Section 2
Nassau County's Groundwater System

All groundwater systems are dynamic – they respond to groundwater withdrawal and any other stresses imposed on the system by always seeking a new state of equilibrium, or balance, between water flowing into the system and water flowing out of the system. After many years spent studying and evaluating Nassau County's groundwater system, DPW has gained considerable insight into the system's behavior and how it has adjusted to changes resulting from development.

This section explains the behavior of Nassau County's groundwater system, how it functions, and how the system has responded to changes brought about by development by discussing the hydrologic cycle, hydrogeology, and groundwater flow patterns that are typical of the aquifers that comprise the County's groundwater system. A generalized cross section representing the County's aquifers is shown in Figure 2-1.

2.1 Hydrologic Cycle

The process by which water is transferred from the ocean and lakes/surface waters, to the atmosphere, to the land, and back again to the water bodies is called the hydrologic cycle. The cycle begins with water evaporating from the ocean and surface waters into the atmosphere. Water then falls on the land surface as precipitation, and then eventually returns to the water bodies. In Nassau County, the water may return quickly via streams and stormwater runoff. Alternatively, the water may seep deep underground into the County's aquifers, delaying its return for hundreds or even thousands of years. Water is also returned to the ocean via treated wastewater, this being a relatively recent man-made impact.

Before the County underwent development, the hydrologic cycle was characterized by a natural, balanced flow of water into and out of its aquifers. Extensive development over the past several decades has changed these conditions, altering flow pathways both into and out of the aquifers that has resulted in a new, different state of equilibrium.

Predevelopment Conditions

Predevelopment conditions in the context of this report are prior to 1940, which is prior to the time that Nassau County began undergoing significant development. During predevelopment times, precipitation was the source of water recharging the groundwater system. On average, about half of the precipitation falling on the land surface was returned to the atmosphere by evaporation and by transpiration from vegetation (a process called evapotranspiration). A very small amount ran directly into streams that discharged to the saltwater bays on the south shore and to the bays and Long Island Sound on the north shore. The other half of the precipitation infiltrated into the ground to recharge the groundwater supply, then continued its flow through the aquifers. Eventually this water discharged to surrounding saltwater bodies, either as surface streamflow or as underflow from the freshwater system into the saltwater system beneath the bays, ocean, and Long Island Sound. A very minor amount of groundwater was withdrawn from the system by water supply wells, with most of that water being returned to the groundwater system via on-site wastewater disposal systems. Therefore, very little water was lost from the system due to man's activities. During predevelopment times, the vast majority of groundwater flowing out of the system was through the aforementioned natural pathways.

Present Day Conditions

Development has modified the hydrological cycle that is characteristic of predevelopment conditions. Precipitation remains the source of water recharging the groundwater system. Slightly less than half of the precipitation falling upon the County is returned to the atmosphere through evapotranspiration, and a little more than half replenishes the aquifers. However, large quantities of groundwater are now withdrawn from the aquifers for water supply purposes and most is discharged as wastewater to sanitary sewers. The wastewater is then conveyed to wastewater treatment plants, where it is treated and then discharged offshore to the Atlantic Ocean or Long Island Sound and bays along the north shore. This loss of water from the aquifers as a result of development has significantly increased the consumptive use (water that is lost from the groundwater system). Although sanitary sewers are instrumental in protecting groundwater quality, they have essentially eliminated the return of wastewater to the groundwater system via on-site disposal systems. This water loss has permanently lowered the water table and hydrostatic pressures in the deeper aquifers, and has produced other fundamental changes in the groundwater system.

Recharge

One key component of the hydrological cycle is recharge, since all groundwater originates with precipitation that infiltrates through the soil to replenish, or recharge, the underlying aquifers. An average of 44 inches of precipitation falls upon the County each year. This amounts to approximately 660 million gallons of precipitation falling upon the land surface of the County each day. Under present conditions, slightly more than half of this precipitation recharges the groundwater system either by infiltrating through the soil in unpaved areas or through the bottoms of recharge basins.

In concert with development, the County, State, and local municipalities have constructed stormwater drainage systems and recharge basins to collect and recharge stormwater runoff from roads, parking lots, and other paved areas. When impounding basins (recharge basins as they are called today) were first proposed by the County during the 1930s, it was recognized that the basins were not only an economical component of a comprehensive drainage plan to control stormwater and flooding, but also served the important purpose of directing stormwater into the ground to conserve the underground water supply. Thus, a significant amount of stormwater that would otherwise be discharged directly to the south shore bays and Long Island Sound was recharged to the groundwater system as far back as the 1930s when the first basins were constructed.

There are currently over 800 recharge basins in the Nassau County, most of which are located in the central portion of the County, generally between Northern Boulevard and Hempstead Turnpike. Few are located along the shorelines, particularly the south shore, where the water table is close to the ground surface and recharge is not possible. Stormwater first enters a catch basin or storm drain in the street or along a roadway and is then carried through a network of storm sewers to the recharge basin. Stormwater then enters the basin, and is stored until much of it infiltrates through the bottom of the recharge basin and into the groundwater below.

Unlike precipitation, which is generally distributed rather evenly throughout the year, recharge varies with the seasons. Recharge is greatest during the non-growing season when evapotranspiration is low. During the growing season, evapotranspiration increases significantly, and recharge to the groundwater system is greatly reduced.

2.2 Hydrogeology

Nassau County, like the rest of Long Island, is underlain by consolidated bedrock, which does not store or yield any significant amount of groundwater. Overlying the bedrock is a wedge of unconsolidated gravel, sand, silt and clay deposits. Groundwater is stored within the pore spaces of this material. The thickness of the wedge of these deposits increases form zero feet where bedrock outcrops along the north shore in Queens, up to about 2,000 feet along the south shore barrier islands. The saturated layers of unconsolidated water bearing deposits within this wedge are called aquifers. Aquifers are capable of storing, transmitting, and yielding large quantities of water.

Nassau County's complex groundwater system consists of three major aquifers – the Upper Glacial, the Magothy, and the Lloyd – and one major, relatively impermeable clay layer – the Raritan Clay. In addition, several smaller aquifers (Jameco and North Shore) and confining clay layers (North Shore confining unit and Gardiners Clay) contribute to the complexity of the system and affect aquifer behavior in localized parts of the County. The thickness of each of these subsurface formations is variable. Beneath the south shore, for instance, the Magothy and Lloyd aquifers are thickest. Overall, the average saturated thickness of the entire groundwater system in Nassau County can be considered to be 800 feet thick.

The amount of gravel, sand, silt and clay particles present may vary considerably from location to location within the County, and also varies considerably with depth. The hydraulic conductivity (the relative ease with which water can move through the material of a hydrogeologic unit) of each aquifer varies significantly from location to location. In most cases, the hydrogeologic units are anisotropic; that is, their ability to transmit water in the horizontal direction is greater than their ability to transmit water vertically. The horizontal hydraulic conductivity is often an order of magnitude – or more – greater than the vertical hydraulic conductivity for a specific hydrologic unit.

As groundwater is withdrawn for public water supply, new water – primarily from precipitation – continuously recharges the aquifers from the land surface. Water also flows back and forth between aquifers, and is continuously discharged underground to the Atlantic Ocean and Long Island Sound through a process called "underflow."

2.3 Groundwater Flow Patterns

All groundwater originates with precipitation that infiltrates through the unsaturated soil to eventually recharge the underlying aquifers. If the infiltrating water becomes contaminated during its flow over the land surface, or from contact with contaminated soil, it carries the contaminants into the groundwater supply. Upon reaching the uppermost surface of the saturated zone, or water table, the infiltrating water becomes part of the groundwater system, subject to the physical laws that govern groundwater flow.

Within the groundwater system, water flows horizontally from areas of higher water elevation toward areas of lower water elevation in the topmost Upper Glacial aquifer and upper portion of the Magothy aquifer. Groundwater flows horizontally from areas of higher pressure to areas of lower pressure in the deeper Magothy and Lloyd aquifers. In Nassau County, the resulting horizontal flow pattern forms a groundwater divide from west to east, located roughly beneath the Long Island Expressway. South of the divide, groundwater flows southward toward the Atlantic Ocean; north of the divide, groundwater flows northward toward the Long Island Sound.

Groundwater also travels vertically, flowing from the Upper Glacial aquifer and into the Magothy aquifer, then through the Raritan Clay, and finally into the confined Lloyd aquifer (refer to Figure 2-1). Just as in horizontal flow, the water moves from areas of higher water pressure to areas of lower water pressure. In most of Nassau County, vertical flow is generally downward from the water table in the Upper Glacial aquifer into the Magothy aquifer. Only near the shorelines and offshore along the south and north shores does the flow pattern reverse itself, moving upward from the Magothy to the Upper Glacial aquifer. Downward flow from the Magothy aquifer through the Raritan Clay into the Lloyd aquifer only takes place in a relatively small area of the County near the groundwater divide.

Water quickly infiltrates through the soil after a precipitation event, provided that the ground surface is not frozen. Travel time to the water table, or upper surface of the groundwater system, generally takes only hours, or at most, a few days, depending on the location in the County. Once in the groundwater system, water travels quite slowly. The age of water that has infiltrated into the groundwater system can range from days in the Upper Glacial aquifer to more than several thousand years at the deepest portion of the Lloyd aquifer.

When public water supply wells are pumped, horizontal and vertical flow patterns as well as the travel times of water are altered greatly. The time it takes water to travel into deeper portions of an aquifer is dramatically reduced once a well is pumped. As water infiltrates through the soil and recharges the groundwater system, it can easily carry contaminants from the land surface down into the aquifers. Activities of man, land use, and waste disposal practices have significant impact on what contaminants enter the groundwater and on which aquifers the contaminants ultimately reach.

2.4 Groundwater System Behavior

Changing conditions, such as increases in water withdrawn from the aquifers to satisfy public water demand and fluctuations in the amount of recharge, are the two main factors that affect the behavior of the groundwater system. Since the flow of water into the groundwater system will always be in balance with the flow out of the system, these changes cause the groundwater system to constantly strive to reach a new equilibrium state. The groundwater system is therefore considered to be in a state of "dynamic equilibrium" as it continually adjusts to change.

Under predevelopment conditions, water from precipitation traveled down through the groundwater system and naturally discharged from the aquifers, either as baseflow to streams, or as underflow to the surrounding saltwater bodies. Relatively few supply wells existed to withdraw groundwater, so almost all flow out of the system was through natural means. During predevelopment times, water elevations of the water table were at their highest levels and were also above the beds of stream corridors and pond bottoms. As a result, streamflow was abundant with year round flow. Additionally, water elevations in ponds were at their highest levels and the ponds contained water throughout the year.

