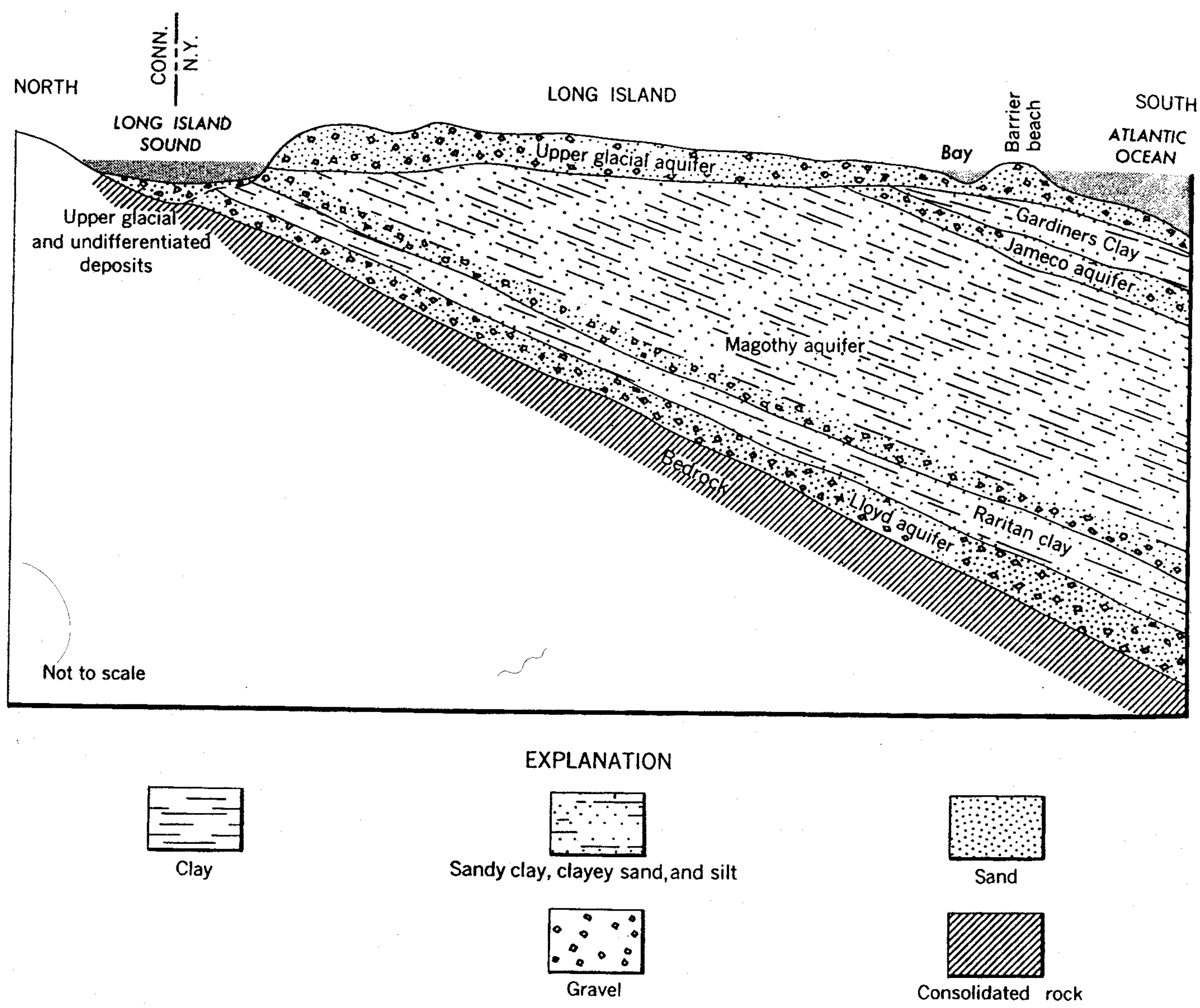
LONG ISLAND GROUNDWATER[1]

