EXHIBIT 12

PART 2 OF 2

Required Setback Distance of Sewage Treatment Plants **SCDHS Standards for Approval for Sewage Disposal Systems For Other Than Single-Family Residences Appendix A vs Appendix B**			
Enclosed STP w/o Odor Control (Less Than or Equal to 15,000 GPD – Appendix A)	200	100	150
Enclosed STP (Greater Than 15,000 GPD - Appendix B)	200	200	150
STP Open to the Atmosphere (Greater Than 15,000 GPD - Appendix B)	400	400	350
Distance to Leaching Structures (or expansion area)	25	25	25

The types of systems installed meeting Appendix A requirements are normally considered package systems. Two systems, which are currently being installed in Suffolk County are the CromaFlow (formerly known as Cromaglass) treatment system and the biologically engineered single-sludge treatment processes (BESST) (See **Figure 1-23**).

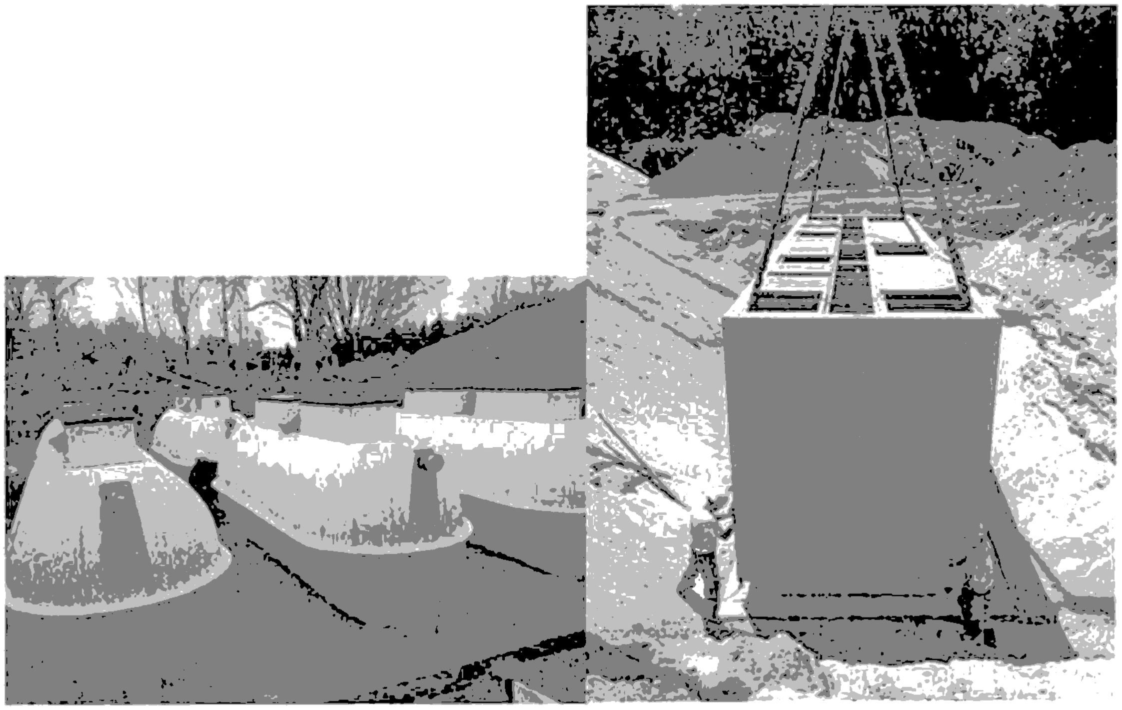


Figure 1-23 CromaFlow (Left) and BESST (Right) Treatment Tanks

Appendix A STPs represent an important tool in the toolbox of wastewater management in Suffolk County because they can accommodate reduced setbacks, are capable of achieving less than 10 mg/L total nitrogen and can be used as a central wastewater treatment method for existing properties where implementation of full-scale sewering (e.g., Appendix B systems) and/or upgrades to individual properties through I/A OWTS are not viable options. For example, the minimum lot size to site an Appendix B system is approximately four acres while the minimum lot size to accommodate an Appendix A system is 0.75 acres. Despite the existing accommodation for reduced setbacks, industry professionals and stakeholders have expressed that the use of Appendix A systems is limited in Suffolk County by:

- The maximum flow limitation of 15,000 gpd. Many projects that could benefit from advanced wastewater treatment hit a dead end because their flows exceed 15,000 gpd and the additional costs associated with going to a full-scale Appendix B system are not economically feasible to the property owner(s);
- Existing setbacks preclude retrofits of existing properties in many cases because there is insufficient land availability to meet the setbacks. This is especially prevalent in downtown commercial areas and on existing (grandfathered) parcels with limited space to install an advanced treatment unit; and,
- The existing administrative/permitting framework for Appendix A systems is cumbersome, particularly for existing parcels with multiple owners who wish to install a new Appendix A treatment plant.

Recommendations to offset the concerns identified above and facilitate more expanded use of Appendix A systems are provided in Sections 2.2.3.2 and 8.1.2 of this SWP.

As of 2017, Suffolk County had 200 operational STPs. Of the 200 STPs, 39 STPs are considered municipal or industrial STPs, and the rest are considered decentralized STPs that are privately owned and operated. Fourteen sewage treatment plants discharge directly to surface waters. The SCDHS' Sewage Treatment Plant Bureau, under dedicated authority by NYSDEC, inspects and oversees all of the privately owned STPs in the County. The plants operate under a SPDES Permit issued by NYSDEC. Municipal plants are enforced by NYSDEC and privately-owned plants are enforced by SCDHS.

The majority of STPs in Suffolk County are considered "tertiary plants" and are capable of reducing Biochemical Oxygen Demand (BOD_5), Total Suspended Solids (TSS), and Total Nitrogen (TN) (See **Table 1-18** at the end of this section). There are 183 tertiary STPs that are designed to remove nitrogen from wastewater with typical effluent total nitrogen of 10 mg/l or less. The 2017 average effluent total nitrogen for the all tertiary plants in steady-state was 6.3 mg/L, less than the permitted 10 mg/L. These numbers indicate that the vast majority of the STPs in the County achieved the efficiency necessary to consistently operate at the required and desired performance level. The remaining 17 STPs are considered "secondary plants" capable of reducing BOD_5 and TSS. These plants pre-date SPDES total nitrogen removal requirements. Most of the secondary treatment plants are in the process of transition to tertiary plants and are projected to upgrade their facilities with nitrogen removal technology by the end of 2019. In 2017, 11 of these secondary treatment plants were under order on consent to replace their facility with either a new plant or to connect to an existing sewer district.

SCDHS requires installation of monitoring wells at each STP that discharges to groundwater in order to detect any impacts to groundwater caused by the discharged effluent. Groundwater monitoring data is reported on a quarterly basis on the required discharge monitoring report (DMR) and if an increase in total nitrogen is observed downgradient from a STP, SCDHS can issue an order on consent to upgrade a facility. SCDHS uses this data to mandate that a secondary treatment plant be updated to tertiary treatment. SCDHS prepares an annual report on the status of STPs in the County. **Table 1-19** includes some of the key performance indicators used to review trends in the annual report.

Table 1-19 Key Performance Indicators from the 2017 STP Report

	2011	2012	2013	2014	2015	2016	2017
Number of High-Risk Facilities	N/A	60	50	50	38	26	28
Total Nitrogen (All Tertiary STPs in Steady State) in mg/l	9.9	8.6	8.7	7.8	7.6	5.95	6.3
Percent of Tertiary STPs meeting NYS Discharge limits for Total Nitrogen (All Tertiary STPs in Steady State)	71.0%	79.6%	82.8%	85.0%	85.8%	95.3%	93.7%

There are approximately 23 centralized STPs located in Suffolk County. Some of the major centralized sewer districts in the County are Bergen Point (Southwest Sewer District #3), Selden (Sewer District #11), Town of Riverhead, and Village of Patchogue, which serve multiple individually owned tax lots and are operated by municipalities. The Bergen Point wastewater treatment plant (WWTP), the largest treatment plant in Suffolk County with an operating capacity of 30 million gallons per day (MGD), is currently under construction to expand the plant to 40.5 MGD. The Bergen Point WWTP, shown on **Figure 1-24**, is the County's only regional facility and is a secondary plant that discharges treated effluent two miles south of Fire Island into the Atlantic Ocean.

Most of the STPs located within Suffolk County are considered to be decentralized STPs. Decentralized STPs are designed to operate on a smaller scale than centralized STPs and do not require multiple remote pump stations to convey sewage to the plant. The historical use of decentralized STPs in the County has been to serve single lots containing condominium complexes, apartment complexes, hotels, and/or industrial/commercial buildings.

The SCDHS has been actively requiring older plants that are underperforming and/or lack nitrogen removal capability, to undergo renovations or replacement. During the past 15 years, 100 new STPs were constructed, of which 20 were constructed to replace existing facilities whose physical conditions and/or treatment capability deteriorated over the years. For example, the Kings Park Sewage Treatment Plant located on the grounds of the former Kings Park Psychiatric Center main structure was built in 1935, rehabilitated in 1960, and upgraded again in 2004 to a sequencing batch reactor.

Figure 1-24 Aerial Photo of Bergen Point STP (Courtesy of Newsday)

1.1.6.6 Sewer Expansion Projects

Sewering is an important part of the overall wastewater management strategy in Suffolk County. Despite the issues related to scandals associated with construction of the Southwest Sewer District in the 1980's, the importance of sewering as a critical tool in the toolbox of nitrogen removal options must be acknowledged. As documented further in Section 2.2.2 of this SWP, while the use of I/A OWTS represents the most cost effective solution in many areas of the County, sewering may have advantages over I/A OWTS in locations with significant water quality impairments due to nitrogen, in areas with challenging site conditions (e.g. small lots, high groundwater, poor soils), in areas within close proximity to existing sewer districts, and in areas with special considerations such as areas that are prone to sea level rise. Using a countywide, parcel-specific scoring analysis modeled from the Chesapeake Bay TMDL Watershed Implementation Plan, it is estimated that as many as 50 percent of the parcels located within the highest priority areas for wastewater upgrades could benefit from sewering as the preferred means for wastewater treatment. This is not to imply that these parcels should connect to sewers as there are multiple other factors that need to be considered when evaluating individual regions for sewer expansion; however, it underscores that sewering is an important element of the overall wastewater management strategy in Suffolk County.

A variety of sewering proposals have been evaluated for feasibility in Suffolk County over the last 20 years. A summary of these proposals, along with their current status, is provided in **Tables 1-20** (County-led projects) and **1-21** (Town/Village-led projects)(please see tables at the end of Section 1). As shown in **Tables 1-20** and **1-21**, over 20 County-led projects have been recently evaluated and over 15 Town/Village-led projects have been evaluated.

The most notable projects currently being advanced by Suffolk County include three Suffolk County Coastal Resiliency Initiative (SCCRI) sewer extension projects that are being funded through the Governor's Office of Storm Recovery's (GOSR) post-Sandy resiliency funding. In 2014, Governor Andrew Cuomo announced that $383 million of funding would be made available to sewer communities along four river corridors in unsewered low-lying areas along Suffolk County's south shore that had been inundated by Superstorm Sandy. This award represented the first major sewering based project within Suffolk County in more than 40 years. The goal of the project is to reduce nitrogen pollution to ground and surface waters to improve coastal resiliency against future storm events.


A8

TOP STORIES

TWO SEWER PLANS OKd

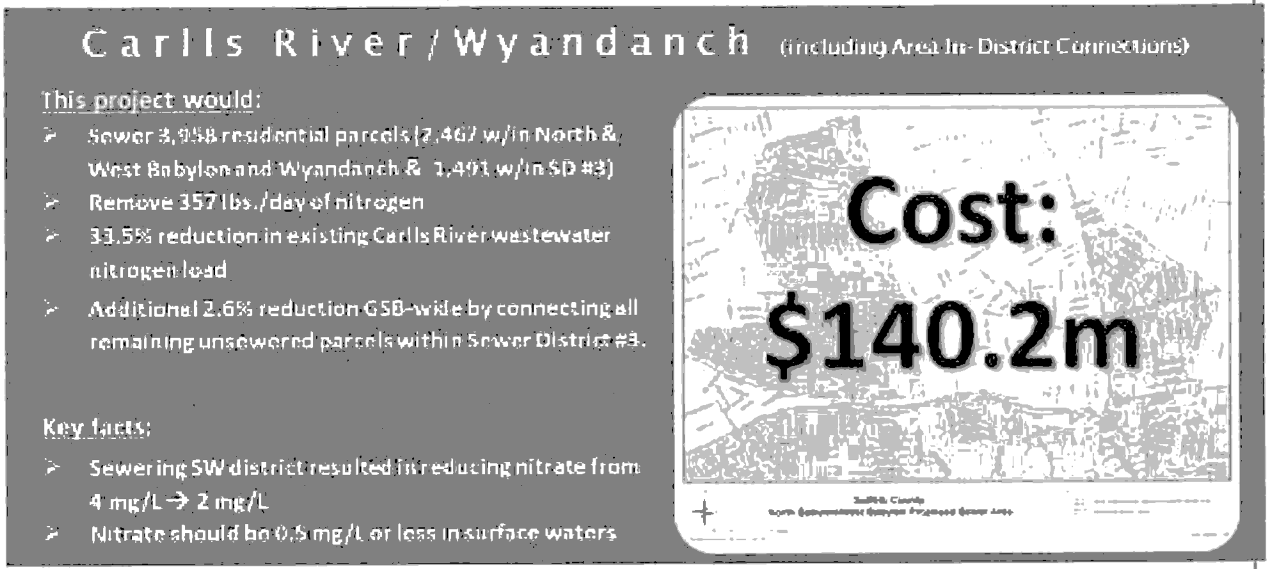
Mastic, Babylon voters say yes; Great River, no

A voter at the Mastic Fire Department on Tuesday casts a ballot on the proposed $191.3 million sewer project along the Forge River.

In January 2019, the Babylon, Mastic, and Great River sewer projects went to ballot for three separate public votes. The Village of Patchogue project did not require a public vote because it involves an expansion of the Village sewer district. The Babylon and Mastic projects were overwhelmingly approved through the ballot while the Great River project was defeated. As a result, the three project areas that are currently being advanced include:

- Carlls River Watershed in North Babylon, West Babylon and Wyandanch, Town of Babylon
- Forge River Watershed in Mastic, Town of Brookhaven
- Patchogue River Watershed in the Village of Patchogue

A project overview and summary of key facts for each of the three SCCRI projects is provided on **Figure 1-25a** through **Figure 1-25c**.



Carlls River / Wyandanch (including Area In-District Connections)

This project would:

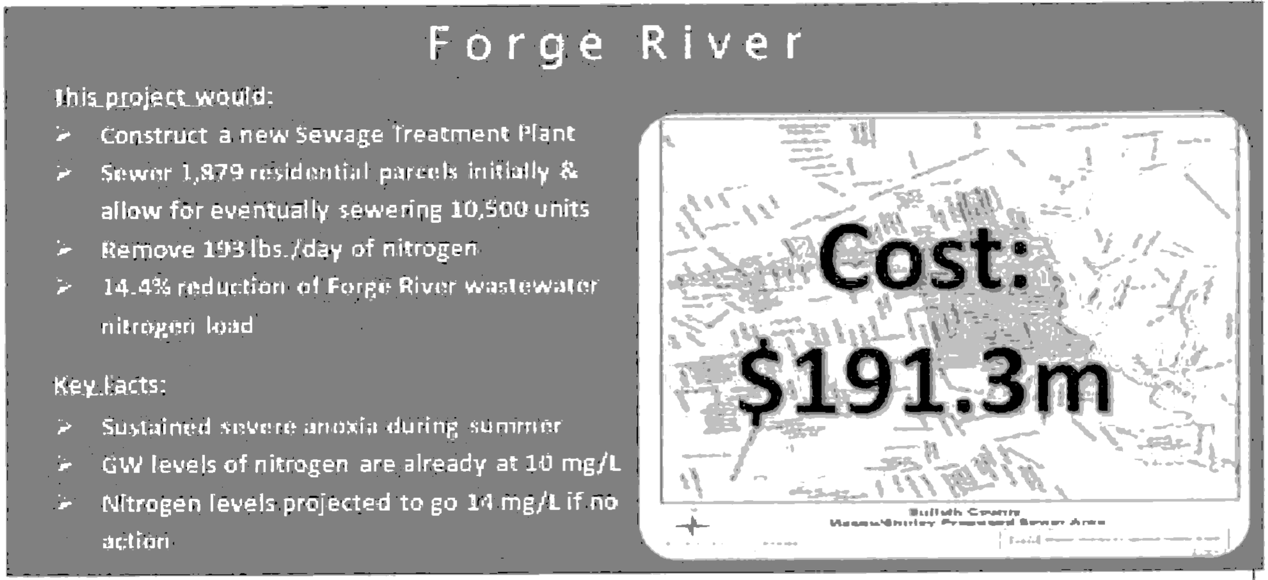
- Sewer 3,958 residential parcels (2,467 w/in North & West Babylon and Wyandanch & 1,491 w/in SD #3)
- Remove 357 lbs./day of nitrogen
- 33.5% reduction in existing Carlls River wastewater nitrogen load
- Additional 2.6% reduction GSB-wide by connecting all remaining unsewered parcels within Sewer District #3.

