

STATE OF THE AQUIFER 2018 UPDATE

Long Island Commission for Aquifer Protection



LICAP



Long Island Commission
for Aquifer Protection



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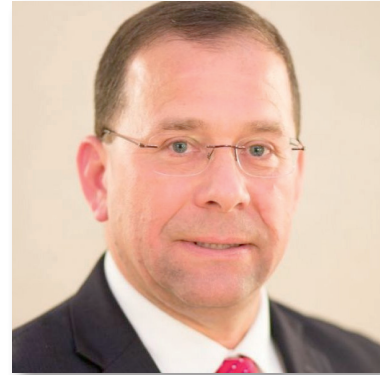
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MESSAGE FROM THE CHAIRMAN

The Long Island Commission for Aquifer Protection, or LICAP, is very proud to have had its work ratified and mission extended by the Suffolk Legislature and Nassau Legislature, which both voted this year to extend our work in developing measures to preserve Long Island's aquifer system for another five years. While we've accomplished a great deal in our first five years, there is much to do in the next five years as well.

The following is our second update to our original State of the Aquifer report, a first-of-its-kind document that is helping stakeholders pinpoint issues that need to be addressed. In this update—which is meant to serve as a snapshot of key issues that have emerged this year, not a rewrite of the original report—we cover vital issues such as Long Island's recharge patterns; streamflow discharges, and how they've been impacted by human activity; current groundwater levels; emerging contaminants; and an update on the Grumman/Navy Bethpage groundwater plume.



Stan Carey, 2018 Chairman, LICAP

This report, though vital to our mission, represents just a small fraction of the important work being conducted by LICAP's public water supply professionals, elected officials, environmental advocates and representatives of agencies dedicated to public health. Our interim Groundwater Resources Management Plan, which will provide a blueprint for the management and protection of our groundwater supplies, is in the process of being finalized. And our extended mission comes with two new important directives: Educating Long Islanders about how to conserve our vital groundwater supply through a new subcommittee that is actively developing a comprehensive conservation messaging campaign and developing recommendations for concrete actions to be taken to make sure our water supply remains sustainable for future generations. We're also tasked to work with the Long Island Nitrogen Action Plan (LINAP) working group, which is seeking to reduce nitrogen in Long Island's surface waterways and groundwater.

There has been much public discussion recently about the importance of the preservation and proper management of the sole source aquifer that provides 100% of Long Island's drinking water. It's a positive step that so many people with so many perspectives are stepping to the forefront and getting involved, offering their thoughts, their analyses, their specific proposals. We at LICAP welcome the public dialogue, and, for our part, will continue in our next five years to do what we've done in our first five years: Solicit input from a wide variety of knowledgeable stakeholders to make sure we are acting to protect Long Island's most valuable natural resource.

Stan Carey,

2018 Chairman, Long Island Commission for Aquifer Protection



LICAP Members

(as of January, 2019)

VOTING MEMBERS AND THE ORGANIZATIONS OR OFFICES THEY REPRESENT

Jeffrey W. Szabo

Chairman
Suffolk County Water Authority

Paul Granger

Vice-Chairman
Long Island Water Conference

Stan Carey

Nassau-Suffolk Water Commissioners Assoc.

Walter Dawydiak

Suffolk County Commissioner of Health

Don Irwin

Nassau County Commissioner of Health

Brian Schneider

Nassau County Executive

Dorian Dale

Suffolk County Executive

Chris Ostuni

Nassau County Legislature Presiding Officer

Michael White

Suffolk County Legislature Presiding Officer

David Gamin

Nassau County Soil & Water Conservation District

Corey Humphrey

Suffolk County Soil & Water Conservation District

EX-OFFICIO MEMBERS AND THE ORGANIZATIONS OR OFFICES THEY REPRESENT

Honorable Tom Cilmi

Suffolk County Legislature Minority Leader

Sarah Meyland

Nassau County Legislature Minority Leader

Christina DeLisi

Suffolk County Legislature Presiding Officer

Gilbert Anderson, P.E.

Suffolk County Commissioner of Public Works

Nick Gibbons

Suffolk County Commissioner of Parks,
Recreation and Conservation

Michael Comerford

Nassau County Commissioner of Parks

Satish Sood

Nassau County Planning Commission

Carrie Meek Gallagher

New York State Department
of Environmental Conservation

Stephen Terracciano

U.S. Geological Survey Long Island Program Office

Henry Bokuniewicz

SUNY Stony Brook School of Marine and Atmospheric
Sciences



LICAP FACTS

FOUNDED: By unanimous votes of the Suffolk County and Nassau County Legislatures in 2013. Reauthorized in 2018 and extended to 2023.

MISSION: To advance a coordinated, regional approach to the protection of Long Island's sole source aquifer through the preparation of a State of the Aquifer report, to be updated annually, and a Groundwater Resources Management Plan.

MEMBERS: LICAP has 11 voting members. The Suffolk County Water Authority, the Long Island Water Conference, the Nassau-Suffolk Water Commissioners Association and the Nassau and Suffolk Departments of Health are permanent members. Additionally, the Nassau County and Suffolk County Executives each appoint one member as do the presiding officers of each County's Legislature and the Nassau and Suffolk Soil and Water Conservation Districts. There are also ex-officio members with no voting power.

COMMITTEE STRUCTURE: LICAP maintains four standing subcommittees: The 2040 Water Resources and Infrastructure Subcommittee will identify long-term risks to the water supply industry created by global climate change. The Water Resource Opportunities Subcommittee will identify and quantify short-term risks to groundwater resources. The Conservation Subcommittee will develop strategies to educate Long Islanders about the importance of conserving our groundwater. The fourth subcommittee will work in conjunction with Long Island Nitrogen Action Plan (LINAP) working group.

MEETINGS: LICAP is required to meet at least quarterly and hold one public hearing in each county annually.

THE STATE OF THE AQUIFER: ASSESSING HYDROLOGIC CONDITIONS ON LONG ISLAND

This year's State of the Aquifer report update focuses on hydrologic conditions on Long Island, highlighting both our long history of monitoring hydrologic conditions and the current status of groundwater levels, patterns of precipitation and recharge, and streamflow.

Though 2018 has seen significantly above average precipitation, most of the years between 2010 and 2017 were below average for precipitation. This led to abnormally low groundwater levels and streamflows in many areas during these years, and underscores the importance of educating Long Islanders on the importance of water conservation. Recovery of aquifer levels and stream flows in 2018 has been robust, but levels are still below normal in many areas.

Emerging contaminants (also known as contaminants of emerging concern, or CECs), including pharmaceuticals and personal care products (PPCPs), are also assessed in this update, which also provides an update on the Grumman/Navy Bethpage groundwater plume.



HYDROLOGIC CONDITIONS IN NASSAU AND SUFFOLK COUNTIES

The following is the latest information on hydrologic conditions on Long Island, including groundwater monitoring efforts, precipitation and recharge patterns, streamflow data and groundwater levels.

A Century of Groundwater Resource Monitoring

Governmental agencies and water suppliers have for nearly 100 years monitored the public water delivered to Long Islanders to ensure it meets all drinking water standards. But this is only a fraction of the job. Stakeholders also monitor groundwater resources to detect potential water quality issues that may ultimately threaten the public water supply or otherwise threaten the environment.

This dual purpose has been accomplished through the maintenance of extensive networks of both shallow and deep monitoring wells and by conducting special investigative studies when a threat has been detected or suspected. This approach has throughout the years helped to pinpoint contaminants of potential concern, and in turn led to additional monitoring of public water supplies and both surface and groundwater resources for these chemicals. (Source Water Assessment Program, Task 1C Report, 2003).

But water quality is only one aspect of such monitoring. Water quantity monitoring has also historically been an important aspect of groundwater data collection on Long Island, with networks of wells utilized by the United States Geological Survey (USGS); the Nassau County Department of Public Works (NCDPW) and Department of Health (NCDH); and the Suffolk County counterparts of these agencies. Additionally, groundwater resource monitoring (separate from assessing the quality of water pumped by a given well) is often required of public water suppliers as part of the well permit process, and also by wastewater treatment plants as part of their discharge permits.

This abundance of groundwater data, acquired over such a long period of time, ensures that water suppliers and agencies are well informed about the condition of the aquifer system at any given time, which aids in making key decisions to protect public health. And any future actions to protect public health will be even better informed due to the creation in 2016 of a coordinated effort (known as the Long Island Sustainability Project) to protect and manage Long Island's groundwater resources.

That new initiative and the other ways in which Long Island groundwater has been monitored throughout the last century are covered below.

United States Geological Survey (USGS)

On Long Island (including Brooklyn and Queens), the USGS has operated and maintained a cooperative hydrologic surveillance program since the early 1900s. The current program, run out of the New York Water Science Center in Coram, consists of data collection from approximately 550 groundwater monitoring wells, 55 streams and two lakes. This program is funded cooperatively with other national, state, county, and local partners and provides the seamless, long-term data needed to accurately assess conditions and properly manage the region's water resources.

Groundwater data is the primary focus of the USGS hydrologic surveillance program on Long Island. Because most streams, ponds, and lakes in the region are hydraulically connected with the shallow groundwater system, the USGS monitors stream discharge and lake levels as part of its hydrologic surveillance network. Groundwater level, lake level, and stream discharge data are all needed to accurately assess seasonal fluctuations and long-term trends in groundwater.



Hydrologic data collected by the USGS supports several objectives: Providing scientists and water managers with an islandwide data set of representative hydrologic conditions using nationally consistent data collection techniques; promoting the timely exchange of scientific information and research between the USGS, state, county, local agencies, and local water suppliers and managers; allowing for the production and revision of islandwide water level, depth to water, and hydrogeologic maps; providing the necessary data for regional and national hydrologic studies; allowing for the prompt dissemination of USGS collected data online through NWISWeb and other related outlets; and in times of drought or flood, providing the data needed to properly manage the resource and inform critical flood response activities by emergency managers and communities.

In addition to these specific objectives, USGS hydrogeologic data collection serves to advance the overall knowledge of Long Island's regional hydrologic system by providing standardized, quality-assured data that are available to the public. This data can be used to better understand the variations in hydrologic conditions due to both natural and human induced factors. Understanding these changes is essential in order to properly manage Long Island's water resources. (https://www.usgs.gov/centers/ny-water/science/us-geological-survey-hydrologic-monitoring-long-island-new-york?qt-science_center_objects=0#qt-science_center_objects)

Groundwater pumpage, installation of sanitary and storm sewer systems and variations in precipitation all affect regional groundwater levels and aquifer storage. This in turn, can affect the region's water resources as well as environmentally sensitive habitats. In order to properly manage this resource, a consistent hydrologic data set is necessary for water managers and scientists to assess changes within the aquifer system that can detrimentally affect this vital resource. (https://www.usgs.gov/centers/ny-water/science/long-island-groundwater-network?qt-science_center_objects=0#qt-science_center_objects)

The frequency of data collection within this program varies throughout the region from annual-synoptic, which provides data for baseline statistical studies and groundwater model calibration; monthly, which (in addition to the above), provides data needed for water availability and saltwater intrusion studies, groundwater/surface water interaction studies, seasonal trend analysis, climate change and sea level rise analysis, and drought and flood monitoring; and continuous recording (or real-time) collection, which provides additional data required for short-term trend analysis, recharge and tidal variation studies, local groundwater withdrawal monitoring and drought and flood monitoring.

All project data is available online through the USGS National Water Information System: Web Interface (NWISWeb) and other online systems. (See appendix for links).

USGS also conducts hydrologic studies that address a wide variety of water resources issues, including water supply, contamination, nutrient loading, effects of land use on water quality and quantity and other basic hydrologic research.

Nassau County

The Nassau County Department of Public Works (NCDPW) maintains a network of 620 groundwater monitoring wells screened at various depths in each of the three major groundwater aquifers as follows:

- 366 upper glacial wells
- 167 Magothy wells
- 66 Lloyd wells
- 21 other

This network was originally established in the 1940s and 1950s to provide water level information for both industrial and residential development. The network was expanded in the 1960s and 1970s as development in Nassau County continued.