Nassau and Suffolk Counties with close to 3 million people are completely dependent on groundwater for all of their freshwater needs. As a result the hydrology of Long Island has been extensively studied. Long Island is completely surrounded by salt water. New York City derives its water from upstate, but the supply is just adequate to provide the needs of the city. Thus the only source of freshwater on Long Island now or in the future is precipitation that becomes part of the groundwater system. Luckily an adequate supply of high quality freshwater is available if Long Island properly manages its water. Long Island's groundwater aquifer consists of a very large wedge of unconsolidated Cretaceous sands, gravels, silts and clay overlain by similar glacial sediments. This wedge of sediments feathers out to the north of the island and thickens to some 2000 feet at Fire Island. It comprises three major aquifers, an Upper Glacial aquifer at the top, the Magothy aquifer in the middle and a deep less accessible Lloyd aquifer lying just above the Paleozoic metamorphic basement rocks. There are two major confining units. The Pleistocene Gardiners Clay is found mainly on the southern part of the island and provides some restriction of flow between the Upper Glacial and the Magothy aquifers. The other confining unit is the Raritan confining unit which is quite thick and restricts the flow between the Lloyd and the Magothy aquifers.



Precipitation enters the groundwater system by infiltration through the porous soil at Long Island's surface. Due to the porous soil Long Island has an immature stream development, thus a relatively high percentage of wet

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[1]This summary is derived mainly from "Proceedings of the Conference on Water Quality on Long Island" sponsored by The Center for Regional Policy Studies and the Long Island Regional Planning Board held at the State University of New York at Stony Brook, January 26, 1993.

precipitation reaches the groundwater. The water moves laterally in the Upper Glacial aquifer to streams and shoreline or moves downward through the Upper Glacial aquifer to the lower units. Some of the water from the Magothy circulates downward and then flows upward toward the shoreline and then into the Long Island Sound or Atlantic Ocean. The rest mixes at depth with salt water under the Long Island Sound and Atlantic Ocean. A very small percentage of the water penetrates the Raritan confining unit and enters the Lloyd aguifer. The height of the water table and the location of the interface between the freshwater and saltwater at depth are transient and are affected by the extent of pumping and rainfall. Most streams on Long Island are effluent, that is they are fed by groundwater. If an area has too little rainfall or is pumped extensively, streams, lakes and ponds dry up.

