SOUTH FORK, SUFFOLK COUNTY, NEW YORK

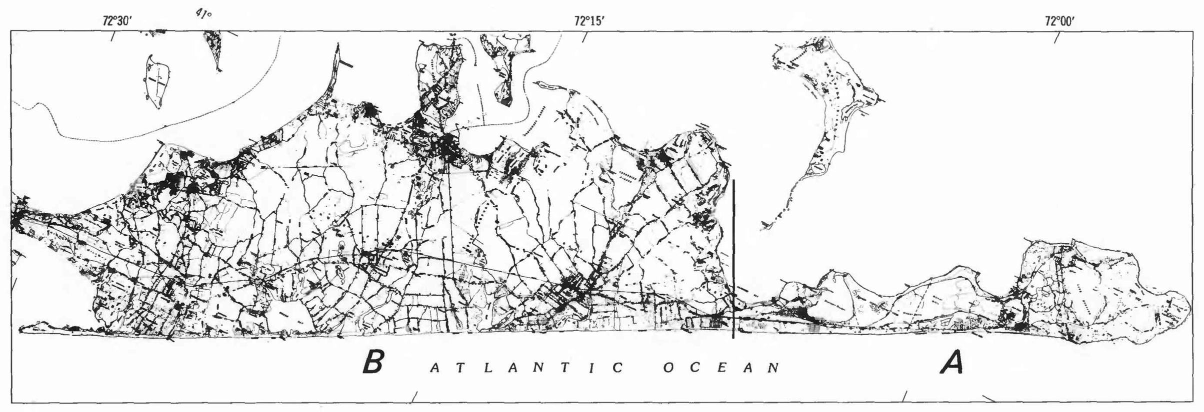
PREPARED IN COOPERATION WITH THE
SUFFOLK COUNTY DEPARTMENT OF HEALTH SERVICES AND
SUFFOLK COUNTY WATER AUTHORITY

EXPLANATION

Depth to water table

- 0–25 feet
- 25–50 feet
- 50–75 feet
- 75–100 feet
- >100 feet





SOUTH FORK, LONG ISLAND AREA

Base from U.S. Geological Survey, 1:62,500:
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1956; Quogue, 1956; Sag Harbor, 1956;
Shinnecock Inlet, 1955; Southampton, 1956;
Southhold, 1956