In the late 1970s, laboratory equipment (gas chromatograph) was purchased by both NCDPW and Nassau County Department of Health (NCDH), which allowed for the detection of volatile organic compounds (VOCs) in groundwater. New monitoring wells were installed in the 1980s and 1990s on county property right-of-ways at various depths depending on land uses potentially affecting groundwater quality. Well locations were often selected in consultation with the United States Geological Survey (USGS), New York State Department of Environmental Conservation (NYSDEC) the New York State Department of Health (NYSDOH) and the NCDH.

Due to the high cost of well installation (from \$1,000 to more than \$100,000 for a single well depending on depth, construction materials and installation method), many government agencies and groundwater consulting firms have come to rely on existing wells in both the USGS and Nassau County monitoring well networks to investigate water quality issues.

One current program is funded by the NYSDEC and involves sampling 32 existing well locations for the presence of CECs, including PFOA and 1,4-dioxane. In order to survey conditions expeditiously and across the island, the USGS made an existing sub-network of shallow monitoring wells available for this investigation. This sub-network was established previously to investigate agricultural chemicals in groundwater and has the benefit of an existing baseline of water quality conditions measured over a number of years. Five wells were later added to this sub-network in both Nassau and Suffolk bringing the total number of wells to be sampled to 37. This program is designed to test for the presence of these compounds under a variety of land usages and potentially provide an early warning to some water providers.

A second program is funded by the NYSDEC and administered jointly by the USGS and the NCDPW. The program is under development and will utilize existing wells in the Nassau County groundwater monitoring network. The program will sample a minimum of 50 monitoring wells across Nassau County and will sample for a wide variety of contaminants (including CECs) at various locations and depths.

NCDPW also has an ongoing cooperative hydrologic monitoring program with the USGS whereby the county funds routine water level, streamflow and saltwater intrusion monitoring at outpost wells on the north and south shores of Nassau County.

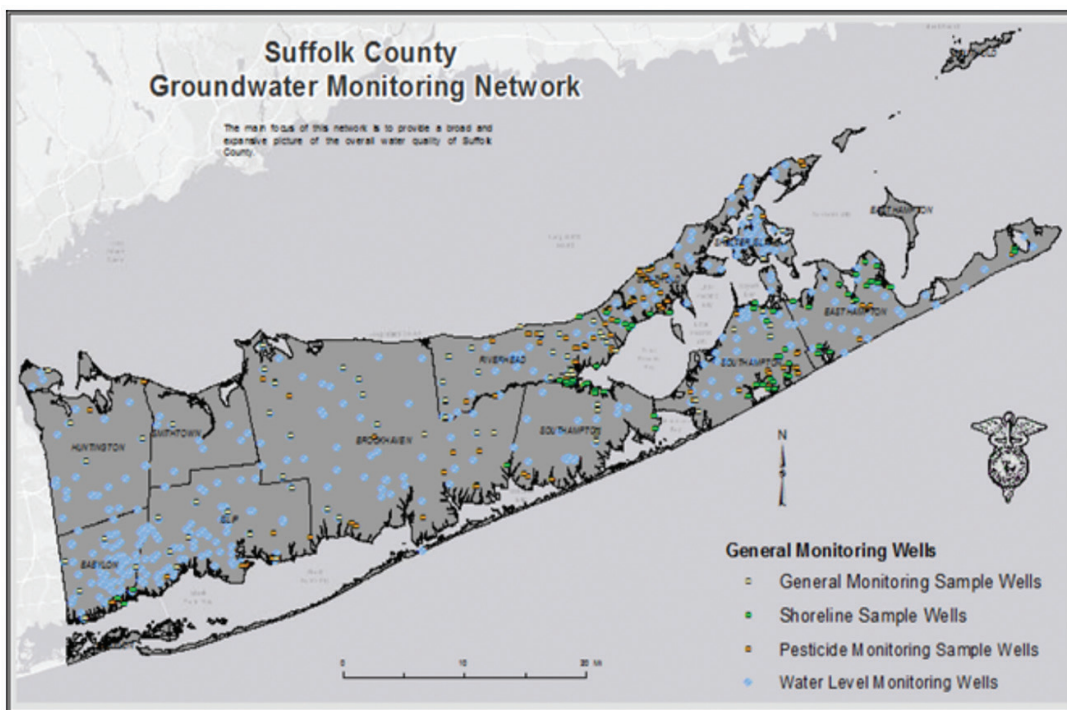
Another active monitoring program is the ongoing NYSDEC - Nassau County Pesticide Monitoring program, which also utilizes the existing Nassau County monitoring well network. It is a cooperative program funded by the NYSDEC involving NCDH and the NCDPW. The program was initiated in 2014 and has been sampling for pesticides, VOCs, SVOCs and CECs in groundwater collected from a wide range of locations. A total of 331 wells have been sampled as of 2018 as part of this program, as indicated below:

Year	Number of wells sampled
2014	95
2015	100
2017	68
2018	68

All of these programs test for the presence of CECs and update groundwater conditions in each of the aquifers beneath Nassau County. However, it should be noted that these samples are being collected from groundwater monitoring wells and represent untreated groundwater and not water collected from public supply wells, which supply water for public consumption.

Suffolk County

Suffolk County established a groundwater surveillance and investigative groundwater program in the 1970s, when a monitoring network was established within the county. As part of this effort, Suffolk County developed its own well drilling and investigatory capabilities and continues to develop and maintain a groundwater monitoring network on an ongoing basis. Wells have been installed in each of the three major aquifers including exploratory wells to bedrock at several locations throughout Suffolk County. This effort was performed in cooperation with the United States Geological Survey (USGS) and still continues today. In total, more than 1000 wells exist within the monitoring network, including water table elevation wells and wells used to collect water quality samples at some frequency. A map of the current monitoring network together with a description of the approximate locations and types of monitoring wells are provided below.



Groundwater investigations and studies are conducted by the Bureau of Groundwater Investigations (Bureau) unit within the Suffolk County Department of Health Services (SCDHS) Office of Water Resources to help assess potential impacts to groundwater quality from a variety of contaminants and sources. Bureau staff collect water level measurements in hundreds of wells to help determine groundwater flow directions. Additional monitoring wells that help to determine the extent and magnitude of groundwater contamination and to delineate contaminant plumes are installed with auger drilling equipment for wells up to 300 feet deep, while shallow plumes are investigated using a Geoprobe. Geophysical conditions are also determined by using gamma and induction logs of the boreholes.

In 1996, the New York State Pesticide Reporting Law was established to monitor pesticide use throughout the state on a regular basis for the purpose of assessing potential impacts to water quality and to assist with the regulation of various pesticides. On Long Island, this study is conducted by the SCDHS Office of Water Resources. A key part of the program has been the establishment of a countywide monitoring well network



consisting of more than 200 wells to monitor pesticide and nitrogen use associated with various land uses. Sample results from the pesticide monitoring network have identified more than 100 pesticide-related compounds in our groundwater since 1997, with agricultural areas being the most heavily impacted. Additionally, these efforts have helped to facilitate the withdrawal of several pesticides on Long Island, including aldicarb, carbofuran, oxamyl, dacthal, dichloropropane, metolochlor and alachlor. These results have provided and continue to provide invaluable data for several management and regulatory programs, including the Comprehensive Water Resource Management Plan and the New York State Department of Environmental Conservation (NYSDEC) Long Island Pesticide Use Management Plan. Since 1997, the NYSDEC has provided approximately \$250,000 annually to the SCDHS to conduct this work. As part of this effort, the SCDHS provides the NYSDEC with an annual report of its findings and analytical results.

The Bureau also performs groundwater investigations at county-owned brownfield sites to help determine the extent of cleanup required. This helps to facilitate the reuse of abandoned commercial and industrial properties.

Over the years, hundreds of specific groundwater investigations have been conducted in response to findings of significant contamination in potable supply wells and at monitoring wells and to help delineate the extent of groundwater contamination. This work has also assisted with identifying potential sources of groundwater contamination. For example, since 2002, over 80 vertical profile wells have been installed in the hamlet of Speonk for an investigation involving contamination found in private wells from volatile organic compounds (VOCs). An extensive plume was delineated and data from the profile wells provided the basis for a Superfund application that resulted in public water being supplied to the affected homeowners. Similar investigations are underway in Hauppauge, Lindenhurst, Calverton and East Hampton. In 2016, the Bureau conducted an extensive groundwater investigation at the Suffolk County Firematics Training facility with the installation of eight wells. Subsequently, an additional 26 off-site wells were installed to help assess the extent and magnitude of groundwater contamination from perfluorinated compounds, specifically PFOS and PFOA, which are found in among other products, firefighting foams. As a result of this work, the firematics facility was listed as a Superfund site by the NYSDEC. Additionally, impacted private wells located within and downgradient of the site were connected to public water. Since 2016, similar groundwater investigations involving perfluorinated compounds were conducted by the Bureau at six other sites within Suffolk County.

Groundwater Investigations were also conducted to investigate illegal dumping in 2014 at various locations, including Roberto Clemente Park in Brentwood, Brook Avenue in Babylon and Veterans Way in Hauppauge. In 2015, the Suffolk County Legislature directed the SCDHS to install and sample monitoring wells in the vicinity of the Sand Land property located on Middle Line Highway in Bridgehampton to assess potential impacts to groundwater quality. Ultimately, the Bureau conducted a comprehensive groundwater investigation which included the installation of approximately 20 on and off-site monitoring wells, and the collection of over 80 groundwater samples. The investigation of various land uses including industrial, agricultural, commercial and residential are an integral part of an ongoing program, along with addressing new contaminants of concern that may threaten public health and the environment.



Long Island Sustainability Project

Saltwater intrusion, decreases in groundwater levels, and an increase in groundwater contamination have led to concerns about the future availability of groundwater on Long Island. Development and use of groundwater on Long Island is constrained by interactions between groundwater and surface water ecosystems and water quality concerns.

As a result, in 2016, Governor Andrew Cuomo announced a partnership between New York State, United States Geological Survey (USGS), Nassau County and Suffolk County to study the effective management of Long Island's groundwater resources. The continued collection, analysis, and management of groundwater data from both existing and newly developed sources is a key component to the success of this project.

This study will evaluate the sustainability of Long Island's groundwater resources. The project contains three main components: Hydrogeologic framework mapping, saltwater interface mapping, and groundwater flow modeling. Each of these components involves significant data collection and analysis efforts.

The hydrogeologic framework component will provide updated information on the physical locations and extents of the subsurface geology of the aquifers, building upon previous USGS work performed in 1990 (Smolensky and others, 1990). As part of this update, a network of new groundwater monitoring wells will be installed at about 25 locations in the Lloyd and Magothy aquifers throughout the island to fill in data gaps within the existing observation network. During the drilling process, geologic core samples will be collected and analyzed to improve the understanding of the subsurface geology. Additionally, borehole geophysical logging techniques will also provide additional information on both the geology and groundwater salinity as part of the saltwater interface mapping component of the investigation.

The saltwater interface mapping component will use borehole geophysical logs in addition to newly developed surface geophysical soundings at selected locations considered most susceptible to saltwater intrusion. These geophysical techniques will help define the extent of freshwater in aquifer system. This effort will build upon earlier studies conducted throughout the Northern Atlantic Coastal Plain aquifer system. (Charles, 2016).

Groundwater models represent the state of knowledge of how groundwater flow systems work, and they provide tools that water resource managers can use to more effectively plan for and anticipate the impacts of aquifer development. Unfortunately, existing models often lack the necessary geologic information to make them fully effective. The new geologic information gained by the drilling of new monitor wells (as described above) will improve the effectiveness of future modeling efforts.