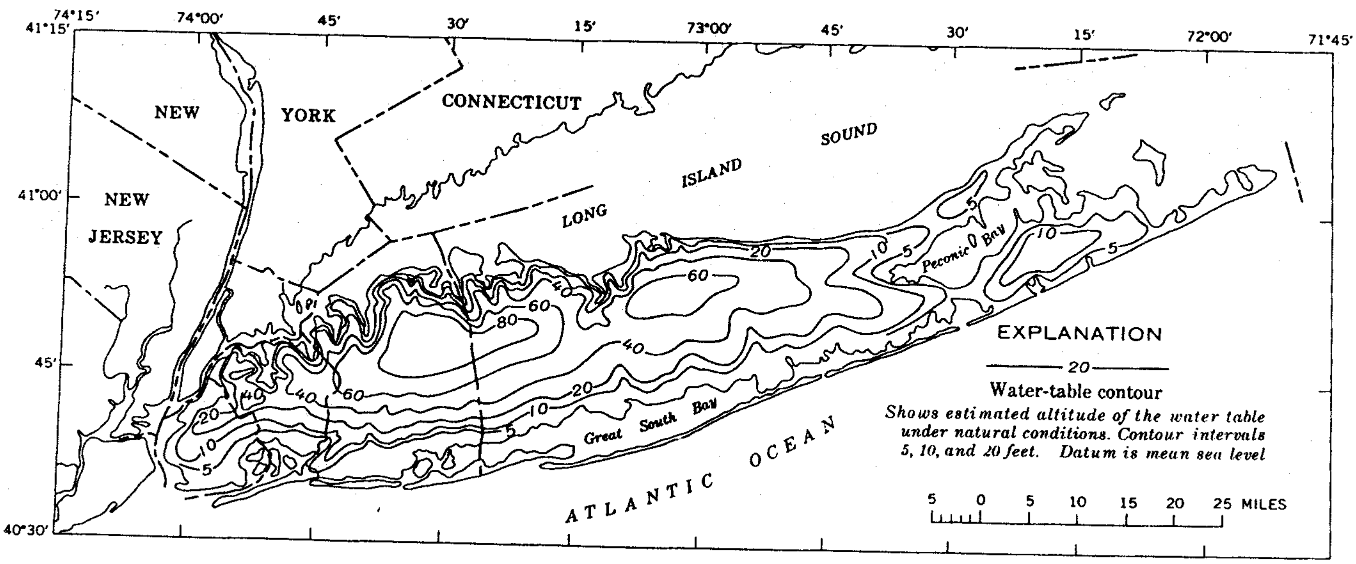
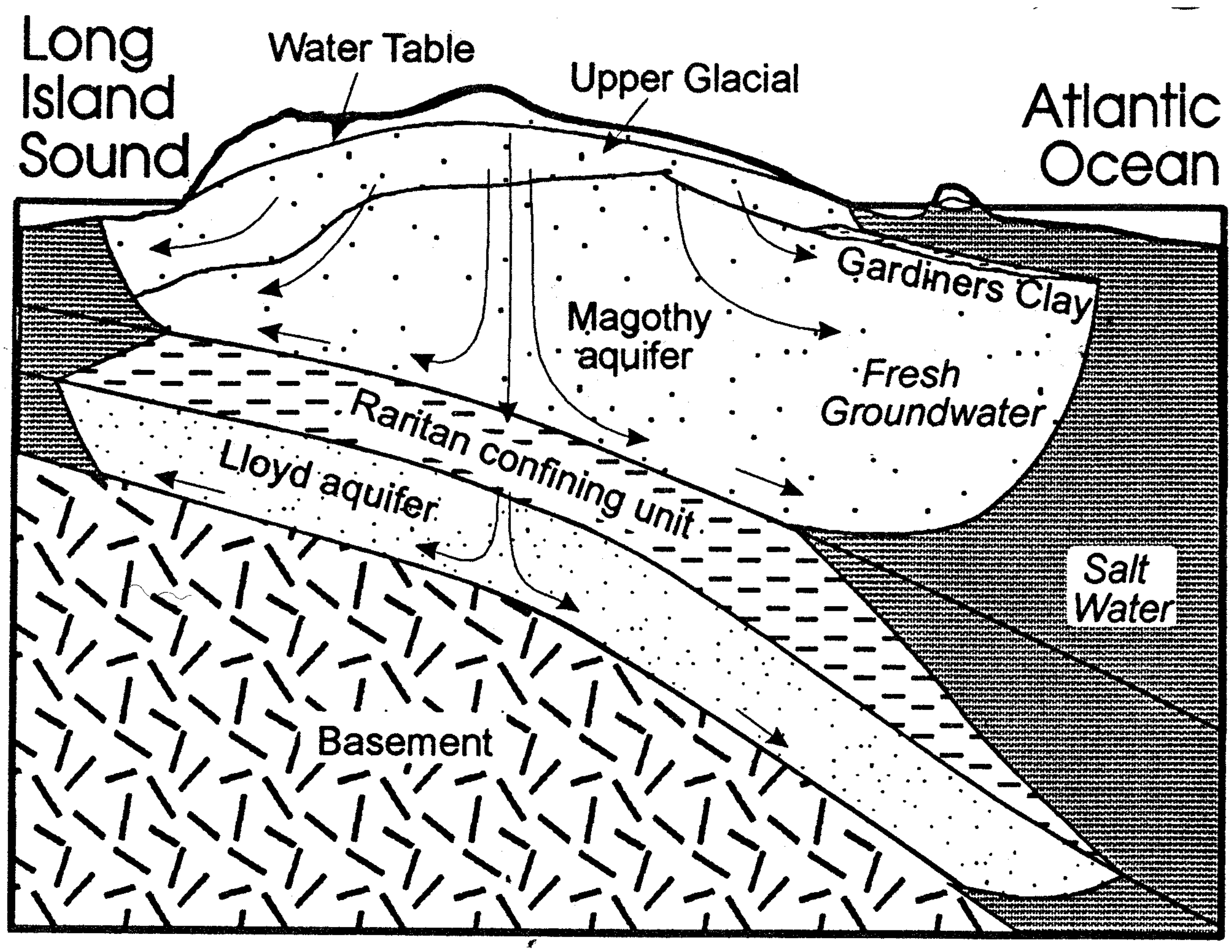


FIGURE 9.—Estimated average position of the water-table under natural conditions.