Key facts:

- Sewering SW district resulted in reducing nitrate from 4 mg/L → 2 mg/L
- Nitrate should be 0.5 mg/L or less in surface waters

Cost: $140.2m

Figure 1-25a Suffolk County Great South Bay Coastal Resiliency Projects



Forge River

This project would:

- Construct a new Sewage Treatment Plant
- Sewer 1,879 residential parcels initially & allow for eventually sewering 10,500 units
- Remove 193 lbs./day of nitrogen
- 14.4% reduction of Forge River wastewater nitrogen load

Key facts:

- Sustained severe anoxia during summer
- GW levels of nitrogen are already at 10 mg/L
- Nitrogen levels projected to go 14 mg/L if no action

Cost: $191.3m

Figure 1-25b Suffolk County Great South Bay Coastal Resiliency Projects

Patchogue River

This project would:

- Sewer 513 residential parcels
- Remove 75 lbs./day of Nitrogen
- Increase Patchogue River sewered nitrogen removal by >100%
- 25% reduction in Patchogue River/Patchogue Lake wastewater nitrogen load (0-2 year contributing area sewer plan)

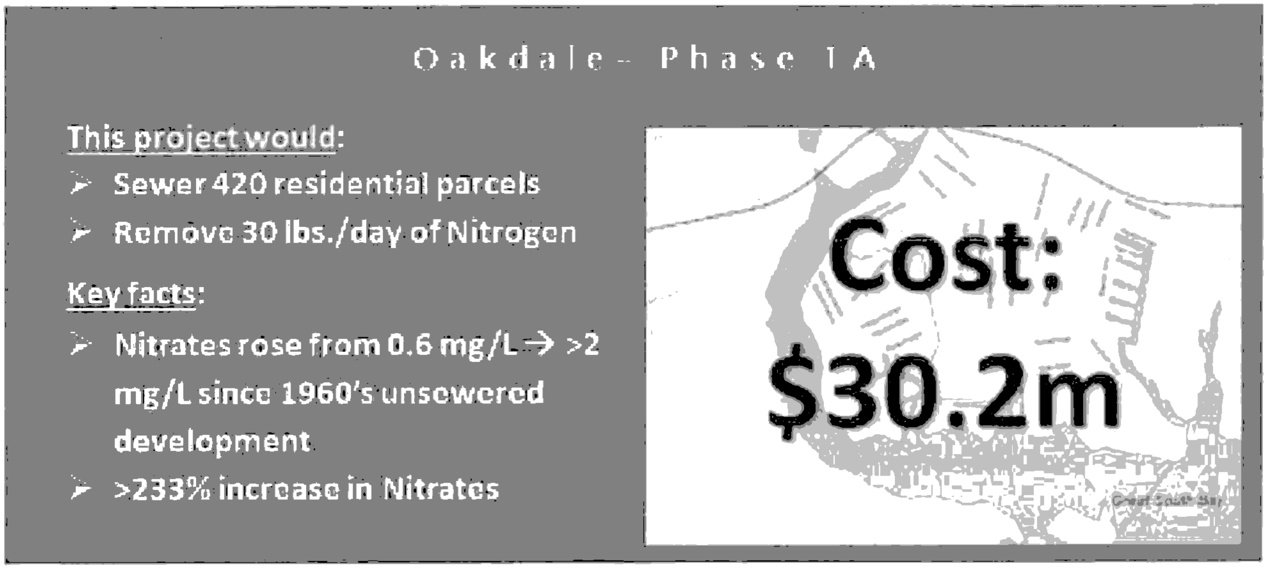
Key facts:

- Eastern GSB nitrates have risen significantly
- Eastern GSB flushing rates are poor (>100 days)
- Nitrates rose from 0.5 mg/L → >2.5 since 1960's

Cost: $29.6m

Figure 1-25c Suffolk County Great South Bay Coastal Resiliency Projects

Other notable County-led projects currently under various stages of advancement include the Oakdale Phase 1A extension (**Figure 1-26**), the Ronkonkoma Hub extension (**Figure 1-27**), and the Kings Park Business District (**Figure 1-28**). Each of these projects has construction funding identified and the projects are in various stages of design and/or construction. A short summary of each project is provided by the following text.



Oakdale – Phase 1A

This project would:

- Sewer 420 residential parcels
- Remove 30 lbs./day of Nitrogen

Key facts:

- Nitrates rose from 0.6 mg/L → >2 mg/L since 1960's unsewered development
- >233% increase in Nitrates

Cost: $30.2m

Figure 1-26 Overview of Proposed Oakdale Phase IA Extension

1.1.6.6.1 Ronkonkoma Hub

The Ronkonkoma Hub project includes the construction of a 1.5 million gallon per day pump station and force main to connect the Ronkonkoma Hub Transit Oriented Development (TOD) to the Bergen Point WWTP. The design for the project is complete and the construction contract for the force main has been awarded. Project completion is currently forecasted for the Winter of 2019-2020. In addition to promoting economic development within the Ronkonkoma TOD area, the pump station also includes additional capacity for the connection of existing developed parcels in the region. One project that is currently under evaluation is the MacArthur Industrial District which includes the connection of the existing commercial/industrial district surrounding MacArthur Airport. It should be noted that the proposed district limits shown on **Figure 1-27** below are approximate and subject to change.

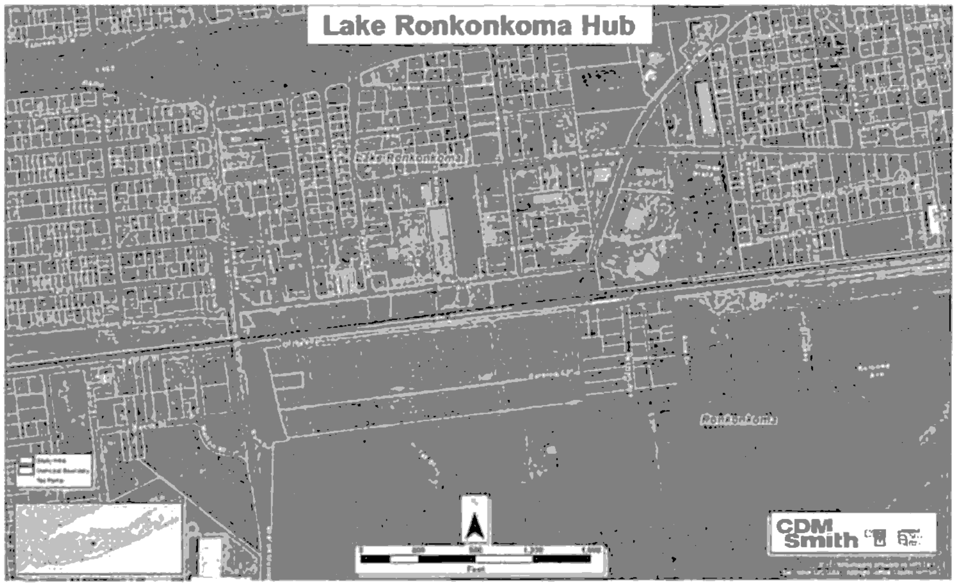


Figure 1-27 Ronkonkoma Hub

1.1.4.6.2 Kings Park Business District

The Kings Park Sewer Project involves the connection of approximately 140 businesses in the Kings Park business district, an apartment complex of approximately 100 units served by a failing septic system, and 27 residential parcels to the Suffolk County Sewer District #6 – Kings Park treatment plant. The project design is almost complete and $20M in state grant funding is sufficient to complete the project. It is anticipated that construction will start in 2020 and end in 2023. An overview of the project area is shown in **Figure 1-28.**

Figure 1-28 Proposed Kings Park Sewer District Extension

1.1.6.6.3 Town/Village Projects

There are several Town/Village led sewer projects that are also in various stages of advancement. **Table 1-20** (please see tables at the end of Section 1) provides a summary of the additional 15 Town and Village led projects that were identified as of March 2019. Projects that are currently noted as having construction funding identified include the Calverton/EPCAL WWTP expansion project and the Village of Westhampton Beach Downtown Commercial Expansion project (see **Figures 1-29** and **1-30**).

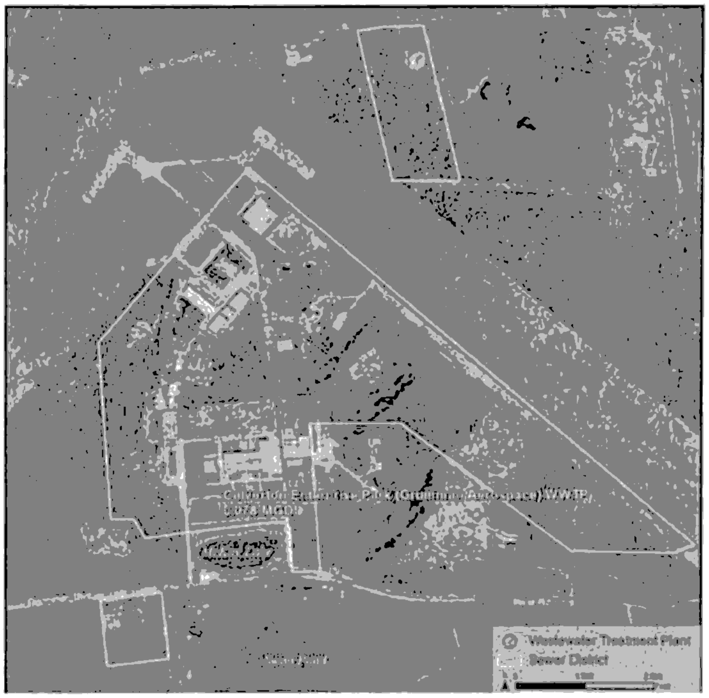
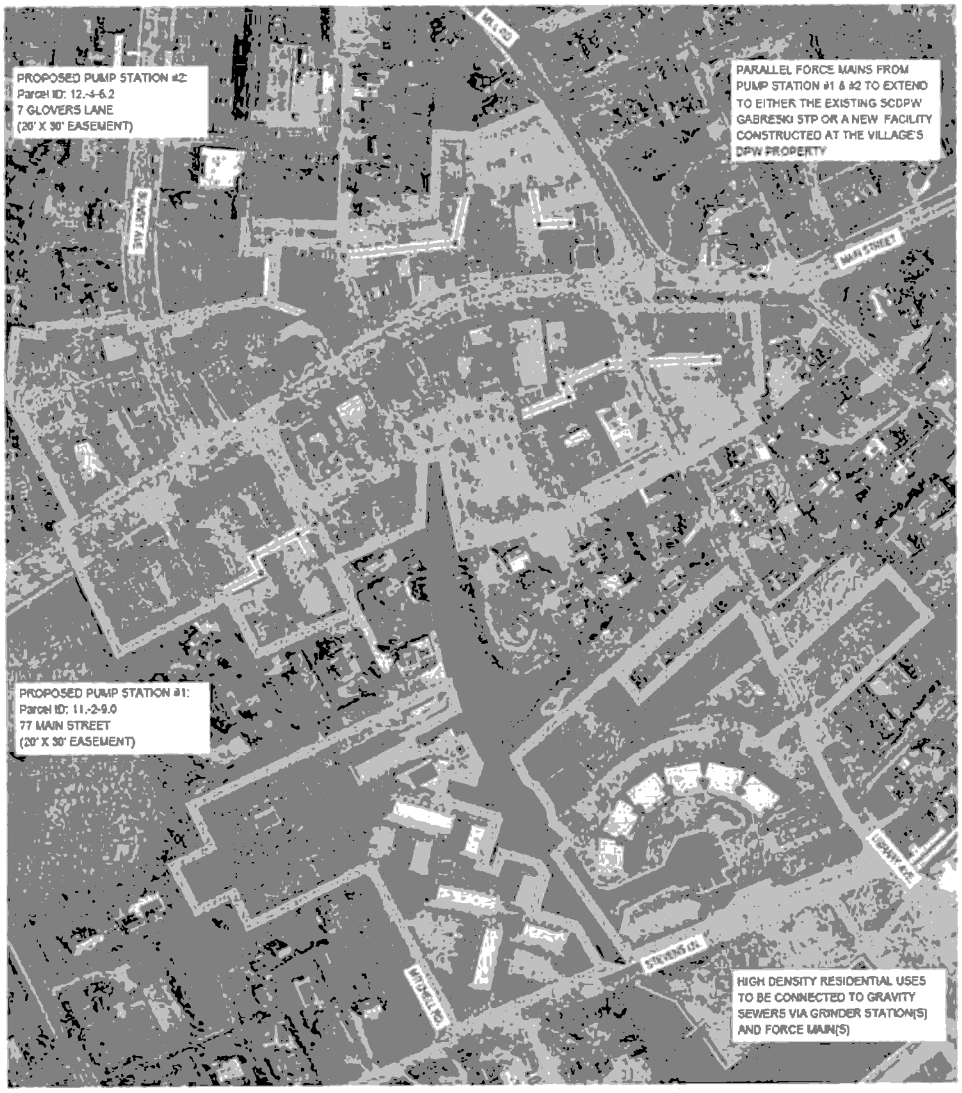


Figure 1-29 Proposed Calverton/EPCAL WWTP expansion project



Preliminary Phase 1 Sewer Service Area Map

SCALE 1" = 200'-0"

N

* AERIAL BACKGORUND IMAGERY WAS OBTAINED FROM THE NEW YORK STATE GIS CLEARINGHOUSE WEBSITE:http://gis.ny.gov/gateway/mg/

LEGEND

▨ PROPOSED SEWER SERVICE AREA

PROPOSED SEWER SYSTEM EASEMENT LOCATIONS (IF REQD)

▨ PROPOSED PUMP STATION SITE

● PROPOSED GRAVITY SEWER MAN HOLE

Sanitary Flow Projection based on SCWA usage records. (ADF approx. 60,000 gpd)

NYS Land Use	Description	Area		Tax Parcels
		Acerage	% Acreage	Tax Parcel Count
100	Agricultural	0.00 ac.	0.0%	0 parcels
200	Residential	21.95 ac.	70.2%	88 parcels
300	Vacant Land	0.34 ac.	1.1%	1 parcels
400	Commercial	8.70 ac.	27.8%	66 parcels
500	Recreation & Entertainment	0.00 ac.	0.0%	0 parcels
600	Community Services	0.30 ac.	1.0%	1 parcels
700	Industrial	0.00 ac.	0.0%	0 parcels
800	Public Services	0.00 ac.	0.0%	0 parcels
900	Wild, Forested, Conservation Lands & Public Parks	0.00 ac.	0.0%	0 parcels
	TOTAL . . .	31.29 ac.	100%	156 parcels

CLIENT
Incorporated Village of Westhampton Beach

PROJECT #
WHBV 16-01

DATE
7/14/2016

H2M
architects + engineers

Figure 1-30 Village of Westhampton Beach Downtown Commercial Expansion Sewer Project

Other projects with a relatively high likelihood of moving forward include the Town of Southampton Riverside redevelopment project, Town of Babylon Wyandanch expansion project, and the Village of Northport STP expansion project.

Additional recommendations for sewering are discussed in Section 8.1.5 of this SWP.

1.1.6.7 Considerations for Commercial Parcels

Many commercial parcels in Suffolk County represent a unique challenge because of the diversity of wastewater flow and quality, potential administrative concerns associated with tenant-owner agreements, potential for substantial costs associated with wastewater upgrades, and potential for significant flow that exceeds allowable density in Suffolk County. For the purposes of discussion within this SWP, commercial parcels with special considerations have been categorized into four subgroups including:

1. Parcels with 1980s passive denitrification systems;
2. Grandfathered parcels constructed prior to the requirements set forth in Article 6 of the Suffolk County Sanitary Code in 1984;
3. Parcels that contain OSDS meeting the definition of a USEPA Large Capacity Cesspool; and,
4. Exempt parcels such as school districts.

Another primary concern for each of the subgroups identified above is that the locations of existing OSDS under each subgroup are unknown. As such, the extent of the potential impacts to individual water bodies cannot be determined relative to the evaluations and recommendations provided within this SWP. To address this concern, the SWP provides a recommended timeline for development of a SWP addendum as described in Section 8.4.11. A description of each of the three subgroups is provided below.

1.1.6.7.1 1980s Passive Denitrification Systems

After the commercial density requirements went into effect in 1984, the SCDHS approved passive denitrification systems as a form of treatment that allowed commercial properties to exceed Article 6 density as long as the total flow generated was less than 15,000 gallons per day (gpd). Passive denitrification systems were installed between 1985 and 1994. There are approximately 450 of these systems installed throughout Suffolk County. Originally, these systems were truly passive treatment systems. Later, in an effort to increase performance, pumps were added to the system to optimize the dosing of the treatment works. The system had five main components. The pretreatment unit consisted of a standard septic tank and grease trap and was followed by a dosing siphon or pump station that distributed flow to the downstream treatment units.

The treatment process included a buried aerobic sand filter where nitrification would take place followed by an upflow denitrification filter that was charged with sulfur and limestone. The limestone acted to buffer the solution and the sulfur acted as the food source for the sulfur-fixing bacteria that performed the denitrification process. The overflow from the denitrification filter was passed on to the final step which was effluent recharge via leaching pools.

Over time, most of these systems failed hydraulically and were bypassed to conventional treatment systems. These systems originally operated under SPDES permits requiring that they met the groundwater nitrogen discharge limit of 10 mg/L. When the systems were discontinued from use, the SPDES permits were modified to eliminate the effluent limitations and place the permittee on notice that additional treatment may be required in the future.

1.1.6.7.2 Grandfathered Commercial Parcels Constructed Prior to 1984

Grandfathered commercial parcels constructed prior to 1984 represent a unique challenge for wastewater management because design flows may potentially significantly exceed the requirements set forth in the design and construction standards for commercial projects. In addition, while some Towns maintain records regarding the location of grandfathered parcels, most grandfathered parcels predate the use of electronic and/ or geospatial related databases or records of their locations do not exist. Because the locations of grandfathered commercial parcels are unknown, the potential magnitude of parcel-specific impacts could not be evaluated as part of this SWP and requires additional study (see Section 8.4).

Historically, grandfathered commercial parcels had a perpetual tacit approval to continue exceeding Article 6 density requirements so long as they met one of the codified exemptions (e.g., developments or other construction projects previously approved by SCDHS and/or development or other construction projects, other than realty subdivisions, approved by a town or village planning or zoning board of appeals prior to January 1, 1981). In 2017, the Suffolk County Legislature took a monumental step toward extinguishing the perpetual as-of-right grandfathering of commercial parcels by approving revisions to Article 6 of the Suffolk County Sanitary Code that set forth new requirements for the practice of grandfathering. Under this amendment to Article 6, certain currently grandfathered sites would no longer have an exemption. However, the proposed amendment to Article 6 would allow maintenance of the grandfathered sanitary flow IF such sites designed and installed an approved I/A OWTS at the time of application to the Office of Wastewater Management. Such applications are required when there is new construction, including additions to or changes of use of existing buildings. The I/A OWTS will provide increased protection of water resources, as compared to an onsite sewage disposal system consisting of a septic tank and leaching structure only.