For the groundwater flow modeling portion of the sustainability project, a three-phased approach will be used to simulate groundwater flow conditions throughout Long Island. This will include an initial model based on existing information for current (2005–2015) average conditions, the addition of time-varying stresses to simulate changes in hydrologic conditions from 1900 to 2015 and a final model that incorporates the new interpretation of the hydrogeologic framework and salinity distribution into the model simulations. The final model will be used to simulate various future scenarios, including changes in groundwater withdrawals, aquifer recharge management and climate change. These scenarios will be developed in collaboration with the NYSDEC and the Sustainability Project Steering Committee. (https://www.usgs.gov/centers/ny-water/science/groundwater-sustainability-long-island-aquifer-system?qt-science_center_objects=0#qt-science_center_objects)

Water Level Maps and Hydrogeologic Information for Long Island

Below is a partial list of USGS sources of information regarding water levels and hydrologic conditions for Long Island:

Groundwater Data for Long Island

- Suffolk County Wells – Current Conditions Groundwater Watch Mapper
- Nassau County Wells – Current Conditions Groundwater Watch Mapper
- Queens County Wells – Current Conditions Groundwater Watch Mapper
- Kings County Wells – Current Conditions Groundwater Watch Mapper
- Historical Groundwater Wells – Interactive Maps (Kings) (Queens) (Nassau) (Suffolk)
- Wetlands Monitoring Station at Laurel, NY
- Groundwater Conditions on Long Island, NY in 2016 – Interactive Map Viewer (coming soon)
- Depth to Water on Long Island, New York in 2016 – Interactive Map Viewer (coming soon)
- Groundwater Conditions on Long Island, New York in 2013 – Interactive Map Viewer
- Depth to Water on Long Island, New York in 2013 – Interactive Map Viewer
- State of the Long Island Aquifer System – Information Related to the Island’s Water Supply
- Long Island Hydrogeologic Framework

Surface Water Data for Long Island

- Real Time and Continuous Recording Streamflow Stations – (Interactive Map)
- Real Time and Continuous Lake Level Gages – (Interactive Map)
- Miscellaneous Streamflow Stations – (Interactive Map)
- Historical Surface Water Stations – (Interactive Map)
- Meteorological Stations – (Interactive Map)
- Wetlands Monitoring Station at Laurel, NY
- Recharge Basin Salinity Monitoring Station at Peconic, NY



PRECIPITATION AND RECHARGE ON LONG ISLAND

Precipitation is the principal means by which water enters Long Island's aquifers. Approximately half of all precipitation recharges the aquifers, which roughly approximates to one million gallons of water per day for each square mile of land. Most recharge occurs during the non-growing season (October to May). From June through September, aquifer recharge is minimal. Very little if any precipitation enters the groundwater system during these warmer months, due to higher evaporation and increased plant activity (transpiration). These two factors are collectively referred to as "evapotranspiration." Therefore, the timing of precipitation events can have an impact on water levels in the aquifer system as much as the overall quantity of precipitation.

Land uses and stormwater management practices can also affect groundwater recharge. In coastal areas, stormwater is typically routed to nearby creeks and streams, and does not recharge the aquifer system. More inland locations utilize regional stormwater recharge basins, and recharge is maximized in these areas. In undeveloped rural areas, groundwater recharge occurs but may be hindered somewhat by the abundance of plant life and natural features which may allow for greater evapotranspiration. Fortunately, the quality of the recharged water in undeveloped rural parts of Long Island is typically excellent.

Water levels within Long Island's aquifers have fluctuated greatly during the past decade, from record highs in many areas in 2010 to near record lows in many areas in 2016 and 2017. Given the importance of precipitation to the aquifer system and water levels within it, weather and climate data from the past ten years were examined. In particular, annual total precipitation was evaluated for the years 2009 to 2018. In addition, snowfall totals were also evaluated as a possible additional factor affecting recharge. As expected, precipitation has fluctuated greatly during this period. The following is an analysis of these precipitation trends.

Long Island and New York City have numerous weather stations that have been collecting temperature and precipitation data for lengthy periods of record. For this report, data from the Islip weather station was utilized. Islip's period of record is sufficiently long, and its data collection is quite accurate and comprehensive, with no significant data gaps. Additionally, its location close to the center of Long Island, serves to average out the influences of the coastal climatic effects more common to southeastern Suffolk and the more mainland or continental climatic effects found in western Nassau and Queens.

For the period from 1981 to 2010, Islip's statistical mean precipitation was as follows: Annual precipitation, 46.24 inches; total annual snowfall, 24.8 inches. The following table summarizes precipitation for calendar year 2018 along with departures from normal (with negative departures shown in red).

Year	Total Precip.	Depart. From Mean	Total Snowfall	Depart. from Mean
2009	52.7	6.46	51.1	26.3
2010	43.07	-3.17	43.4	18.6
2011	52.34	6.1	40.7	15.9
2012	44.73	-1.51	9.2	-15.6
2013	39.22	-7.02	50.5	25.7
2014	57.17	10.93	55.7	30.9
2015	38.60	-7.64	63.3	38.5
2016	34.99	-11.25	44.6	19.8
2017	43.44	-2.8	42.1	17.3
2018	64.17	17.93	64.2	39.4
Average '09-'18	47.04	0.80	46.5	21.7

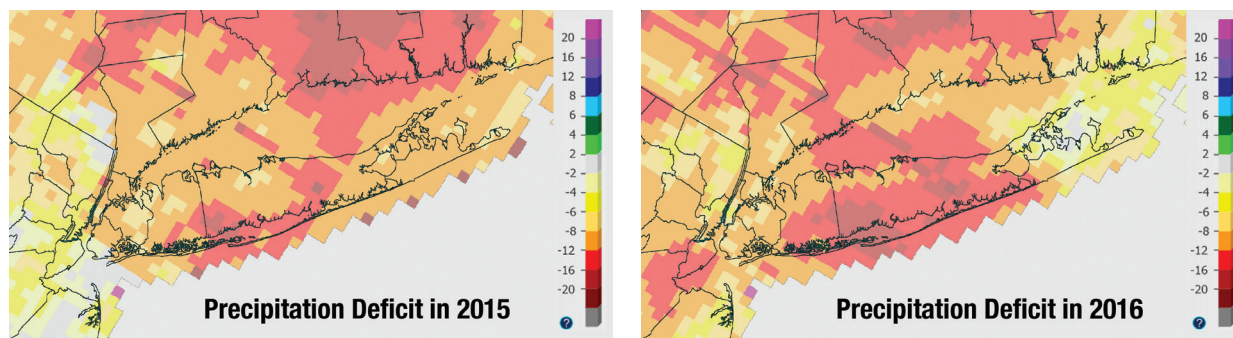
As anticipated, water levels in the aquifers have fluctuated largely in accordance with fluctuations in total precipitation. The winter of 2009-2010 was particularly wet, with more than eight inches of precipitation in December of 2009 and more than nine inches in March of 2010. The record high water levels observed in many wells in early 2010 are a direct result of this high precipitation.

April of 2010 began a lengthy dry period which lasted for several years, with some interruptions. Even though 2011 had above normal precipitation for the year, much of this is attributable to a single storm event. More than six inches of rain fell in one day in August of 2011, skewing the statistics for that year. November and December of 2011 were drier than normal, as were calendar years 2012 and 2013. Similar to 2011, 2014 was an anomalous year for rainfall statistics. Annual totals were almost 11 inches above normal. However, more than 13 inches of rain fell in one day in August of 2014. A drier than normal period continued for the next three years, as 2015 through 2017 saw a cumulative departure from normal of almost 22 inches during that time, roughly equivalent to six months of precipitation. Furthermore, if the two above-mentioned one day rainfall events are subtracted from the total, Long Island would have experienced eight consecutive years of below normal precipitation.

In addition to this dry period affecting all of Long Island, there has been significant spatial variation in rainfall as well. The red shaded areas shown in the figures below indicate where precipitation was particularly deficient in 2015 and 2016, undoubtedly exacerbating the situation.

This trend has been reversed in 2018, which was a very wet year, with more than 64 inches of total precipitation (more than 35% above normal). As a result, water levels and stream flows in many areas have recovered from their historic low levels, though some are still below long term average levels.

Snowfall data for Islip were also examined to see if it had any affects on aquifer conditions. Snowfall amounts for the 2009 to 2018 period were well above normal levels. Only one year, 2012, saw snowfall below normal (by more than 15 inches). Islip's annual snowfall for the period averaged over 46 inches, almost double the 1981 to 2010 normal of 24.8 inches. The data appears to show that this snowfall had minimal impact on aquifer levels. Some of the heaviest snowfall years correlated with lower than normal overall precipitation, and resulting lower water levels. Increasing snowfall amounts may have significant water quality impacts to the upper glacial aquifer—particularly rising chloride levels due to additional road salting that may occur during snow events. However, snowfall, though perhaps interesting from a future climate change perspective, does not appear to influence overall hydrologic conditions.



STREAMFLOW ON LONG ISLAND

Long Island's streams are in direct hydraulic contact with the upper glacial aquifer. Under natural (undeveloped) conditions, 95 percent of the total stream discharge originates as ground water seepage (Franke and McClymonds, 1972); the remaining five percent consists of direct runoff. Accordingly, the flows of Long Island's streams closely reflect changes in the water table altitude. Discharge data has been collected almost continuously since the early 1930s at most of Nassau County's major streams, and since the early 1940s at most of Suffolk County's major streams. Stream discharge in western Long Island, (Valley Stream, East Meadow Brook, and Massapequa Creek), has never returned to pre-1960s drought levels due to widespread use of sanitary and storm sewer systems in Nassau and western Suffolk Counties that discharge to tidal waters, thus permanently lowering the water table in those sewered areas. Stream discharge in central and eastern Long Island has returned to near or slightly above normal conditions after the 1960s drought. The USGS drought monitoring network consists of eight streams that are representative of the range of conditions found throughout Long Island. A map of their locations is shown to the right.

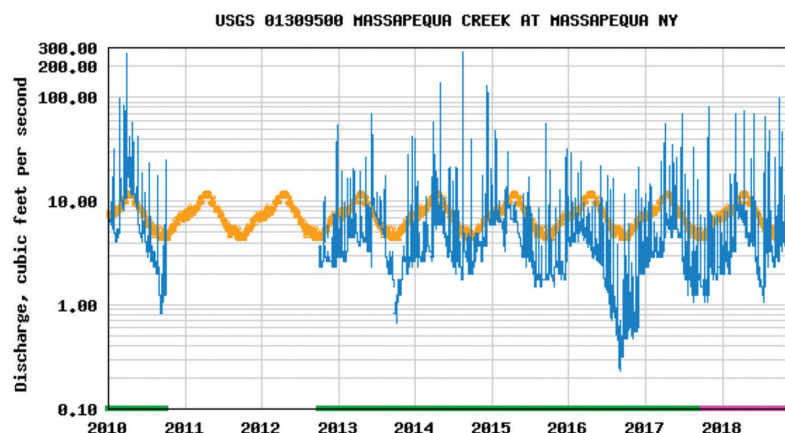


The following section describes streamflow data from selected sites within the USGS network for the period of 2010 to 2018. The statistics for each graph are described for a specific date in late October and compared with the entire period of record for that particular station on that date. Nassau County streamflow reflects the significant human effects of sewerage and groundwater pumping on water levels within the Upper Glacial aquifer. As mentioned above, stream discharges have decreased markedly since the 1960s, and have not recovered due to these effects. Shown in this section are hydrographs of more recent (2010 to 2018) conditions. The orange trend line indicates the long term average values. Note that there is a significant gap in data collection for Nassau streams from 2011 to 2013.

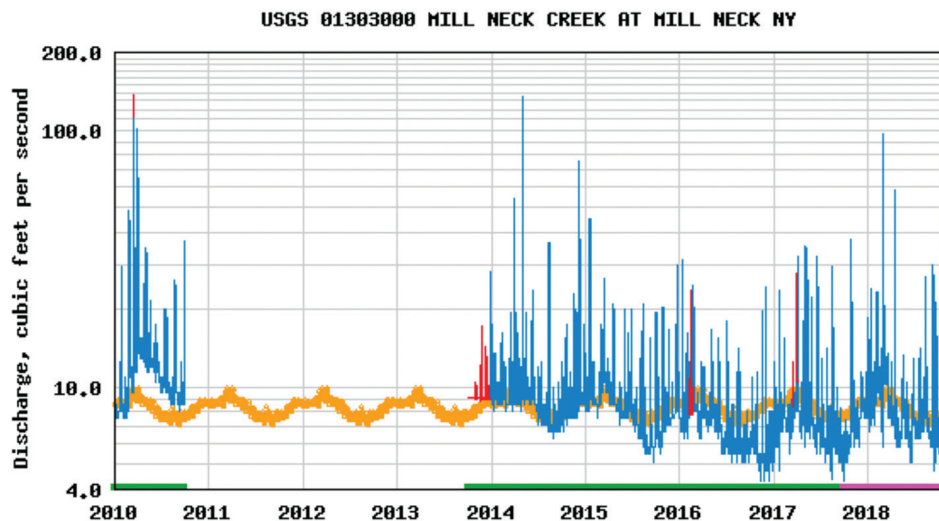
Massapequa Creek – Massapequa. Discharge is currently in the low end of the normal range with some recovery continuing from the record lows of 2017.