The major zone of recharge, especially to the Magothy and Lloyd aquifers, is along the center of the island where the water table is highest. The water system is a freshwater bubble surrounded by saltwater. There is no outside source of freshwater to the system. Recharge is not possible from the mainland. The only rocks on the mainland associated with Long Island are the impermeable basement rocks that crop out in New York to the west and Connecticut to the north. Long Island receives on average 44 inches of rain, or its equivalent in snow, per year distributed equally throughout the year, that is 3 to 4 inches per month. Approximately 50% of this rainfall is returned to the atmosphere as evapotranspiration. Each day 1,126 million gallons of water are recharged from precipitation. This is a dynamic system essentially at steady state, so an equal amount of water must be lost from the system as enters it. Before development 460 million gallons per day (MGD) were discharged through streams, 585 MGD along the shore, and 81 MGD at depth through the freshwater-saltwater interface. Of the recharge that entered Long Island's aquifer system 235 MGD would reach the base of the Magothy aquifer and 36 MGD would cross the Raritan confining unit and enter the Lloyd aquifer. The recharge of the Magothy and Lloyd Aquifers is dominantly at the groundwater divide near the center of the island.

The water is quite pure with about 50 mg/liter, or 50 ppm, of total dissolved solids, TDS. The water is, however, quite acid with a pH of 4.4 to 6.1, similar to that of the precipitation. As a result the water is quite corrosive. Due to the inert character of the minerals making up the aquifer, dominantly quartz sand, neither the concentration of TDS nor pH changes appreciably as the water travels through the aquifers.

The water travels relatively fast through the aquifer. Near surface the rate of flow may be about 300 feet per year. At depth the rate of flow may be one foot per year. The time necessary for the water to traverse the aquifer is indicated by the estimated age of water. At the top of the Magothy the water is about 10 years old. Near the center of the Magothy it is 100 years old. Near the base of the Magothy the water is some 500 years old. The Magothy is the source of much of our drinking water. Thus, in many places we are drinking water that fell on Long Island before it was extensively developed. Within the Lloyd aquifer the water is much more ancient. Near the groundwater divide the water is 1000 years old and as the freshwater-saltwater interface it is approached beneath the Atlantic Ocean the water is some 8000 years old.



The flow of water is dominantly to the north or to the south of the ground water divide along the center of the island west of William Floyd Highway. Therefore there is little east-west mixing of the groundwater. East of William Floyd Highway there is significant flow eastward associated with the Peconic River.

What affects the pattern and quantity of water that enters the system? Paving of recharge areas and pumping. In Nassau and Suffolk Counties there is an extensive system of recharge basins that collect water from storm sewers and recharge the system. Water is withdrawn through some 1000 wells for public supply, irrigation, commercial and industrial uses. We then redeposit some of this withdrawn water through septic tanks. Where there are major sewer systems the outflow water is generally discharged to the the Atlantic Ocean or Long Island Sound. Thus, little of this water is returned to the system. With irrigation a high percentage of the water is lost through evapotranspiration. During the 1980's wells pumped 366 MGD for public supply, 41 MGD for industrial and agricultural use, there was a loss of an additional 81 MGD due to increased runoff associated with development. Of the 489 MGD removed from the system, 249 MGD were returned to the system, for a net loss to the aquifer of 240 MGD.

The result of this excess withdrawal has been shrinkage of the freshwater bubble. This has resulted in:

saltwater incursion near the Nassau-Queens border,
reduction of the height of the water table in Jamaica to below sea level,
reduction of the height of the water table by some 20 feet in Nassau County,
the subsequent drying up of streams and lakes in Nassau County, and
the reduction of the height of the water table in Suffolk County by a few feet.

Nassau and Suffolk counties share the same aquifers but have different problems associated with the differences in population densities and times of development of the two counties.