As discussed further within Section 8.4, the recommendations for commercial parcels within this SWP have been subdivided into commercial parcels with design flows of less than 1,000 gpd and commercial parcels with design flows of greater than 1,000 gpd. This recommendation acknowledges that the methods and cost to upgrade small commercial projects (e.g., less than 1,000 gpd) will typically be similar to the scope of upgrading a single-family residential parcel. However, methods and associated costs for upgrading parcels with large design flows, particularly for those on small lots, may be significantly more challenging and costly than single family residential upgrades. Nonetheless, a review of the Office of Wastewater Management Blacksmith database for commercial final construction approvals between January 1, 2013 and December 31, 2016 indicates that approximately 76 percent of all commercial systems have design flows of less than 1,000 gpd; therefore, the majority of the individual commercial OSDS in Suffolk County are recommended to be subject to all recommendations set forth within this SWP. The remaining, large flow, commercial OSDS will require additional study to identify their respective locations, quantify their design flows and nitrogen loads, and identify recommendations for priority and funding options in the form of a SWP Addendum as proposed in Section 8.4 of this SWP.

1.1.6.7.3 Commercial Parcels with USEPA Large Capacity Cesspools

The USEPA regulates and defines Large Capacity Cesspools as residential multiple-dwelling, community, or regional systems (e.g., townhouse complexes or apartment buildings) that dispose of sanitary waste, or non-residential cesspools that have the capacity to serve 20 or more persons per day (e.g., rest areas or churches) if they receive solely sanitary waste (40 CFR 144.3). Large capacity cesspools do not provide primary treatment through a septic tank. In Suffolk County, this generally includes parcels that meet the USEPA definition described above that were constructed prior to the year 1984.

While large capacity cesspools represent an environmental concern, they also provide a potential opportunity for leveraging federal regulations that require upgrades of Large Capacity Cesspools. Specifically, beginning April 5, 2005, the USEPA requires that all existing Large Capacity Cesspools be replaced with technology that conforms to USEPA regulations. Upgrade options permitted by the USEPA include:

- **Sanitary sewer hookup -** Often, a sewer system hookup may be available even though it was not an option when the home or building was constructed.

- **Holding tanks -** Store the sanitary waste in a holding tank, which is then periodically pumped out for proper disposal of the waste. The amount of wastewater that has to be stored can be reduced by conserving water (e.g., using low-flow shower heads and low-flow toilets). It should be noted that holding tanks or "hold and haul" is currently not an allowable sewage disposal method in Suffolk County.

- **Large-capacity septic systems** - Large-capacity septic systems include a septic tank for primary treatment followed by a leaching pool for disposal of grey water. Note that large-capacity septic systems are regulated as Class V wells and must be approved by the permitting authority prior to construction. In addition, large capacity septic systems are only permitted in Suffolk County if the accompanying land use meets the density flow requirements as set forth in Article 6 of the Sanitary Code.

- **Package plants** - Small wastewater treatment systems, known as package plants, are designed to treat limited sewage flow. These plants use prefabricated steel tanks and hold the wastewater for a longer time as part of the treatment process. In Suffolk County, package plants could include Appendix A STPs or approved I/A OWTS.

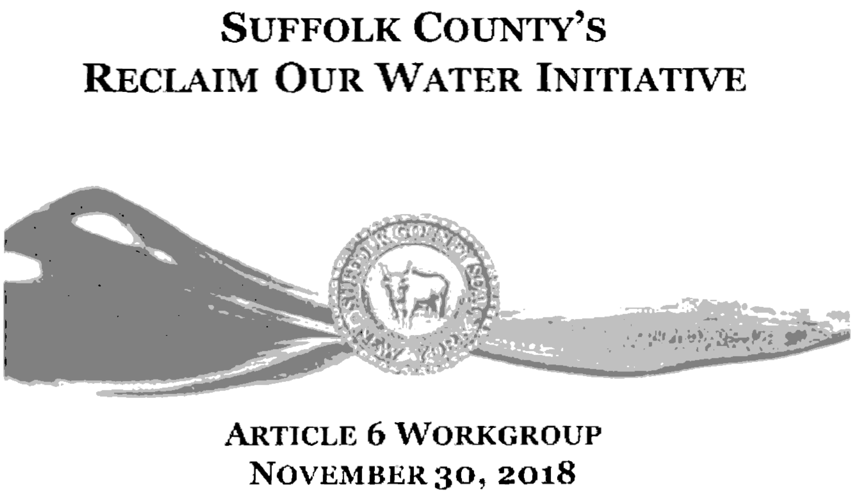
Similar to concerns regarding the identification of grandfathered commercial parcels, the locations of USEPA Large Capacity Cesspools are generally not known in Suffolk County. Additional study will be needed to identify their respective locations, quantify their design flows and nitrogen loads, and identify recommendations for priority and funding options in the form of a SWP Addendum as proposed in Section 8.4 of this SWP. It should be noted that USEPA has sole jurisdiction over Large Capacity Cesspools, however, Suffolk County has been coordinating with the USEPA on establishing the best means to identify non-compliant systems and how to incorporate their upgrade in the context of the overall wastewater management strategy in Suffolk County.

1.1.6.7.4 Exempt Parcels

The SCDHS Office of Wastewater Management reviews and approves sanitary facilities for public schools as an agent for the NYSDEC. New York State has jurisdiction over the type of sanitary system and amount of wastewater flow permitted to be discharged by a public school parcel. As New York State does not set forth density requirements or wastewater treatment requirements for flows of less than 30,000 gallons per day, public schools are currently not subject to the density requirements set forth in Article 6 of the Sanitary Code. In most cases, students who attend public schools likely live and attend school within the same subwatershed, as delineated within this SWP. Therefore, and consistent with the methodology used in regional nitrogen loading models, there would hypothetically be no net increase in estimated nitrogen loading from public schools. However, the evaluations within this SWP indicate that many subwatersheds require significant nitrogen load reductions to restore and protect surface water quality and further recommend wastewater upgrades in support of achieving those reductions. Therefore an evaluation of the impact that individual schools may have on water quality to subwatersheds that are sensitive to nitrogen loading is warranted and recommended for further study as discussed further in Section 8, Implementation Plan.

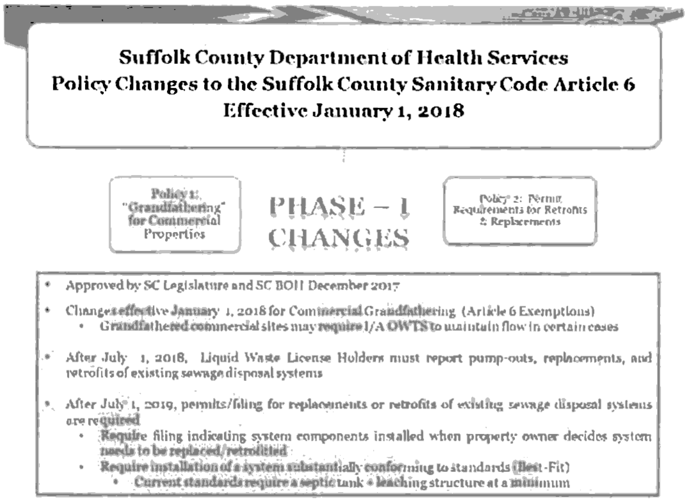
1.1.6.8 Article 6 Workgroup

As discussed previously, Article 6 of the Suffolk County Sanitary Code was enacted primarily to protect public health by limiting nitrogen loading from sanitary wastewater discharges to maintain groundwater nitrogen concentrations to levels of less than 4 mg/L in Groundwater Management Zones III, V and VI and to less than 6 mg/L everywhere else throughout the County. However, Article 6 did not consider the density or sanitary wastewater treatment levels necessary to protect downgradient groundwater-fed surface waters with the exception of GWMZ VI.



SUFFOLK COUNTY'S
RECLAIM OUR WATER INITIATIVE

ARTICLE 6 WORKGROUP
NOVEMBER 30, 2018



Suffolk County Department of Health Services
Policy Changes to the Suffolk County Sanitary Code Article 6
Effective January 1, 2018

Policy 1: "Grandfathering" for Commercial Properties

PHASE – I CHANGES

Policy 2: Permit Requirements for Retrofits & Replacements

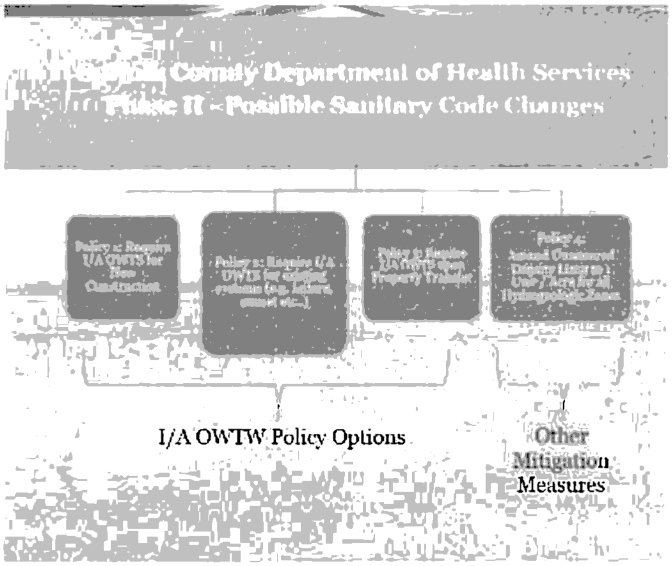
- Approved by SC Legislature and SC BOH December 2017
- Changes effective January 1, 2018 for Commercial Grandfathering (Article 6 Exemptions)
  - Grandfathered commercial sites may require I/A OWTS to maintain flow in certain cases
- After July 1, 2018, Liquid Waste License Holders must report pump-outs, replacements, and retrofits of existing sewage disposal systems
- After July 1, 2019, permits/filing for replacements or retrofits of existing sewage disposal systems are required
  - Require filing indicating system components installed when property owner decides system needs to be replaced/retrofitted
  - Require installation of a system substantially conforming to standards (Best-Fit)
    - Current standards require a septic tank + leaching structure at a minimum

In 2016, Suffolk County established the Article 6 Work Group, a multidisciplinary team of elected officials, regulatory agencies, Town/Village representatives, and other stakeholders to guide changes to the Suffolk County Sanitary Code that will ultimately support protection of County water resources. Through leadership from Suffolk County, the Article 6 Work Group recommended implementing sanitary code amendments in a two-phased approach. Phase I sanitary code changes, adopted in January 2018, included "no regrets" actions that did not need to wait for additional study. Phase I changes included:

1) Addressing 'Grandfathering' for commercial properties;

2) Establishing reporting requirements for sanitary pump-outs; and,

3) Eliminating the practice of replacing cesspools in-kind by requiring installation of a sanitary system that conforms to current standards.



Suffolk County Department of Health Services
Phase II – Possible Sanitary Code Changes

Policy 1: Require I/A OWTS for New Construction

Policy 2: Require I/A OWTS for existing systems (e.g. failure, [illegible] etc.)

Policy 3: Require I/A OWTS upon Property Transfer

Policy 4: Amend Unsewered Density Limit to 1 Unit / Acre for All Hydrogeologic Zones

I/A OWTW Policy Options

Other Mitigation Measures

Phase II sanitary code changes included recommendations on how, when, and where to use new I/A OWTS for the protection of the groundwater-fed surface waters and drinking water. Through consultation with the Article 6 Workgroup, it was concluded that this SWP would be the platform through which recommendations for Phase II sanitary code changes would be established. Phase II policy options that were retained for evaluation in the SWP include:

1) I/A OWTS required for new construction;

2) I/A OWTS required at system failure;

3) I/A OWTS required at property transfer; and,

4) Countywide increase in minimum lot size to 1 acre.

As of February 2019, 15 Article 6 Work Group meetings were held. The Article 6 Workgroup process was an invaluable tool for soliciting feedback from a broad spectrum of stakeholders. The process ultimately resulted in Sanitary Code changes that were defensible and supported by these stakeholders which helped streamline the approval process by local policymakers. Based on the overwhelming success of the program, it is recommended that the workgroup continue to be consulted as individual program recommendations within this SWP are rolled out for execution.

1.1.6.9 Evaluation of Existing Capacity of Scavenger Plants

Suffolk County accepts scavenger waste at the Bergen Point WWTP, and scavenger waste is accepted at the Town of Huntington and Town of Riverhead plants to treat waste sludge from STPs and pump-outs from onsite sewage disposal systems. STP sludge holding tanks are pumped on average once a month. Onsite sewage disposal systems are typically pumped only when they start to back up into the building they serve. This means if a system has a septic tank and leaching pool that the septic tank was excessively full, and solids were discharging from the septic tank, clogging leaching systems. Most I/A OWTS systems have septic tanks preceding the treatment system, which should be pumped out routinely to ensure system performance. If clogging or back-up occurs in an I/A OWTS it would mean the I/A OWTS system was probably improperly maintained and therefore wasn't treating wastewater to meet effluent total nitrogen requirements. The implementation of an I/A OWTS program will require that SCDHS create a pump-out schedule to maintain proper treatment. Some jurisdictions require pumping of an I/A OWTS every 3 to 5 years. Massachusetts Department of Energy and Environmental Affairs website provides a reference guide for homeowners which states "have your septic tank pumped out and system inspected every 3 to 5 years by a licensed septic contractor". Currently the existing overall treatment capacity of the three municipal scavenger waste plants is 1.46 MGD (See **Table 1-22**). In addition, there are at least two private scavenger waste facilities in Babylon, the 100,000 gpd Tully/Clearbrook facility in Bay Shore and the 400,000 gpd ClearFlo facility in Lindenhurst.

Table 1-22 Suffolk County Scavenger Plant Capacities

Scavenger Waste Treatment Plant	Capacity (MGD)
SCDPW Bergen Point	0.55
Town of Huntington	0.086
Town of Riverhead	0.1
Tully/Clearbrook	0.1
ClearFlo	0.4

Based upon preliminary evaluation of the recommended wastewater alternative discussed in Section 8.4.3 of this SWP, it estimated that up to approximately 0.08 MGD scavenger waste treatment capacity would be required for pump outs of I/A OWTS. As shown above, the existing municipal scavenger plant capacity is well above the anticipated demand for I/A OWTS maintenance. If future demand increases, the County could consider re-evaluation of Suffolk County Department of Public Works' (SCDPW) 2001 proposed 100,000 to 200,000 gpd scavenger waste treatment facility on County property in Yaphank to provide better access for waste generated in the eastern part of the County.

1.1.7 Surface Water Restoration Success Stories

Successful nutrient management programs that have resulted in measurable water quality improvements have been implemented on both a national and local level. These programs demonstrate, that if action is taken, Suffolk County can Reclaim Our Water to enable lasting fisheries, restored shellfish habitat, resilient wetlands that protect the coast, and a natural environment that is beneficial to humans and wildlife. To demonstrate the potential benefits associated with nutrient reduction and management, the following subsection provides an overview of three of the largest national and regional surface water quality improvement projects with measurable water quality improvements. Specific project case studies presented include:

- Tampa Bay Estuary Program, Florida
- Chesapeake Bay Program, Maryland & Virginia
- Long Island Sound Study
- Boston Harbor

Although not discussed further within this SWP, other successful programs include the Buzzard's Bay National Estuary Program and the Mumford Cove nutrient reduction project. Readers interested in these projects can find additional information on them at the following links:

- Buzzard's Bay:
  An estuary impacted by excess nutrient loading from septic systems resulted in the loss of eelgrass beds, accumulation of benthic algae smothering shellfish beds, and low oxygen concentrations that have resulted in fish kills. Buzzards Bay National Estuary Program was established in 1985 with a mission to protect and restore water quality and living resources in the Bay through the implementation of the Comprehensive Conservation and Management Plan (CCMP). The original 1989 Buzzards Bay CCMP contained 119 recommended actions. By 2009, 68 of these recommendations were complete with significant progress on many of the remaining ones. Some key indicators in Buzzards Bay, like reductions in shellfish bed closures, showed remarkable declines during this time period. The CCMP was updated in 2013 and lays out a variety of approaches for achieving the ultimate goal of a clean and healthy bay and surrounding watershed system of streams, ponds, wetlands, and groundwater.

  Buzzards Bay National Estuary Program. https://buzzardsbay.org/

  Southeast New England Program for Coastal Watershed Restoration.
  http://restore.buzzardsbay.org/index.html

- Mumford Cove:
  Until 1987, more than 3 MGD of secondary effluent was discharged into Mumford Cove. A sewage discharge outfall pipe diversion project resulted in significant nutrient reductions in the water column, 99 percent for both nitrogen and phosphorus, a reduction in the biomass of the macroalgae *Ulva lactuca* and a restoration of eelgrass beds.

  Long Island Sound Resource Center, a CT DEP and UCONN Partnership.
  http://www.lisrc.uconn.edu/eelgrass/index.html

An overview of the four success case studies documented in this SWP is provided below.

1.1.7.1 Tampa Bay, Florida – Restoration of an Estuary

The Tampa Bay nutrient management strategy has become a national and international model for successful watershed management collaborations. Coastal development and urban expansion between 1950 and 1980 negatively impacted the water quality in Tampa Bay (see **Figure 1-31**) due to excess nitrogen load inputs that resulted in high chlorophyll-*a* concentrations, a 50 percent decrease in seagrass coverage, fish kills and dead zones (2). Citizen outcry and community involvement was a major factor in bringing attention to Tampa Bay's declining water quality. Specifically, citizens complained of the phytoplankton and macroalgae that visually plagued the Tampa Bay waterways. Poorly-treated domestic wastewater sources, untreated industrial point sources, stormwater, as well as dredge and fill activities led locals to declare Tampa Bay as "dead". Scientists attributed the poor water quality conditions to coastal urbanization and polluting activities.

