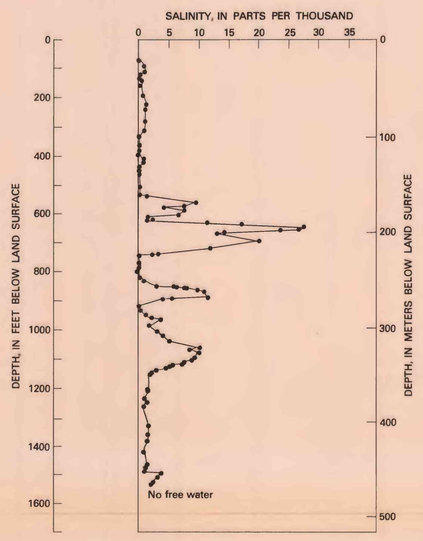
QUALITY OF WATER



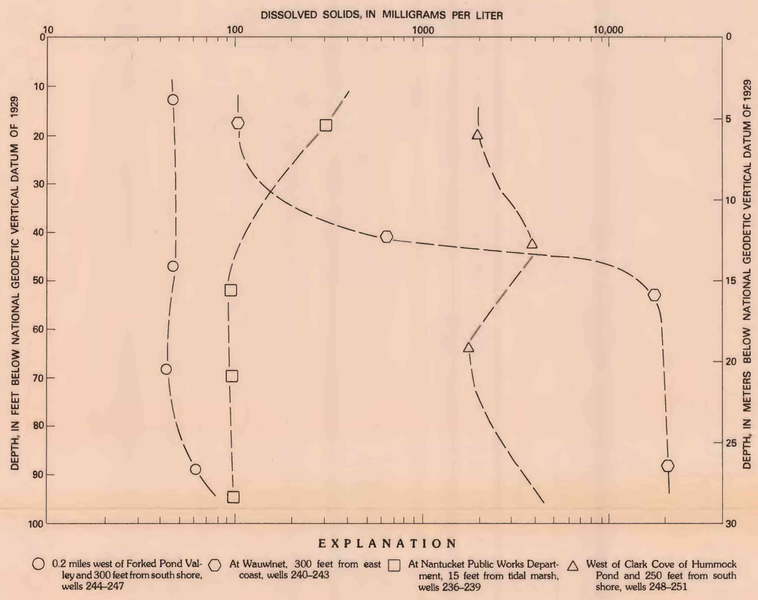
CHANGES IN SALINITY WITH INCREASING DEPTH.—The salinity of water deep beneath Nautucket was determined from samples obtained during the drilling of the 1,686-ft test hole. Pore water samples were obtained by squeezing lithologic core samples in a hydraulic press. Freshwater containing less than 1 ppt of dissolved solids occurred to a depth of about 520 feet below land surface. Below this point, the salinity increased irregularly to more than 25 ppt at a depth of 650 feet (in comparison with 33 ppt for seawater).

Anomalously, the salinity of the pore water did not increase to that of sea water below 650 feet. Salinity declined to less than 0.5 ppt between 740 and 820 feet, and ranged from 0.5 ppt to 11 ppt in the section from 820 to 1,150 feet. From 1,150 feet to about 20 feet above the top of weathered basalt at 1,500 feet, the salinity remained below 2 ppt.

The most likely explanation for the presence of relatively freshwater below the zone of transition (520–650 ft) is that freshwater was recharged to these strata prior to or during the last glaciation, when sea level was about 400 feet lower than it is at present (Milliman and Emery, 1968). During the approximately 8,000 years since the post-glacial rise of sea level isolated Nantucket from the mainland, sea water has not displaced the freshwater where it occurs trapped under layers of relatively impermeable clay (Kohout and others, 1977).

The water level measured in the piezometer tapping Cretaceous sand at 1,433 ft is 24 feet above sea level, about 12 feet higher than the water table in the freshwater lens at the same site. This 12-ft head difference indicates that water in the deep Cretaceous sand is not in equilibrium with local surface hydrologic conditions at this time, and that over the last 8000 years or more low permeability of the sediments has prevented displacement of the freshwater by seawater.