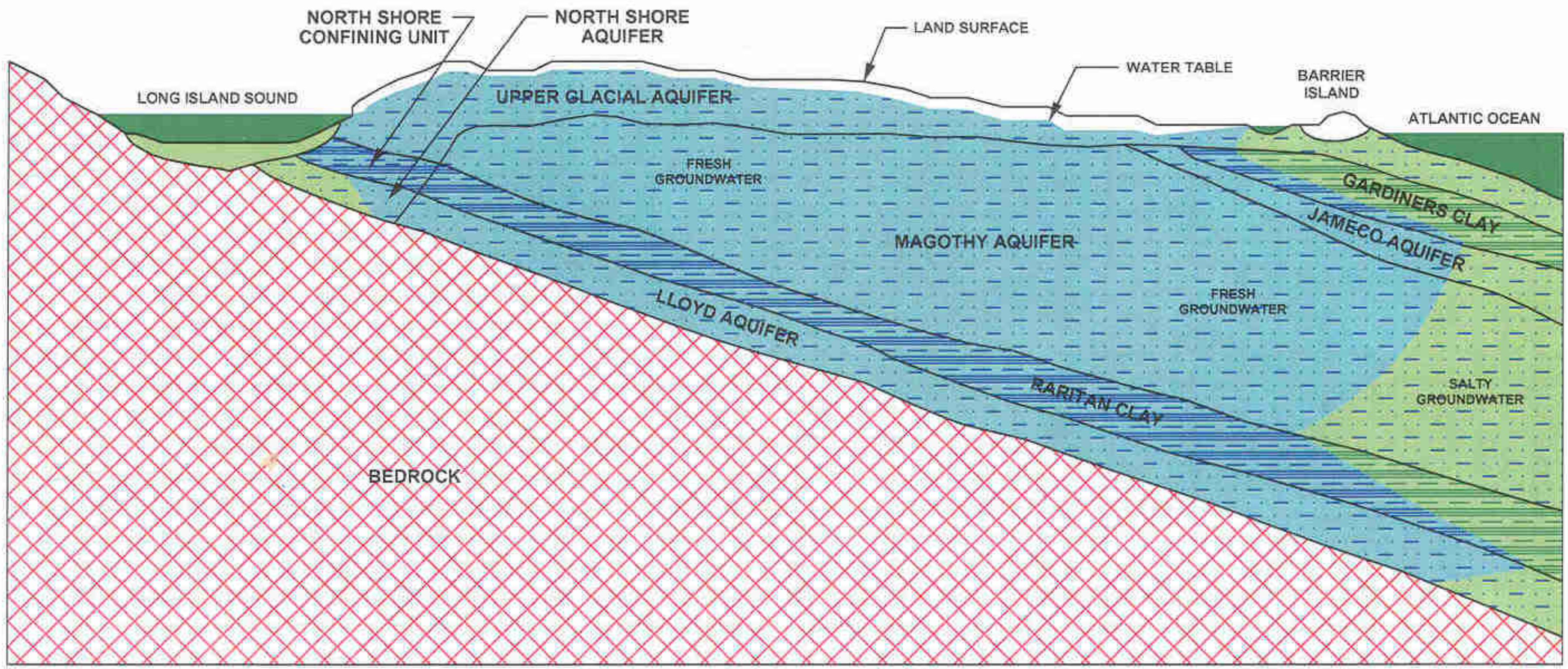
With the vast development that has occurred in Nassau County during the latter half of the 20th century, the behavior of the groundwater system has been significantly altered, and has adjusted itself to be in a new state of equilibrium. While most of the flow out of the system was by natural means prior to development, groundwater is now also lost from the system through man made means – primarily through large scale groundwater pumping to satisfy public water demand and wastewater disposal via sanitary sewers – which have permanently lowered the water table. In many areas of the County, the water table no longer intersects the beds of stream corridors and the bottoms of ponds. As these features are no longer continuously fed by groundwater, they are frequently dry except for conveying and/or capturing stormwater runoff during precipitation events.

With the great ability the aquifers have to adjust to the impacts of development and to re-establish equilibrium, the flow into the groundwater system still remains in balance with the flow out of the system. The adjustments that the groundwater system made in seeking a new state of equilibrium in response to development include reduced streamflow during dry weather conditions, reduced underflow from the aquifers to the surrounding saltwater bodies, and a permanent lowering of the water table resulting from the installation of sanitary sewers. Thus, the two major environmental impacts of development are reduced streamflow and surface water levels in ponds, and altered movement of the saltwater interfaces along the north and south shores of the County.

Previous study by DPW has determined that, presently, approximately 341 million gallons of water per day (mgd) recharges the County's groundwater system. This amount is slightly more than half of the precipitation falling upon the land surface each year, and is also a slight increase from predevelopment times. The increase essentially resulted because the recharge basins have been successful in capturing additional stormwater runoff for aquifer recharge. Even with the effects of development, as long as recharge exceeds the amount of groundwater withdrawn for public supply (currently fluctuating in the 200 mgd range), the quantity of groundwater available for public supply purposes will be more than adequate. Fluctuations in pumping rates and amounts of recharge that are expected from year to year will be discernable in fluctuating groundwater elevations, and visually evident in pond levels and the amount of streamflow during dry weather conditions.

Figure 2-1

NASSAU COUNTY'S AQUIFERS



GENERALIZED NORTH-SOUTH CROSS SECTION THROUGH NASSAU COUNTY

Prepared By: Nassau County Dep't. of Public Works

Section 3
Groundwater Monitoring Program Components

Nassau County's groundwater monitoring program is comprehensive in that the program includes measurement and monitoring of all variables that affect the behavior of the groundwater system. Through various measurements and testing conducted directly on the system, the effects of the variables, and the associated fluctuations in those variables, on the groundwater system can be determined. Variables that have direct influence on system behavior include climatic conditions (temperature and precipitation) and the amount of groundwater withdrawn from the system for water supply. Through a series of measurements made directly on the system that include those for determining groundwater levels in monitoring wells and testing raw groundwater for quality, the behavior of the system can be ascertained and the impacts of 1.3 million people living above the water supply can be determined.

3.1 Weather Monitoring

Since all groundwater originates with precipitation, and since water use is largely influenced by temperature, these weather conditions are monitored on a continuous basis by DPW. Presently, DPW operates three (3) weather stations that are each equipped with instrumentation for continuous recording of temperature and precipitation. These stations are located in the Mineola, Wantagh and Upper Brookville areas and represent a north-south spatial distribution throughout the County. The Mineola and Wantagh stations are official National Oceanic and Atmospheric Administration (NOAA) weather stations. DPW serves as a cooperative weather observer for NOAA whereby the weather data collected by DPW personnel is forwarded to NOAA for inclusion in their regional and national databases. The Mineola weather station was established in 1936, the Wantagh station in 1975, and the Upper Brookville station in 1989. DPW has served as a cooperative weather observer since 1941.

3.2 Groundwater Monitoring

Monitoring wells are the mechanism utilized to gain access to the groundwater for measuring groundwater levels and obtaining raw groundwater quality samples. These monitoring wells tap into all aquifers of the County's groundwater system, and a typical groundwater monitoring well construction detail is shown in Figure 3-1. Monitoring wells generally consist of a two or four inch diameter casing (steel or PVC plastic pipe), which is connected to a slotted piece of pipe or continuous wire wound well screen that is set at a selected depth in an aquifer. The annular space between the borehole and well screen is packed with specifically sized gravel to allow transmission of groundwater into the well from the surrounding geological formation while simultaneously preventing fine sand and silt from entering the screen zone. The annular space above the screen zone is sealed with a bentonite seal, and then grouted up to the land surface to form a tight seal with undisturbed formation material. This prevents any water that may accumulate at the ground surface from seeping downward along the outer surface of the well casing and ultimately into the groundwater. Additionally, the seal and grout prevent a hydraulic interconnection between geologic formations. The well is fitted with a removable cap and finished at grade with a locking curb box that provides security and accessibility to the well.

DPW's groundwater monitoring network currently consists of 620 monitoring wells. Of these, 366 are screened in the Upper Glacial aquifer, 167 in the Magothy aquifer, 66 in the Lloyd aquifer and 21 are screened in smaller, but nevertheless important geologic formations (8 monitoring wells in the Jameco aquifer and 13 in the North Shore aquifer). Figure 3-2 depicts all monitoring wells in DPW's groundwater monitoring network. Figures 3-3, 3-4, and 3-5 depict monitoring wells in the Upper Glacial, Magothy (plus Jameco), and Lloyd (plus North Shore) aquifers, respectively. As more stratigraphic and geologic information becomes available for the north shore, it is likely that some monitoring wells currently designated as being screened in the Lloyd aquifer may be reclassified as being screened in the North Shore aquifer. Under DPW's Deep Well Drilling capital project, new monitoring wells will be installed to fill gaps in the existing monitoring networks of the deeper aquifers for both potentiometric head and raw groundwater quality information. The reader is referred to Section 7 – Going Forward, for additional information on this project.

Not all monitoring wells are currently viable for measuring water elevations and/or collection of groundwater quality samples for various reasons. A large number of the older (pre 1950s) monitoring wells are shallow 1¼" diameter piezometers that are not suitable for obtaining groundwater quality samples. These piezometers are generally only used to obtain water level information. Numerous other monitoring wells, including some that are over 60 years old, are in need of rehabilitation/replacement and/or maintenance in order to restore reliability for quality sampling and water level measurements. There are also monitoring wells included in the network that are screened in poor material, and as a result, yield insufficient water for quality sampling and give unreliable water level information.

At the present time, 500 monitoring wells are considered viable for gathering water level information and quality samples. The 120 wells that are not considered viable for these purposes are to be evaluated, and if they cannot be rehabilitated into viable wells, will be abandoned, with new monitoring wells installed in their place as deemed appropriate. The reader is referred to Section 7 – Going Forward, for more information on the planned installation of new wells.

3.2.1 Groundwater Levels

The groundwater system's response to changing conditions – fluctuating precipitation, changing amounts of recharge, and varying amounts of groundwater withdrawal for public water supply purposes – can be monitored through a series of groundwater level measurements at select monitoring wells at regular frequencies. These measurements can be taken with a steel surveyor's tape or an electronic water detection tape. The depth to water is measured from a reference point of known elevation (usually the top of the monitoring well casing relative to mean sea level) and recorded to the nearest 1/100 of a foot. The depth is then subtracted from the elevation of the known reference point to obtain the elevation of the water in the monitoring well. DPW maintains several discrete water level monitoring networks, which provide detailed hydraulic information on specific segments of the groundwater system. These sub-networks are described as follows:

Regional Water Level Measurements

A comprehensive set of water levels are measured at selected monitoring wells, distributed throughout the County, on a bi-annual basis to track changes in water table elevations and potentiometric heads in the deeper aquifers. The regional water level measurements are taken at approximately 400 monitoring wells during the fall (September) and spring (March) of each year. These two seasonal intervals correspond to periods after little recharge occurs during the growing season, and after significant recharge occurs during the dormant (non-growing) season, respectively. The measurements are typically completed within a one to two week period. There are no static water level measurements taken at any pumping wells during the monitoring well measurements; thus, there is no need for DPW to make arrangements for pumping to be suspended at any production wells. The regional water levels collected from monitoring wells by DPW can be considered to be representative of the dynamic state of the groundwater system, including any pumping effects from public supply wells, industrial/commercial wells, irrigation wells, and cooling water wells that occur at the time the measurements are collected.