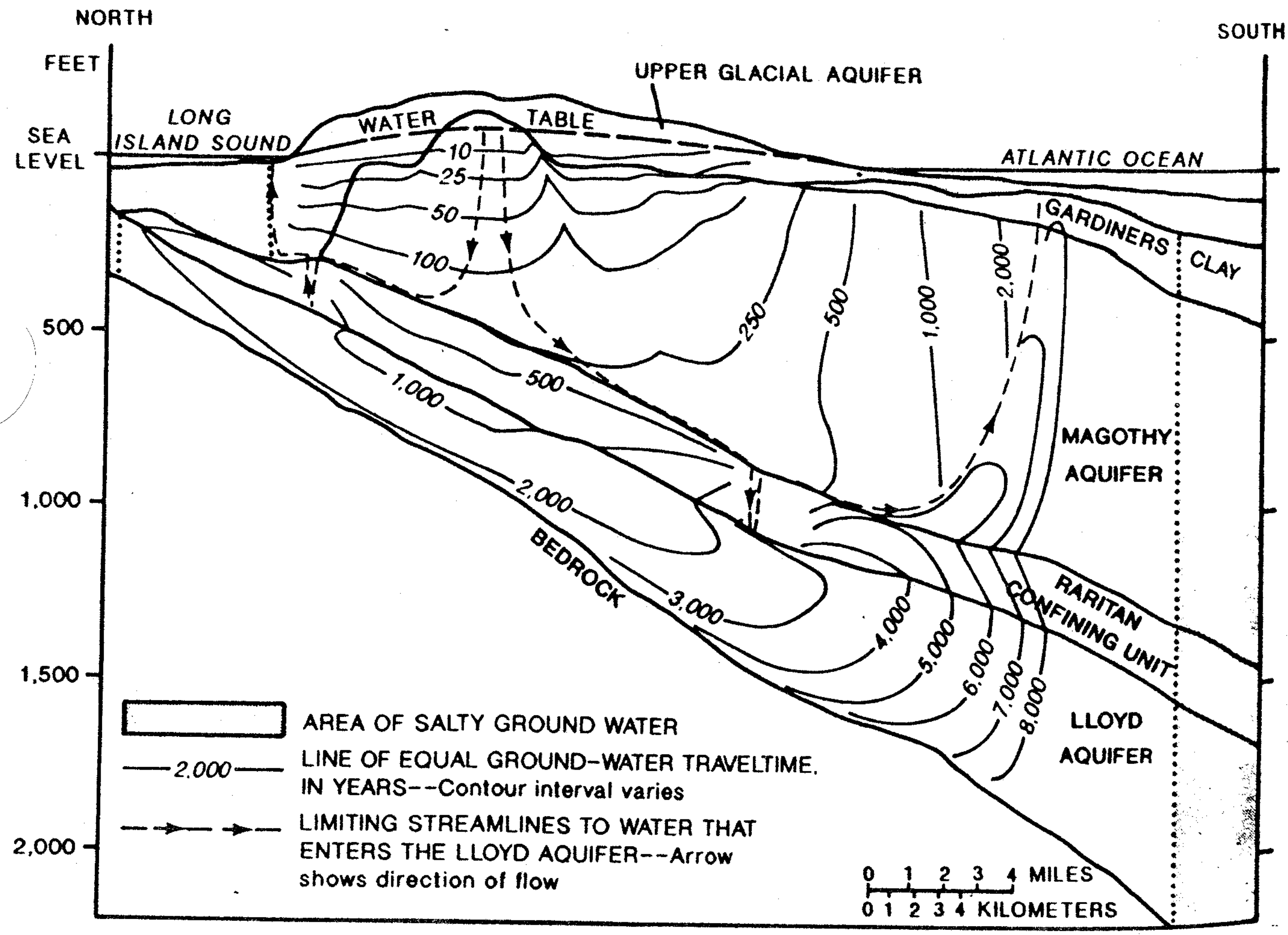


Fig. 8. Distribution of ground-water traveltime within modeled section.

Buxton & Modica

NASSAU COUNTY

Nassau County presently has a population of some 1.3 million people and an area of about 300 square miles. Precipitation provides 660 MGD of which 315 MGD is lost to evapo-transpiration and 15 MGD to direct runoff. Recharge into the groundwater system is 330 MGD. 180 MGD is pumped from the groundwater system, 40 is discharged through effluent streams, and 110 MGD is discharged underground. Consumptive use amounts to 180 MGD of which 140 MGD is lost through the sewer system, 34 MGD through sprinkling and 6 MGD through industrial-commercial use. Earlier when there was a projected population of 2.3 million people it was feared that Nassau County would not have enough water to serve its population. Nassau County did feasibility studies showing that it could take waste water, treat it and then recharge the aquifer. However, this would be very expensive and is now thought not necessary. This is because the population has stabilized or is decreasing and water conservation has reduced water use.