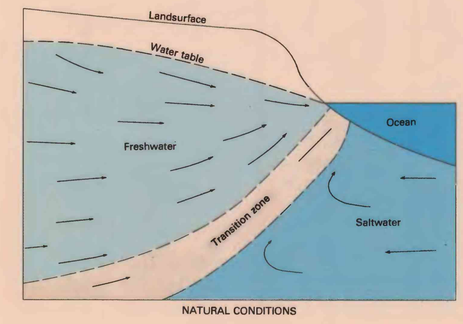
Water from kaolinitic sand of Cretaceous age pumped from 1,433 feet contained 2,360 mg/L dissolved solids; sodium (780 mg/L) and chloride (1,200 mg/L) constituted most of the dissolved solids. This analysis is similar to an analysis of pore water squeezed from a sediment sample from 1,427 feet deep, which contained 850 mg/L sodium and 1,200 mg/L chloride. The water had a pH of 7.2, 1 mg/L total iron, and a calcium to magnesium ratio of 21 mg/L to 34 mg/L or 0.62. The dominance of sodium and chloride ions and a calcium to magnesium ratio less than 1 suggest a brackish-water marine marginal (back barrier) paleoenvironment for the origin of the water. This origin is generally consistent with the depositional environment for Cretaceous sediments from 420 to 1,145 feet deep overlying the sand from which the water was pumped.



CHANGES IN SALINITY AT NEAR-SHORE SITES.—A cluster of four test wells (wells 240–243) at Wauwinet near the coast in northeastern Nantucket, shows that transition from freshwater with 100 mg/L dissolved solids, to saline water with 18,000 mg/L dissolved solids occurs between depths of 17 and 52 feet below sea level. At about 300 feet from the south shore of the island and a little west of Forked Pond Valley, the top of the zone of transition is at a depth of about 90 feet below sea level (wells 244–247).

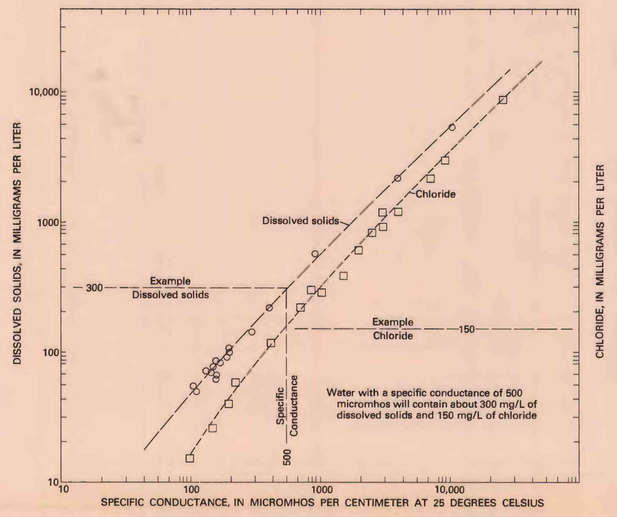
A cluster of wells (wells 236–239) 15 feet from a salt marsh and estuary on the south side of Nantucket Harbor tapped only freshwater (less than 100 mg/L dissolved solids) to a depth of 94 feet below sea level. Artesian head in the well screened at 52 feet below sea level was about 3 feet above mean sea level, and head increased slightly with increased depth in the wells screened at 69 and 94 feet below sea level. The top of the zone of transition is probably greater than 120 feet below sea level at this point. Water level in the shallowest well, screened at 17 feet below sea level, was at about the altitude of the marsh and estuary, and dissolved solids were 300 mg/L, indicating some influx of brackish water into the shallow aquifer. The conditions here explain the observation by Nantucket well drillers that some wells near the shore will yield freshwater if they are driven below shallow depths.

A cluster of test wells (wells 248–251) just west of Hummock Pond on the south shore of the island and about 250 feet from the sea yielded water containing 1,800 to 3,900 mg/L of dissolved solids at depths between 19 and 84 feet below sea level. This anomalous occurrence of brackish water is probably caused by seaward ground-water flow of brackish water from Hummock Pond. The pond is opened to the sea each spring by a channel dug in the sand bar that separates it from the sea.