Drought Indicator Well Network
In order to ascertain the effects of drought conditions (low precipitation and the resultant decrease in recharge) on the aquifer system, a network of 24 monitoring wells were selected and are depicted in Figure 3-6. These wells, which are called the "drought indicator wells," lie between the Long Island Expressway and Hempstead Turnpike. Since these monitoring wells are generally located along the groundwater divide where water table elevations are highest, they are most sensitive to changes in recharge and will display the largest variations in water levels of any monitoring wells in the network. Water elevations from the drought indicator wells are collected on a monthly basis, at the beginning of each month.

Southwest Nassau Indicator Well Network
During early 2002, the City of New York (NYC) proposed to withdraw water from the aquifers underlying the Brooklyn-Queens area to supplement the City's surface water supply in response to drought conditions that were expected to arise during the warmer months of that year. Realizing that withdrawing groundwater from the Brooklyn-Queens area could have significant effects on the aquifers underlying Nassau County, DPW selected a network of 19 monitoring wells near the Queens border. These wells are referred to as the "southwest Nassau indicator wells" and are depicted in Figure 3-7. Most recently, NYC has proposed an aquifer storage and recovery (ASR) approach that would utilize the portion of the Lloyd aquifer beneath the Brooklyn-Queens area to store surface water from upstate reservoirs in times of surplus. Stored water would then be pumped out of the aquifer to make up for lost supply capacity during the shutdown period of one of NYC's water supply tunnels for maintenance operations. The Lloyd aquifer is under consideration for ASR since the confined nature of the aquifer would theoretically allow water to be pumped into and stored, then withdrawn, from the Lloyd aquifer. NYC also intends to evaluate the ASR approach for its future potential as a back up water supply during times of water deficiencies when upstate reservoir levels are low.

Although NYC pumping as initially proposed has not commenced and the ASR project is in the proposal stages, water levels from the southwest indicator well network are nevertheless collected on a monthly basis, at the beginning of each month, in order to provide a solid baseline should either of these actions commence in the future. The southwest Nassau indicator well network was established in March 2002, immediately after learning of the City's initial proposal. Therefore, a considerable amount of baseline data, under varying weather conditions, has already been collected.

3.2.2 Raw Groundwater Quality Sampling
The results of development, disposal of sanitary wastes, prior human activities concerning the use and disposal of hazardous substances, and pumping of groundwater for water supply purposes has impacted the quality of Nassau County's raw groundwater in certain areas. As a result, approximately 23% of public supply wells in the County (90 out of 400 active supply wells) presently require treatment for removal of Volatile Organic Chemicals (VOCs) in order to meet drinking water quality standards that have been promulgated on the federal, State, and local levels for protection of public health. In addition, other types of water quality treatment are applied at public supply wells and include corrosion control (95%), chlorination (89%), and iron removal/control (35%).

In order to track quality trends in the raw groundwater quality, DPW routinely samples and analyzes groundwater from numerous monitoring wells of the network. Although it is impossible to sample each monitoring well every year, nor is it necessary, the monitoring wells selected for sampling give a regional distribution throughout the County. In this manner, a global representation of the overall raw groundwater quality throughout Nassau's groundwater system is achieved and can be tracked over time.

Since DPW's monitoring wells are not equipped with permanently installed pumping/sampling apparatus, raw groundwater samples are obtained by using a combination of portable pumps and hand bailers following professionally recognized protocols. Groundwater samples are then delivered to the appropriate laboratory for analysis. All sampling apparatus undergoes a rigorous decontamination procedure after each sample is taken.

Volatile Organic Chemicals (VOCs)
Raw groundwater quality testing results presented in previous comprehensive groundwater studies, along with the appearance of volatile organic chemicals (VOCs) at some public supply wells, demonstrated that the presence of VOCs in Nassau County's groundwater was the most significant countywide groundwater concern**.** As a result of those findings, the main focus of groundwater quality sampling during the 2000 – 2003 period was on VOC analysis. Table 3-1 lists the analytes included in DPW's Environmental Laboratory analysis for VOCs in the raw groundwater. These analytes are the Principal Organic Contaminants (POCs) that are monitored in drinking water by public water suppliers as mandated under the New York State Sanitary Code, Part 5, Subpart 5-1: Public Water Systems.

VOC samples have been collected from the monitoring network by DPW on a routine basis since the mid-1980s. The present goal is to sample for VOCs from network monitoring wells at the rate of approximately 125 wells per year, thus making a three to four year cycle in which an adequate number of monitoring wells are sampled to give a countywide representation of VOC concentrations in the raw groundwater. Certain specific monitoring wells that have shown impacts will be sampled at a greater frequency in future years.

Pesticides
Over the last several years, DPW and the Nassau County Department of Health, in cooperation with the Suffolk County Department of Health Services (SCDHS), embarked on the "Water Quality Monitoring Program to Detect Pesticides in Groundwater" in both counties. The program is funded in part by both the New York State Department of Environmental Conservation (NYSDEC) and SCDHS. State-of-the-art laboratory analysis that addresses over 100 pesticide compounds and their degradation products is performed by the SCDHS Public and Environmental Health Laboratory (PEHL) for samples collected by both counties.

These analytes are presented in Table 3-2, and Figure 3-8 depicts the 85 monitoring wells that were sampled for these substances during the 2001 – 2003 period. The list of analytes includes the Specific Organic Chemicals (SOCs – Group 1 and 2 Chemicals) that are monitored in drinking water by the public water suppliers as mandated under the New York State Sanitary Code. The majority of monitoring wells selected for pesticide monitoring were shallow wells most likely susceptible to pesticide impacts. Such wells were specifically chosen near former agricultural areas, proximity to parks and athletic fields, golf courses, small active farms, and utility right-of-ways. Sampling also included monitoring wells from residential areas in order to check for the presence of pesticides resulting from use in residential settings.

Pharmaceuticals
Included in the analysis for pesticide and associated degradation products are a number of pharmaceutical compounds/consumer products that include caffeine, triclosan, and ibuprofen. Each compound was added to the routine analyses conducted by SCDHS after its first detection in Long Island groundwater. The pharmaceutical compounds are identified in the analyte listing of Table 3-2, and were included in the analysis of Nassau County's raw groundwater samples from 42 monitoring wells that were delivered to SCDHS-PEHL during the 2002 – 2003 period under the

pesticide monitoring program. Reference is made to Figure 3-8 for the locations of monitoring wells sampled for pharmaceutical compounds.

Inorganic Chemicals

Sixteen (16) monitoring wells were sampled for inorganic chemicals (including metals) during the 2000 – 2003 period with subsequent analysis performed by DPW's Environmental Laboratory. Previous groundwater studies have documented that, except for nitrate in isolated areas, and heavy metals at several localized hazardous waste sites, inorganic chemicals are not a significant problem in Nassau County's raw groundwater. These studies have also documented that countywide nitrate concentrations in the raw groundwater have significantly decreased as a result of the installation of sanitary sewers, which virtually eliminated the major source of nitrogen loading (on-site disposal of sanitary waste) on the groundwater system. Inorganic chemical analysis, including nitrate, is planned for a larger set of monitoring wells in future years to further document these trends.

Perchlorate, an inorganic compound that is utilized as an oxidizer in rocket propellants and explosives, contained in some fertilizers, and used in electronics manufacturing, has recently been discovered in the nation's soil and groundwater. This compound is routinely analyzed by the SCDHS-PEHL, and results were thus reported for Nassau County's raw groundwater samples that were delivered to Suffolk County for pesticide analysis during the 2001 – 2003 period. Reference is made to Figure 3-8 for locations of 85 monitoring wells that were sampled for perchlorate. Additional perchlorate monitoring is discussed in Section 7 – Going Forward.

Chlorides

Area specific monitoring well networks have been defined to monitor saltwater intrusion on both the north and south shores of the County. The south shore saltwater monitoring network consists of 54 County wells. On the north shore, where the subsurface geology is much more complex, 101 wells comprise the north shore saltwater network. The monitoring wells of both networks are sampled on a regular frequency based on the likelihood of being impacted by saltwater, and the proximity to public supply wells. These networks serve as early warning for any significant movement of the saltwater interface, and are depicted in Figures 3-9 and 3-10. South shore chloride sampling dates back to the 1960s while chloride sampling on the north shore began in earnest during the mid-1990s after the completion of several north shore monitoring well drilling projects. Several wells located in southeastern Queens County are used to augment the south shore monitoring network and serve as an aid in tracking landward movement of saltwater in southwestern Nassau County. Although the Queens wells are under the jurisdiction of the New York City Department of Environmental Protection, they are periodically sampled for chlorides by DPW as part of Nassau's south shore saltwater intrusion monitoring efforts.

3.2.3 Streamflow

Over the last 25 years, Nassau County has been active in pursuing opportunities to protect and enhance key streams and surface water bodies in the County. These efforts have included various studies and ongoing projects, which are described as follows:

In the Flow Augmentation Needs Study (FANS), which was completed in the early 1980s, the impacts of sanitary sewers on south shore streams were identified, along with options to mitigate the negative effects (decline in streamflow and inland surface water levels) of the lowered water table caused by the installation of sanitary sewers. FANS also evaluated the potential for salinity increases in the bays and estuaries due to the reduced streamflow discharges to these shoreline water bodies.

Building on FANS, the County initiated a capital project, the Stream and Wetland Area Management Program (SWAMP), as well as several site specific capital projects, to provide funding needed to implement measures for improving conditions at key streams and inland surface water bodies. Several additional site-specific capital projects were subsequently developed to augment the funding derived through SWAMP. The main mitigating measures that were implemented included construction of stormwater detention facilities and check dams, dredging and/or pond deepening, and flow augmentation with shallow wells during dry periods. Through the end of 2003, $15,000,000 was expended on physical means to improve the County's surface water features. It is estimated that a total of $25,000,000 will have been expended by the time all selected streams and inland surface water bodies have been addressed, anticipated to be by the end of 2010.

Beginning in 2003, DPW has devoted significant efforts into developing a comprehensive Storm Water Management Program (SWMP) to satisfy the federal mandate under Phase II of the National Pollution Discharge Elimination System (NPDES) permit regulations for storm water discharges. These regulations were promulgated by the United States Environmental Protection Agency (EPA) under the Clean Water Act to protect surface waters of the United States, including the Long Island Sound and South Shore Estuary, from harmful impacts of unregulated sources of stormwater discharges to surface water bodies.

Under the regulations, Nassau County and all municipalities within the County are required to obtain permits for their stormwater system discharges. Since the stormwater infrastructures of most municipalities are connected to major trunk lines, open drainage corridors, and stormwater outfalls that are under the jurisdiction of the County, and given that Nassau County is the largest municipality, coupled with DPW's experience with stormwater issues, the County has taken the lead in forming an inter-municipal coalition to address the permitting requirements. This approach will facilitate the sharing of knowledge between all parties and provide assistance to other municipalities as they structure their respective SWMPs. In order to begin the implementation of SWMP, Nassau County received a grant in the amount of $500,000 from New York State. Additional funds will be expended by Nassau County as SWMP proceeds forward.

Major components of the SWMP include public education, the implementation of best management practices along streams and open drainage corridors, streamflow quality sampling, establishment of a drainage use ordinance, and illicit discharge detection and elimination. Best management practices could include installation of check dams and sedimentation basins at selected stream channel locations and capture structures at outfalls to retain floatable debris, oil, grease, and sediment prior to discharge. As mentioned previously, the check dams and sedimentation basins serve an additional function in augmenting streamflow during dry weather conditions, and have already been constructed at certain streams for this purpose under SWAMP.