SCALE 1:48 000

1 ½ 0 1 2 3 MILES

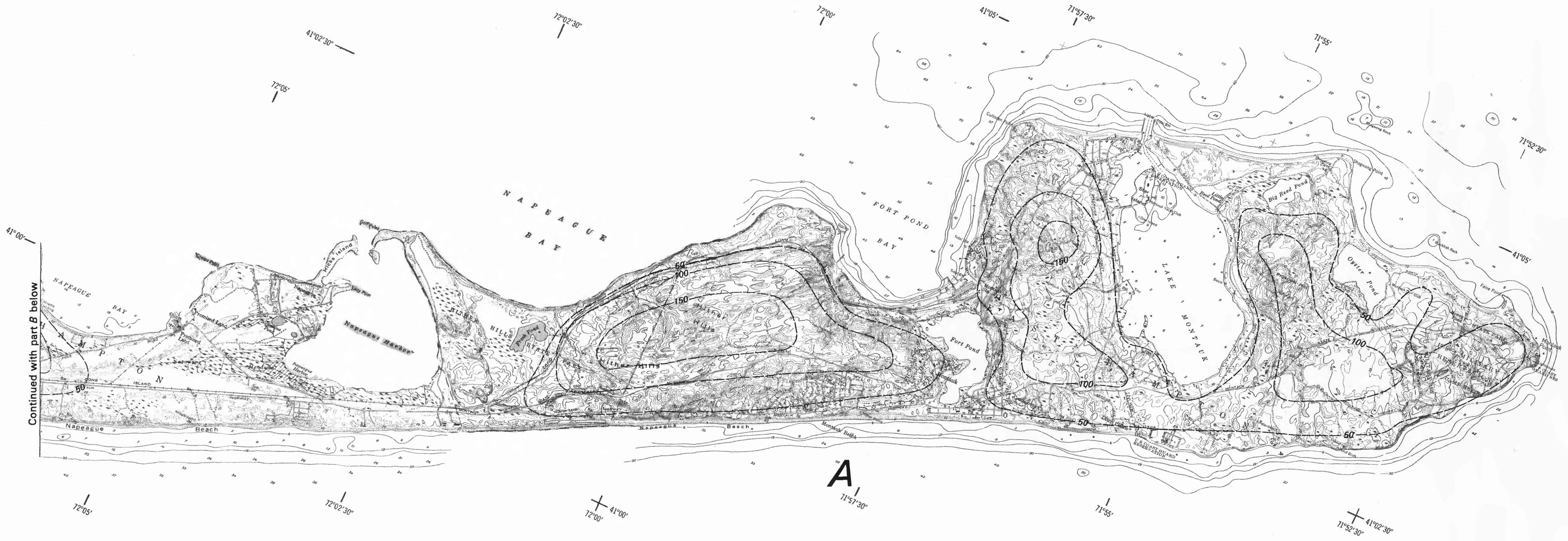
1 .5 0 1 2 3 KILOMETERS

CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Hydrology by Nemickas and Koszalka, 1977

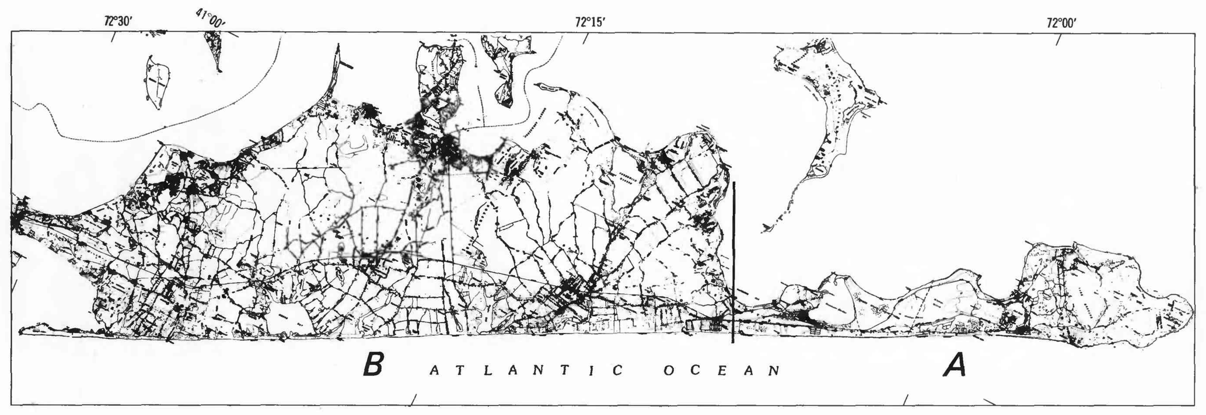
MAP SHOWING APPROXIMATE DEPTH TO WATER TABLE ON THE SOUTH FORK, SUFFOLK COUNTY, NEW YORK

PREPARED IN COOPERATION WITH THE
SUFFOLK COUNTY DEPARTMENT OF HEALTH SERVICES AND
SUFFOLK COUNTY WATER AUTHORITY



EXPLANATION

—— 100 ——
Line of equal saturated thickness
contour interval 50 feet



SOUTH FORK, LONG ISLAND AREA

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1956; Quogue, 1956; Sag Harbor, 1956;
Shinnecock Inlet, 1955; Southampton, 1956;
Southhold, 1956