Statistical Data

Date: October 29, 2018
 Discharge: 4.05 cubic ft. per second (cfs)
 Avg. for date: 6.5 cfs
 Max. for date: 20.4 cfs (1954)
 Min. for date: 0.51 cfs (2017)



Mill Neck Creek – Mill Neck. Discharge from this stream declined significantly in 2017 and 2018. Discharge is currently still below normal. The statistical discharge data for late October of 2018 were unavailable.

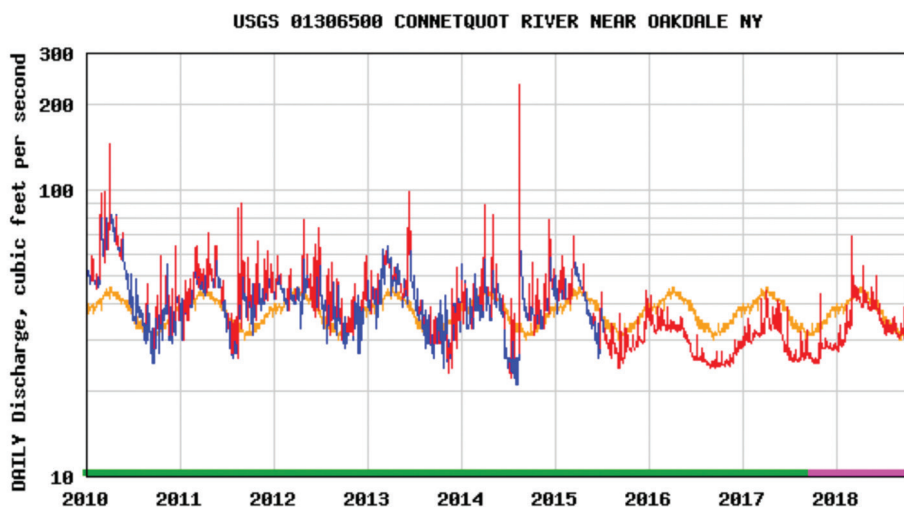


In Suffolk, streams show the full spectrum of human impacts, from quite high in southwestern Suffolk to minimal in central and eastern Suffolk. Additionally, there was a significant rainfall deficiency in east-central Suffolk in 2016 and 2017. Flows in streams in those areas were affected to a greater extent than the rest of Long Island.

Connetquot River - Oakdale. This stream is significant in that it is situated on the border of areas showing significant human impacts (to its west) and minimal human impacts (to its east). Flow had been below normal for more than two years between 2015 and early 2018. Currently, discharges are in the normal range with recovery from recent lows continuing.

Statistical Data

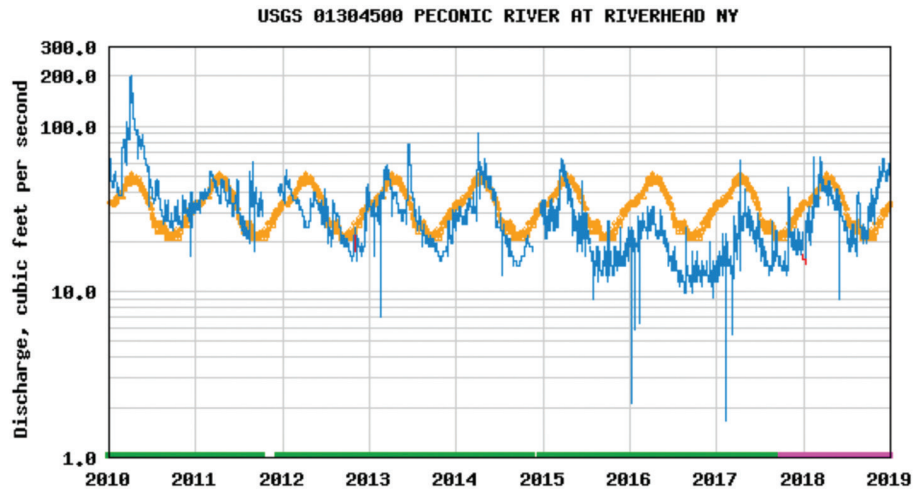
Date: October 28, 2018
 Discharge: approx. 33 cfs
 Avg. for date: 36 cfs
 Max. for date: 86 cfs (2007)
 Min. for date: 23 cfs (1989)



Peconic River – Riverhead. This stream is located in an area that demonstrates minimal human influences. Flow for this stream in eastern Suffolk reflected the two-year low in rainfall that occurred in this portion of east-central Suffolk in 2016 and 2017. After a long period of below normal flow, discharges are currently above normal and increasing in response to high 2018 precipitation.

Statistical Data

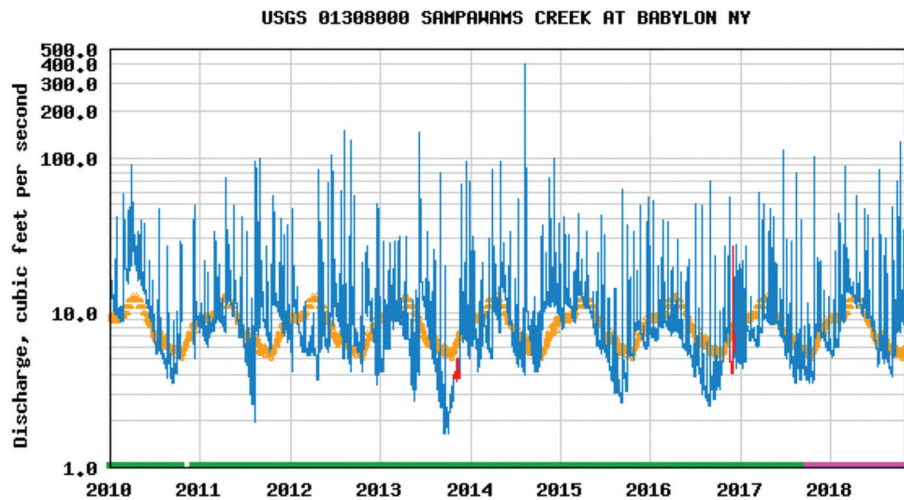
Date: October 29, 2018
 Discharge: approx. 38.3 cfs
 Avg. for date: 28 cfs
 Max. for date: 86.9 cfs (1959)
 Min. for date: 8.6 cfs (1987)



Sampawams Creek – Babylon. This stream is situated within the Southwest Sewer District area, and would be expected to reflect the effects of sewerage within its watershed. Discharges were low during the summers of 2015 to 2017. Recovery from this dry period is occurring, and discharges are currently above long term averages.

Statistical Data

Date: October 30, 2018
 Discharge: 10.7 cfs
 Avg. for date: 7.6 cfs
 Max. for date: 27.6 cfs (2012)
 Min. for date: 2.01 cfs (2002)

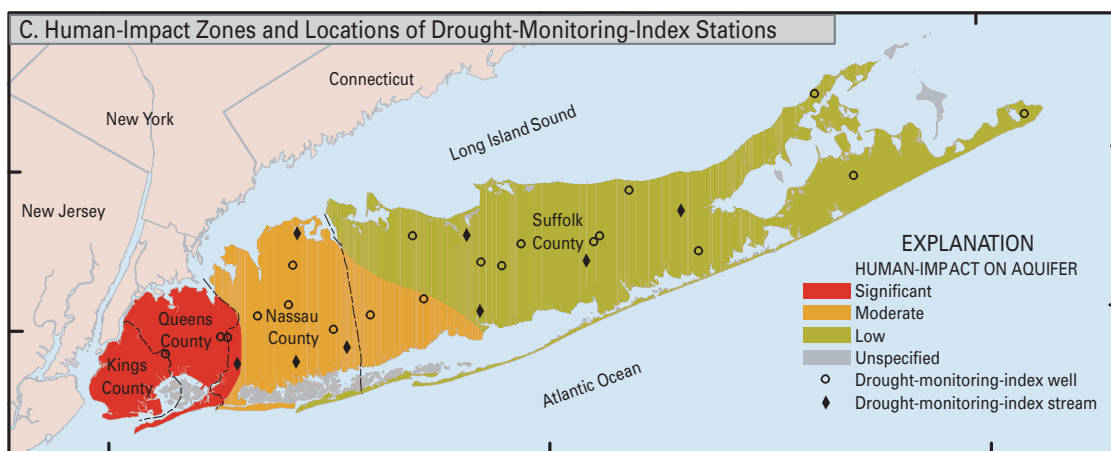


GROUNDWATER LEVELS ON LONG ISLAND

Historically on Long Island, human activities have had a significant effect on groundwater levels. Population densities on Long Island range from less than 10 people per acre to more than 180 people per acre (in parts of Queens and Brooklyn). Groundwater levels are strongly influenced by the associated differences in groundwater pumpage, sewerage practices and stormwater management. Generally speaking, groundwater levels have been drawn down in areas of higher density but relatively unchanged in areas of lower density.

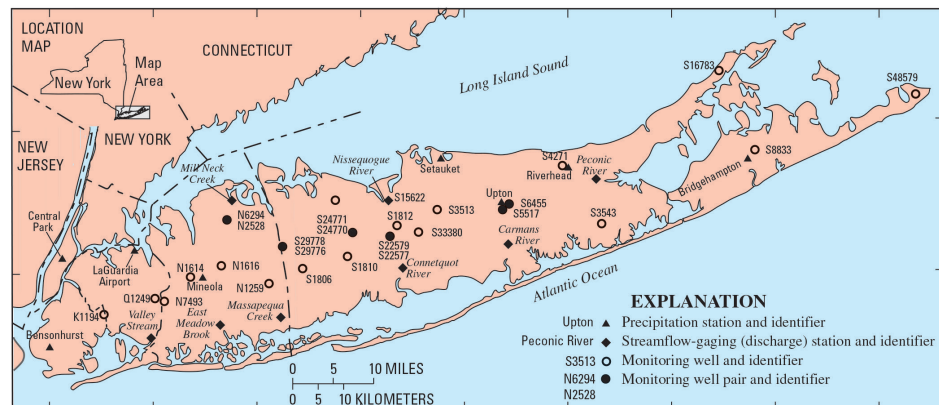
The first large-scale groundwater pumping began in Brooklyn during the late 19th century. By the early 1940s, pumpage had increased sharply, and by 1947, saltwater intrusion necessitated the shutdown of all public supply wells in the Flatbush area, which caused a water level rise of up to 19 feet (Luszczynski, 1952). In the ensuing decades, pumpage in Queens and Nassau Counties continued to increase in response to increasing urbanization. This eventually led to saltwater intrusion in southern Queens. By 1974, most public supply wells in western Queens were shut down, causing a water level rise of more than 10 feet. By the late 1980s, new concerns about saltwater intrusion and groundwater contamination caused the Jamaica Water Supply Company to sharply decrease pumpage in central and eastern Queens. In response, groundwater levels rose more than 20 feet in these areas.

In the early 1900s, most homes on Long Island utilized private septic waste systems that returned wastewater directly to the water table aquifer. While this practice preserves water quantity, the contamination that resulted eventually led to the installation of extensive sanitary sewer systems in the heavily populated parts of western Long Island. Regional sewer systems were installed in Brooklyn and Queens in the early and mid-1900s, in southwestern Nassau by the early 1960s, and southeastern Nassau and southwestern Suffolk County by the mid-1980s. All of these sewer systems reduced the contamination of the upper glacial aquifer by discharging wastewater offshore, but also resulted in major declines in groundwater levels. By the mid-1970s water levels in Nassau had reached a new equilibrium at about nine feet below pre-sewer conditions (Franke, 1968; Garber and Sulam, 1976; Sulam, 1979). This lowering of groundwater levels also decreased the base flow of nearby streams. Base flow of East Meadow Brook decreased by about 45 percent from 1965 to 1974, 75 percent of which was attributed to the effects of sanitary sewers. The figure below illustrates the affects of human activities on hydrologic conditions throughout Long Island.