The illicit discharge detection and elimination component of the program will serve to identify illegal pipe connections to the drainage system infrastructure and subsequently have such connections removed. Streamflow quality sampling commenced in 2003 to identify illicit discharges. Sample results will also provide a baseline for gauging the performance of the best management practices as they are implemented.

Streamflow measurement has typically been a task conducted by the United States Geological Survey (USGS) as part of their hydrologic data gathering activities conducted under the cooperative agreement with Nassau County. As a result of the cessation of the cooperative agreement by the previous County administration, streamflow has not been measured in the County since 1999. This has resulted in a gap in streamflow measurement data that continued through 2004. With the reestablishment of the cooperative agreement by County Executive Thomas R. Suozzi, streamflow will again be measured in Nassau County by the USGS during 2005. Although streamflow data is useful to tie all interrelated components of the groundwater system together, the data is not essential for evaluating the behavior of the groundwater system and in monitoring raw groundwater quality.

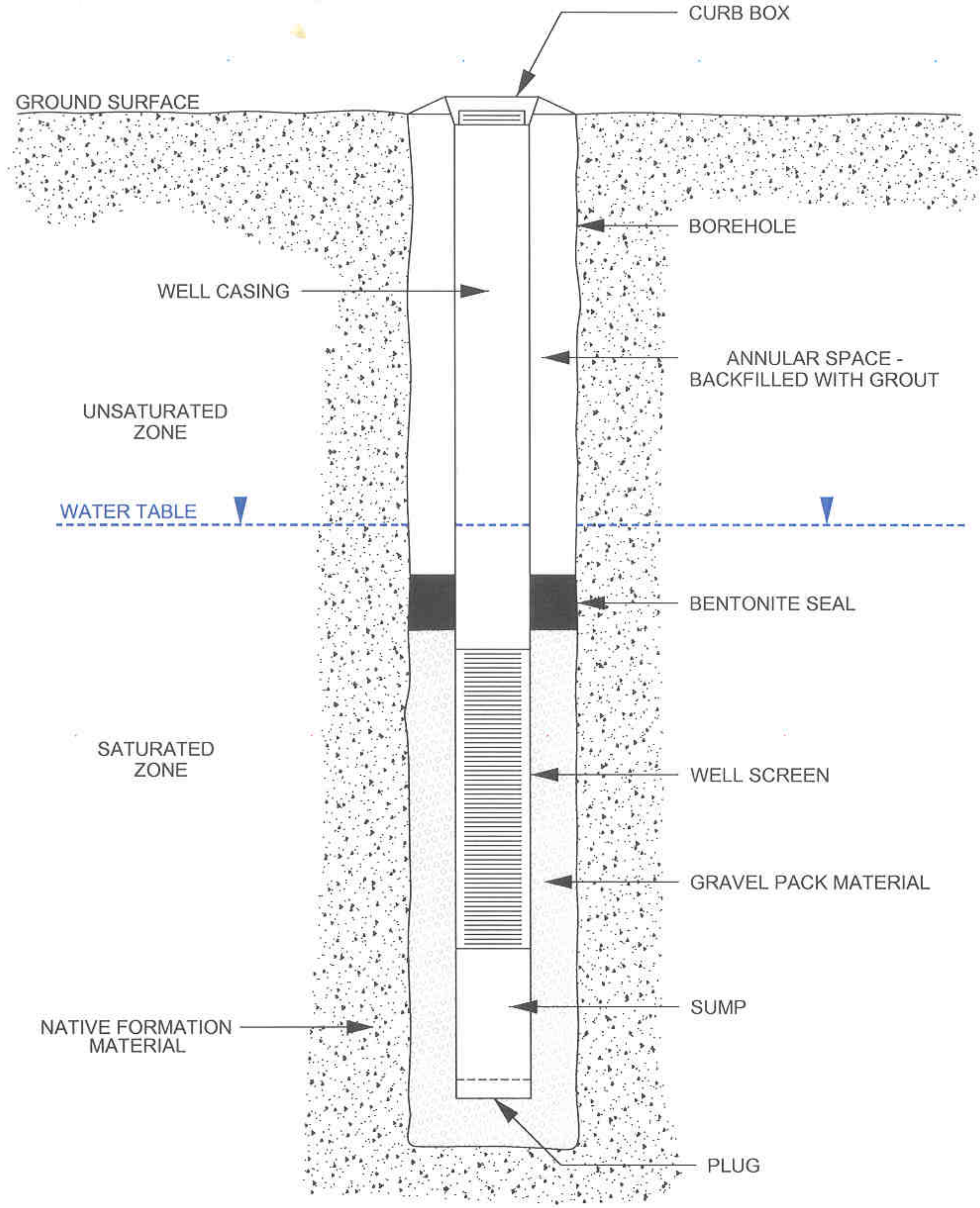
For additional information on the stormwater program, and associated augmentation and protection efforts, the reader is referred to DPW's annual reports on this program that are prepared by June 1st of each year and available on Nassau County's website.

3.3 Public Water Supply Withdrawal

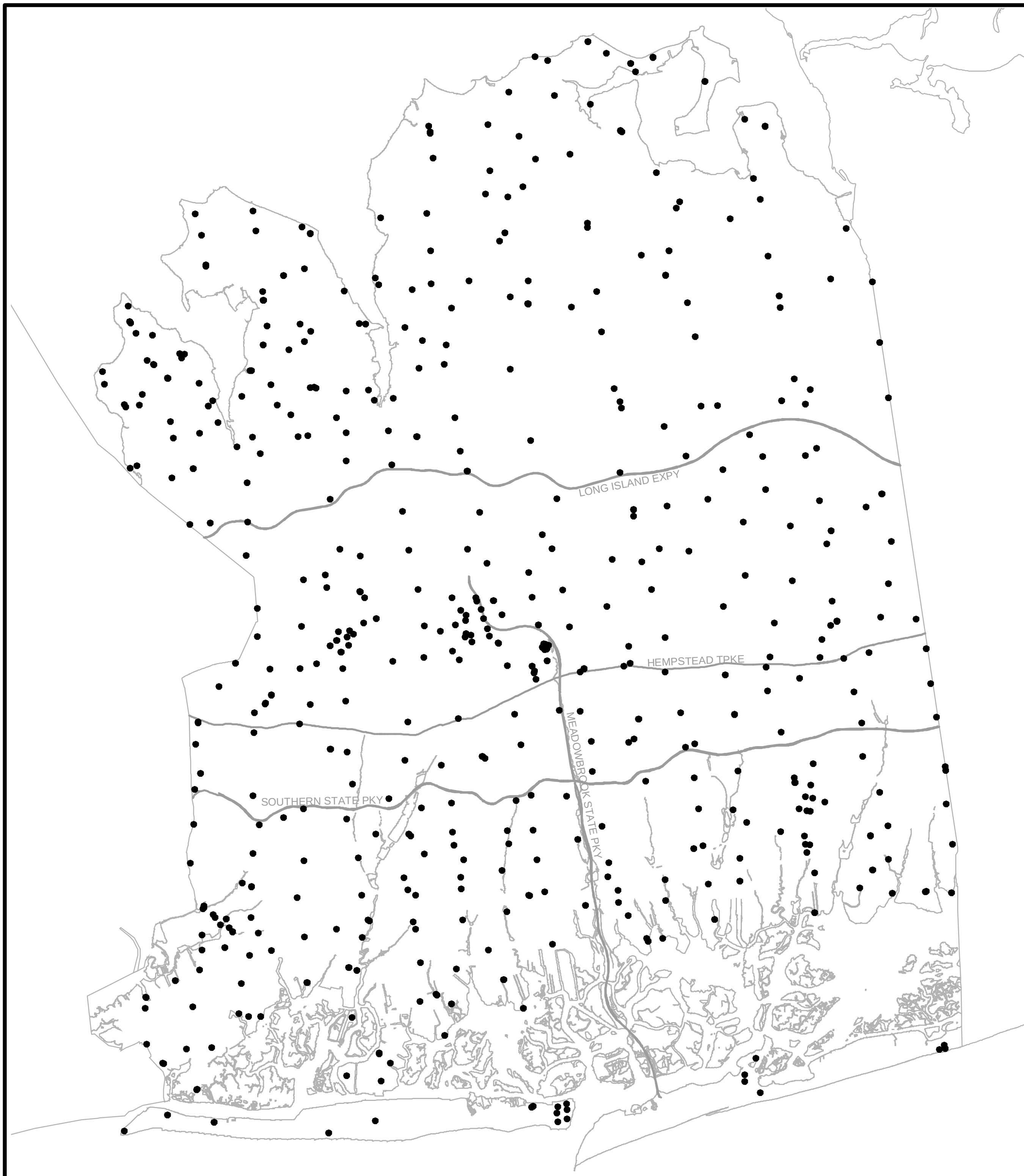
One of the conditions of the water supply well permits, that are issued by NYSDEC, is that the respective public water suppliers record and report amounts of water pumped from all of their supply wells to NYSDEC on a monthly basis. Water suppliers located in Nassau County also report this information directly to DPW. The information is then tabulated and evaluated by DPW in order to track trends in water usage throughout the County and determine impacts on groundwater system behavior.