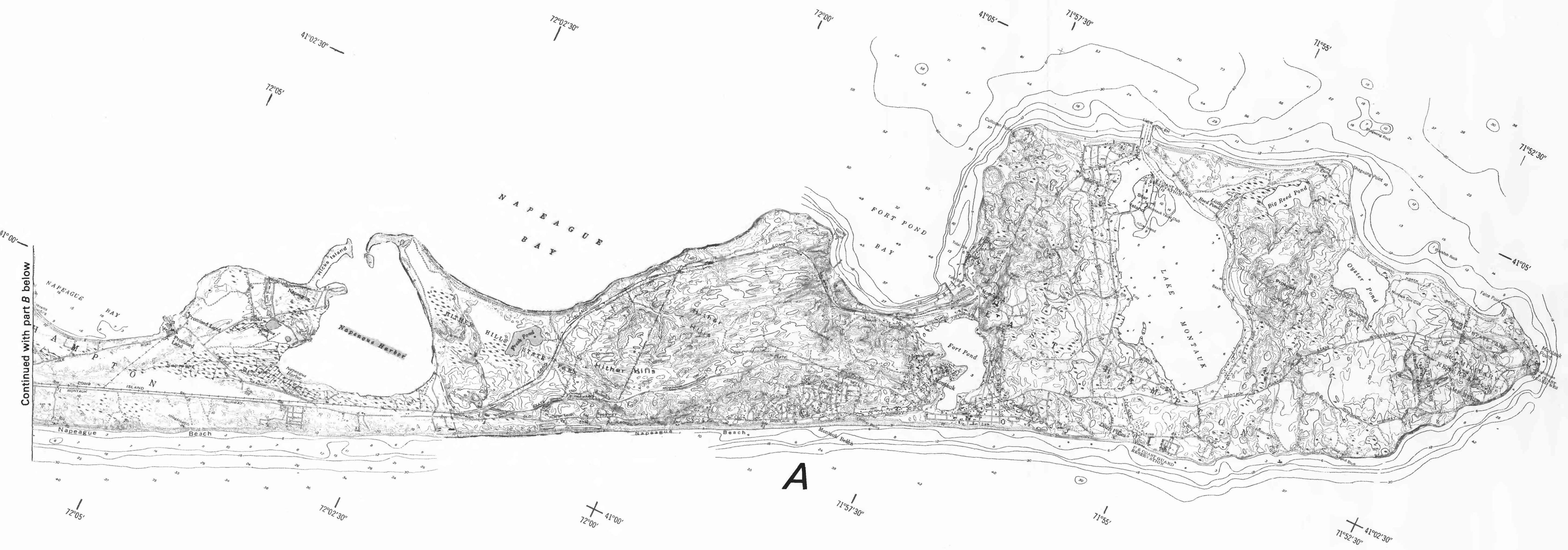
MAGNETIC NORTH / TRUE NORTH 14°
APPROXIMATE MEAN DECLINATION, 1981

SCALE 1:48 000
1 ½ 0 1 2 3 MILES
1 .5 0 1 2 3 KILOMETERS
CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Hydrology by Nemickas and Koszalka, 1977