<https://pubs.usgs.gov/sir/2004/5152/sir20045152.pdf>

Groundwater levels on most of Long Island are generally highest in March, April, and May and lowest in September, October, and November. This is due to seasonal variations in natural recharge and seasonal pumping patterns. In an effort to better understand natural vs. human affects on water levels, the United States Geological Survey (USGS) has incorporated a network of monitoring points as part of its drought monitoring network. Data from the eight precipitation monitoring stations, eight stream discharge stations, 15 upper glacial aquifer monitoring wells, and five Magothy monitoring wells were selected as drought monitoring sites and reflect the wide variation in hydrologic conditions across Long Island. A map showing the locations of these sites is shown at right.

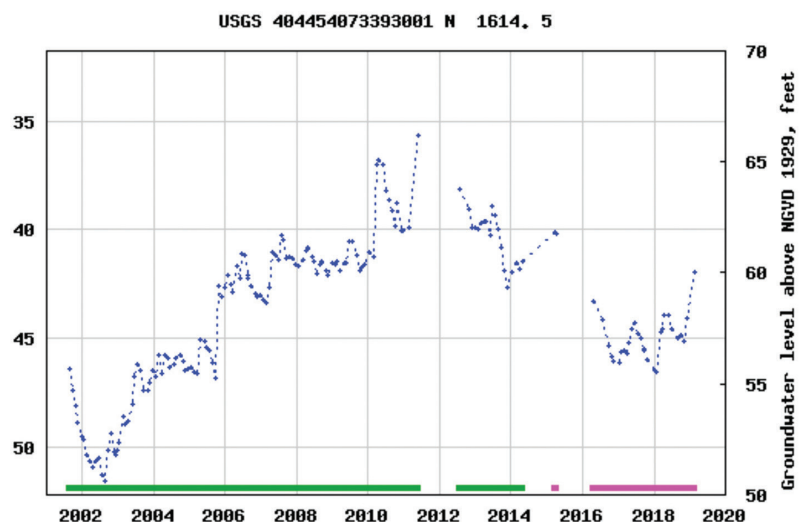


<https://pubs.usgs.gov/sir/2004/5152/sir20045152.pdf>

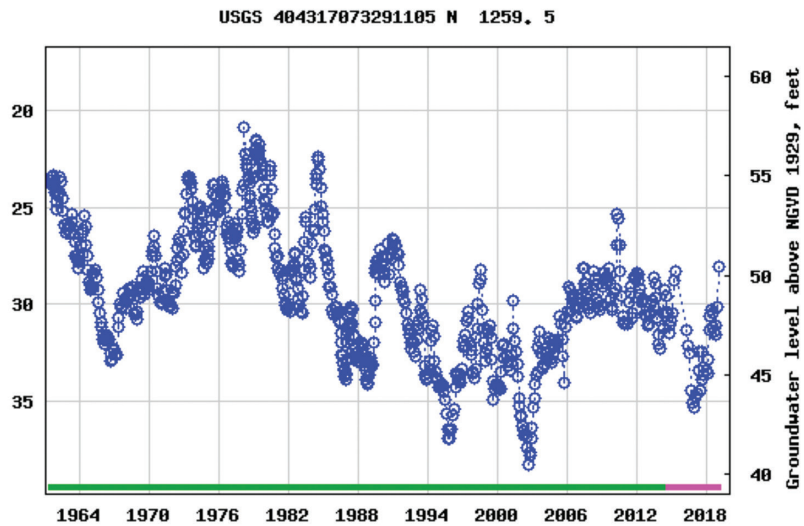
During the past decade, parts of Long Island have seen some very large fluctuations in aquifer water levels over a relatively short period of time. For example, in 2010, many parts of Suffolk County were experiencing historically high water levels, following several years of high precipitation. By 2017, many of these same areas were experiencing record low water levels. In the ensuing 18 months, most have recovered significantly from these record lows, though many are still below historical normal levels. Further analyses from selected wells within USGS drought monitoring network follows.

Nassau County Wells - Upper Glacial Aquifer. Virtually all of Nassau's upper glacial aquifer wells show impacts of human activities, as described above. The following are two specific examples taken from the USGS Drought Monitoring Network.

N 1614. 5. This well is located in western Nassau, is 75 feet deep, and has been collecting data since mid-2001. Water levels are affected by pumping and sewerage and are therefore prone to large fluctuations. The highest water level on record for this well was 66.31 feet above mean sea level (+66.31 msl) in June of 2011, and its lowest recorded water level was +50.43 msl in August of 2002. This fluctuation of almost 16 feet in nine years illustrates the effects of human activities in the area. According to USGS historical data (not shown here), water levels in this well are currently slightly below historical median values, with recovery continuing. Shown at right is a hydrograph for this well.

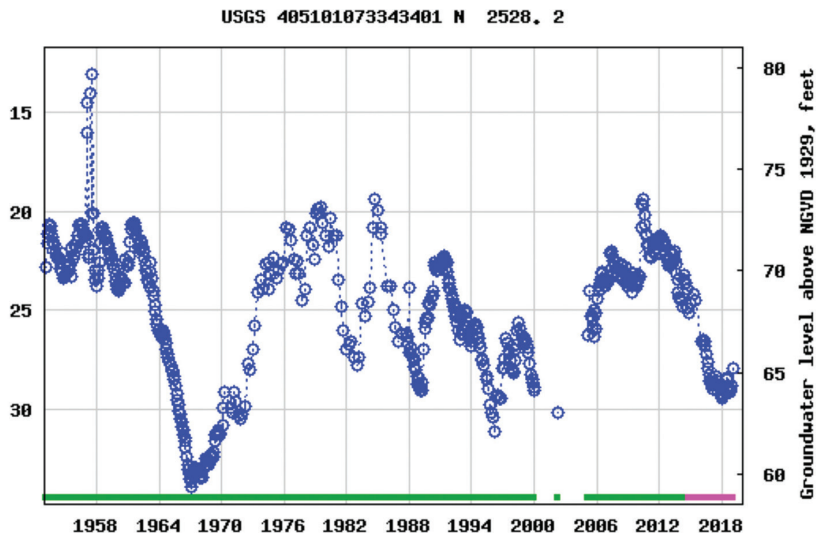


N 1259. 5. This well is located in eastern Nassau and is 41 feet deep. Data has been collected at this site continuously since 1961. Its highest water level was +57.6 feet msl in early 1978. Its lowest was +40.29 msl in August of 2002. Its hydrograph (right) shows the affects of the mid-1960s drought, as well as declines in subsequent years due to regional sewerage in the area. According to USGS historical data (not shown here), water levels are currently slightly below historical median values with recovery continuing.



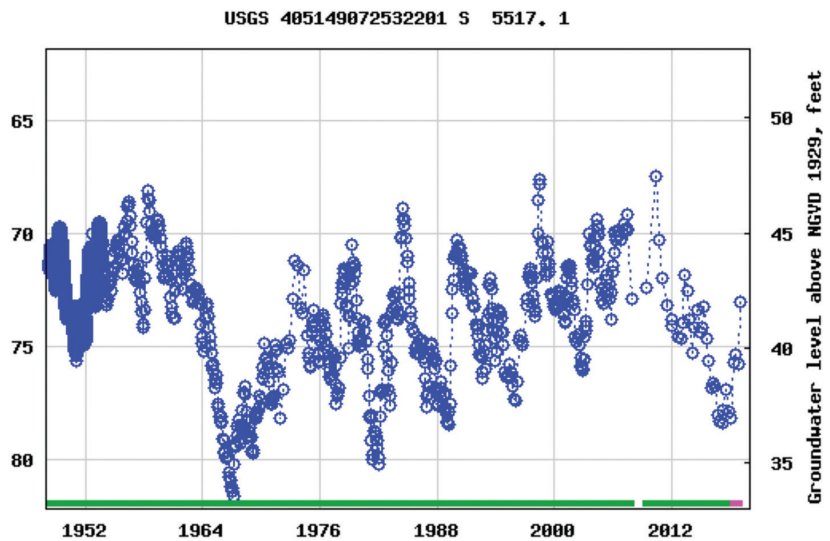
Nassau County Wells – Magothy Aquifer. Most wells screened in the Magothy aquifer in Nassau County also experience water level fluctuations that reflect the influence of human factors. The following is an example from the drought monitoring network.

N 2528. 2. This Magothy monitor well is 328 feet deep, and data has been collected from it since 1953. Its highest observed water level was in mid-1957 at +79.92 msl. Its lowest water level was +59.12 in early 1967. This 20-foot water level fluctuation within a ten-year period is a strong indication of the influence of regional pumpage. According to USGS historical data (not shown here), water levels in this well are currently below historical median values (see hydrograph at right).

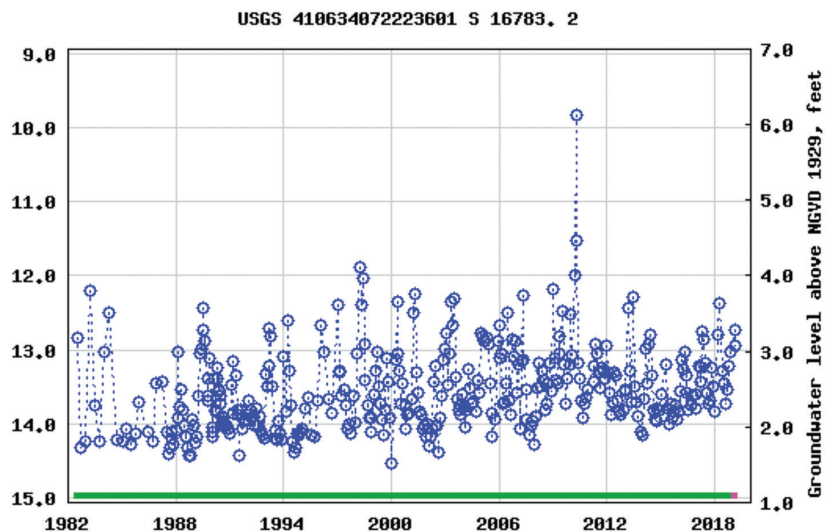


Suffolk County Wells – Upper Glacial Aquifer. Water levels in the upper glacial aquifer vary greatly due to human activity in different geographical locations. In addition, precipitation in east-central Suffolk was quite a bit lower than the rest of Long Island during 2016 and 2017, resulting in near record low water levels in some upper glacial wells. The following is a summary of selected upper glacial wells from the drought monitoring network in Suffolk.

S 5517. 1. This well is located near Brookhaven National Laboratory. It is 91 feet deep and has been in use since 1948. Its record high water level is +47.53 msl (2010) and its lowest was +33.34 msl (1967). The hydrograph (right) shows this well's range of conditions during this lengthy period of record, including the record low recorded during Long Island's mid-1960s drought. According to USGS historical data (not shown here), water levels are currently below historical median values with recovery continuing.