Figure 3-1

CONSTRUCTION DETAIL
GROUNDWATER MONITORING WELL

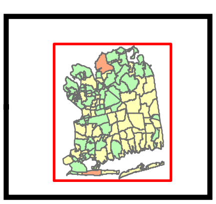


Prepared By: Nassau County Dep't. of Public Works



Legend

• Location of NCDPW Groundwater Monitoring Well



Site Location

FIGURE 3-2

NASSAU COUNTY DEP'T. OF PUBLIC WORKS

GROUNDWATER MONITORING WELL NETWORK ALL AQUIFERS

Prepared By: Nassau County Dep't. of Public Works

N W E S

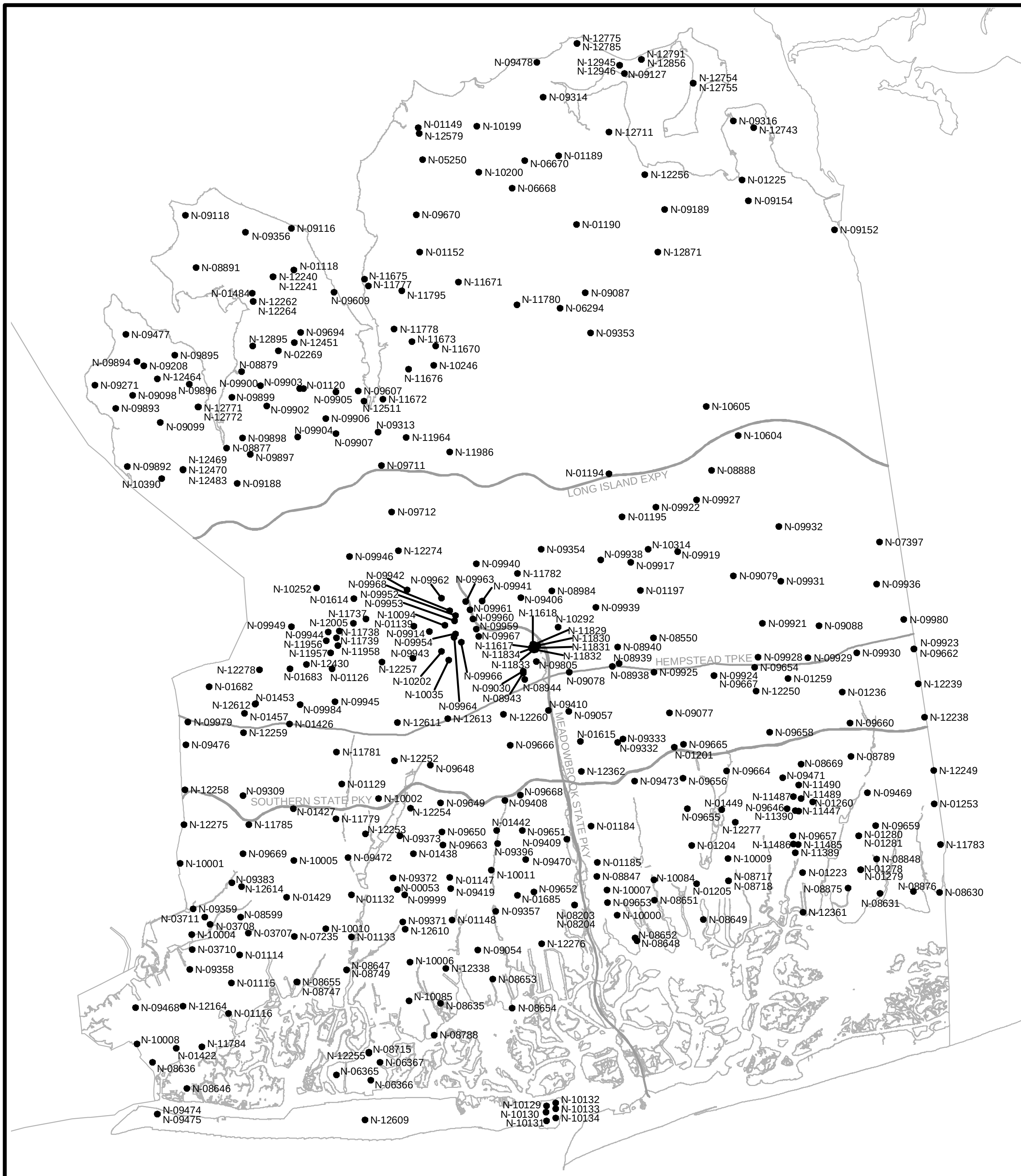
0 4,000 8,000 16,000 Feet

Nassau County

NASSAU COUNTY GEOGRAPHIC INFORMATION SYSTEM

Geographic Information System

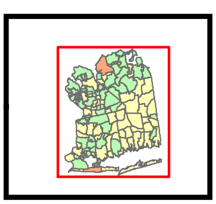
Date: 12/31/2003



Legend

Location of NCDPW Groundwater Monitoring Well with NYS Well No. - Upper Glacial Aquifer

● N-01194



Site Location

FIGURE 3-3

NASSAU COUNTY DEP'T. OF PUBLIC WORKS

GROUNDWATER MONITORING WELL NETWORK UPPER GLACIAL AQUIFER

Prepared By: Nassau County Dep't. of Public Works

N W E S

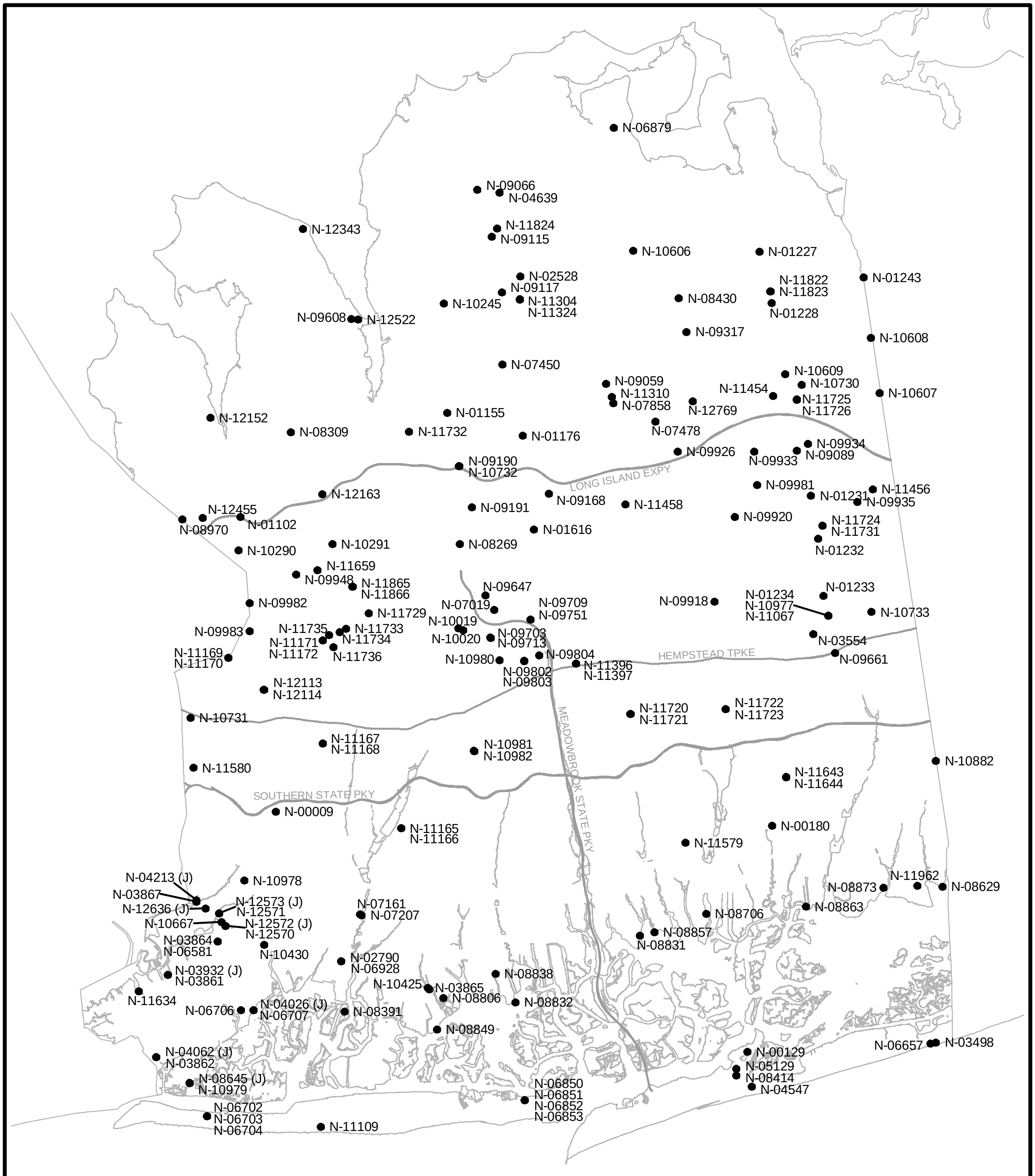
0 4,000 8,000 16,000 Feet

Nassau County

NASSAU COUNTY GEOGRAPHIC INFORMATION SYSTEMS

Geographic Information System

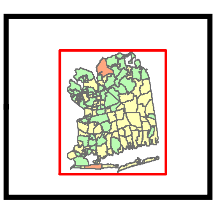
Date: 12/31/2003



Legend

Location of NCDPW Groundwater Monitoring Well with NYS Well No. and Aquifer Designation as follows:

- N-09918 Magothy Aquifer
- N-03932 (J) Jameco Aquifer



Site Location

FIGURE 3-4

NASSAU COUNTY DEP'T. OF PUBLIC WORKS

GROUNDWATER MONITORING WELL NETWORK MAGOTHY AQUIFER (ALL DEPTHS) AND JAMECO AQUIFER

Prepared By: Nassau County Dep't. of Public Works

N / W / E / S

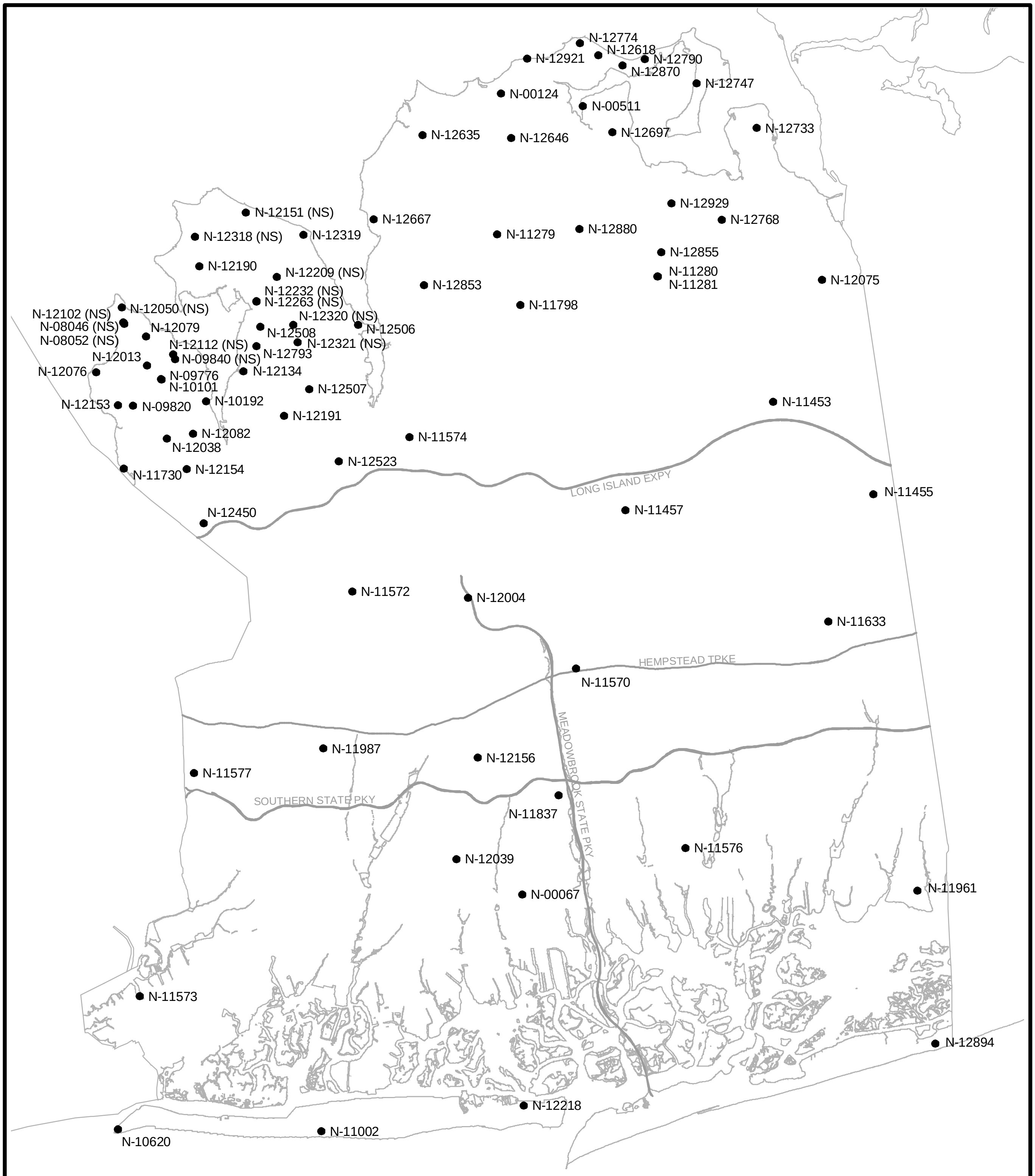
0 4,000 8,000 16,000 Feet

Nassau County

NASSAU COUNTY GEOGRAPHIC INFORMATION SYSTEMS

Geographic Information System

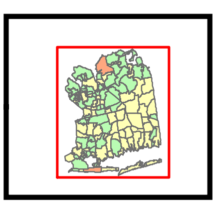
Date: 12/31/2003



Legend

Location of NCDPW Groundwater Monitoring Well with NYS Well No. and Aquifer Designation as follows:

● N-11457	Lloyd
● N-12050 (NS)	North Shore



Site Location

FIGURE 3-5

NASSAU COUNTY DEP'T. OF PUBLIC WORKS

GROUNDWATER MONITORING WELL NETWORK LLOYD AND NORTH SHORE AQUIFERS

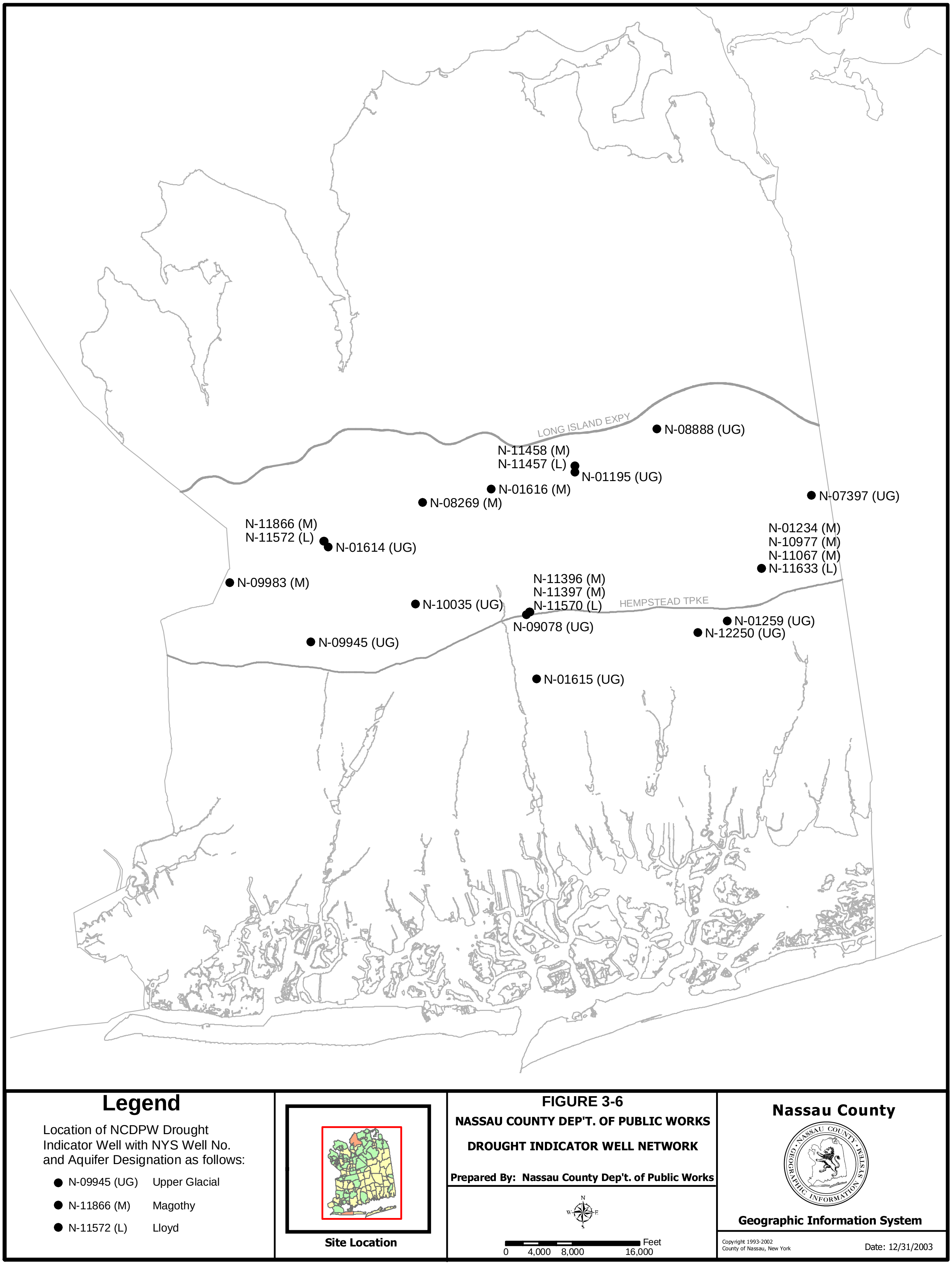
Prepared By: Nassau County Dep't. of Public Works

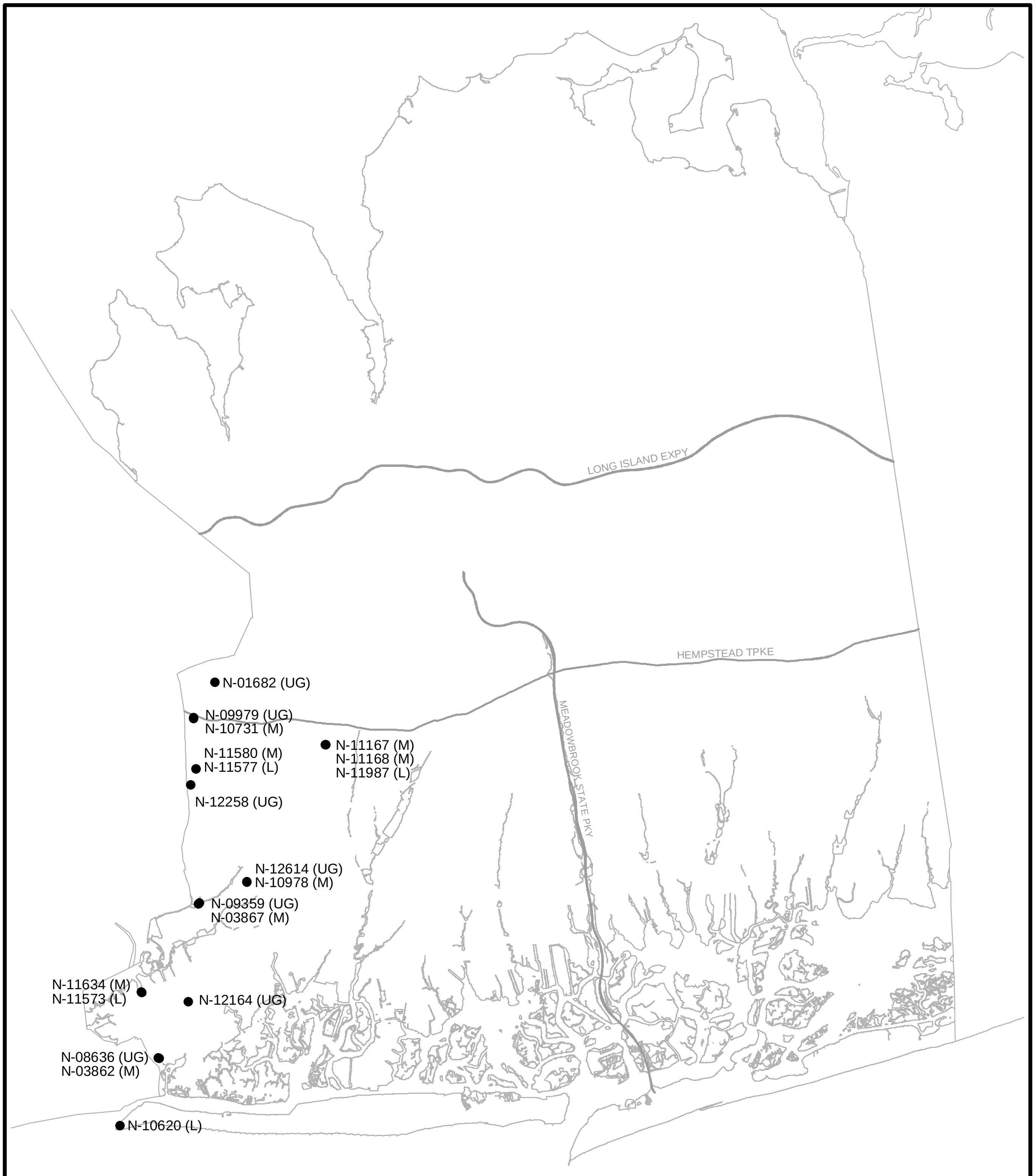
0 4,000 8,000 16,000 Feet

Nassau County

Geographic Information System

Date: 12/31/2003

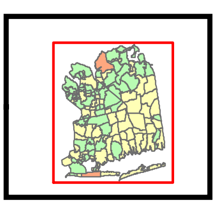

LONG ISLAND EXPY
HEMPSTEAD TPKE
N-08888 (UG)
N-11458 (M)
N-11457 (L)
N-01195 (UG)
N-01616 (M)
N-08269 (M)
N-07397 (UG)
N-11866 (M)
N-11572 (L)
N-01614 (UG)
N-01234 (M)
N-10977 (M)
N-11067 (M)
N-11633 (L)
N-09983 (M)
N-11396 (M)
N-11397 (M)
N-11570 (L)
N-10035 (UG)
N-09078 (UG)
N-01259 (UG)
N-12250 (UG)
N-09945 (UG)
N-01615 (UG)
Legend
Location of NCDPW Drought Indicator Well with NYS Well No. and Aquifer Designation as follows:
N-09945 (UG) Upper Glacial
N-11866 (M) Magothy
N-11572 (L) Lloyd
Site Location
FIGURE 3-6
NASSAU COUNTY DEP'T. OF PUBLIC WORKS
DROUGHT INDICATOR WELL NETWORK
Prepared By: Nassau County Dep't. of Public Works
Feet
0 4,000 8,000 16,000
Nassau County
NASSAU COUNTY GEOGRAPHIC INFORMATION SYSTEM
Geographic Information System
Copyright 1993-2002
County of Nassau, New York
Date: 12/31/2003



Legend

Location of NCDPW Southwest Nassau Indicator Well with NYS Well No. and Aquifer Designation as follows:

● N-01682 (UG)	Upper Glacial
● N-10731 (M)	Magothy
● N-11577 (L)	Lloyd



Site Location

FIGURE 3-7

NASSAU COUNTY DEP'T. OF PUBLIC WORKS

SOUTHWEST NASSAU INDICATOR WELL NETWORK

Prepared By: Nassau County Dep't. of Public Works

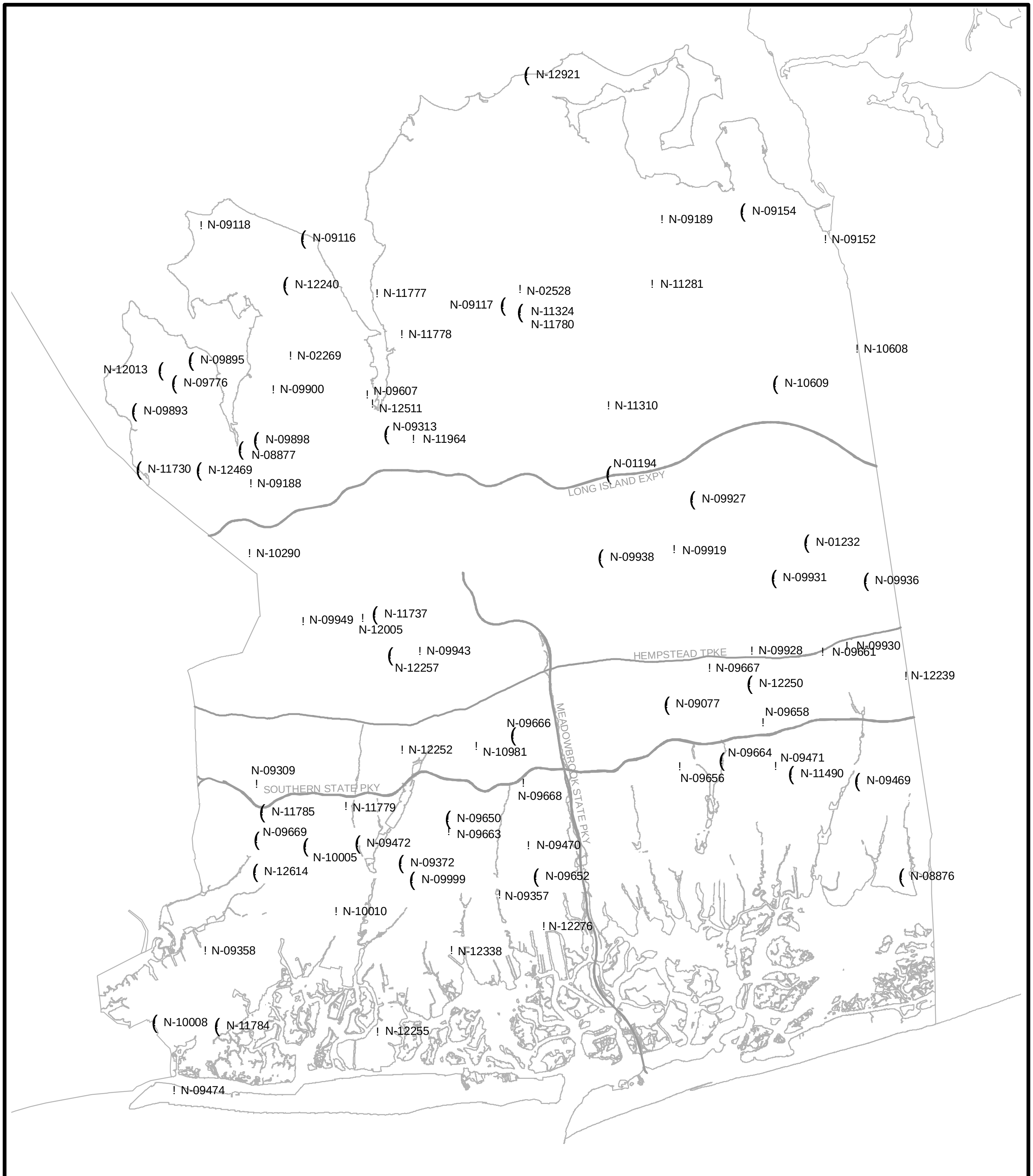
N W E S

Feet 0 4,000 8,000 16,000

Nassau County

Geographic Information System

Date: 12/31/2003

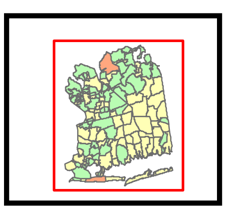


Legend

Location of NCDPW Groundwater Monitoring Well Sampled for:

! Pesticides and Perchlorate 2001 - 2003

(Pharmaceuticals 2002 - 2003



Site Location

FIGURE 3-8

NASSAU COUNTY DEP'T. OF PUBLIC WORKS

GROUNDWATER MONITORING WELLS SAMPLED FOR PESTICIDES, PERCHLORATE, AND PHARMACEUTICALS

Prepared By: Nassau County Dep't. of Public Works

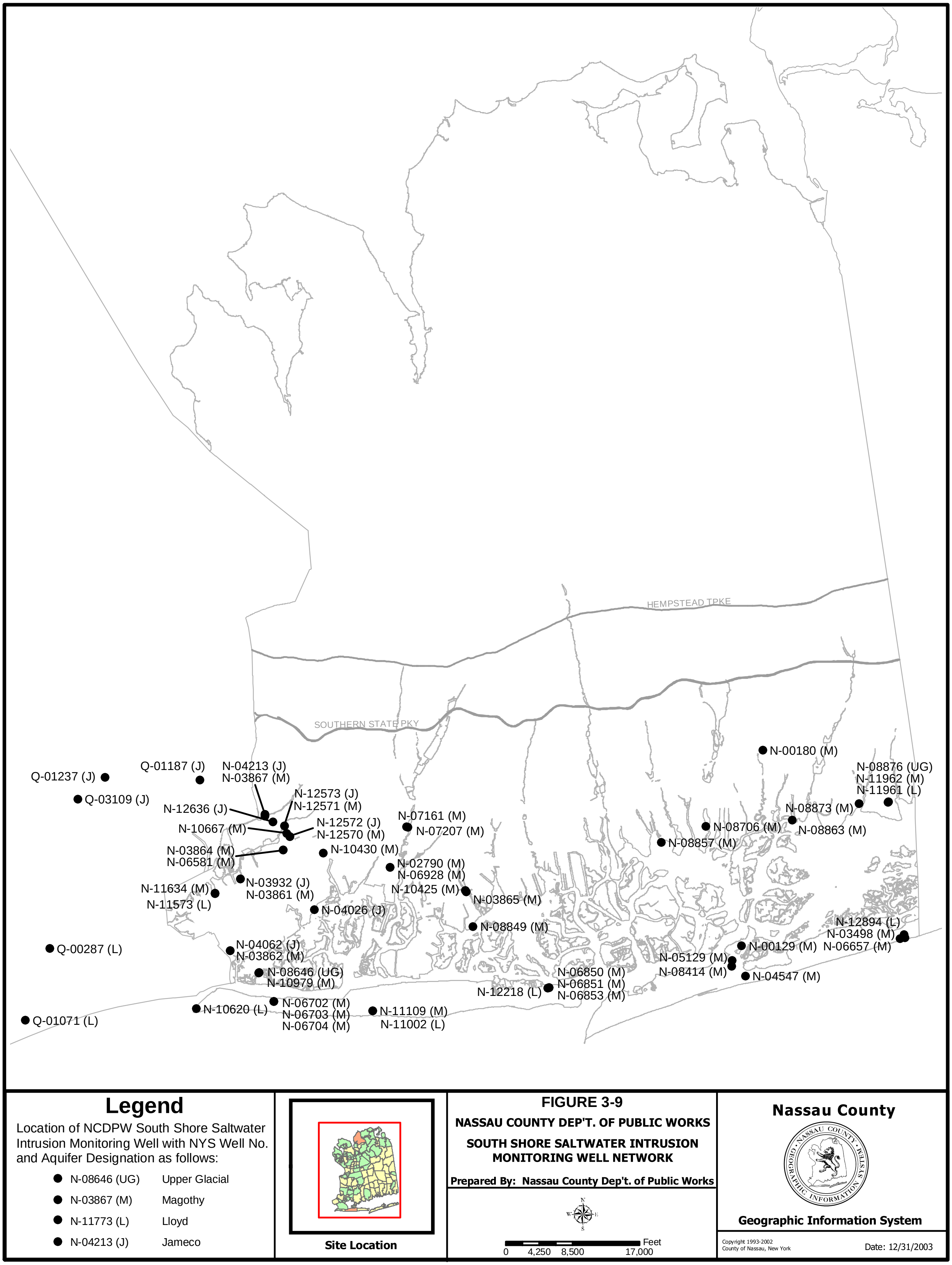
µ

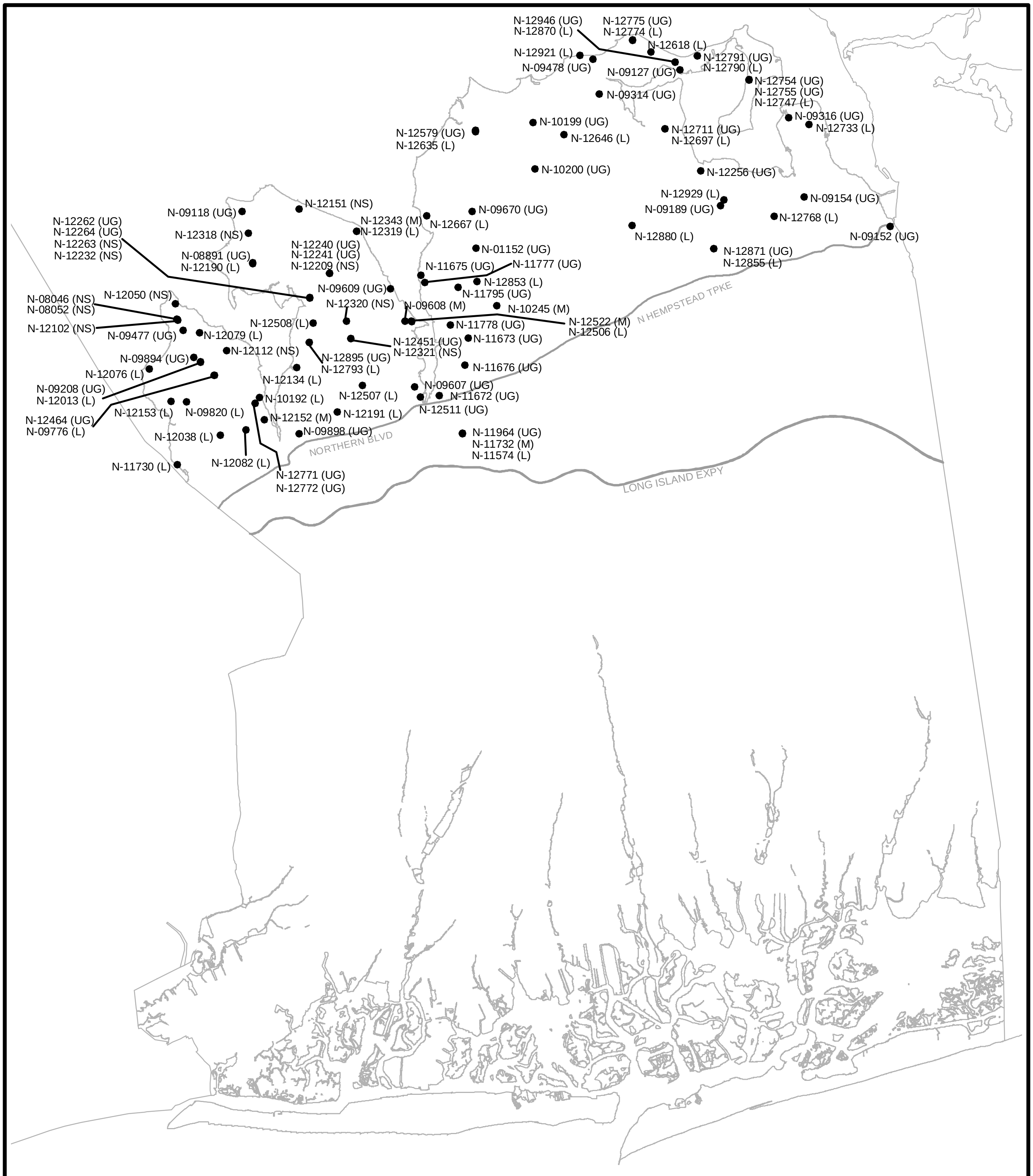
0 4,000 8,000 16,000 Feet

Nassau County

Geographic Information System

Date: 12/31/2003

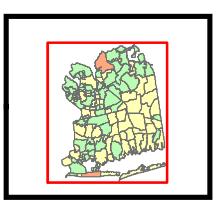

HEMPSTEAD TPKE
SOUTHERN STATE PKY
Q-01237 (J)
Q-03109 (J)
Q-01187 (J)
N-04213 (J)
N-03867 (M)
N-12636 (J)
N-12573 (J)
N-12571 (M)
N-10667 (M)
N-12572 (J)
N-12570 (M)
N-03864 (M)
N-06581 (M)
N-10430 (M)
N-07161 (M)
N-07207 (M)
N-03932 (J)
N-03861 (M)
N-11634 (M)
N-11573 (L)
N-02790 (M)
N-06928 (M)
N-10425 (M)
N-03865 (M)
N-04026 (J)
N-08849 (M)
Q-00287 (L)
N-04062 (J)
N-03862 (M)
N-08646 (UG)
N-10979 (M)
N-10620 (L)
N-06702 (M)
N-06703 (M)
N-06704 (M)
N-11109 (M)
N-11002 (L)
Q-01071 (L)
N-12218 (L)
N-06850 (M)
N-06851 (M)
N-06853 (M)
N-00180 (M)
N-08876 (UG)
N-11962 (M)
N-11961 (L)
N-08873 (M)
N-08706 (M)
N-08863 (M)
N-08857 (M)
N-12894 (L)
N-03498 (M)
N-06657 (M)
N-00129 (M)
N-05129 (M)
N-08414 (M)
N-04547 (M)
Legend
Location of NCDPW South Shore Saltwater Intrusion Monitoring Well with NYS Well No. and Aquifer Designation as follows:
N-08646 (UG) Upper Glacial
N-03867 (M) Magothy
N-11773 (L) Lloyd
N-04213 (J) Jameco
Site Location
FIGURE 3-9
NASSAU COUNTY DEP'T. OF PUBLIC WORKS
SOUTH SHORE SALTWATER INTRUSION
MONITORING WELL NETWORK
Prepared By: Nassau County Dep't. of Public Works
N
W E
S
0 4,250 8,500 17,000 Feet
Nassau County
Geographic Information System
Copyright 1993-2002
County of Nassau, New York
Date: 12/31/2003



Legend

Location of NCDPW North Shore Saltwater Intrusion Monitoring Well with NYS Well No. and Aquifer Designation as follows:

● N-12262 (UG)	Upper Glacial
● N-12343 (M)	Magothy
● N-12190 (L)	Lloyd
● N-12263 (NS)	North Shore



Site Location

FIGURE 3-10

NASSAU COUNTY DEP'T. OF PUBLIC WORKS

NORTH SHORE SALTWATER INTRUSION MONITORING WELL NETWORK

Prepared By: Nassau County Dep't. of Public Works

N W E S

Feet 0 4,000 8,000 16,000

Nassau County

NASSAU COUNTY GEOGRAPHIC INFORMATION SYSTEM

Geographic Information System

Date: 12/31/2003

TABLE 3-1

Monitoring Well Network
Raw Groundwater Quality Sampling

VOLATILE ORGANIC CHEMICAL ANALYSIS
(EPA METHOD 524.2)

Analyses conducted by NCDPW Environmental Laboratory

Analyte
Dichlorodifluoromethane
Chloromethane
Vinyl Chloride
Bromomethane
Chloroethane
Trichlorofluoromethane
1,1-Dichloroethene
Methylene Chloride
t-1,2-Dichloroethene
1,1-Dichloroethane
2,2-Dichloropropane
c-1,2-Dichloroethene
Chloroform
Bromochloromethane
1,1,1-Trichloroethane
1,1-Dichloropropene
Carbon Tetrachloride
1,2-Dichloroethane
Benzene
Trichloroethene
1,2-Dichloropropane
Bromodichloromethane
Dibromomethane
c-1,3-Dichloropropene
Toluene
t-1,3-Dichloropropene
1,1,2-Trichloroethane
1,3-Dichloropropane
Tetrachloroethene
Dibromochloromethane

Analyte
1,2-Dibromoethane
Chlorobenzene
1,1,1,2-Tetrachloroethane
Ethyl Benzene
m,p-Xylene
o-Xylene
Styrene
Isopropylbenzene
Bromoform
1,1,2,2-Tetrachloroethane
1,2,3-Trichloropropane
n-Propylbenzene
Bromobenzene
1,3,5-Trimethylbenzene
2-Chlorotoluene
4-Chlorotoluene
t-Butylbenzene
1,2,4-Trimethylbenzene
sec-Butylbenzene
p-Isopropyltoluene
1,3-Dichlorobenzene
1,4-Dichlorobenzene
n-Butylbenzene
1,2-Dichlorobenzene
1,2-Dibromo-3-Chloropropane
1,2,4-Trichlorobenzene
Hexachlorobutadiene
Naphthalene
1,2,3-Trichlorobenzene
Methyl Tertiary Butyl Ether (MTBE)

TABLE 3-2

Monitoring Well Network
Raw Groundwater Quality Sampling

PESTICIDES, PESTICIDE DEGRADATION PRODUCTS AND PHARMACEUTICALS

SEMI- VOLATILE ORGANIC CHEMICAL ANALYSIS
(EPA METHOD 525.2)

Analyses conducted by Suffolk County Department of Health Services PEHL for Nassau County DPW

Analyte	Analyte	Analyte
Hexachlorocyclopentadiene	Metolachlor	Hexachlorobenzene
Dacthal	Simazine	Butachlor
Atrazine	bis-2-ethylhexyl adipate	Metribuzin
bis-2-ethylhexyl phthalate	Alachlor	Benzo-a-pyrene
Propachlor	Bromacil	Diazinon
Prometon	Metalaxyl	Pentachlorobenzene
Tebuthiuron	Disulfoton	Acetochlor
Ethofumesate	Malathion	Chlorpyriphos
Isofenphos	Cyfluthrin	Trifluralin
Benfluralin	Pentachloronitrobenzene	Chlorothalonil
Vinclozolin	Triadimefon	Pendimethalin
Iodofenphos	Iprodione	Permethrin
EPTC	Terbufos	Dinoseb
Terbacil	Cyanazine	Disulfoton sulfone
Napropamide	Kelthane	Bloc
Dichlorbenil	Methoprene	Resmethrin
Sumithrin	Piperonyl butoxide	Ethyl parathion
Methyl parathion	Azoxystrobin	Propiconazole
Dieldrin	Endosulfan sulfate	Allethrin
Caffeine ***(P)***	Cypermethrin	Deltamethrin
Dichlorvos	Naled (Dibrom)	Prometryne
Methoxychlor	Chlordane	Diethyltoluamide (DEET)
Benzophenone ***(P)***	Gemfibrozil ***(P)***	Chlorofenvinphos
Chloroxylenol ***(P)***	Ibuprofen ***(P)***	Carisoprodol ***(P)***
Triclosan ***(P)***	Butylated Hydroxyanisole ***(P)***	Butylated Hydroxytoluene ***(P)***
Benzo(a)anthracene	Chrysene	Benzo(b)fluoranthene
Benzo(k)fluoranthene	Indeno(1,2,3-cd)pyrene	Dibenzo(a,h)anthracene
Benzo(ghi)perylene	Dibutyl phthalate	Dimethyl phthalate
Diethyl phthalate	Benzyl butyl phthalate	Dioctyl phthalate
Naphthalene	Acenaphthylene	Acenaphthene
Fluorene	Phenanthrene	Anthracene
Fluoranthene	Pyrene	Carbamazepine ***(P)***
1,2,4-Trichlorobenzene	Hexachlorobutadiene	

(P) = Pharmaceutical/consumer product

TABLE 3-2

Monitoring Well Network
Raw Groundwater Quality Sampling

PESTICIDES, PESTICIDE DEGRADATION PRODUCTS AND PHARMACEUTICALS

CARBAMATE PESTICIDE ANALYSIS
(EPA METHOD 531.1)

Analyses conducted by Suffolk County Department of Health Services PEHL for Nassau County DPW

Analyte
Aldicarb
Aldicarb sulfoxide
Aldicarb sulfone
Carbofuran
3-Hydroxycarbofuran
Oxamyl
Carbaryl
1-Naphthol
Methomyl
Propoxur
Methiocarb

CHLORINATED PESTICIDE ANALYSIS
(EPA METHOD 505)

Analyte
Alpha-BHC
Beta-BHC
Gamma-BHC
Delta-BHC
Heptachlor
Heptachlor Epoxide
Aldrin
Dieldrin
Endosulfan I
Dacthal

Analyte
4,4 DDE
4,4 DDD
4,4 DDT
Endrin
Endrin aldehyde
Chlordane
Alachlor
Methoxychlor
Endosulfan II
Endosulfan sulfate

TABLE 3-2

Monitoring Well Network
Raw Groundwater Quality Sampling

PESTICIDES, PESTICIDE DEGRADATION PRODUCTS AND PHARMACEUTICALS

Analyses conducted by Suffolk County Department of Health Services PEHL for Nassau County DPW

HERBICIDE METABOLITE ANALYSIS
(LC/MS Method Developed at SCDHS PEHL)

Analyte
Didealkylatrazine
Deisopropylatrazine
Desethylatrazine
Imidacloprid
Alachlor OA (Oxanilic Acid)
Alachlor ESA (Sulfonic Acid)
Metolachlor Metabolites (4)
Metolachlor OA
Metolachlor ESA
2-Hydroxyatrazine
Malaoxon
Trichlorfon
Siduron
Dichlorvos
Propamocarb hydrochloride
2,6-Dichlorobenzamide
Ibuprofen ***(P)***
Gemfibrozil ***(P)***

DACTHAL METABOLITE ANALYSIS
(HPLC/LC-GC/MS Method Developed at SCDHS PEHL)

Analyte
Monomethyltetrachloroterephthalate (MM)
Tetrachloroterephthalic acid (TCPA)

(P) = Pharmaceutical/consumer product