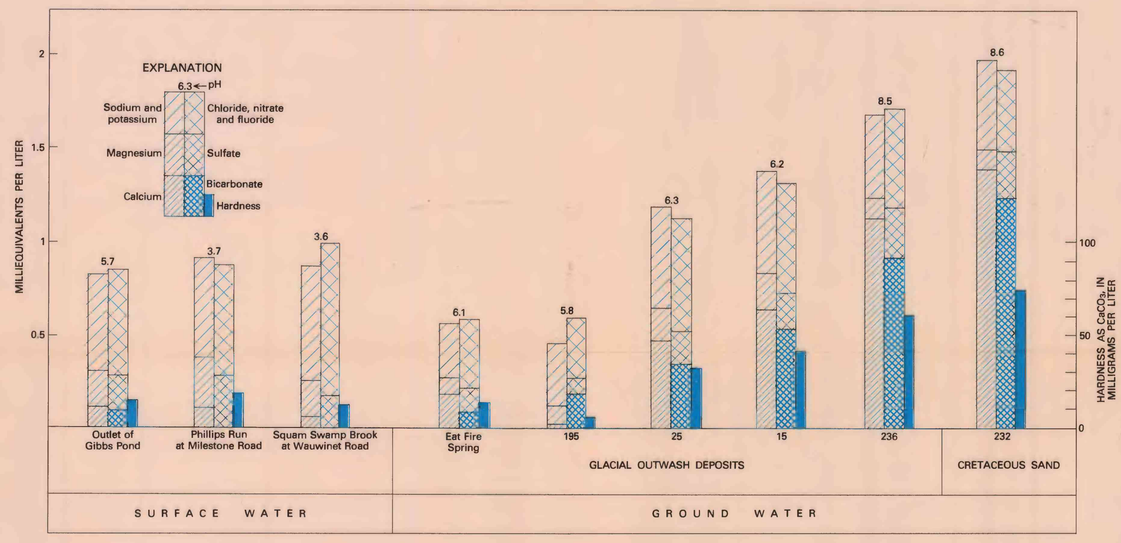


(Vertical exaggeration, X100; adapted from Baldwin and McGuinness, 1963) (thickness of freshwater lens diagrammatic; not to true scale)

EFFECTS OF PUMPING FRESHWATER NEAR THE COAST.—Pumping a well near the ocean lowers the water table locally, causing the saltwater to rise. If the rate of pumping and attendant decline of the water table are large enough, the saltwater may rise to the bottom of the well.



SPECIFIC CONDUCTANCE AND CONCENTRATION OF DISSOLVED SOLIDS AND CHLORIDE.—Specific conductance, a measure of the electrical conductivity of water, depends mainly on the amount of dissolved solids and to a lesser degree on the type of dissolved solids. With the aid of these graphs, the concentration of dissolved solids and of chloride can be estimated from determinations of specific conductance, which can be made rapidly with a field instrument.



CHEMICAL CHARACTER OF FRESH SURFACE WATER AND GROUND WATER.—Sodium and chloride are the principal dissolved substances of inland surface waters of Nantucket, as represented by samples from Phillips Run, Squam Swamp Brook, and the outlet of Gibbs Pond. Water of the brooks of Nantucket, which drain from swamps, is normally soft (less than 30 mg/L as $CaCO_3$), tea brown in color, owing to complex humic acids generated in the swamps, and, therefore, also acid. Iron content of the representative surface-water samples ranged from 0.53 to 0.74 mg/L, higher than the 0.3 mg/L maximum recommended for public drinking water supplies (U.S. Environmental Protection Agency, 1975).

Ground water of Nantucket shows greater range in chemical composition than surface water, because of progressive changes as the water moves through the ground-water reservoir.

Waters from well 195, 27 feet deep in the south-central part of Nantucket, and from the Eat Fire Spring on Wauwinet Road, have 34 and 39 mg/L dissolved solids, respectively, about as low as any ground water on the island. The water from these sources comes from the upper part of the saturated zone and is derived from local recharge. It is chemically much like surface water, in that sodium and chloride are the principal dissolved solids, but it is less acid than the surface water.

In water from the well points of the Wannacomet Water Company (wells 25 and 26) about 40 feet deep and the gravel-packed 56-ft well (well 15) of the Siasconset water system, half or more of the dissolved solids are calcium, magnesium, bicarbonate, and sulfate. The water from these wells has moved through more of the aquifer at greater depths and has been in contact with soluble minerals of the ground-water reservoir for longer periods of time than the water from well 195 or Eat Fire Spring.

A 96-ft deep well (well 236) close to the south shore of Nantucket Harbor, produces alkaline water having a pH of 8.5 in which the principal dissolved substances are calcium and bicarbonate, probably derived from the zones of abundant fossil shell fragments in the aquifer.