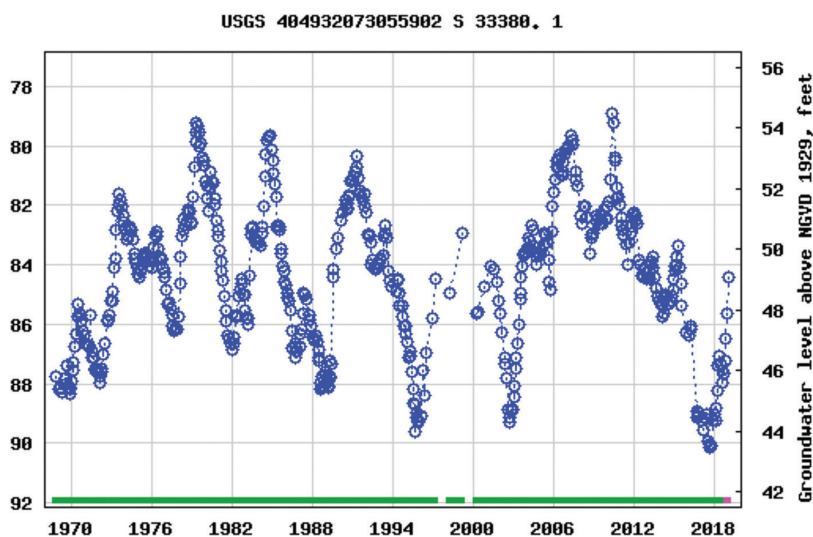


S 16783. 2. This well is located in Greenport, on the North Fork of eastern Suffolk County. It is 28 feet deep and has been in use since 1982. Its all-time record low water level was +1.47 ft. msl in late 1999, and its record high was +6.18 ft. msl in 2010. The North and South Forks of eastern Long Island have their own groundwater flow system separate from that of the main body of Long Island. Groundwater on the East End is contained within several isolated “bubbles” of fresh water which essentially “float” atop salty groundwater below. Even though the maximum fluctuation in water levels within this well is less than five feet, this represents significant changes in the groundwater flow system for this portion of the North Fork. According to USGS historical data (not shown here), current water levels in this well are significantly higher than historical median values, as shown in the hydrograph (right).



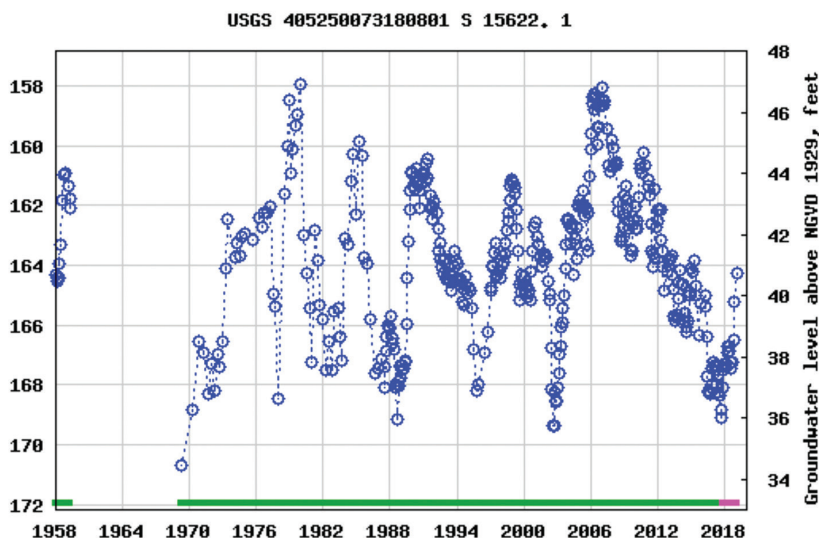
Suffolk County – Magothy Aquifer. Water levels in the Magothy aquifer in Suffolk reflect great differences in the degree to which they are influenced by human activity. The Magothy water levels in southwestern Suffolk are heavily impacted by sewerage (in both Suffolk and Nassau Counties) and by groundwater pumpage. Magothy water levels in eastern Suffolk are much less affected by these factors. Additionally, deeper Magothy monitor wells are generally less influenced by pumpage, since there are still many large capacity wells that utilize the upper glacial and shallow Magothy aquifers. Even so, 10 to 12 foot cyclical fluctuations in water levels are common in the Magothy aquifer. The following is an analysis of trends from two of Suffolk’s Magothy monitor wells: One deep Magothy well in central Suffolk, and one middle Magothy well in western Suffolk.

S 33380. 1. This well is located in Ronkonkoma in central Suffolk County. It is 855 feet deep and monitors water levels in the deepest portions of the Magothy aquifer, which are largely unaffected by human activities. The well has been in use since 1968. Its highest recorded water level was +54.6 ft. msl (2010) and its lowest recorded level was +43.36 ft. msl (2017). Its hydrograph (right) shows that water levels are currently recovering from its 2017 record low, but are below long term average.



S 15622. 1. This 455-foot deep middle Magothy well is located in East Northport, and has been in use since 1958. This area is largely unsewered, but significant public water supply pumpage occurs in this area. Its record low water level is +34.33 ft. msl (1969) and its record high level is +47.09 ft. msl (1980).

The hydrograph to the right shows that current water levels are well below historical median values with recovery continuing.



The hydrographs presented in this section illustrate how aquifer levels respond to fluctuating precipitation on Long Island, as happened during the past nine years. The years 2010 and 2018 saw well above normal precipitation, while the intervening years saw mostly below normal precipitation. Water levels in the aquifers, as well as stream flows, have fluctuated in response. Currently, aquifer levels and streamflows are increasing from their record to near record lows of 2016 and 2017, though many areas are still below long term average levels. Some future climate change predictions indicate that rainfall patterns may continue to fluctuate. This will undoubtedly result in continued fluctuations in aquifer levels and streamflows.



EMERGING CONTAMINANTS

Emerging contaminants (also known as contaminants of emerging concern, or CECs) are a class of chemicals that are used and encountered in everyday life, but when present in ground and surface water represent a potential concern to environmental or human health. Pharmaceuticals and personal care products (PPCPs) and endocrine disrupting compounds (EDCs) are among the prime examples of emerging contaminants. Personal care products—such as soaps, cosmetics, and fragrances—also find their way into our water. Endocrine disruptors are substances that may interfere with the function of hormones in the body. Trace amounts of these contaminants are being discovered in water throughout the country. The U.S. Environmental Protection Agency (USEPA) is working to improve its understanding of several emerging contaminants, including perchlorate, PPCPs and EDCs.

CECs and PPCPs are increasingly being detected in ground and surface waters at trace levels. In many cases, the risk to human health is not yet fully known, while they are known to represent an environmental threat to aquatic life. (<https://blogs.scientificamerican.com/guest-blog/emerging-contaminants-taint-drinking-water-supply/>). In the case of PPCPs on Long Island, detection is often at levels 1/1000 or less than the amount known to have any health impact on humans (known as the “minimum therapeutic dose”). Technology has only recently been able to detect such minute quantities.

PPCPs and EDCs include thousands of compounds and associated metabolites. Examples include prescription and over the counter drugs, veterinary drugs, fragrances, lotions, cosmetics, detergents, plasticizers, pesticides and flame retardants. The presence of PPCPs and EDCs in water supplies has been known for many years. Many of the original concerns were associated with reports of physiological abnormalities affecting fish and other aquatic organisms in areas near or surrounding discharge sites of wastewater treatment facilities. Over time the concerns associated with wastewater effluent have expanded into the drinking water arena.

There are a number of routes by which PPCPs and EDCs can find their way into surface water and groundwater supplies. Elimination from the body, flushing or improper disposal in landfills of unused or expired drugs, or in the case of personal care products, rinsing down the drain while showering or doing laundry are common pathways to the environment. In the case of agricultural products or veterinary drugs, runoff offers another pathway to surface water or groundwater reserves. The occurrence of PPCPs and EDCs in both surface water and groundwater sources is global in nature. The number of compounds being detected in these waters continues to grow as advancements in analytical equipment and techniques drive quantifiable reporting levels to lower and lower concentrations. (https://www.wqa.org/Portals/0/Technical/Technical%20Fact%20Sheets/2014_Ps-PCPs-EDCs.pdf).

Unlike many other contaminants found in groundwater, pharmaceuticals serve an important purpose in maintaining human health. The question is whether these chemicals will have unintended consequences if detected at significant levels in groundwater and consumed in drinking water by the general public. A number of different approaches have been taken to evaluate the risks associated with PPCPs/EDCs detected in drinking water. Generally, this has involved the calculation of an acceptable daily intake (ADI) or tolerable daily intake (TDI). Calculating the ADI or TDI requires that the minimum therapeutic dose (MTD) be known, with an uncertainty factor applied. Depending upon the chemical, the uncertainty factor could range 1000 to 10,000 in order to provide a safety buffer considered to be sufficiently conservative per USEPA guidelines. From that a drinking water effect level (DWEL) can be calculated. Comparing the DWEL against available occurrence data for a given chemical allows for the calculation of the margin of safety. See the table on the following page for examples of the margin of safety calculated for select PPCP/EDC chemicals based upon the corresponding DWEL value. The table below illustrates the drinking water effect levels for several common PPCPs and EDCs. Concentrations are often referenced in parts per trillion (ng/L).

The detection level for pharmaceuticals and personal care products is typically 50 ng/L (50 parts per trillion). A typical dose of medication is five to 50 milligrams (mg). That is a factor of 100,000 to 1,000,000 times greater than the detection level. Therefore, a person would have to consume approximately 100,000 liters of water in order to inject a dose of medication at the levels typically found in groundwater. If a person drank two liters of such water per day, it would take 137 years (50,000 days) to consume one equivalent dose.

Chemical	Type (EDC/PPCP)	Finished Water Concentration	Safety Level (DWEL)
Meprobamate	Anti-anxiety	3.8 – 42 ng/L	6000
Phenytoin	Anti-convulsant	2.3 ng/L	210
Atenolol	Beta blocker	1.2 – 18 ng/L	2700
Carbamazepine	Anti-seizure	6.3 ng/L	670
Naproxen	Analgesic	0.52 ug/L	40,000,000
Bisphenol A	Plasticizer	25 ng/L	72,000
Linuron	Herbicide	6 – 6.2 ng/L	8400
Nonyl Phenol	Surfactant	100 ng/L	16,000

PPCPs/EDCs are subject to a variety of potential treatment technologies in both waste water treatment and drinking water treatment processes. Conventional wastewater treatment technologies can be effective in reducing some compounds. However, advanced wastewater treatment processes, including ozonation, UV irradiation, photolysis, reverse osmosis, peroxidation (peroxide and UV), and ultrasound can generally achieve higher reduction percentages than conventional treatment. While there are a wide range of drinking water treatment processes in use, none have been specifically designed for the reduction of PPCPs/EDCs. The effectiveness of the current processes used in drinking water treatment are largely dependent upon the properties of the PPCP/EDC material. For example, activated carbon (both powdered and granular) has demonstrated effectiveness in reducing a number of PPCPs/EDCs, with effectiveness related to both chemical adsorption as well as biodegradation. Carbon type, loading and contact time are critical factors. Reverse osmosis has also demonstrated effectiveness. Chlorination, ozonation, and peroxidation are also effective in the oxidation of many PPCPs/EDCs. The effectiveness of oxidizing agents is highly dependent upon pH and dose.

Monitoring data is essential to better characterize occurrence levels and frequency of PPCPs and EDCs in surface waters, finished drinking water, and drinking water in distribution. Such data will help fill in existing knowledge gaps and allow for better risk characterization. The USEPA has included 12 PPCP/EDC materials in the Chemical Contaminant List 3 (CCL3). Inclusion on the CCL3 is an indication that these compounds need further evaluation in terms of both occurrence and safety. It is through this review that the decision is made as to whether any given contaminant should be regulated under the Safe Drinking Water Act with an established maximum contaminant level assigned.

These compounds have been present in drinking water at some level since the inception of the use of pharmaceuticals. The increase in the amount of drugs being used, coupled with the increased analytical capabilities and the ability to measure lower and lower concentrations of these chemicals is in large part the reason why this issue has been driven forward. The data collected to date does not indicate that the trace levels of PPCPs/EDCs in finished drinking water supplies pose an unacceptable risk in terms of health effects. However, there remain extensive data gaps in terms of occurrence levels, pervasiveness, and synergism/interaction between chemicals that require additional investigations.

The extensive monitoring well networks mentioned in the previous section of this report have been instrumental in aiding the study of CECs throughout Long Island. Some public supply wells have had detections of CECs, but many are present in shallow groundwater, and may not be present in deeper public supply wells. The monitoring well networks provide additional sampling points and provide data for shallow groundwater that might not be available if only public supply wells were sampled. Data for shallow groundwater are especially important in areas not served by public water, and can serve as an early warning for potential environmental impacts to wetland ecosystems.