There was also a concern that salt water incursion would become a serious issue. This incursion appears to have stabilized and is a problem in only a few areas. The reasons for salt water incursion near Great Neck and along the south shore include the effects of pumping and the continuous sea level rise of about one foot per century.

Limits on the amount of water that can be pumped (caps) have been placed by New York State DEC in response to problems of saltwater incursion and the drying up of streams and lakes. Presently over 90% of Nassau County is served by sewers. Essentially 100% of the water in sewered areas is lost from the system. Three sewer disposal districts handle 140 MGD and this is discharged into surrounding saltwater bodies. This compares to 180 MGD of water that is pumped out of the system. Of the water pumped, 89% is from the Magothy, 5% is from the Upper Glacial and 6% is from the Lloyd aquifers. The 400 public supply wells are distributed evenly about the county.

There are several water quality problems. The water is very acidic due to the low pH of rain. The water is neutralized by adding lime or caustic soda to prevent leaching of the pipes through which the water flows.

Another problem is nitrates. Six percent of the wells in Nassau exceed 10 mg per liter of nitrogen as nitrate that is the EPA minimum standard for drinking water. Such wells are either abandoned or the water from the well is blended with that from a well that has a lower nitrate concentration. It is generally thought that the nitrate contamination resulted from septic systems used prior to the installation of the sewer system. Since the installation of the sewer system the nitrate concentration of the Upper Glacial aquifer waters has decreased from 8 to 10 mg/liter to 3 to 4 mg/liter.

Synthetic organic compounds from cleaning solvents, cesspool cleaners, etc. affect 17% of the wells. Most of the contamination occurred prior to 1976 when testing first started because the contamination levels are remaining relatively constant. These organics in the water are treated by air stripping or passing the water over activated charcoal.

High chloride concentrations for some wells are the result of salt water incursion or road salt. This problem is too expensive to treat. When high chloride concentrations appear in a well pumping is stopped. If the freshwater replaces the salty water in a well, pumping may be restarted.

The last problem is high iron concentration from natural iron within the aquifer system. Twenty-eight percent of the wells need to be treated to reduce the iron concentration to below 0.3 milligrams per liter. This is done by filtering or chemically removing the iron.

NASSAU COUNTY GROUNDWATER SYSTEM

WATER QUALITY PROBLEMS IN PUBLIC SUPPLY WELLS

PROBLEM	CAUSES	% OF WELLS EXCEEDING STD.	TREATMENT	COST
ACIDIC	• LOW PH OF RAIN	NO STD.	• CHEMICAL ADDITIVE	LOW
NITRATES (>10 PPM)	• HUMAN WASTE • ANIMAL WASTE • FERTILIZERS • NATURAL ORGANIC DECOMPOSITION	6	• BLENDING	LOW
			• ION EXCHANGE • BIOLOGICAL DENITRIFICATION	HIGH
SYNTHETIC ORGANICS (>5 PPB)	• CLEANING SOLVENT DISPOSAL • SPILLS • CESSPOOL CLEANERS	17	• AIR STRIPPING • ACTIVATED CARBON	MEDIUM
CHLORIDES (>250 PPM)	• SALTWATER INTRUSION • ROAD SALT	<1	• REVERSE OSMOSIS • ION EXCHANGE • DISTILLATION • ELECTRODIALYSIS	HIGH
IRON (>0.3 PPM)	• NATURALLY OCCURS IN SOIL	28	• FILTRATION • CHEMICAL SEQUESTERING	HIGH LOW

NCDPW

SUFFOLK COUNTY

Suffolk County with an area of 884 square miles covers a much larger area than Nassau County, but the population of 1.4 million is similar to that of Nassau County with 1.3 million. The recharge in the area is 990 MGD. The total capacity of the aquifers underlying Suffolk County is about 70 trillion gallons. There are more than 600 public supply wells in Suffolk County. About 210 MGD are withdrawn by pumping with equal amounts coming from the Magothy and Upper Glacial. Most of this water is returned to the aquifer with consumptive loss estimated to be 95

MGD. The loss is through sewage systems, marine discharges and evapotranspiration associated with irrigation and lawn sprinkling.