A sample from well 232, 480 feet deep, near to the base of the freshwater zone, was of the calcium bicarbonate type, had a pH of 8.6 and 114 mg/L dissolved solids.

The concentration of chloride in 16 samples of fresh ground water from Nantucket Island ranged from 9.8 to 39 mg/L. The median values for chloride and sodium are 23 mg/L and 13 mg/L, respectively. Wells sampled on Tuckernuck Island showed a range in chloride from 14 to 32 mg/L.

During the past 20 years, the concentration of chloride has fluctuated between the narrow ranges of 19 and 22 mg/L in water pumped in the Wannacomet Water Company, and between 18 and 22 mg/L in water pumped by the Siasconset water system.

A storm in January of 1976 was attended by winds of 80 miles per hour, and salt spray was thrown over the entire island. Resampling in the spring of 1976 showed that dissolved-solids concentrations of inland surface water averaged 13 mg/L more than in the spring of 1975.

The quality of ground water of Nantucket is to be considered good by commonly accepted criteria, excluding brackish water from a few wells very near to the shore. Iron concentration ranges from 0.01 to 12 mg/L, with a median value of 0.28 mg/L, indicating that somewhat less than half the wells sampled yield water with more than the 0.3 mg/L of iron recommended as an upper limit for public supplies (U.S. Environmental Protection Agency, 1975).

Although pathogenic bacteria are filtered out of water moving through sand, some dissolved constituents such as nitrate are persistent. Nitrate from sewage is a potential contaminant of ground water on the Nantucket Islands. The maximum allowable concentration of nitrate as nitrogen for public drinking water supplies is 10 mg/L (U.S. Environmental Protection Agency, 1975).

Four of 16 samples analyzed for nitrate exceeded 2 mg/L nitrate as nitrogen. One was located in Madaket (well 110, 2.8 mg/L), where homes built on small lots have private septic systems and supply wells. A monitoring well (138) about 150 feet north of the sewage-disposal beds at Surfside, had 2.1 mg/L nitrate as nitrogen, and well 105 had 2.3 mg/L. Water from well 148, not used for drinking and known to be influenced by fertilizer, contained 16 mg/L nitrate nitrogen, 30 mg/L potassium, but only 0.03 mg/L dissolved phosphorus as P. Dissolved oxygen ranged from 1.5 to 16.1 mg/L and was less than 5 mg/L at 25 percent of the sites sampled.

Samples from five surface-water sites and four wells were analyzed for arsenic, cadmium, chromium, cobalt, copper, lead, mercury, selenium, and zinc. The amounts detected did not exceed limits recommended for drinking water (U.S. Environmental Protection Agency, 1975).

Determinations for pesticides were made on water and bottom sediment at four surface-water sites and on water from two wells. No pesticides were found in water except for traces of dieldrin in Phillips Run at Milestone Road. However, bottom sediments from two brooks showed significant amounts of pesticides. Sediment from Mill Brook at Hawthorne Road contained 23 ug/L (micrograms per liter) of DDD, 5 ug/L of DDE, and 53 ug/L of DDT. Sediment from Squam Swamp Brook at Wauwinet Road contained 180 ug/L of DDD, 16 ug/L of DDE, and 90 ug/L of DDT. The swamps that these brooks drain were last sprayed with pesticides for mosquito control in 1966, according to report. The pesticides are adsorbed onto fine particles of sediment and remain there until flows during an exceptional storm scours out the sediment and carries it downstream.

SELECTED REFERENCES

Baldwin, H. L., and McGuinness, C. L., 1963, A primer on ground water: U.S. Geological Survey, 26 p.

Cooper, H. H., Kohout, F. A., Henry, H. R., and Glover, R. E., 1964, Sea water in coastal aquifers: U.S. Geological Survey Water-Supply Paper 1613–C, 84 p.

Eckis, Rollin, 1934, Geology and ground-water storage capacity of valley fill: California Division Water Resources Bulletin 45, p. 91–245.

Folger, D. W., Hathaway, J. C., Poag, C. W., Valentine, P. C., Weed, E. G. A., Rhodehamel, E. C., and Barrett, W., 1976, Mesozoic stratigraphic test, Nantucket Island, Massachusetts: American Association of Petroleum Geologists Bulletin, v. 60, no. 4, 672 p.

Hubbert, M. K., 1940, The theory of ground-water motion: Journal of Geology, v. 48, no. 8, pt. 1, p. 785–944.