Most supply wells that have had CEC contaminant issues have been outfitted with a granular activated carbon (GAC) filter or air stripper. Some are located in populated areas that have a range of wastewater disposal methods, from block cesspools to decentralized onsite wastewater treatment systems (aka "package systems"), which typically discharge to groundwater. Contaminants associated with wastewater disposal systems can eventually be pulled into supply well capture zones through natural groundwater flow patterns, pumpage, and other factors. Through monitoring, some water suppliers have noticed variability in detection frequency and concentration of pharmaceuticals between raw and finished well water samples. More information is needed to determine the removal ability of conventional treatment (such as GAC) for PPCPs. The following section describes current and past studies of the effects of CECs in ground and surface waters in the Long Island area.

United States Geological Survey Studies. One recent USGS study, entitled "The Impact of Onsite Wastewater Disposal Systems on Groundwater in Areas Inundated by Hurricane Sandy in New York and New Jersey", compared shallow groundwater quality (nutrients, pharmaceuticals, and hormones) downgradient of on-site wastewater disposal systems (OWDS) before and after Hurricane Sandy. It established a baseline for wastewater influence in coastal communities inundated by the storm. Nutrients and CECs (including numerous prescription and non-prescription drugs) were detected from monitor wells screened in shallow groundwaters located downgradient of OWDS in two settings along the New Jersey and New York coastlines. The well networks utilized were from two distinct settings: An area served by a single large institutional OWDS in Sandy Hook, New Jersey, and multiple coastal locations in New York served by several OWDS in residential and mixed-use settings. The New York samples were collected on both Fire Island and the Suffolk County mainland. The report concluded that samples collected from mixed-use and medium density settings on Fire Island had the highest pharmaceutical concentrations.

A cooperative study between the USGS and the Suffolk County Water Authority (SCWA), entitled "Assessing Occurrence and Persistence of Emerging Contaminants in Groundwater, Suffolk County, NY" will continue to monitor CECs associated with wastewater in raw and finished groundwater at their supply wells. Data collected by the USGS in cooperation with the SCWA over the past decade have shown that land use practices in urbanized areas and increased public supply well pumpage can both result in transport of surface contaminants to supply wells faster than natural hydraulic processes would otherwise allow. Increasing population, and resulting changes in land use and density has altered wastewater treatment practices in much of Suffolk. Long Island water purveyors rely on only a few types of treatment systems to remove nitrogen and other contaminants (VOCs, pesticides, iron,) from groundwater before delivery to the public. However, little is known if these systems can also remove low-level PPCPs.

This study will provide a means to evaluate these treatment systems for numerous wastewater indicator compounds (including PPCPs) and add additional monitoring at selected public supply wells for numerous PPCPs and pesticides (and their degradates) in both sewered and agricultural areas. Supply wells selected for this study are downgradient from wastewater treatment facility discharges. Finished samples will be collected after groundwater has undergone the targeted treatment system (GAC, advanced oxidation process[AOP], or nitrate removal).

A third important study of CECs is entitled "Sentinel Monitoring of Groundwater for Contaminants of Emerging Concern to Provide Advanced Warning for Supply Wells on Long Island, New York." Its primary objective is to develop a network of sentinel wells in order to detect contaminants in groundwater before they are captured by public supply wells. A secondary objective is to maintain a publicly accessible database of contaminants detected across Nassau and Suffolk Counties at these sentinel locations.

Increased demands on the aquifer system have accelerated the downward flow of groundwater into the deeper parts of the system from which most wells withdraw water. This, in turn, has increased the potential for contaminants introduced at land surface, such as pharmaceuticals, 1,4-dioxane, and perfluorinated compounds, to reach supply wells sooner than under normal groundwater flow conditions. Consequently,



the types and concentrations of potential contaminants are often not foreseen until they reach the wellhead, which then requires the water supply to be treated, blended, or the well to be taken offline. Advance detection of these CECs would allow water purveyors to better plan for treatment at the well head, and may also facilitate the ability to proactively address contaminants at the source rather than at the wellhead. The proposed monitoring of groundwater at sentinel locations throughout the two counties would provide concerned parties with advanced warning of potential CEC contamination before it reaches supply wells.

Analytical capabilities have been developed by USGS laboratories to detect hundreds of agricultural, industrial, and wastewater-related compounds at the parts-per-trillion level, thereby aiding in the detection of anthropogenic contaminants in groundwater as early as possible. The USGS has begun to implement these trace-level analytical methods. (https://www.usgs.gov/centers/ny-water/science/sentinel-monitoring-groundwater-contaminants-emerging-concern-provide?qt-science_center_objects=O#qt-science_center_objects)

Drinking Water Quality Council

In response to rising concerns about emerging contaminants such as 1,4-dioxane, on February 11, 2017, New York State Governor Andrew Cuomo sent the acting United States Environmental Protection Agency (USEPA) administrator a letter calling for federal action to regulate 1,4-dioxane and to provide guidance and funding for treatment. Governor Cuomo's letter indicated that if the EPA did not act, New York State would convene an advisory panel of experts to set an MCL at the state level.

The state's Drinking Water Quality Council met on December 18, 2018 and proposed the following MCL's: PFOS- 10 parts per trillion; PFOA- 10 parts per trillion; 1,4 dioxane- 1 part per billion.

New York State has also invested \$2.5 billion dollars towards clean and drinking water infrastructure projects and water quality protection under the Clean Water Infrastructure Act of 2017. This provides approximately \$1 billion dollars to the New York State Environmental Facilities Corporation to provide grants for municipal water quality infrastructure projects. Several Long Island public water suppliers have been awarded some of the \$112.5 million specifically slated for drinking water projects such as water main extensions to connect residents impacted by emerging contaminants.

1,4-Dioxane

As previously mentioned in the 2017 State of the Aquifer Report, 1,4-dioxane is a synthetic organic chemical that has been used as a solvent and a solvent stabilizer for industrial chemicals. It is used in inks and adhesives, as well as in some consumer products such as cosmetics, shampoos, detergents and deodorants. It has been characterized as a likely carcinogen by the USEPA and has been associated with a variety of other illnesses. However, most of what we know about the chemical's health effects is derived from studies in occupational settings, where people have been exposed to much higher levels than would be expected from consumption through public drinking water. 1,4-dioxane has been found in groundwater at numerous sites throughout the United States and on Long Island. 1,4-dioxane also moves easily through soil, completely mixes with groundwater, is persistent in the environment and does not readily degrade.



Many public water suppliers on Long Island have been actively working to evaluate treatment options to remove 1,4-dioxane from their groundwater supply as conventional treatment technologies are not effective. The Suffolk County Water Authority received approval for an innovative new treatment technology called advanced oxidation process (AOP). This treatment system involves the injection of an oxidizer, such as hydrogen peroxide, followed by an ultraviolet light reactor, which releases a hydroxyl radical and oxidizes the 1,4-dioxane and is followed by conventional treatment technologies. The SCWA's AOP system received approval from the New York State Department of Health in March of 2018 and continues to effectively remove approximately 99% of 1,4-dioxane from the water at its Commercial Boulevard pump station. At least one additional AOP system has also been installed on Long Island at a Bethpage Water District pump station in Nassau County for the removal of 1,4-dioxane and is awaiting regulatory approval.

As part of its evaluation and public health protection efforts, the Suffolk County Department of Health Services (SCDHS) continued to collect 1,4-dioxane samples from drinking water throughout Suffolk County in 2018. Readily available data collected between April 2015 and September 2017 indicate that 2,909 drinking water samples were analyzed by the Suffolk County Public and Environmental Health Laboratory, with the following results:

- 27% detection rate in community water supply wells tested
- 8% detection rate in non-community water supply wells tested
- 4% detection rate in private wells tested

SCDHS has collected samples as part of its potential point source evaluation efforts. Out of the 125 samples analyzed with the lowest method detection level of four parts per billion (ppb) for non-potable water and soils, detections were observed at establishments involving the use of washing machines and detergents (e.g. laundromats and car washes, and strip malls with businesses using washing machines). SCDHS staff has also sampled groundwater wells near five dry cleaners and laundromats with detections in 11 out of 36 samples. The highest concentration observed in this sampling effort was 4.95 ppb. Additional samples were collected as part of groundwater investigations near Superfund sites and illegal dumping sites with detections in 138 out of 832 samples at concentrations up to 14.9 ppb. Suffolk County also collected 1,4-dioxane samples from the county's monitoring well network. These wells are not located near any specific contamination source and are intended to reflect general background water quality in the county. There were detections in 19 out of 238 samples and the highest concentration reported was 1.38 ppb. The NYSDEC and NYSDOH are coordinating with Suffolk County on characterization of potential sources on legacy Superfund sites.

SCDHS staff has continued to collect samples from freshwater streams and tributaries. Three additional water bodies had detections of 1,4-dioxane over the last year of sampling. The chemical has now been detected in a total of nine Suffolk water bodies at levels up to 9.65 ppb (Little Neck Run in Brookhaven).



Suffolk County has also collected samples for 1,4-dioxane from select sewage treatment plants. A total of 13 samples were collected from sewage treatment plant effluents. There were no detections at or above four ppb in 10 of the samples and no detections at or above 10 ppb in the remaining three samples. SCDHS has initiated collection of additional samples from the influent and effluent from sewage treatment plants. Groundwater samples were collected near the groundwater recharge for several sewage treatment plants in Suffolk County using a lower minimum reporting level. One out of six monitoring wells located hydraulically upgradient from the sewage treatment plant effluents had a detection of 0.16 ppb, with the remaining wells all showing no detections. Six out of the 10 downgradient wells sampled had detections up to 0.66 ppb of 1,4-dioxane and the other four wells did not have detections. Additional sampling is planned for 2019 near wastewater treatment systems.

Per- and Polyfluoroalkyl Substances

According to the USEPA, per- and polyfluoroalkyl substances (PFAS) are a group of manmade chemicals that have been manufactured and used in a variety of industries since the 1940s. PFAS can be found in food packaging, commercial household products including stain and water repellent fabrics and non-stick products (e.g., Teflon), polishes, waxes, paints and cleaning products. Firefighting foams were also a major source of PFAS groundwater contamination at places such as airports and military bases where firefighting training occurred. Other potential sources of PFAS are facilities doing chrome plating, electronics manufacturing, or oil recovery operations and landfills and wastewater treatment plants (Ref: <https://www.epa.gov/pfas/basic-information-pfas>).

Perfluorooctanoic acid (PFOA) and Perfluorooctane sulfonate (PFOS) have been the most extensively produced and studied of this large group of chemicals. Both chemicals are very persistent in the environment and in the human body, meaning that they don't break down and they can accumulate over time. There is evidence that exposure to PFAS can lead to adverse human health effects. (Ref: <https://www.epa.gov/pfas/basic-information-pfas>). Based upon the toxicity, mobility, and bioaccumulation potential of PFOA and PFOS which could result in potential adverse effects on the environment and human health, in May of 2016 the USEPA released a fact sheet setting a Health Advisory Level of 70 parts per trillion (ppt) for the individual or combined concentrations of PFOA and PFOS. This level is not a drinking water standard, but it is meant to provide information to regulators and public health officials on contaminants that can cause human health effects.

The SCDHS, working in close collaboration with the NYSDOH, NYSDEC and public water suppliers, has worked diligently to identify potential sources of PFAS and ensure public and private wells in these areas are sampled. Between 2016 and 2018, more than 20 private well surveys have been initiated in Suffolk County. More than 850 homes with private wells were sampled during this period and approximately 50 private wells were identified with detections of PFOA and/or PFOS above the USEPA health advisory level. The highest concentration of PFOA and/or PFOS detected in a private well was 1,880 ppt. These homes have either been provided with bottled water, granular activated carbon filtration systems or they have been connected to public water. More than 350 additional private wells sampled had detections, but were below the USEPA health advisory level. Based upon these detections, extensive public water connection programs were implemented in private well survey areas located in Yaphank and Wainscott.

To support the investigation and characterization of potential PFAS source areas, Suffolk County staff have also drilled nearly 100 groundwater wells and collected over 400 samples. Thirty samples exceeded the USEPA health advisory level of 70 ppt for PFOA and/PFOS. The highest concentration observed in a groundwater well as part of these efforts was 15,080 ppt.