Most of Suffolk County is not sewered. Instead most homes have septic tank systems that discharge their waste water back to the groundwater system. As a result a relatively small percentage of the recharge in Suffolk County is consumptively lost, about 10%, compared to 55% for Nassau County. The most serious problem when using septic tanks is the introduction of nitrates into the ground water. When sewage is discharged to a septic tank or cess pool, some nitrogen is lost as ammonia or nitrogen gases and about half is oxidized to nitrate. EPA standards limit nitrogen as nitrate concentrations to less than 10 mg per liter. If Suffolk County limits housing to one to two dwellings per acre, the nitrate standards should not be violated with the continued use of septic systems.

Pathogenic bacteria in septic systems generally die off as the water passes through the zone of aeration and into the zone of saturation. It is not clear that this is true for all viruses.

As long as people do not dispose of organic compounds (paint thinners, petroleum products, grease cutters, and other household chemicals) through septic systems or pour it on the ground the water should not be contaminated by organic compounds.

In areas where the density increases to greater than two dwellings per acre, sewering will be required. The effluent from such systems could be discharged to the groundwater system and not to saltwater. While sewage systems can be built to produce effluent that meets drinking water standards, homeowner associations usually do not maintain such systems at a level to meet the standards.

Of the 600 public supply wells 48 have been taken out of service due to organic contamination. Most of this contamination was a result of earlier industrial disposal practices (gasoline and fuel storage areas, leaking underground storage tanks, dry cleaners, etc.). These practices have been severely limited by new health codes. Industries can no longer afford to dispose of their wastes improperly.

As in Nassau County high pH and iron are problems that must be treated before water can be distributed to the public.

Pine Barrens

The Pine Barrens in Suffolk County have been the focus of attention for the last few years. This is because they are the last large nearly undeveloped area on Long Island, consisting of some 100,000 acres. Also, because they are within the deep recharge zone of the Magothy aquifer. Due to the limited development in the Pine Barrens the ground water in this area is particularly pure. (Degradation of groundwater quality is inevitable wherever there are humans.) The present plan for the Pine Barrens is to retain a core of 50,000 acres of undeveloped land and have restricted development on the remaining 50,000 acres. The main reason for preserving the Pine Barrens would appear to be to preserve this special ecosystem. While the water is pure, extensive pumping would potentially harm the ecosystem by lowering the water table. Also, the high cost of pumping to developed areas would make use of this groundwater unfeasible for the foreseeable future.

SUMMARY OF CHARACTERISTICS OF LONG ISLANDS GROUNDWATER

Only source of water is precipitation
44 inches of rain per year
Daily average ppt is 1600 mgd
- 780 is evapotranspiration
- 820 enters hydrologic cycle
- 340 mgd is stream runoff
- 480 mgd enters groundwater

The 480 mgd groundwater is returned ocean
- 340 mgd from glacial aquifer to groundwater fed streams
- 140 mgd goes directly to salt water

Long Island groundwater is quite pure 50 mg/L of TDS 50 ppm. Purity oes not change as it travels through ground
- pH is 4.4 to 6.1, that means it is corrosive
- Fe sometimes exceeds 0.3 mg /L or 0.3 ppm

Concept of safe yield, that is the amount of water that should be removed from the aquifer is a societal decision.
Consumptive use results in

- lowering of water table
- decrease in streamflow
- lowering of potentiometric surface in deep aquifers
- intrusion of salt water

Contamination Ground Water Sources on Long Island

- Storm runoff into recharge basins
- Household sewage gets into groundwater through leaky pipes, cesspools and septic tanks
- Accidental spills and casual dumping
- Precipitation is now more acid (pH=4.5) and contains hydrocarbons and heavy metals
- Automotive wastes, road salts, pesticides and fertilizers

Characteristics of LI ground water

- Long Island is surrounded by salt water. No recharge of fresh water outside Long Island
- There is only one source of water which is rain or snow, which is relatively pure
- Relatively abundant rainfall average 44" per year
- Consistent rain all year, i.e. 3" to 4" per month
- Large section of porous sand with few aquicludes
- Thus, relatively rapid flow of water through section, 300 feet/y near surface less than 1 foot/y at depth.
- Flow is dominantly north-south west of William Floyd highway
    - i.e., in most developed area of Long Island, therefore there is little mixing of groundwater in the east-west direction
- Significant proportion of water used is recharged and re-used
- Recharge of Magothy and Lloyd only from near ground-water divide