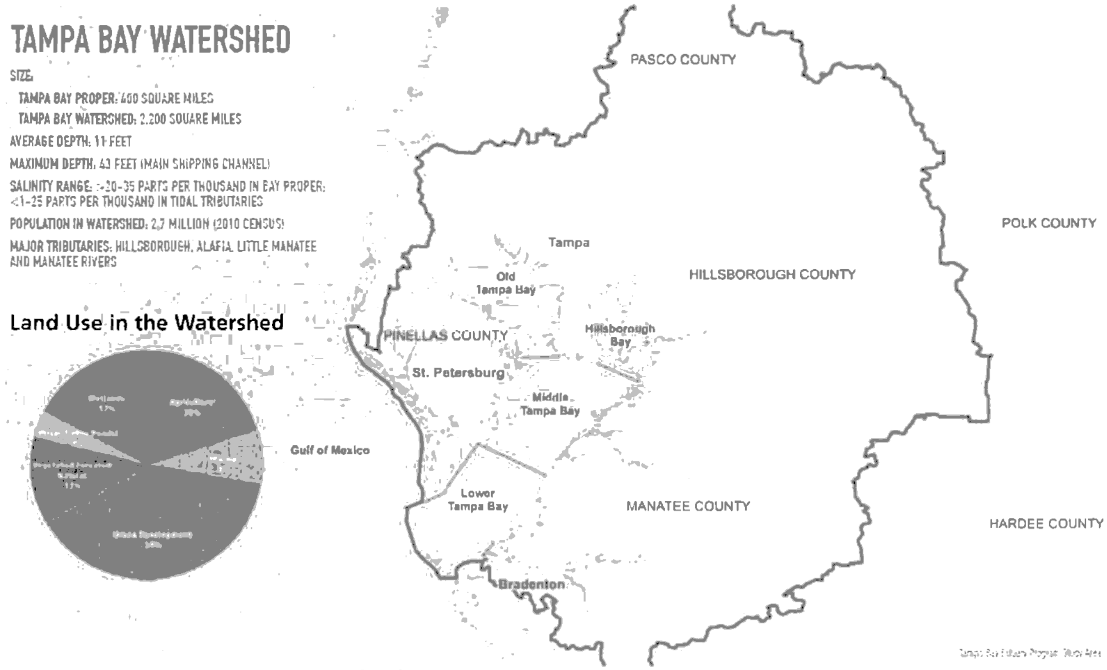


Figure 1-31 Tampa Bay Watershed

According to the Florida Department of Health, there are approximately 250,000 septic systems in the four coastal counties of the Tampa Bay area, many of which were built prior to 1970 and do not meet current standards. In order to amend the nitrogen load from these non-point sources, there have been efforts to convert properties to sanitary sewers when new developments are built, as well as field-testing new nitrogen reducing septic systems for areas where sewers are not feasible (1). Working together over several years, Tampa Bay stakeholders achieved water quality recovery by curbing nitrogen pollution through wastewater and fertilizer management. Wastewater nutrient loading alone was reduced by 90 percent, which jump-started the restoration of the Bay. Other

> "Due to a steady decline in total nitrogen loading from point, nonpoint and atmospheric sources, coincided with a decrease in chlorophyll-a, Tampa Bay has surpassed the seagrass recovery goal of 38,000 acres and now has an equivalent to the amount of seagrass acres present in the 1950s."

actions taken to improve water quality include stormwater regulations, fertilizer restrictions, and upgrades to polluting facilities. Nutrient management actions in the public and private sectors led to a steady decline in total nitrogen loading from point, nonpoint and atmospheric sources coincided with a decrease in chlorophyll-*a* and nitrogen concentrations. By the year 2006, all bay segments achieved Tampa Bay Estuary Program's set water quality targets(1). Nitrogen loads have been significantly reduced and as a result, reduced chlorophyll-*a* concentrations, greater seagrass abundance, and enhanced fishery stocks have been observed in long-term monitoring. These improvements in water quality occurred while the human population in the Tampa Bay metropolitan area increased by more than one million people (3). Tampa Bay is now considered a worldwide model for a recovering estuary.

The major elements and milestones of the restoration program include:

- Florida's 1972 Wilson-Grizzle Act required wastewater plants discharging to Tampa Bay to upgrade to advanced wastewater treatment standards or enact 100 percent reclaimed water. Over the next ten years, all major wastewater treatment plants upgraded to meet this requirement.

- In 1982, a Statewide Stormwater Rule was enacted which required nutrient management from all municipal stormwater systems within the Tampa Bay watershed.

- In the mid-1990s, the Tampa Bay Nitrogen Management Consortium, a public-private partnership, implemented water quality management targets and collectively accepted responsibility for meeting nitrogen load reduction goals. The Tampa Bay Nutrient Management Consortium utilized several approaches to reduce nutrient impacts to the Bay, including wastewater reuse and aquifer recharge, septic conversions and reduction in sewer overflows, stormwater treatment, reduction in fertilizer use, process improvements for industrial manufacturing and power plants, habitat restoration, and homeowner education. Members include the Tampa Bay Estuary Program, government and regulatory agencies, local phosphate mining companies, agricultural parties and electric utilities.

- Tampa Bay Estuary Program was established in 1991 after Congress designated Tampa Bay as an "estuary of national significance." In 1995, the Estuary Program adopted a goal of restoring seagrass to 1950 levels after decades in decline. Initial monitoring of Tampa Bay's ecology began in the 1950s, prior to the initial boom in coastal development, and continuous monitoring through various programs document the decline and recovery of the Tampa Bay estuary. By 2014, Tampa Bay surpassed the seagrass recovery goal of 38,000 acres, as shown in **Figure 1-32**. By 2016, seagrass coverage increased to 41,655 acres. (1) Eelgrass coverage is now equivalent to the number of acres present in the 1950s. (2)

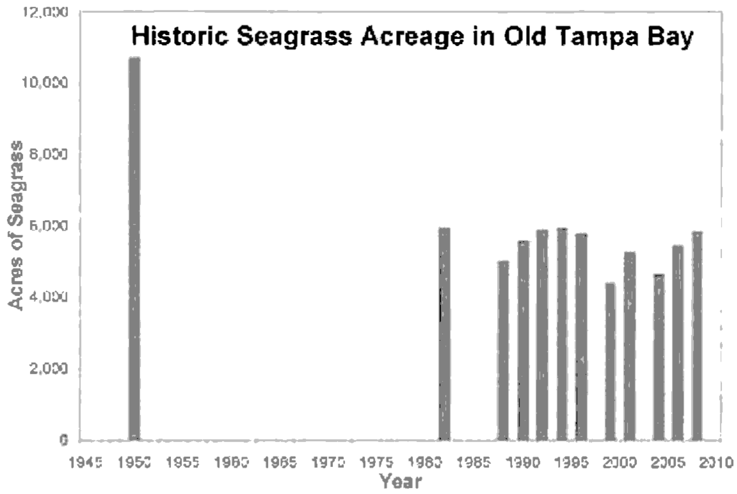


Figure 1-32 Seagrass Acreage with Time in Old Tampa Bay [1]

Successful public education efforts, like the 'Be Floridian' campaign by the Tampa Bay Estuary Program, urge residents to decrease their use of residential fertilizer. Print and digital ads, vehicle ads and billboards like **Figure 1-33** remind residents to avoid use of fertilizer in the summer. The 'Be Floridian' website provided resources to homeowners of how to maintain their property in a way that protects Florida's waterways.

An online pledge shown in **Figure 1-34**(1) infers that fertilizer use results in the loss of Florida's natural resources that residents and tourists enjoy. Evaluations of the campaign showed an increase in knowledge and compliance with fertilizer ordinances, with less than 5 percent of those polled identifying summer months as the best time to fertilizer lawns. (1)

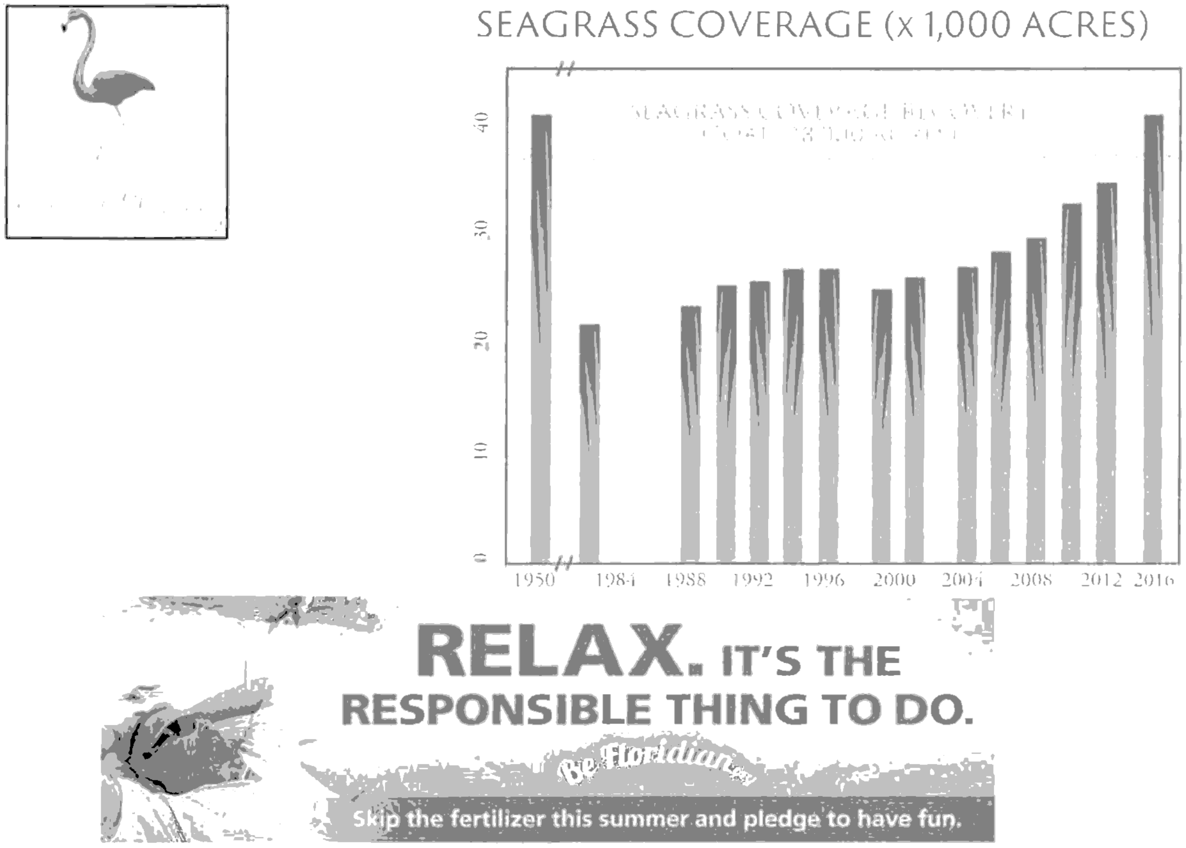


Figure 1-33 Examples of Tampa Bay Estuary's "Be Floridian" Campaign

FLORIDA IS IN DANGER OF LOSING ITS FUN

Without my support, lazy days at the beach and drinks with little umbrellas could become a thing of the past.

This summer, I will skip fertilizing my lawn and do the responsible thing instead: I will relax and have fun.

I PLEDGE TO GO TO THE BEACH

I PLEDGE TO GO FISHING

I PLEDGE TO GO BOATING

I PLEDGE TO DINE BY THE WATER

Figure 1-34 Tampa Bay Estuary Program (1)

(1) Tampa Bay Estuary Program (2017) Charting the Course: The Comprehensive Conservation and Management Plan for Tampa Bay

(2) Sherwood, E.T., Greening, H.S., Janicki, A.J., Karlen, D.J., (2015) Tampa Bay estuary: Monitoring long-term recovery through regional partnerships. *Regional Studies in Marine Science*

(3) Greening, H., Janicki, A., Sherwood, E.T., Pribble, R., Johansson, J.O.R., (2014) Ecosystem responses to long-term nutrient management in an urban estuary: Tampa Bay, Florida, USA. *Estuarine, Coastal and Shelf Science*

(4) Sherwood, E. (2010) Tampa Bay Estuary Seagrass Coverage Trends. https://www.tbeptech.org/data/other-data/73-tampa-bay-estuary-seagrass-coverage-trends

1.1.7.2 Chesapeake Bay Program

The Chesapeake Bay is an estuary of national and international significance for its economic, cultural and ecological importance. The Bay's watershed covers 64,000 square miles within six states and is home to 18 million people. Due to a significant decline in water quality resulting from wastewater discharges as well as urban and agricultural runoff within the watershed, the Chesapeake Bay Program was established in 1987. Several actions were taken to reverse the declining trend in water quality, including the organization of committees, the enactment of laws and implementation of best management practices. Amongst other recommendations and objectives, the primary overall objective of the initial program was to lower the amount of nitrogen and phosphorus entering the Bay by 40 percent by the year 2020. Since much of the Chesapeake Bay watershed was connected to sanitary sewers, a significant focus of the program concentrates on upgrading large scale wastewater treatment plants, see **Figure 1-35.** Other important actions taken include upgrading all individual on-site wastewater disposal systems where sewers were not feasible, agricultural regulations on feed types, animal manure management, forest buffers, erosion control and on-farm conservation practices, reducing the amount and entirely banning phosphorus in lawn fertilizers as well as suburban land planning. Additional elements of the program were enacted in 2000 and in 2010, including the establishment of a TMDL requiring a 25 percent reduction in nitrogen, a 24 percent reduction in phosphorus and 20 percent reduction in sediment in order to fully restore the Bay and its tidal rivers by 2025. In 2015, for the first time, annual progress in wastewater pollution reductions effectively met the TMDL 2025 nutrient pollution limits, due to upgrades at the ten largest wastewater treatment plants, the 472 municipal and industrial plants in the Bay watershed, as well as upgrades to individual on-site wastewater disposal systems.

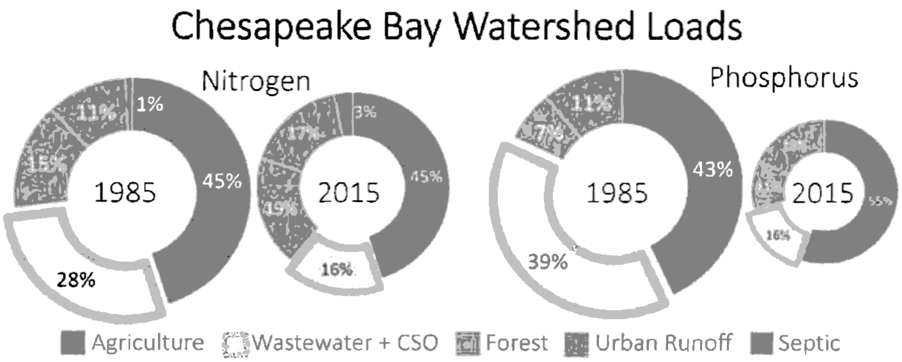


Figure 1-35 Nitrogen Loads to the Chesapeake Bay Watershed

Funding wastewater upgrades was key to the success of the restoration of the Chesapeake Bay. In Virginia, the Virginia Water Quality Improvement Act of 1997 was enacted in response to the need to finance the nutrient reduction strategies being developed for the Chesapeake Bay and its tributaries. The funding assists local governments and individuals prevent, reduce and control nutrient pollution from point source loads to the Chesapeake Bay. In 1999 the Virginia Land Conservation Act established a state tax credit to reward those who donate land or easements for conservation. In Maryland, the Bay Restoration Fund was enacted in 2004 to create a dedicated fund, financed by wastewater treatment plant users, to fund upgrades to Maryland's wastewater treatment plants so that they are capable of achieving effluent quality of 3 mg/L total nitrogen. In addition, the fund paid by septic system users is utilized to fund upgrades to onsite systems.

> "Nitrogen concentrations reductions by 23% since 1984 resulted in a restoration of 17,000 hectares of submerged aquatic vegetation, its highest cover in almost half a century."

Thirty years of scientific monitoring coinciding with the introduction of management actions to reduce nutrients within the Chesapeake Bay region have shown promising results. Submerged aquatic vegetation are a critical part of the Chesapeake Bay ecosystem and are good indicators of the overall health of the ecosystem. As shown in **Figure 1-36**, reductions in nitrogen concentration of 23 percent and phosphorus concentrations of 8 percent since 1984 resulted in a restoration of 17,000 hectares of submerged aquatic vegetation, its highest cover in almost half a century and four times the amount of vegetation than previously has been observed in the Chesapeake Bay (1), (2).This represents the biggest resurgence of underwater grasses ever recorded, not only in the Chesapeake Bay, but in the world.

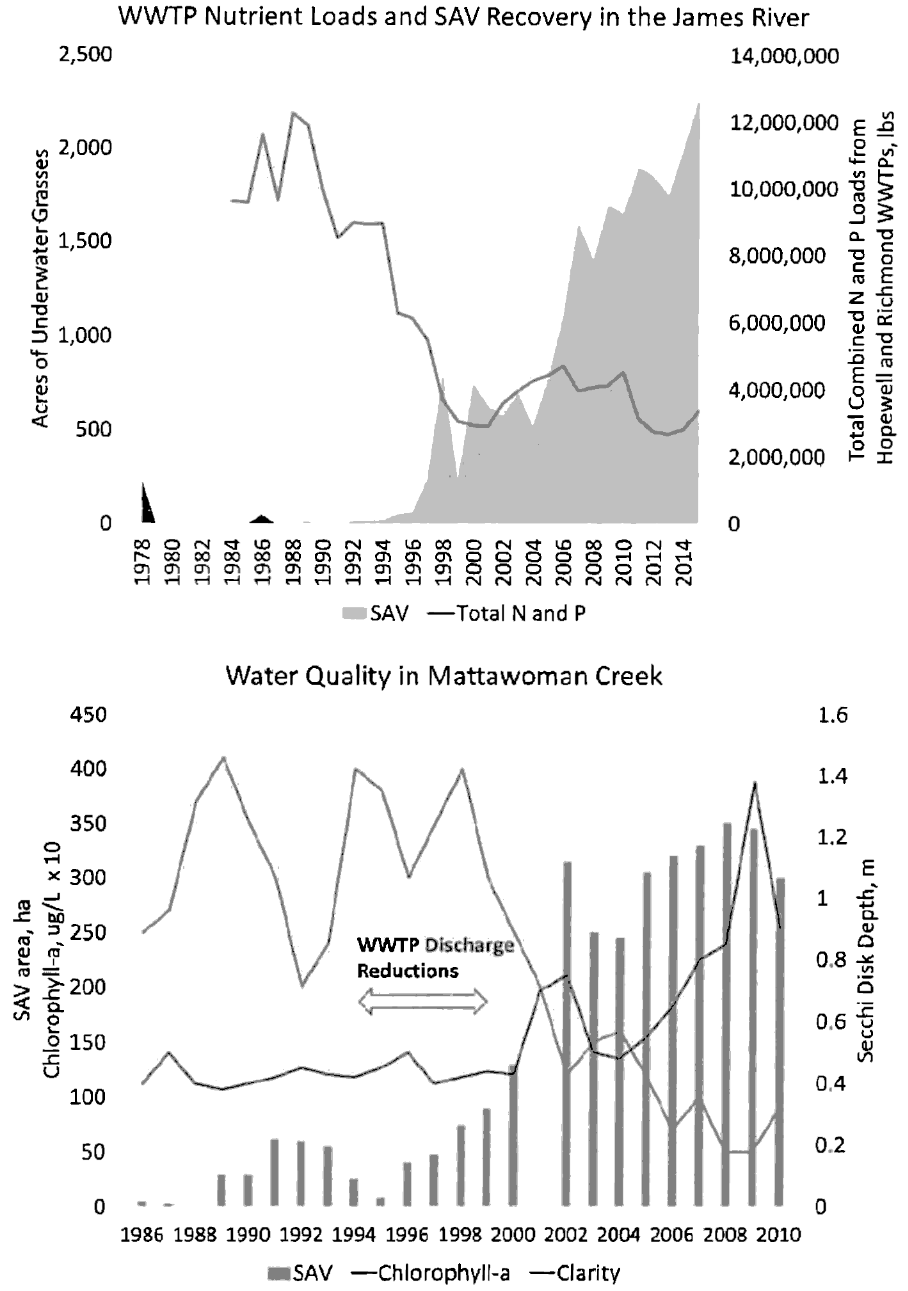


Figure 1-36 Wastewater Treatment Plant Loads, Submerged Aquatic Vegetation Recovery and Water Quality in the James River and Mattawoman Creek (Courtesy of USEPA (3))

Economically important and iconic species like striped bass, blue claw crab and oyster were once abundant fisheries but had seen major declines in population that required declaration of emergency moratoriums. Fortunately, improvements have been observed in all three of these species. The biomass of adult female striped bass is currently above the overfished threshold after a fishing ban in 1985 and harvest limits in multiple states were implemented. The Chesapeake Bay Program reported the adult female blue crab population was above the sustainable goal of 215 million. Lastly, although today's native oyster populations in the Bay are at less than 1 percent of historic levels, hundreds of acres of oyster reefs are successfully being restored in Maryland and Virginia waterways as part of a goal to restore reefs and populations in ten rivers by 2025.