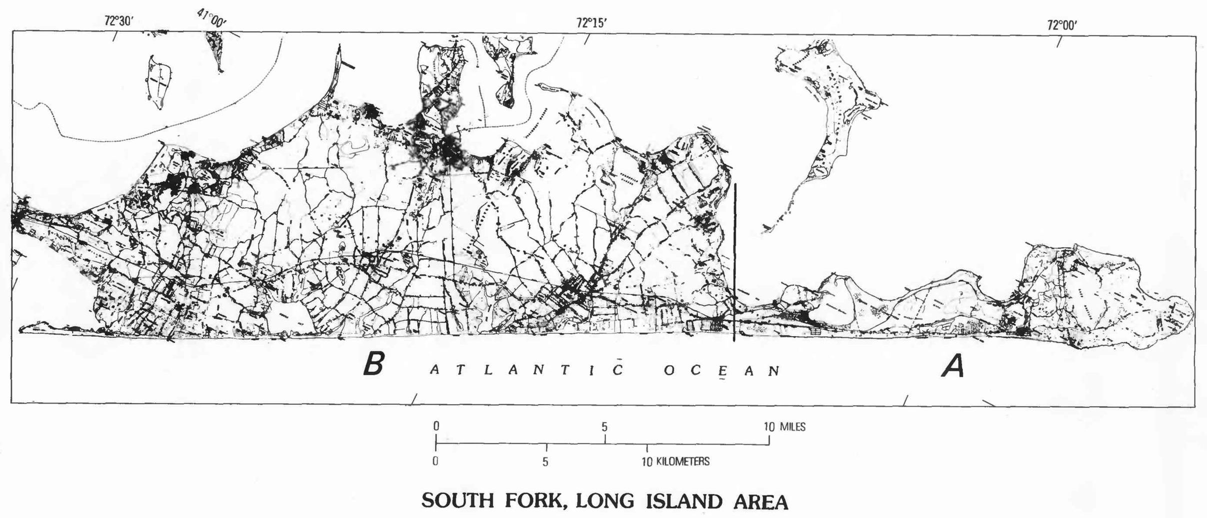
MAP SHOWING THICKNESS OF FRESHWATER ZONE IN THE UPPER GLACIAL AQUIFER ON THE SOUTH FORK, SUFFOLK COUNTY, NEW YORK

PREPARED IN COOPERATION WITH THE
SUFFOLK COUNTY DEPARTMENT OF HEALTH SERVICES AND
SUFFOLK COUNTY WATER AUTHORITY



EXPLANATION

——200—— Line of equal saturated thickness; contour interval 50 feet



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Gardiners Island West, 1956; Greenport, 1956;
Mattituck, 1956; Montauk Point, 1956; Napeague Beach,
1956; Quogue, 1956; Sag Harbor, 1956;
Shinnecock Inlet, 1955; Southampton, 1956;
Southhold, 1956