Johnson, A. I., 1967, Specific yield—Compilation of specific yields for various materials: U.S. Geological Survey Water-Supply Paper 1662–D, 74 p.

Kohout, F. A., Hathaway, J. C., Folger, D. W., Bothner, M. H., Walker, E. H., Delaney, D. F., Frimpter, M. H., Weed, E. G. A., and Rhodehamel, E. C., 1977, Fresh ground water stored in aquifers under the Continental Shelf, Implications from a deep test, Nantucket Island, Massachusetts: American Water Resources Association, Water Resources Bulletin, v. 13, no. 2, p., 373–386.

Milliman, J. D., and Emery, K. O., 1968, Sea levels during the past 35,000 years: Science, v. 162, no. 3858, p. 1121–1123.

Pluhowski, E. J., and Kantrowitz, I. H., 1964, Hydrology of the Babylon-Islip area, Suffolk County, Long Island, New York: U.S. Geological Survey Water-Supply Paper 1768, 119 p.

Shaler, N. S., 1889, The geology of Nantucket: U.S. Geological Survey Bulletin 53, 55 p.

Strahler, A. N., 1972, The environmental impact of ground water use on Cape Cod: Impact Study III, Association for the Preservation of Cape Cod, 68 p.

Theiss, C. V., 1963, Estimating the transmissibility of a water-table aquifer from the specific capacity of a well: U.S. Geological Survey Water-Supply Paper 1536–I, p. 332–336.

Thornthwaite, C. W., and Mather, J. R., 1957, Instructions and tables for computing potential evapotranspiration and the water balance, *in* Publications in Climatology: Drexel Institute of Technology, v. 10, no. 3, p. 185–311.

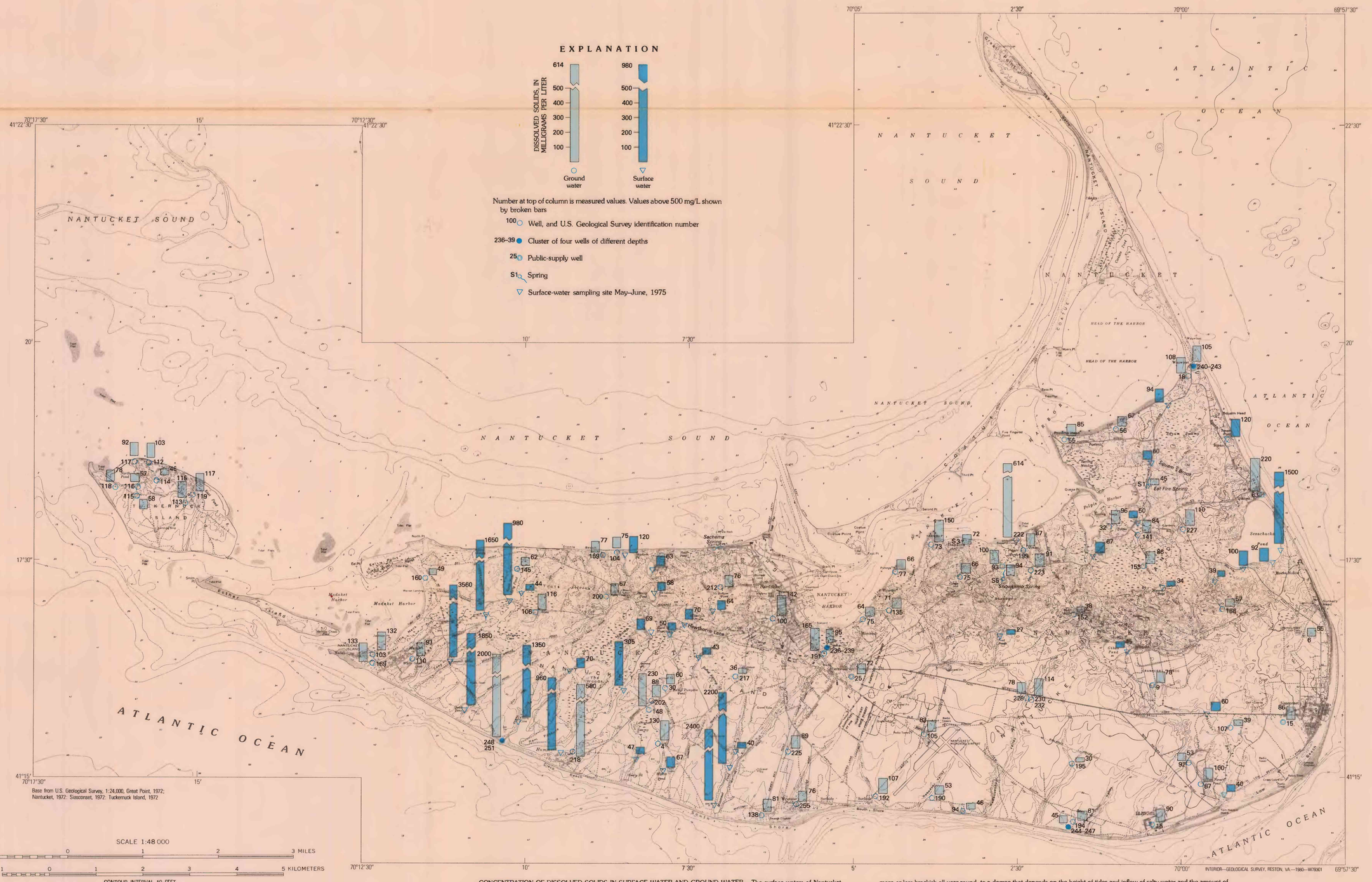
U.S. Environmental Protection Agency, 1975, National interim primary drinking water regulations: Federal Register, v. 40, no. 248, Wednesday, December 24, 1975, pt. IV, p. 59566–59587.