(1)Lefcheck, J. S., et. al. (2018) "Long-term nutrient reductions lead to the unprecedented recovery of a temperate coastal region." *Proceedings of the National Academy of Sciences.* 115 (14) 3658-3662.)

(2) https://www.chesapeakebay.net/news/blog/rebounding_underwater_grasses_signal_recovering_chesapeake_bay

(3) https://www.epa.gov/sites/production/files/2016-06/documents/wastewater_progress_report_06142016.pdf

1.1.7.3 Long Island Sound Study

Since the Long Island Sound watershed consists of land in six different states (see **Figure 1-37**, LISS - http://longislandsoundstudy.net/ ecosystem-target-indicators/ watershed-population/), a joint effort was necessary to plan and implement water quality preservation and restoration efforts. The Long Island Sound Study (LISS) was formed in 1985 as a bi-state partnership focused on monitoring, restoring, and protecting the waters of the Long Island Sound. The partnership consists of federal and state agencies, user groups, concerned organizations, and individuals

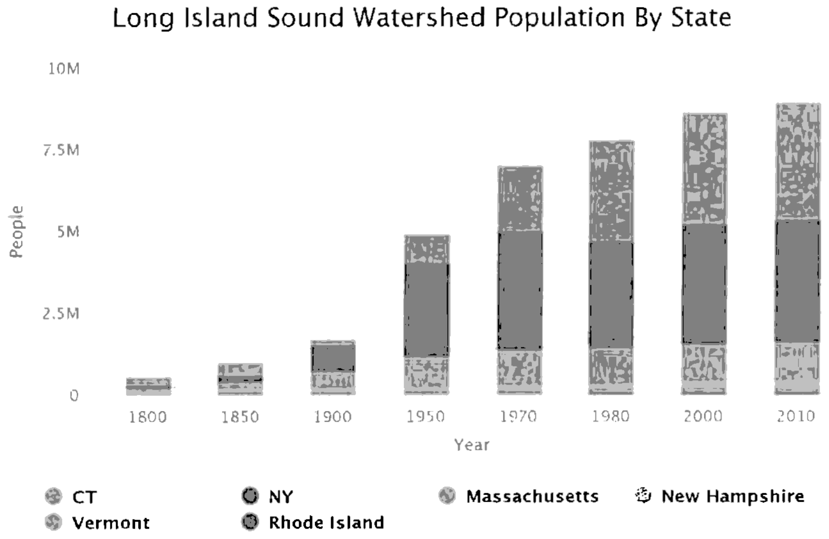


Figure 1-37 Long Island Sound Watershed Population by State

dedicated to implementing the Comprehensive Conservation and Management Plan which provides guidance on actions to address hypoxia, reduce toxic substances and pathogens, and restore natural habitats. Water quality monitoring and field surveys implemented through the plan have identified nitrogen pollution as the primary cause of the chronically low dissolved oxygen levels common to the LIS. The poor dissolved oxygen creates dead zones throughout the estuary, which result in fish kills and ecosystems in overall poor health (**Figure 1-38**).

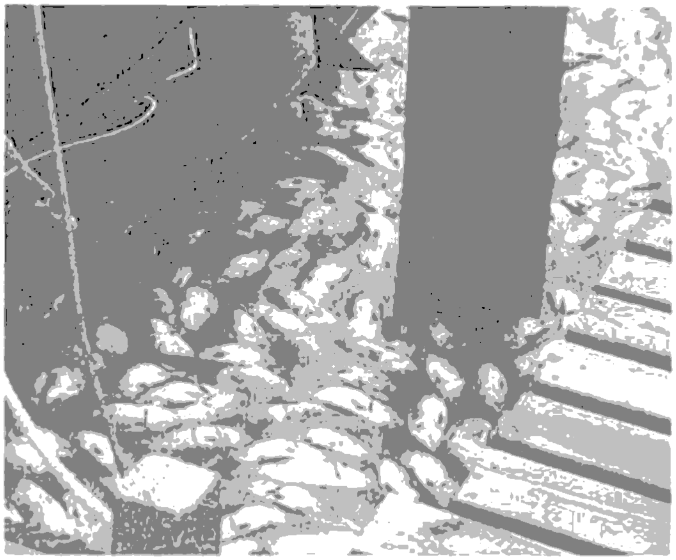


Figure 1-38 LISS - Menhaden kill, along the Mianus River, 1988

In 2000, the USEPA approved New York and Connecticut's TMDL plan, which called for a 58.5 percent reduction in nitrogen loads entering the Long Island by 2017. The TMDL identifies actions and schedules to reduce nitrogen from the Sewage Treatment Plants discharging to Long Island Sound waters. In addition, recommendations are provided to reduce nitrogen from tributary and atmospheric sources and to implement non-treatment alternatives (like bioextraction, aeration, etc.).

Nutrient concentrations from tributaries draining to Long Island Sound have continually decreased since the implementation of the TMDL actions. By 2011, the communities under the TMDL achieved nearly 83 percent of the target, representing 35,000,000 pounds of nitrogen prevented from entering the Sound by using upgrades to advanced wastewater treatment (1). TMDL goal progress as of 2015 included upgrades to a total of 106 wastewater treatment facilities resulting in a 51.5 percent reduction in nitrogen load, or 40 million fewer pounds of nitrogen, compared to baseline levels. In addition, Federal Clean Air Act controls have reduced atmospheric deposition in the watershed by an average of 25 percent for total nitrogen and 50 percent for nitrate (2). In 2016 and 2017, the states of New York and Connecticut successfully met and exceeded the goal to reduce nitrogen discharges by 58.5 percent, representing 45 million fewer pounds of nitrogen discharged annually to the Sound from human wastewater (**Figure 1-39**). As a result of the reduction of nitrogen loading into the Long Island Sound, there have been improvements to dissolved oxygen and overall water quality, benefitting fisheries, wildlife and eelgrass. A 2018 Newsday article reports that Long Island Sound water quality is graded regularly by Save the Sound and the most recent report showed grades improving throughout the Long Island Sound and stated reducing nitrogen in wastewater really does improve water quality (4).

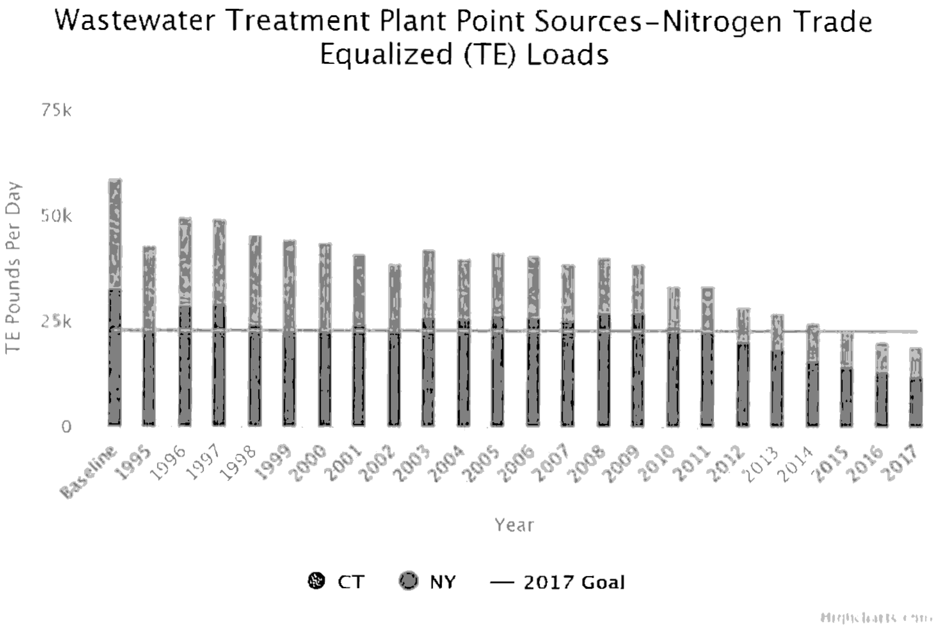


Figure 1-39 Wastewater Treatment Plant Point Sources Loading
http://longislandsoundstudy.net/ecosystem-target-indicators/nitrogen-loading

> "By 2016, New York and Connecticut successfully met and exceeded the goal to reduce nitrogen discharges by 58.5%, representing 45 million fewer pounds of nitrogen discharged annually to the Sound from human sewage. As a result, the average duration of hypoxia in Long Island Sound from 1991 to 2013 was 55 days per year, but in 2017 the duration of hypoxia was only 26 days."

Dissolved oxygen in the Long Island Sound commonly fell to levels less than NYSDEC's acute hypoxia standard of 3 mg/L in an area referred to as the "dead zone", which affected the entire western half of its area in some years. This condition of hypoxia can be lethal, harmful and/or limit growth in adult and juvenile fish, invertebrates, and other animals. However, as work to reduce nitrogen loads to the Sound has been implemented, the hypoxia severity has decreased in both area and duration. Annual monitoring of dissolved oxygen has documented a 57 percent reduction in the area of hypoxia compared to pre-2000 TMDL average hypoxic area (2). As shown in **Figure 1-40**, the average peak area of waters with unhealthy levels of dissolved oxygen in the Sound in 2018 was 89 square miles, less than half the pre-2000 average of 205 square miles (3). In addition, the duration of hypoxia has also had a decreasing trend since the implementation of nutrient reduction actions (**Figure 1-41**). The average duration of hypoxia in Long Island Sound from 1991 to 2013 was 55 days per year, but in 2017 the duration of hypoxia was only 26 days.

In addition to improvements in dissolved oxygen, significant positive trends have also been observed in eelgrass beds. As shown in **Figure 1-42**, eelgrass beds have increased in extent by 29 percent between 2002 and 2012 (2). The LISS now has a new goal to restore and maintain an additional 2,000 acres of eelgrass by 2035 from the 2012 baseline of 2,061. This target is planned to be achieved through implementation of additional water quality protections and associated reductions in land-based inputs of nutrients, as well as restoration and replanting efforts (5). The results of a recent eelgrass survey will determine how progress is coming along on the goal since 2012.

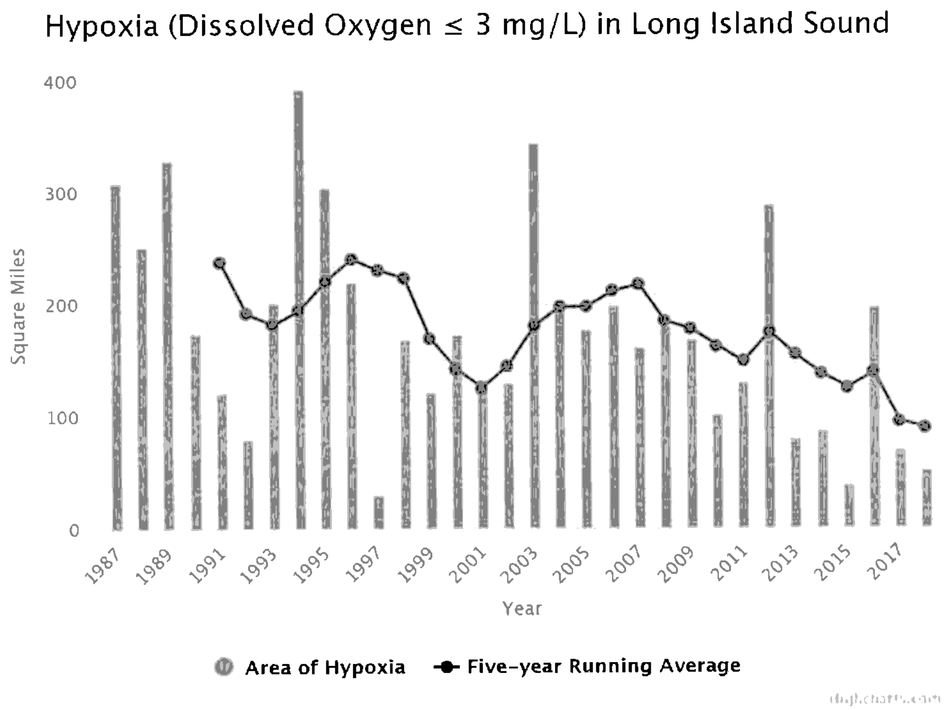


Figure 1-40 Area of Hypoxia in Long Island Sound http://longislandsoundstudy.net/ecosystem-target-indicators/lis-hypoxia/

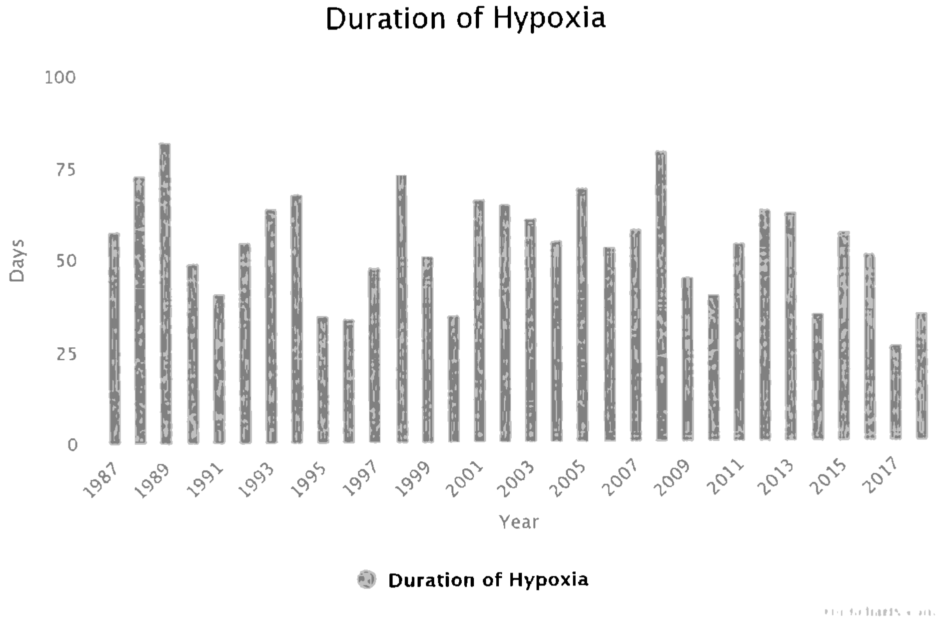


Figure 1-41 Duration of Hypoxia in Long Island Sound http://longislandsoundstudy.net/ecosystem-target-indicators/duration-of-hypoxia/

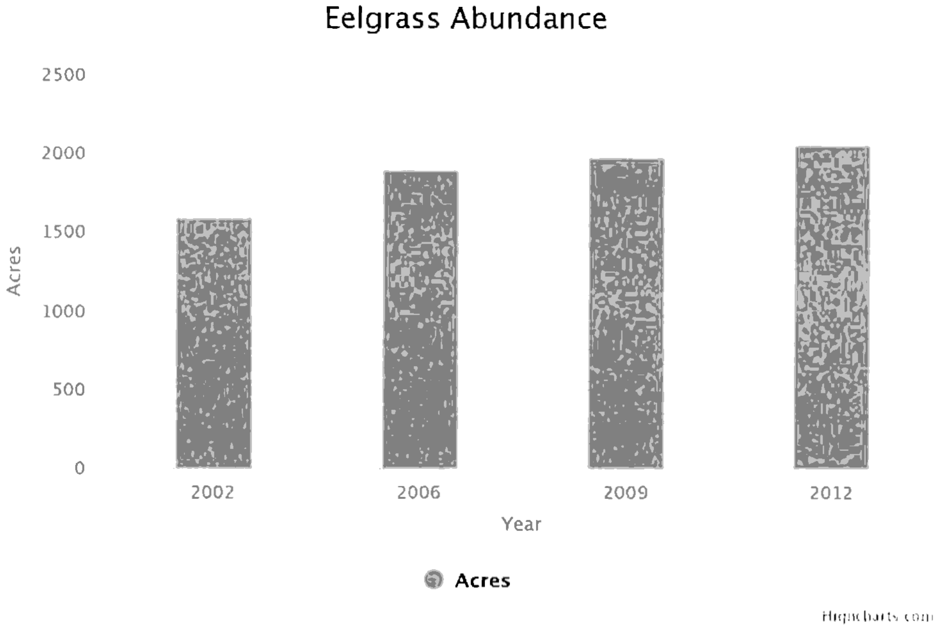


Figure 1-42 Eelgrass Abundance with Time in Long Island Sound
LISS- http://longislandsoundstudy.net/ecosystem-target-indicators/eelgrass-extent/

(1)Long Island Sound Study "2011-2012 Biennial Report – Protection & Progress"

(2) US EPA (2015) "Evolving the Long Island Sound Nitrogen Reduction Strategy."

(3) Long Island Sound Study. Spring 2018 Sound Update Newsletter – LISS's Year in Review: 2017 (Mark Tedesco)

(4) Gralla, Joan. "Report: LI Sound is cleaner and clearer." (2018-9-26). Newsday, p. A21.