APPROXIMATE MEAN DECLINATION, 1981

SCALE 1:48 000

1 ½ 0 1 2 3 MILES

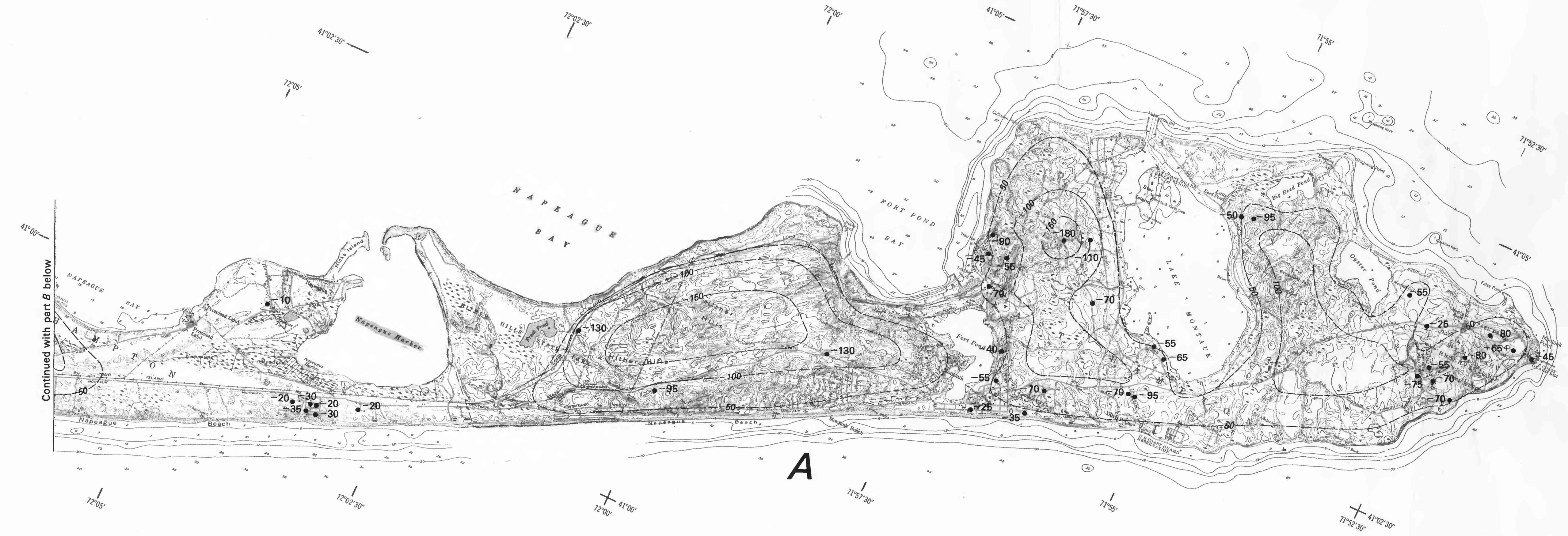
1 .5 0 1 2 3 KILOMETERS

CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Hydrology by Nemickas and Koszalka, 1977

MAP SHOWING THICKNESS OF FRESHWATER ZONE IN THE MAGOTHY AQUIFER ON THE SOUTH FORK SUFFOLK COUNTY, NEW YORK

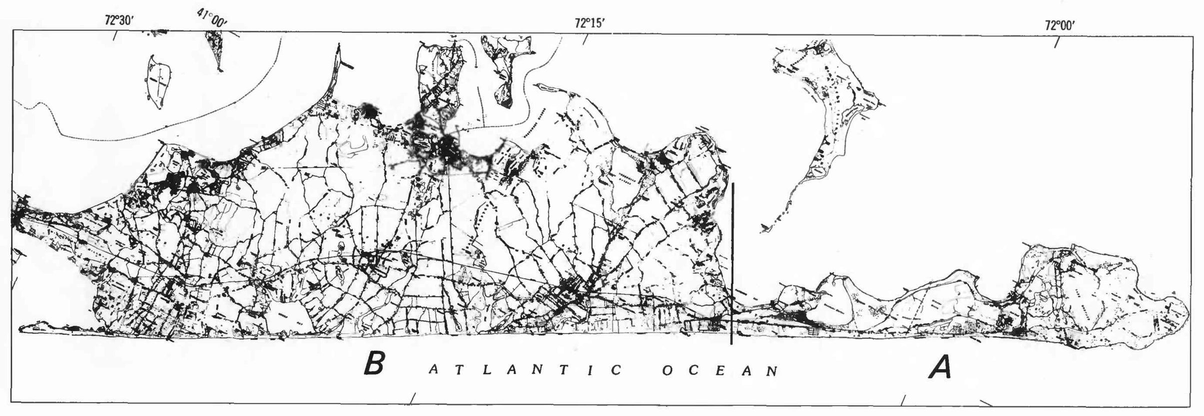
PREPARED IN COOPERATION WITH THE
SUFFOLK COUNTY DEPARTMENT OF HEALTH SERVICES AND
SUFFOLK COUNTY WATER AUTHORITY



EXPLANATION

——100——
Contours on base of fresh water
Contour interval 50 feet. Datum is National Geodetic Vertical Datum of 1929

●
Control well
Number is altitude of base of fresh water, in feet, below National Geodetic Vertical Datum of 1929



SOUTH FORK, LONG ISLAND AREA

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Southhold, 1956

APPROXIMATE MEAN DECLINATION, 1981

SCALE 1:48 000

1 ½ 0 1 2 3 MILES

1 .5 0 1 2 3 KILOMETERS

CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Hydrology by Nemickas and Koszalka, 1977

MAP SHOWING ALTITUDE OF BASE OF FRESH WATER ON THE SOUTH FORK, SUFFOLK COUNTY, NEW YORK