Wallace, Floyd, Ellenzweig, Moore, Inc., 1977, Massachusetts water supply policy study, Cambridge, Mass.: 197 p., appendices A through I.

Whitman and Howard, Inc., 1973a, Report on water resources in Madaket, Nantucket, Massachusetts, 20 p.

_____ 1973b, Water quality study, Nantucket, Massachusetts, 4 p.

Woodworth, J. B., and Wigglesworth, Edward, 1934, Geography and geology of the region including Cape Cod, the Elizabeth Islands, Nantucket, Martha's Vineyard, No Mans Land, and Block Island: Harvard University Museum Comparative Zoology Memoirs, v. 52, 322 p.



Base from U.S. Geological Survey, 1:24,000, Great Point, 1972; Nantucket, 1972; Siasconset, 1972; Tuckernuck Island, 1972

SCALE 1:48 000

1 0 1 2 3 MILES

1 0 1 2 3 4 5 KILOMETERS

CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
DEPTH CURVES AND SOUNDINGS IN FEET—DATUM IS MEAN LOW WATER
SHORELINE SHOWN REPRESENTS THE APPROXIMATE LINE OF MEAN HIGH WATER
THE MEAN RANGE OF TIDE IS APPROXIMATELY 1.7 FEET ALONG THE ATLANTIC OCEAN AND 2.6 FEET IN NANTUCKET SOUND

CONCENTRATION OF DISSOLVED SOLIDS IN SURFACE WATER AND GROUND WATER.—The surface waters of Nantucket consist of small, intermittent brooks that drain swampy areas, inland ponds, and coastal ponds separated most of the time from the sea by bars.

The small brooks that drain swamps characteristically have low dissolved solids, ranging from 40 to 90 mg/L. Inland ponds, such as Gibbs, Almanac, and Pout Ponds have 30 to 60 mg/L dissolved solids.

The dissolved-solids concentration in coastal ponds ranges from as low as observed in inland ponds to almost as salty as the sea, and varies from season to season and from year to year. Long Pond in the western part of Nantucket is connected to the sea by a ditch and is more or less brackish all year round, to a degree that depends on the height of tides and inflow of salty water and the amount of precipitation. Hummock Pond is fresh under natural conditions because it receives drainage from a fairly large inland area and is normally closed from the sea by a bar. The bar is cut in spring to lower the pond and, thereby, drain some low-lying farm land and swamps. Some sea water enters before waves and currents rebuild the bar. The bars that enclose Miacomet and Sesachacha Ponds are likewise cut in spring and sea water invades them. Moreover, during severe storms that occur every few years, as in January of 1976, the barrier bars are breached or overtopped and sea water enters the ponds. Ponds which normally are fresh, such as Squam Pond on the east coast, are brackish for many months thereafter.

WATER RESOURCES OF NANTUCKET ISLAND, MASSACHUSETTS

By
Eugene H. Walker

1980