1.1.7.4 Boston Harbor

Boston Harbor was once known as the "dirtiest harbor in America" but today is called a "Great American Jewel" due to the much improved water quality as a result of the infrastructure upgrades conducted by the Massachusetts Water Resources Authority (MWRA). After nearly $4 billion invested in wastewater treatment, the harbor clean-up is widely recognized as one of the nation's greatest environmental achievements. Eutrophication, measured by amounts of algae, nutrient concentrations (total nitrogen and total phosphorus) and bottom-water dissolved oxygen, have all changed to reflect better water quality since 1994 (Taylor, 2018). More than 300 technical reports and more than 1,000 scientific papers on the subjects of Boston Harbor and Massachusetts Bay document environmental conditions and changes since the new treatment facilities were brought on-line.

In the late 1980s, the harbor ecosystem was severely degraded, and in many regions, was unsafe for human recreational use (Taylor, 2018). In 1986, a federal court-ordered a 13-year schedule to construct wastewater treatment facilities and upgrades to the combined sewer system. The projects have included, among others, the Boston Harbor Project (BHP), the combined sewer overflow (CSO) Control Plan, the Toxic Reduction and Control (TRAC) pretreatment program, and programs to decrease infiltration into the sewer system (MWRA, 2015). The BHP, which is the construction of the Deer Island Treatment Plant and other major sewer facilities, was implemented from 1991 through 2000, and the CSO Control Plan from 1996 to 2015. In 2000, a 10-mile outfall pipe was completed to divert effluent discharges from the Deer Island Treatment Plant out of the Harbor and into the well-flushed Massachusetts Bay. The TRAC pretreatment and the Infiltration and Inflow programs are ongoing.

Treatment upgrades and diversion of wastewater discharges offshore, lowered nitrogen, phosphorus and organic carbon direct inputs into the Harbor by 80 to 90 percent (Taylor, et. al, 2019). Reduced nitrogen concentrations can be seen in **Figures 1-43** and **1-44**. The reduction of nitrogen inputs resulted in a decrease of phytoplankton biomass (algae), increase in dissolved oxygen levels and expansion of seagrass beds.

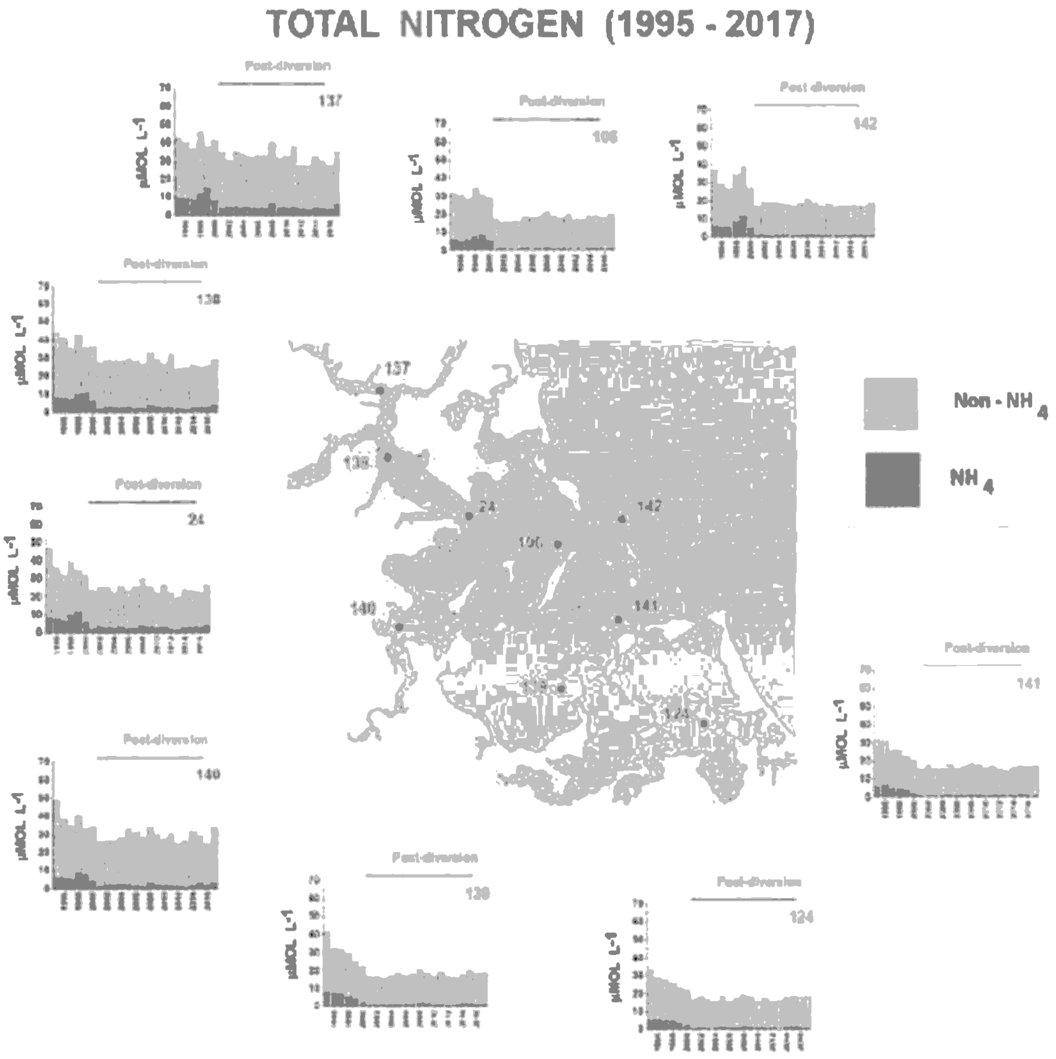


Figure 1-43 Annual total nitrogen concentrations partitioned into the non-ammonium and ammonium fractions at nine sampling locations, 1995-2015 (Taylor, 2018)

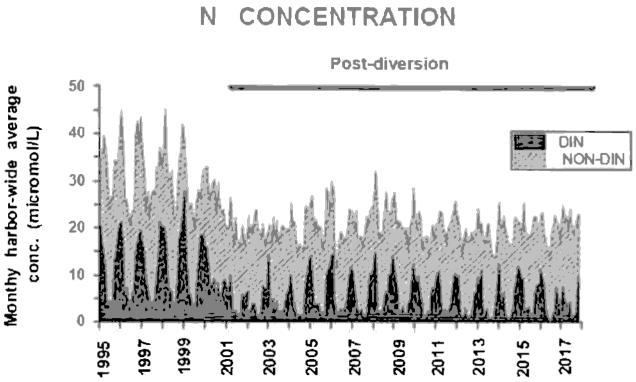


Figure 1-44 Time series plot of monthly harbor-wide average total N concentrations partitioned into the dissolved inorganic N (DIN) and non-DIN fractions, 1995-2017 (Taylor, 2018)

A study conducted by researchers from the Woods Hole Oceanographic Institute and University of Massachusetts Boston sought to develop an economic evaluation of the Boston Harbor Cleanup through a comparison of cleanup costs and relevant ecosystem service values. The results suggest that the ecosystems in the study area provide services to society with a capitalized value ranging from $30 to $100 billion (Jin, et. al, 2018). The $4.7 billion cost of the Boston Harbor Project and Combined Sewer Overflow project is about 5 to 16 percent of the total asset value of ecosystem services. The water quality improvement endeavors completed in Boston Harbor resulted in abundant benefits to the ecosystem, economy and surrounding community. Improvements have been realized harbor-wide and have allowed this "Great American Jewel" to serve as a success story for other harbor-front cities to follow.

1.2 Suffolk County Environmental Setting

Suffolk County's topographic features are generally characterized by sloping hills and vertical bluffs along the glacial moraines of the north shore; and moderately flat lands associated with glacial outwash deposits along the south shore. A series of off-shore barrier beaches that enclose shallow embayments, creating coastal lagoons that are poorly flushed and therefore vulnerable to nutrient related water quality degradation are located along the south shore. Suffolk County receives an average of 48.84 inches of precipitation per year (measured at Brookhaven National Laboratory from 1949 through 2016). Due to the nature of Suffolk County's topography and soils, most precipitation in Suffolk County travels vertically down to recharge the aquifer either naturally or through stormwater recharge basins or pools, or is lost to evapotranspiration. As discussed in Section 8.4.12.5 of the SWP, stormwater is generally not believed to be a major source of nutrient pollution for most water bodies in Suffolk County. However, it is possible that nutrient pollution from stormwater is locally significant in smaller individual subwatersheds along the north shore where significant topographic slopes are present, or in smaller undrained ponds along the south shore.

Suffolk County's sole source aquifer system includes a groundwater reservoir that is divided into three main aquifers (in descending order) – the upper glacial, Magothy, and Lloyd. The surficial upper glacial aquifer can be up to several hundred feet thick, and consists of highly permeable sand and gravel outwash deposits on the south shore and the less permeable, highly variable (e.g., silts, sands, gravels, clays, etc.) glacial moraine till deposits to the north. Groundwater in the upper glacial aquifer provides the majority of the baseflow that reaches Suffolk County's coastal waters and is generally highly aerobic with little organic carbon. Water falling on the hydrogeologic center of the County near the groundwater divide, moves vertically downward in the groundwater system to the deeper aquifers. The velocity of groundwater through the system is on the order of 1 to 2 feet per day in the upper glacial aquifer, and less in the deeper aquifers.

Using 2011 estimates from Suffolk County Planning, major land uses in Suffolk County include: Residential (38.1%); Recreation and Open Space (25.3 percent); and Transportation (12.4 percent), with seven other land uses making up the balance. These include: Commercial (3.0 percent); Industrial (2.4 percent); Institutional (4.9 percent); Agriculture (6.5 percent); Vacant (6.2 percent), Utilities (1.0 percent); and Waste Handling (0.3 percent). The majority of land used for residential purposes is medium density (2-4 dwellings/acre). Farming remains a very important industry in the eastern portion of the county, especially in the Towns of Riverhead, Southold, and Southampton. As a result of the nearly 1,000 miles of shoreline, water related commerce, recreation, and tourism are major activities in Suffolk. The land devoted to recreation and open space includes beaches, marinas, parks, campgrounds, preserves, and over 50 golf courses. Individual land use maps for all subwatersheds evaluated in the SWP are provided in Appendix D.

The Suffolk County Comprehensive Master Plan 2035 (Suffolk County Department of Economic Development and Planning, 2015) indicates a population increase of 6 percent since 2000 to a total of approximately 1.50 million in 2010. Current population trends suggest that by 2035 approximately 1.63 million residents will live in Suffolk County. Population density is concentrated in the five western towns, Huntington, Babylon, Smithtown, Islip, and Brookhaven, which contain 91 percent of the County's population. Demographic trends include an aging population (people age 65 and over increased from 10.7 percent of the population in 1990 to 14.9 percent in 2013) and increasing diversity (the minority population increased from 15 percent in 1990 to 28 percent in 2010).

1.3 Stakeholder Participation

Suffolk County has endeavored to develop the SWP in an open and transparent process, and has incorporated the information, experiences, perspectives and feedback provided by a wide variety of stakeholders engaged throughout the SWP development. Stakeholder participation included:

- Focus Area Work Groups convened by SCDHS to provide technical oversight and guidance on specific technical issues;
- A Wastewater Plan Advisory Committee (WPAC) comprised of representatives with diverse backgrounds and perspectives to provide input, feedback and guidance on SWP development, and
- Stakeholders representing a range of perspectives and interests.

An overview of each group's participation is provided in the following pages.

In addition, SCDHS held bi-weekly project progress calls to update project partners including representatives from the Long Island Regional Planning Council, New York State Department of Environmental Conservation (NYSDEC), New York State Department of State (NYSDOS), State

University of New York School of Marine and Atmospheric Sciences (SUNY SoMAS), Suffolk County Department of Economic Development and Planning (SCDEDP), the Suffolk County Executive's Office, the United States Environmental Protection Agency (USEPA) and the United States Geological Survey (USGS).

Finally, SCDHS presented interim work products and solicited feedback at meetings with individual stakeholders including the Long Island Farm Bureau, NYSDEC, the Peconic Estuary Program (PEP), the Nature Conservancy (TNC), and USEPA.

1.3.1 Focus Area Workgroups

SCDHS convened five Focus Area Work Groups to provide technical expertise, share data and information and guide technical direction. The original Focus Area Work Group subject areas and members are listed on **Table 1-23**. As the project progressed, additional experts and stakeholders contributed to Focus Area Work Group technical meetings and discussions.

Proposed approaches and interim work-products were presented to the Focus Area Work Groups and feedback was obtained at in-person meetings, net-meetings, conference calls and via email.

Table 1-23 Focus Area Work Groups Memberships

Nitrogen Load Model	Groundwater Model	Surface Water Model	Priority Areas/Endpoints
Dr. Chris Gobler, SUNY SoMAS	Chris Schubert, USGS	Dr. Chris Gobler, SUNY SoMAS	Dr. Chris Gobler, SUNY SoMAS
Chris Schubert, USGS	Dr. Chris Gobler, SUNY SoMAS	Dr. Robert Wilson, SUNY SoMAS	Cameron Ross, NYSDEC
Cameron Ross, NYSDEC	Cameron Ross, NYSDEC	Dr. Charles Flagg, SUNY SoMAS	Ken Kosinski, NYSDEC
Ken Kosinski, NYSDEC	Ken Kosinski, NYSDEC	Chris Schubert, USGS	Alison Branco, PEP/TNC
Alison Branco, PEP/TNC	Alison Branco, PEP/TNC	Cameron Ross, NYSDEC	Mike Jensen, SCDHS
Ken Zegel, SCDHS	Ken Zegel, SCDHS	Ken Kosinski, NYSDEC	Ken Zegel, SCDHS
Stephen Lloyd, TNC	Ron Paulsen, SCDHS	Alison Branco, PEP/TNC	Jason Hime, SCDHS
Jamie Vaudrey, UCONN	Steve Colabufo, SCWA	Ken Zegel, SCDHS	Jim Latimer, USEPA
Steve Pacenka, Cornell	Ruth Izraeli, EPA	Jim Ammerman, LIS	Brian Howes, UMASS
Nora Catlin, Cornell	Kristina Heinemann, EPA	Myra Fedyniak/Nancy Rucks, SSER	Tim Kelly, Nassau County
Myra Fedyniak/Nancy Rucks, SSER	Dr. Henry Bokeniewicz, SUNY SoMas	Kristina Heinemann/EPA	Marci Bortman, TNC
Kristina Heinemann/EPA	Jim Ammerman, LIS	Jim Ammerman, LIS	Myra Fedyniak/Nancy Rucks, SSER

Nitrogen Load Model	Groundwater Model	Surface Water Model	Priority Areas/Endpoints
Jim Ammerman, LIS	Tim Kelly, Nassau County	Tim Kelly – Nassau County	Mark Tedesco, LIS
Tim Kelly – Nassau County	Stephen Lloyd, TNC	Stephen Lloyd, TNC	Kristina Heinemann/EPA
Awarded Consultant Experts	Awarded Consultant Experts	Awarded Consultant Experts	Soren Dahl, NYSDEC
			Awarded Consultant Experts

Acronyms:

CCWT – Center for Clean Water Technology
LIFB – Long Island Farm Bureau
LIS – Long Island Sound
NYSDEC – New York State Department of Environmental Conservation
PEP – Peconic Estuary Program
SCDEDP – Suffolk County Department of Economic Development and Planning
SCDHS – Suffolk County Department of Health Services
SSER – South Shore Estuary Reserve
SCWA – Suffolk County Water Authority
SUNY SoMAS – State University of Stony Brook School of Marine and Atmospheric Sciences
TNC – The Nature Conservancy
UCONN – University of Connecticut
UMASS – University of Massachusetts
USEPA – United States Environmental Protection Agency
USGS – United States Geological Survey

Project input provided by the Focus Area Work Groups has been documented in the Task 5, Task 6, Task 7 and Task 11a memoranda and incorporated throughout this SWP. A complete list of Focus Area Work Group meeting participants along with meeting minutes for each Work Group may be found in **Appendix A-1**.

1.3.2 Wastewater Plan Advisory Committee

Because it was important for Suffolk County to develop a SWP based upon the best available information and input from a variety of perspectives, SCDHS convened a Wastewater Plan Advisory Committee (WPAC) comprised of advisors with a wide range of expertise and experiences to help to guide SWP development. Four WPAC meetings were scheduled to present SWP plans and progress and to solicit feedback, input and guidance.

The WPAC included representatives from academia, environmental organizations, local and state government, regulatory agencies and the Suffolk County Water Authority (SCWA); a complete list of WPAC members (in alphabetical order) is provided in **Table 1-24**. In total, more than 140 participants were invited to participate in the WPAC meetings.

Table 1-24 Subwatershed Wastewater Plan Advisory Committee

WPAC Membership
Citizens Campaign for the Environment

WPAC Membership
Cornell Cooperative Extension
Long Island Builders Institute
Long Island Commission on Aquifer Protection (LICAP)
Long Island Farm Bureau
Long Island Nitrogen Action Plan – Executive Council and Project Management Team
Long Island Pine Barrens Society
Long Island Sound Study
New York State Department of Environmental Conservation
New York State Department of Health
New York State Department of State – South Shore Estuary Reserve
New York State Legislators
Peconic Baykeeper
Peconic Estuary Program
Sea Grant
Seatuck Environmental Association
State University of New York – Center for Clean Water Technology
Stony Brook University School of Marine and Atmospheric Sciences
Subwatershed Wastewater Plan Consultant Team
Suffolk County Board of Health
Suffolk County Department of Economic Development and Planning
Suffolk County Department of Health Services
Suffolk County Department of Public Works
Suffolk County Executive Office
Suffolk County Legislators
Suffolk County Water Authority
The Nature Conservancy
Town of Babylon Planning Department
Town of Brookhaven Planning Department
Town of East Hampton Planning Department
Town of Huntington Planning Department
Town of Islip Planning Department
Town of Riverhead Planning Department
Town of Shelter Island Planning Department
Town of Smithtown Planning Department
Town of Southold Planning Department
Town of Southampton Planning Department
United States Environmental Protection Agency
United States Geological Survey

Each of the four meetings were scheduled to solicit WPAC input and guidance on specific aspects of the plan development, as shown by **Table 1-25**.