Major public water suppliers in Suffolk County have continued to sample public water supply wells for PFAS where they have observed detections either during the USEPA Unregulated Contaminant Monitoring Rule sampling conducted in 2015 to 2018 or in subsequent testing. Two public water suppliers in Suffolk County have had detections approaching or exceeding the health advisory level at their wells (Suffolk County Water Authority and the Hampton Bays Water District) and have voluntarily taken mitigating measures such as removing groundwater pumping wells from service, blending, or using conventional treatment such as granular activated carbon. In consultation with the NYSDOH and SCDHS, public notification was also provided.



UPDATE ON GRUMMAN/NAVY BETHPAGE GROUNDWATER PLUME

As noted in the Long Island Commission for Aquifer Protection's initial State of the Aquifer report, in 1976, officials from Grumman Aerospace Corporation contacted the Bethpage Water District to request connection to the public water supply system due to the fact that employees were getting sick from drinking contaminated water. Until that time, all the water used for domestic and fire protection purposes for the 600-acre Navy and Grumman properties was supplied by on-site production wells. When the wells became contaminated with heavy metals and volatile organics (VOCs), the water was not fit for consumption. In that same year, Bethpage Water District Well No. 6-1 first detected 28 ppb of TCE (the primary VOC in the Grumman/Navy Bethpage plume) from a sampling event conducted by the Nassau County Department of Health. This was the first time VOC contamination from the Grumman/Navy Bethpage plume was detected in a public supply well.

Now, 42 years after first being detected, the Grumman/Navy Bethpage plume is approximately four miles long and two miles wide and extends to a depth of up to 1,000 feet below the ground surface in some locations. It is one of the largest, most concentrated and most complex groundwater contamination plumes affecting a U.S. Environmental Protection Agency (USEPA) designated sole source aquifer anywhere in the United States. The communities currently affected by the plume include Bethpage, Levittown, Plainedge, South Farmingdale and North Massapequa. Communities in the path of the plume include Massapequa, Massapequa Park, North Wantagh, Wantagh and Seaford. The contamination concentrations within the plume vary from less than five ppb (NYS drinking water standard) to greater than 14,000 ppb total volatile organics (TVOCs).

The New York State Department of Environmental Conservation (NYSDEC) is the governmental regulating authority having jurisdiction over the groundwater plume and the Potentially Responsible Parties (PRPs), which include the United States Navy and Northrop Grumman Corporation. The NYSDEC has established three primary Operable Units (OUs) for this overall contamination site. OU-1 is designated as the on-site soil/groundwater contamination on the Grumman/Navy property. OU-2 is designated as the off-site groundwater contamination plume emanating from the Grumman/Navy properties, and OU-3 is designated as the on-site/off-site soil and groundwater contamination plume emanating from the former Grumman settling ponds (Bethpage Community Park).

Over the past 42 years, there have been a number of remediation actions and installations to remove contaminated soil and groundwater. Primarily, those actions and installations have included:

1. Contaminated soil removal at Grumman/Navy properties (OU-1)
2. Groundwater extraction and treatment system installation at the downgradient southern Grumman/Navy property boundary to intercept contaminated groundwater flow path and mitigate further off-site plume migration (OU-2).
3. Groundwater extraction and treatment system installation at a designated hot-spot location called GM-38 to remove elevated contaminant concentrations north of Hempstead Turnpike and west of the Seaford-Oyster Bay Expressway (OU-2).
4. Shallow soil vapor extraction and groundwater extraction and treatment system installation at the downgradient southern Bethpage Community Park property boundary to intercept shallow contaminated groundwater flow path and mitigate further off-site plume migration (OU-3).



Additionally, there are several planned remediation actions and installations that have not yet been implemented or completed including:

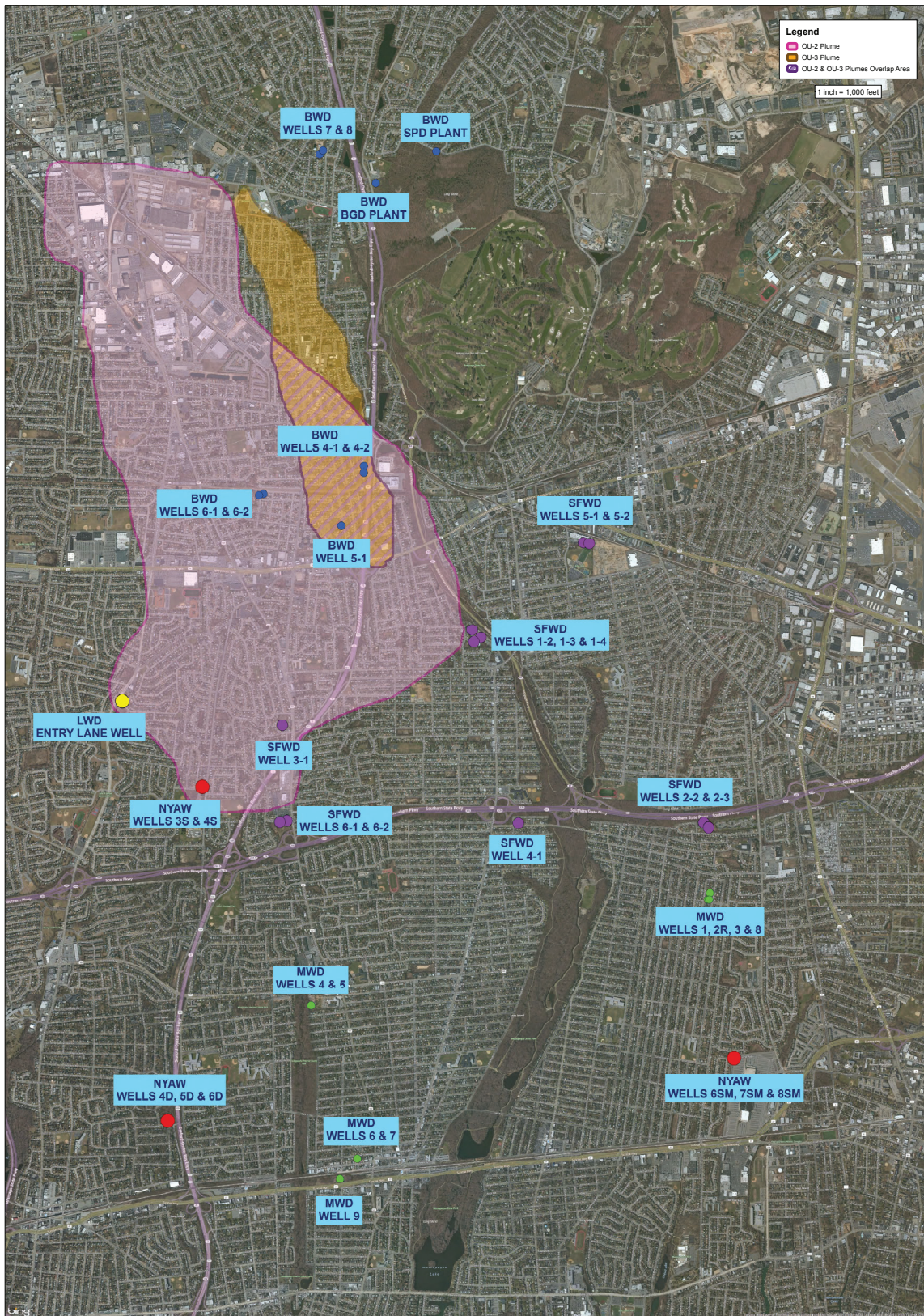
1. Groundwater extraction and treatment system installation at designated hot-spot location called RE-108 to remove elevated contaminant concentrations south of Hempstead Turnpike in the vicinity of Hicksville Road (OU-2).
2. Contaminated soil treatment/removal at Bethpage Community Park (OU-3)
3. Groundwater extraction and treatment system installation at designated hot-spot location called RW-21 to remove elevated contaminant concentrations in the vicinity of south-central Bethpage (OU-2).

Historically, the approach to responding to the Grumman/Navy Bethpage plume for the protection of public health was the installation of wellhead treatment systems at affected or threatened public supply well facilities. Since 1990, original wellhead treatment installations and subsequent treatment upgrades (as necessary) have been installed at the following public supply wells:

- Bethpage Water District Plant No. 4 – Sophia Street and North Herman Avenue, Bethpage
- Bethpage Water District Plant No. 5 – Broadway and Wilson Lane, Bethpage
- Bethpage Water District Plant No. 6 – Motor Parkway and Park Lane, Bethpage
- South Farmingdale Water District Plant No. 1 – Langdon Road, South Farmingdale
- South Farmingdale Water District Plant No. 3 – Hicksville Road and Old Post Road, Plainedge
- New York American Water Seamans Neck Road Plant – Seamans Neck Road, North Wantagh
- Levittown Water District Bowling Lane Plant – Bowling Lane, Levittown, New York

In 2016, the NYSDEC, under new leadership, committed to a greater level of regulatory oversight and leadership following years of relative remedial inaction that has allowed the Grumman/Navy Bethpage plume to grow reasonably unabated and reach its current size, mass and complexity. The NYSDEC recognized that the plume was not being assessed, planned and targeted in a comprehensive and holistic manner, thereby calling for a renewed approach to its regulatory role and place in the remediation program. The NYSDEC, through legislation enacted by New York State and signed by Governor Andrew Cuomo in 2017, has completed a high-level assessment of the full remediation and containment of the Grumman/Navy Bethpage plume. Additionally, in December 2017, the governor announced that \$150 million was being committed in the budget for the full remediation of the plume, and that the state will further commit the resources necessary to complete the full remediation and pursue the costs from the Navy and Northrop Grumman.

Most recently, the NYSDEC is nearing completion of its own independent feasibility study and remedial action plan for the full containment and remediation of the plume. The treatment for emerging contaminants, such as 1,4-dioxane, which are found throughout the plume, will also be addressed as part of the plan. The plan is expected to be released for public presentation and comment by the middle of 2019. Once adopted, the plan will set forth the new foundation and remedial actions to be spearheaded by the NYSDEC to finally contain and remediate the Grumman/Navy Bethpage plume.



Map of Grumman/Navy Bethpage plume, showing the extent of groundwater contamination and affected public supply wells



CONCLUDING THOUGHTS

2018 has been an important year for Long Island's aquifers, as well as LICAP itself. After LICAP's initial successes and the publication of the first State of the Aquifer report in 2016, and an update in 2017, LICAP was reauthorized in 2018 for an additional five years by both County Legislatures. This 2018 State of the Aquifer update is the first LICAP deliverable since this reauthorization. Additionally, the LICAP Board adopted an Interim Groundwater Management Plan in early 2018. A consultant has been retained to complete the plan, and anticipate release of LICAP's Final Groundwater Management Plan in mid-to-late 2019.

After many years of below normal precipitation, and resulting low aquifer water levels and low streamflows, near record precipitation in 2018 has brought those levels and streamflows back to near or above long-term average levels. Existing groundwater and streamflow data collection networks established and maintained by federal and local agencies located on Long Island have been instrumental in monitoring the decline in water levels due to the past dry period, and assessing its strong recovery during 2018. The ongoing Long Island Sustainability Project should ensure that an enhanced level of aquifer monitoring will continue into the future.

Emerging contaminants have continued to be in the forefront of the news affecting public water suppliers. After the successful launch of the first system to treat 1,4-dioxane in 2018, new strict regulations have been proposed for this chemical as well as perfluorinated compounds. The United States Geological Survey, the Nassau and Suffolk County Health Departments and local water suppliers continue to evaluate emerging contaminants and devise strategies to comply with these new regulations.

The Grumman/Navy plume in the Bethpage area should soon be entering a new phase of remediation. While numerous nearby public supply wells have been outfitted with wellhead treatment, additional resources will be committed to containment and remediation of the plume itself. A remedial action plan for the containment of the plume is anticipated to be released by the NYSDEC in 2019.

The Long Island Commission for Aquifer Protection, through its State of the Aquifer update, Groundwater Resources Management Plan and active subcommittee work will continue in its second five-year term to further the goal of protecting and conserving Long Island's most important resource, its groundwater.



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