Table 1-25 WPAC Meeting Overview

WPAC Meeting	Meeting Topics and Requested Input
July 19, 2016	▪ Introduction of SWP Objectives ▪ Request WPAC input and feedback on proposed project scope, list of subwatersheds, and available data
December 22, 2016	▪ Presentation of subwatershed mapping ▪ Presentation of nitrogen load calculation approach ▪ Request for WPAC assistance in filling data gaps and identifying potential pilot areas
June 7, 2018	▪ Presentation of database development ▪ Overview of subwatershed residence time modeling ▪ Overview of subwatershed ranking approach and proposed nitrogen load reduction approach ▪ Request WPAC input and feedback on preliminary priority area mappings
January 24, 2019	▪ Presentation of priority areas and aggregated wastewater management areas ▪ Presentation of nitrogen load reduction goals ▪ Presentation of proposed implementation framework including schedule, costs and implementation triggers

WPAC meeting agendas, PowerPoint presentations and minutes are included in **Appendix A-2** of this SWP along with a complete list of participants in each meeting.

1.3.3 Stakeholder Meetings

In addition to the formal input and guidance provided by the technical experts who participated in the Focus Area Work Groups and the WPAC, SCDHS organized two stakeholder meetings to present the SWP to an even broader spectrum of interested stakeholders. The stakeholder invitation list included more than 300 individuals from academia, environmental organizations, local and state government, regulatory agencies, and the wastewater management industry, and various interest groups. These meetings provided an opportunity both for the County to introduce the SWP to stakeholders and for stakeholders to identify questions and concerns. During the first meeting, held on May 16, 2016, Suffolk County introduced the County's Reclaim Our Waters initiative and NYSDEC provided an overview of the Long Island Nitrogen Action Plan (LINAP). Proposed changes to the County's Sanitary Code and the scope of the SWP were outlined and NYSDEC, the County and their consultant team responded to stakeholder questions.

The PowerPoint presentation and a list of attendees from the first stakeholder meeting may be found in **Appendix B.**

Suffolk County posted the draft SWP on The Subwatersheds Wastewater Plan - A Roadmap to Reclaim Our Water on July 30, 2019. The draft SWP is an appendix to the the draft Subwatersheds Wastewater Plan Generic Environmental Impact Statement (GEIS) that was posted to https://www.suffolkcountyny.gov/Portals/0/formsdocs/planning/CEQ/2019/DGEIS%20for%2

0SWP August%202019 Public%20Posting.pdf?ver=2019-08-16-131340-510 on August 16, 2019. The SWP was presented to the public at two public hearings. The first public hearing was held on September 5, 2019 at Suffolk County's Legislative Auditorium in Riverhead and the second public hearing was held on September 6, 2019 at the Suffolk County Community College Brentwood campus. Suffolk County accepted verbal comments at both hearings and written comments from the public on both the GEIS and the SWP from August 16-October 16, 2019. A record of both public meetings, comments received and a detailed response to comments may be found at https://www.suffolkcountyny.gov/Departments/Economic-Development-and-Planning/Planning-and-Environment/Regulatory-Review/Council-on-Environmental-Quality#cseis.

1.4 Quality Assurance Project Plans

As the SWP project was initiated, two Quality Assurance Project Plans (QAPPs) were developed to document the SWP project's quality control (QC) and quality assurance (QA) requirements and responsibilities. The primary SWP QAPP was developed by CDM Smith to describe the quality control procedures for development of the majority of the SWP tasks. A second QAPP, developed by the consultant Henningson Durham & Richardson Architecture and Engineering P.C. (HDR) under contract to the New York State Department of State describes the quality control procedures that guided development of the surface water hydrodynamic modeling used to characterize the surface water residence times.

1.4.1 Subwatersheds Wastewater Plan Quality Assurance Project Plan

The primary SWP QAPP, provided in **Appendix C-1**, includes a detailed description of:

- Key project team members, required skills, experience and responsibilities for each of the 12 project tasks within the SWP scope;
- The project schedule;
- Communication procedures;
- Data needs, potential data sources, data quality control;
- Project checking and documentation requirements;
- The existing Suffolk County groundwater model codes, modeling framework and model development and calibration;
- Groundwater model updates, refinements and assumptions that were implemented for the SWP;
- The approach for using the models to delineate subwatersheds and to simulate nitrogen fate and transport through the aquifer system, and
- Nitrogen loading model development and planned application.

The QAPP recognized that a wide variety of existing data was to be assembled and used during development of the SWP. Initially, the SWP was to be based on available data and existing tools to develop a first order assessment of nitrogen loading, water quality response and wastewater treatment priorities. No field data collection tasks were identified in the QAPP and the SWP was to be based on secondary data; e.g., data collected to support other programs and purposes.

The QAPP documented that sufficient secondary data did not exist to comprehensively characterize a number of the subwatersheds, nitrogen loading and attenuation, ecological responses to nitrogen loading and wastewater treatment technologies. As the work proceeded, data gaps and data needs were identified to help prioritize additional data needs that can be addressed more rigorously by LINAP and other water quality management initiatives.

Because secondary data was to be used throughout the project, it was recognized that task-specific data quality objectives would guide whether a specific existing data set should be considered. Most data was to be obtained from agencies with existing quality assurance/quality control programs, and as such would be used without significant additional scrutiny. For example, data obtained from LINAP cooperators or Federal, State or County agencies including USGS, NOAA, NYSDEC, SCDHS or SCWA was not validated or verified independently to document the quality achieved, but documented quality concerns were considered and noted. Similarly, it was presumed that the quality of published data had previously been verified; documented concerns would be considered and noted, but no independent data validation was to be performed. Secondary data sources were identified as each task deliverable was submitted. Data from laboratories that are not ELAP certified or from sources that cannot provide an approved QAPP were to be flagged due to potentially less rigorous QA procedures.

To provide an initial dataset for water bodies with no existing data, SCDHS Department of Environmental Quality (DEQ) collected additional field data from dozens of water bodies as described further in Section 2.1.3.1. This primary field data collected and analyzed by SCDHS to support the subwatershed characterizations was collected in accordance with requirements set forth in the Peconic Estuary Program Surface Water Quality Monitoring QAPP.

The QAPP was amended in June 2017 to identify the use of a new, countywide, 2016 land use coverage dataset developed by the SCDEDP in 2017. The new land coverage was built on a unified set of consistent assumptions and methodology for all ten towns.

1.4.2 Surface Water Hydrodynamic Quality Assurance Project Plan

The surface water modeling effort implemented under contract through New York State Department of State (NYS DOS) on behalf of the NYSDEC was documented in a model-specific QAPP. The surface water hydrodynamic modeling QAPP is provided in **Appendix C-2** and describes the following:

- Key project team members, required skills, experience and responsibilities;
- The development of Environmental Fluid Dynamics Code (EFDC) models;
- Data needs, potential data sources, data quality control;
- Application of the models to calculate surface water flushing times
- Procedures used to confirm that modeling results are valid and defensible.

1.5 Report Organization

The SWP has been prepared in ten major sections as defined herein.

Section 1 of the SWP:

- Documents the purpose and need of this SWP, including:
    - Recommendations from previous studies and programs;
    - An overview of the impact of nitrogen on the groundwater and surface water resources in the County;
    - Identification of other wastewater constituents of concern;
    - Discussion of the economic impacts of water quality and
    - Wastewater management in Suffolk County
- Identifies the many stakeholders and technical experts who participated in SWP development and
- Summarizes the quality planning that established the approach to develop the SWP.

Section 2 describes the technical approach and methodology that was implemented to:

- Identify and delineate the subwatersheds,
- Estimate parcel-specific nitrogen loads,
- Characterize and rank the subwatersheds' priorities for nitrogen load reduction,
- Establish priority areas and nitrogen load reduction goals,
- Evaluate wastewater management alternatives,
- Evaluate pilot areas,
- Evaluate the use of open space preservation to accomplish nitrogen load reduction goals,
- Evaluate the impacts of changing permitted density in Hydrogeologic Zone IV,
- Consider pathogen impacts on wastewater planning and
- Develop recommendations for centralized sewage treatment or areas with special conditions.

In addition, Section 2 also presents a summary of the findings of each of the evaluations described above.

Section 3 documents the methodology, findings, and recommendations for the restoration and protection of groundwater and drinking water resources in Suffolk County, including:

- Simulated nitrogen concentrations in the upper glacial aquifer and
- Simulated nitrogen concentrations in community supply wells resulting from nitrogen loading from existing land uses and potential future build out conditions
- Recommended nitrogen load reduction goals and
- Wastewater management approaches.

Section 4 documents the methodology and recommendations for the integrated, Countywide wastewater management program that incorporates the findings of the previous sections including:

- Integration of the surface water and groundwater priority areas;
- Identification and description of integrated implementation phases;
- Methodology, evaluation, and recommendations of implementation alternatives assuming the countywide use of I/A OWTS (with the exception of presumptive sewered areas as defined below);
- Methodology and findings for sewering and clustering expansion alternatives;
- Methodology and results of the line smoothing exercise used to convert model generated boundaries into administratively implementable boundaries; and.
- Anticipated environmental benefits of SWP implementation.

Sections 5, 6 and 7 provide summaries of the model findings, priority ranks, load reduction goals, and wastewater management strategies for each of the major estuary programs in Suffolk County including:

- Section 5 – Long Island Sound subwatersheds;
- Section 6 – Peconic Estuary Subwatersheds; and,
- Section 7 – South Shore Estuary Subwatersheds.

Section 8 summarizes the County's approach to implement the SWP, based on the principles of adaptive management.

Section 9 summarizes the data gaps and recommendations for further evaluation.

Section 10 lists the primary references used to guide the SWP.

This SWP includes the results from a number of individual tasks that were completed together with Suffolk County, Focus Area Work Groups, the Wastewater Plan Advisory Committee and other stakeholders. **Table 1-26** below identifies individual tasks and the SWP section(s) where they are described. In some cases, additional detail is provided in the individual task memoranda.

Table 1-26 SWP Tasks and Plan Sections

SWP Contract Task	Subwatersheds Wastewater Plan
Task 1 – Wastewater Plan Advisory Committee, Meetings and Preliminary Submittal Services	Appendix A – Wastewater Plan Advisory Committee Meeting Materials Appendix B – Stakeholder Meeting Materials Appendix C – Quality Assurance Project Plan
Task 2 – Subwatersheds Delineation Services	Sections 2.1.2 and 2.1.4 Appendix D – Subwatershed Mappings and Planning Criteria
Task 3 - Data Inventory Services	Section 2.1.3
Task 4 – Nitrogen Load Estimate Services	Section 2.1.5 Appendix D
Task 5 – Surface Water Modeling Services	Section 2.1.6
Task 6 – Tiered Priority Area Services	Section 2.1.7 Appendix D
Task 7 – Nitrogen Load Reduction Goals and Ecological Endpoints for Surface Water Services	Section 2.1.8
Task 8 – Evaluation of Wastewater Alternatives for Surface Water Services	Section 2.1.9 Section 2.2.1 Section 4.1
Task 9 – Nitrogen Load Reduction Goals and Wastewater Alternatives for Public Water Supply Wells and Groundwater Services	Section 3.3 Section 3.4 Section 4.2
Task 10 – Cost and Benefit Analysis Services	Section 2.2.2 Section 2.2.3 Section 2.2.6 Section 3.5 Section 4.5 Appendix E Pilot Area Evaluations
Task 11 – Groundwater Model	Section 2.1.4 Section 3

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Section 1 Tables

Table 1-18 List of Suffolk County STPs

Sewage Treatment Plants		
STP Name	Treatment type	Secondary/ Tertiary
Amber Court of Smithtown	SBR	T
Amneal Pharmaceuticals	MBR	T
Apex Rehab, Birchwood, Nursing Home	SBR	T
Artist Lake	Ex Aeration - Denite Filter	T
Avery Village	SBR	T
Bellhaven Nursing Center	SBR	T
Benchmark Senior Living at Whisper Landing	Baby BESST	T
Birchwood @ Spring Lake	Ex Aeration - Denite Filter	T
Birchwood Glen	Ex Aeration - Denite Filter	T
Birchwood on the Green	Ex Aeration - Denite Filter	T
Blue Ridge	SBR	T
Bretton Woods	SBR	T
Bristal @ Lake Grove	Cromaglass	T
Bristal East Northport	Cromaglass	T
Broadway Knolls	SBR	T
Broadway West	Cromaglass	T
Brookhaven Memorial Hospital	SBR	T
Brookhaven National Lab	Modular Aeration	T
Brookhaven Town Hall	Ex Aeration - Denite filter	S
Brookhaven Town SD#2	BESST	T
Brookwood on the Lake	RBC/DENITE FILTER	T
Cabrini Gardens	Cromaglass	T
Calverton Enterprise Park	Ex Aeration	S
Calverton Hills	Ex Aeration	S
Cedar Lodge	Ex Aeration	S
Cenacle Manor	SBR	T
Chelmsford Weald Condominiums	Cromaglass	T
Concern at Middle Island	SBR	T
Concern of Ronkonkoma	Cromaglass	T
Country Point Woods at Smithtown	BESST	T
Country Pointe at Smithtown	SBR ABJ	T
Country View Estates	SBR	T
Country View Estates of Smithtown	Cromaglass	T
Courtyards at Southampton	Cromaglass	T
Crescent Duck Processing Company	Anaerobic Digester SBR	T
Dowling College	RBC/DENITE FILTER	T
DSW Plaza (Loehmann's Plaza)	RBC/DENITE FILTER	T
Eagle Walk	Cromaglass	T
Eastport Meadows	Cromaglass	T
Emanon Group	Cromaglass	T
Emerald Green Apts.	SBR	T
Encore Atlantic Shores (Bristal Estates)	SBR	T
Exit 63 Development	SBR	T
Fairfield @ Ronkonkoma	Cromaglass	T
Fairfield @ Selden	SBR	T
Fairfield Mastic, LLC	Cromaglass	T
Fairfield Southampton	Cromaglass	T
Fairfield Village Garden Apts. (Groton)	MBR	T
Fairfield Villas at Medford	Cromaglass	T
Fairhaven Apartments @ Nesconset	Ex Aeration	S

Table 1-18 List of Suffolk County STPs

Sewage Treatment Plants (cont.)		
STP Name	Treatment type	Secondary/ Tertiary
Fairway Manor	Ex Aeration - Denite Filter	T
Fox Meadow	Ex Aeration - Denite Filter	T
Greenport Village	Aerotor-Clarifier	T
Greenview Commons	SBR	T
Greenview Court PRC	Cromaglass	T
Greenwood @ Oakdale	Ex Aeration - Denite Filter	T
Greenwood Village	Ex Aeration - Denite Filter	T
Gurwin Jewish Assisted Living	SBR	T
Gurwin Jewish Geriatric Center	SBR	T
Hampton Rehab Center (Payton Lane)	SBR	T
Hawthorne Court	MBR	T
Heatherwood @ Holbrook (Hillcrest)	BESST	T
Heatherwood @ Lakeland (Colony Park)	Ex Aeration - Denite Filter	T
Heatherwood House Ronkonkoma	Ex Aeration	T
Heritage Gardens At Brentwood	BESST	T
Hidden Ponds @ Smithtown	Ex Aeration - Denite Filter	T
Hilton Gardens	SBR	T
Holiday Inn	Ex Aeration - Denite Filter	T
Holiday Inn Express	Cromaglass	T
Holt Hotel	SBR	T
Homestead Village	Aeration - Suspended Growth Denite	T
Huntington Town	SBR/RBC	T
Indian Crest Apartments	Cromaglass	T
IRS Service Center	SBR	T
Island View	SBR	T
Islandia Center	Ex Aeration-Denite Filter	T
L A Fitness	BESST	T
La Quinta Inn	Cromaglass	T
Lake Grove Apartments	SBR	T
Lake Pointe	Ex Aeration-Denite Filter	T
Lakes @ Setauket	RBC/DENITE FILTER	T
Lakeview Woods @ Bayport	Cromaglass	T
Larkfield Gardens	SBR	T
Lexington Village	Ex Aeration	S
Mac Arthur Plaza	Ex Aeration - Denite Filter	S
Marriott Courtyard (Browning Hotel)	SBR	T
Marriott Hotel	Cromaglass	T
Medford Hamlet Assisted Living	SBR	T
Medford Multicare Center for Living	SBR	T
Medford Ponds	BESST	T
Melville Mall	RBC/ Denite	T
Memorial Sloan Kettering	Cromaglass	T
Middle Island Co-Op Apts (Hidden Meadows)	Ex Aeration	S
Mill Pond Estates	BESST	T
Mirror Pond	SBR	T
Montauk Manor	OXIDATION DITCH	T
Nesconset Nursing Center	Ex Aeration - Denite Filter	T
Newsday	Aerorotor - Denite Filter	T
North Isle Village	BESST	T
Northport Veterans Hospital	Aeration-Suspended Growth Denite	T
Northport Village	Aeration-Suspended Growth Denite-Denite Filters	T

Table 1-18 List of Suffolk County STPs

Sewage Treatment Plants (cont.)		
STP Name	Treatment type	Secondary/ Tertiary
Oak Hollow Nursing Center	Ex Aeration - Denite Filter	T
Oak Ridge Hollow	Cromaglass	T
Oakcreek Commons	Cromaglass	T
Oakwood Care Center (Affinity)	SBR	T
Ocean Beach	Primary-Chemical-Carbon Filter	S
Patchogue Senior Apartments	SBR	T
Patchogue Village	Aeroter-suspended growth denite	T
Paumanack Village	Ex Aeration-Denite Filter	T
Petite Fleur	Ex Aeration-Denite Filter	T
Pine Hills	Ex Aeration-Denite Filter	T
Pinewood Gardens	Cromaglass	T
Plum Island	EQ-Activated	S
Ponds @ Southampton	BESST	T
Preserve @ Connetquot	Cromaglass	T
Quail Run	SBR	T
Radisson Hotel	Ext Aeration - Denite Filter	T
Residence Inn by Marriott	Cromaglass	T
Riverhead Town	SBR	T
Rocky Point Apartments	EX Aeration	S
Ross Health Care Center	BESST	T
Rough Riders Landing	OXIDATION DITCH	T
S.C.S.D. #13 Windwatch Hotel	Ex Aeration - Denite Filter	T
S.C.S.D. #20 W Leisure Village	SBR	T
S.C.S.D. # 20E Ridgehaven	Ex Aeration - Denite Filter	T
S.C.S.D. # 28 Fairfield @ St. James	Ex Aeration - Denite filter	T
S.C.S.D. #1 Port Jefferson	SBR	T
S.C.S.D. #10 Stony Brook Pump Station	Pump Station	T
S.C.S.D. #11 Selden	SBR	T
S.C.S.D. #12 Holbrook/Birchwood	Aeration - Suspended Growth Denite	T
S.C.S.D. #14 Parkland	Aeration - Suspended Growth Denite	T
S.C.S.D. #15 Nob Hill	Aeration - Suspended Growth Denite	T
S.C.S.D. #16 Yaphank County Center	RBC - Denite Filter	T
S.C.S.D. #18S Hauppauge Industrial Park	SBR	T
S.C.S.D. #21 SUNY	Oxidation Ditch	T
S.C.S.D. #22 Hauppauge County Center	Aeration - Suspended Growth Denite	T
S.C.S.D. #23 Coventry Manor	RBC - Denite Filter	T
S.C.S.D. #24 Gabreski Airport	SBR	T
S.C.S.D. #26 Greens @ Half Hollow	SBR	T
S.C.S.D. #3 Bergen Point	Ex Aeration	S
S.C.S.D. #4 Smithtown Galleria (Avalon)	SBR	T
S.C.S.D. #5 Strathmore Huntington	SBR	T
S.C.S.D. #6 Kings Park	SBR	T
S.C.S.D. #7 Twelve Pines	Aeration - Suspended Growth Denite	T
S.C.S.D. #7 Woodside	Ex Aeration - Denite Filter	T
S.C.S.D. #9 College Park	Aeration - Suspended Growth Denite	T
S.C.S.D.# 2 Tallmadge Woods	SBR	T
Saddle Brook Apartments	Cromaglass	T
Sag Harbor	SBR	T
Sagamore Hills	SBR	T
Sayville Commons	SBR	T
Setauket Meadows	SBR	T

Table 1-18 List of Suffolk County STPs

Sewage Treatment Plants (cont.)		
STP Name	Treatment type	Secondary/ Tertiary
Shelter Island Heights	SBR	S
Silver Ponds	Bio Disc - Denite Filter	T
Smith Haven Mall	SBR	T
Somerset Woods	Ex Aeration	S
Southampton Commons	SBR	T
Southampton Hospital	RBC - DeniteFilter	T
Southern Meadows	SBR	T
Springhorn @ Blue Point	Cromaglass	T
Spruce Ponds Garden Apts	SBR	T
St. Annes Gardens	Cromaglass	T
St. James Nursing Home	Ex Aeration - Denite Filter	T
Stone Ridge at Dix Hills	Cromaglass	T
Stonehurst III	SBR	T
Stonington @ Port Jeff	SBR	T
Stony Hollow	SBR	T
Stratford Greens	MBR	T
Strathmore on the Green (Bal Moral)	Ex Aeration - Denite Filter	T
Suffolk CCC - East Campus	SBR	T
Suffolk County Community College - Selden	Extended Aeration - RBC - Denite Filter	T
Sunrise @ Dix Hills	Cromaglass	T
Sunrise @ East Setauket	Cromaglass	T
Sunrise @ Holbrook	Cromaglass	T
Sunrise Assisted Living @ Smithtown	Cromaglass	T
Sunrise Garden Apartments	BESST	T
Sunrise Village	SBR	T
Tall Oaks	BESST	T
The Inn @ Eastwind	Cromaglass	T
The Orchard at Bulls Head Inn	Cromaglass	T
Timber Ridge @ Westhampton Beach	Cromaglass	T
Towne House Village South	Ex Aeration	S
Valley Forge	SBR	T
Victorian Gardens	SBR	T
Victorian Homes @ Medford	SBR	T
Village in the Woods	Ex Aeration - Denite Filter	T
Villages at Lake Grove	SBR	T
Vineyards @ Moriches	Cromaglass	T
Walden Ponds	SBR	T
Waterways @ Bay Pointe	Ex Aeration - Denite Filter	T
Waverly Park	SBR	T
Westhampton Nursing Home	Ex Aeration - Denite Filter	T
Westhampton Pines	SBR	T
Westhampton Senior Living	BESST	T
Whispering Pines	Ex Aeration - Denite Filter	T
Wildwood Estates	BESST	T
Willow Ponds	SBR	T
Windbrooke Homes	SBR	T
Woodbridge @ Hampton Bays	Cromaglass	T
Woodcrest Estates	SBR	T
Woodhaven Manor	Ex Aeration	S
Woodhull Garden Apts	BESST	T
Yardarm Condos	RBC - Denite Filter	T

Table 1-20 Suffolk County Sewer Projects

Sewer Project	Project Description	Status	Funding	Estimated Population Equivalent	Priority Rank & Contributing Area
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Smithtown Business District	Siting, design and construction of new WWTP to serve 350 parcels in Smithtown business district at estimated cost of $55 million.	Design of collection system essentially complete, but need to identify potentially viable locations for WWTP.	New York State FY 2017-18 Budget includes $20 million to advance project.	2,500	Surface Water 2 Groundwater 3 0-2 Year
Huntington Station	Connection of 290 parcels in proposed Huntington Station TOD to Bergen Point WWTP/SD#3 via Walt Whitman pump station (SD 17) at an estimated cost of $20 million.	The RFP for Planning and Design Services was issued in July 2017. Consultant selected and award process underway.	Planning and Design RFP - $1.25 million appropriated through "Start-Up NY" funds. No funding identified for construction.	1,500	Surface Water 1 Groundwater 3
Carlls River - unsewered areas in West Islip, North Babylon, West Babylon, Deer Park, Wyandanch	Connect 15,706 parcels not being funded through SCCRI to Bergen Point/SD#3 at estimated cost of $800 million.	Feasibility Study completed in 2012.	No funding identified for construction of these remaining projects.	47,100	Surface Water 1 Groundwater 2

Table 1-20 Suffolk County Sewer Projects

Sewer Project	Project Description	Status	Funding	Estimated Population Equivalent	Priority Rank & Contributing Area
Forge River Watershed Sewer District Phases III & IV (Mastic/Mastic Beach)	Connection of 7,607 parcels not being funded under SCCRI to Forge River WWTP at estimated cost of $500 million.	Feasibility Study completed.	No funding identified for design or construction.	22,800	Surface Water 1 Groundwater 3 0-2 Year
Holbrook	Connection of 71 existing commercial parcels and 76 residential units to Bergen Point/SD#3 via Ronkonkoma Hub at estimated cost of $9 million	Feasibility Study completed in 2016.	No funding identified for design or construction.	700	Surface Water N/A Groundwater 3
Port Jefferson Station	Connection of 126 commercial and residential parcels in Port Jefferson Station and Terryville to SD#2, Tallmadge Woods.	Feasibility Study completed. RFP for project design issued 10/17, proposals due 1/12/18. Although $5M in sewer bonds is included the 2018 Capital budget, it cannot be used because a sewer district has not been created.	$500k in sewer bonds appropriated for design in 2017. If additional design funds are needed, a portion of the $5m in 2018 sewer bonds could be appropriated.	1,500	Surface Water 3 Groundwater 3
Sayville Extension (Oakdale, W. Sayville, Sayville, Bayport)	Connection of 8,947 parcels in south Islip communities to Bergen Point/SD #3 estimated cost of $700 million.	Town Feasibility Study completed in 2012. Design contract awarded for Force Main only (estimated project cost $45 million), not for complete collection system.	Design cost of $3 million is funded. No funding identified for construction.	28,100	Surface Water 1 Groundwater 3 0-2 Year
SC SD # 7 Woodside/ Bellport Village/N. Bellport	Upgrades to STP to expand capacity by 160,000 GPD to connect 128 commercial and residential properties in N. Bellport and Bellport (est. cost between $25M and $30M)	SC to begin improvements to expand existing STP capacity and proposed connection to SD #7 using $1.75 million appropriated in Capital Budget.	Capital Budget includes $1.75 million in construction sewer bonds appropriated for upgrades at the STP/No funding identified for connection of new parcels	1,600	Surface Water 1 Groundwater 3
Central Islip	Connection of business district to Bergen Point/SD #3 (# of parcels to be determined)	RFP for Feasibility Study issued in September 2017. Contractor selection process underway.	$200k appropriated for FS. No source of design or construction funds identified.	TBD	Surface Water N/A Groundwater 3
Brentwood	Connection of business district to Bergen Point/SD #3 (# of parcels TBD)	RFP for Feasibility Study to be issued in Spring 2018.	$200k appropriated for FS. No source of design of construction funds identified.	TBD	Surface Water N/A Groundwater 3
MacArthur Industrial Sewer District	Create new district to connect MacArthur Airport and industrial commercial area to Bergen Point WWTP/SD #3 via Ronkonkoma Hub Pump Station at an estimated cost of $125 million	An RFP was issued for Planning and Design Services for Pump station and force main only, not collection system (estimated project cost for force main and pump station is $10 million).	No funding identified for construction.	TBD	Surface Water 1 Groundwater 3
Yaphank	FS to evaluate potential development of County owned land surrounding existing STP.	FS funding never approved	No further funding.	Unknown	Surface Water 1 Groundwater 3

Table 1-20 Suffolk County Sewer Projects

Sewer Project	Project Description	Status	Funding	Estimated Population Equivalent	Priority Rank & Contributing Area
Rte. 25/Middle Island/Selden	FS to evaluate sewering options along Rte. 25A between NYS Rte. 347 and County Rte. 21	FS funding never approved	No further funding.	Unknown	Surface Water N/A Groundwater 3
[illegible]	[illegible]	[illegible]	No further funding.	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	No further funding.	[illegible]	[illegible]

Legend
[illegible]
FS & Design Funded
FS Funded & Complete
FS Funded/Proposed
Undetermined / Under Consideration
[illegible]

Priority Rank dependent on 25% or more of project area falling within the contributing area

Table 1-21 Town / Village Sewer Projects

Sewer Project	Project Description	Status	Funding	Estimated Population Equivalent	Priority Rank & Contributing Area
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Riverside – Town of Southampton	New sewer district required to manage wastewater generated by Riverside redevelopment project.	Draft map and plan completed. Engineering design work completed. Meeting with Suffolk IDA to finalize the sewer district. SEQRA review (supplemental GEIS) to be completed July 2019. Town Board anticipates to create the sewer district by August 2021. Construction and start-up for Phase 1 expected to be completed 2021.	Funding in place: project listed on 2019 NYS EFC Annual Intended Use Plan for $57 million in low interest loans set aside for the construction of the plant and associated infrastructure.	1,500	Surface Water 1 Groundwater 3 0-2 Year
Wyandanch - Town of Babylon	Connection of commercial lots on Acorn Street (52 parcels) and Wyandanch Avenue (57 parcels) to existing Bergen Point WWTP/SD#3.	Acorn Street and Wyandanch Avenue projects are at the RFP stage for design work and cost estimates. Project is expected to be project completed in 2021. Town IDA project. There is overlap with the County's Carlls River projects.	Funding may be coordinated with the IDA, Environmental Facilities Corporation (EFC) loan, and SC Sewer Infrastructure grant. No cost estimates prepared yet.	TBD	Surface Water 1 Groundwater 3

Table 1-21 Town / Village Sewer Projects

Sewer Project	Project Description	Status	Funding	Estimated Population Equivalent	Priority Rank & Contributing Area
Northport Expansion - Village of Northport	Expansion of sewer district into two near-shore areas, Steers Pit and Bluff Point Road. Approx. 40,000 gpd.	Feasibility Study completed. Conceptual construction cost for collection system is $9M to $11M. Preparing maps/surveys/plans.	Awarded $5M Water Quality Improvement Project (WQIP) NYS grant. Additional funding from SC Sewer Infrastructure requested.	450 (149 residential + 2 commercial)	Surface Water 2 Groundwater 3 0-2 Year
Patchogue Expansion - Village of Patchogue	Proposed expansion of existing WWTP capacity from 800K to 1.2M gpd to accommodate new commercial growth.	Facility Plan' feasibility study completed; under Village review. Total project cost, including construction and engineering cost is $10.4M	$100,000 for 'facility plan' funded. Village to apply for NYS water qual. funding for STP improvements project construction. Received $30,000 grant from NYSDEC.	TBD	Surface Water 1 Groundwater 3 0-2 Year
Hampton Bays Downtown - Town of Southampton	Proposed new sewer district for existing commercial development is being planned.	Feasibility Study not completed.	No funding identified for construction.	TBD	Surface Water N/A Groundwater 3
Southampton Downtown - Village of Southampton	Proposed new sewer district for downtown area.	FS/design complete but construction bids came in too high; considering alternative project.	Funding requirements uncertain.	1,500	Surface Water 1 Groundwater 1 0-2 Year
Montauk Downtown - Town of East Hampton	Proposed sewer district for commercial lots around Fort Pond and include Montauk Manor and Rough Riders.	Feasibility Study underway with Lombardo Associates.	FS funded. Initial project costs at $32M. Town applied for $5M in NYS water quality funding for design/construction. $10M in Town CPF funding is uncertain.	TBD	Surface Water 4 Groundwater 1 0-2 Year
East Hampton Downtown - Village of East Hampton	Village has discussed creating a sewer district in the commercial area.	No plans or studies in place.	No funding identified for construction.	TBD	Surface Water 1 Groundwater 1
Springs School District - Town of East Hampton	Town of East Hampton has discussed constructing advanced treatment at the Springs School.	Town is considering package STP or I/A OWTS. No plans or studies in place.	No funding identified for construction.	TBD	Surface Water 3 Groundwater 1 0-2 Year
Port Jefferson – Village of Port Jefferson	FS for expansion/additional connection of parcels within the Village boundary to the existing Village WWTP completed under SC CP 8185	Since the Village is not completely within the district it is possible that use of available capacity that has been discussed for the Village would be for an outside connection. Village indicated no plans to move forward	No further funding.	2,300	Surface Water 3 Groundwater 3

Table 1-21 Town / Village Sewer Projects

Sewer Project	Project Description	Status	Funding	Estimated Population Equivalent	Priority Rank & Contributing Area
Sag Harbor - Village of Sag Harbor	FS for expansion/additional connections to existing Village WWTP completed under SC CP 8185	Possible expansion of the sewer service area under potential built-out scenario (85,000 gpd) - has to be owned/decided on by the Village and requires funding. Village indicated no plans to move forward.	No further funding identified.	800	Surface Water 2 Groundwater 3
Riverhead - Town of Riverhead	FS for expansion/additional connections to existing Riverhead Sewer District WWTP completed under SC CP 8185	No additional capacity for outside connections and no plans for expansion. Owned by Town of Riverhead. Town indicated no plans to move forward.	No further funding identified.	Unknown	Surface Water 1 Groundwater 2
Fire Island Expansion - Village of Ocean Beach	Rebuild STP/collection system to expand sewer service district.	Village indicated no plans to move forward.	No further funding identified	8,000	Surface Water 1 Groundwater 3

Legend
[illegible]
FS & Design Funded
FS Funded & Complete
FS Funded/Proposed
No Plans to Move Forward with Project

Priority Rank dependent on 25% or more of project area falling within the contributing area

Section 2

Project Approach

The recommendations of the SWP were built upon a foundation of state-of-the-art models, data analyses, statistical evaluations, cost analyses, and other technical evaluations. An overview of the various technical approaches used in the SWP and guided by the Wastewater Plan Advisory Committee (WPAC), Focus Area Work Groups and other stakeholders is presented below. A summary of the technical findings associated with each evaluation is also provided, where applicable. While this section focuses on identification and mitigation of nitrogen impacts on surface waters, the evaluation of nitrogen impacts and priority areas for groundwater restoration and protection is described in Section 3 of this SWP.

2.1 Surface Water Priority Ranking and Load Reduction Goals

2.1.1 Overall Approach

Surface water priority ranking for nitrogen load reduction and nitrogen load reduction goals were developed for all 191(1) water bodies evaluated in the SWP using the following general sequence of steps:

- Work with project partners and stakeholders to develop a list of individual surface water bodies to be studied within this SWP;
- Collect available data and develop a database of water quality data to characterize existing water quality within each water body studied in the SWP;
- Use groundwater models to delineate the areas contributing groundwater baseflow to the surface water bodies (e.g., subwatersheds);
- Calculate parcel-specific nitrogen loads from sanitary wastewater, fertilizer, atmospheric deposition and pets for all properties in Suffolk County;
- Use groundwater flow and contaminant transport models to simulate nitrogen concentrations within the aquifer system and the migration of the parcel-specific nitrogen loads through the aquifer;
- Calculate the nitrogen load from groundwater baseflow to each of the surface water bodies;
- Use surface water models to calculate the residence time within each of the surface water bodies;

(1) Working together with the Wastewater Plan Advisory Committee and other stakeholders, SCDHS identified 191 priority surface waters in the County. Groundwater modeling was used to delineate the area contributing groundwater baseflow to each of these surface waters; together the groundwater contributing area and the surface water body itself are referred to as subwatersheds in this task memorandum. 190 of the total 191 subwatersheds evaluated were ranked for nitrogen load reduction priority. One subwatershed, Block Island Sound, was not ranked because it could not be sufficiently characterized to provide a rank. Nitrogen load reductions in upstream subwatersheds will result in nitrogen load reduction to Block Island Sound.

- Define the ecological endpoints that drive priority ranking and establishment of nitrogen load reduction goals;

- Characterize each subwatershed and its associated surface water body based on nitrogen load, residence time and surface water quality data;

- Use a decision support tool along with the subwatershed characterizations to rank each subwatershed's priority for nitrogen load reduction based upon ecological sensitivity to predicted nitrogen loads;

- Consider alternative approaches to define the relationship between nitrogen loads and desired water quality; and

- Identify the nitrogen load reductions that would be required to result in the desired water quality under the defined ecological endpoints.

Each of these steps is described in the remainder of this Section 2.1 of the SWP.

2.1.2 Subwatershed Identification

The 191 individual Suffolk County water bodies evaluated within this SWP were identified in an iterative fashion based on stakeholder outreach and input. Suffolk County's goal was to identify discrete surface waters and their subwatersheds for evaluation of nitrogen loading and resulting water quality to establish priority areas for wastewater upgrades and to establish first order nitrogen reduction requirements. Groundwater modeling was used to delineate the area contributing groundwater baseflow to each of these surface waters; together the groundwater contributing area and the surface water body itself are referred to as subwatersheds. These outputs ultimately guided the establishment of a phased Countywide wastewater upgrade program to address nitrogen from wastewater sources. The NYSDEC Water body Inventory/Priority Water bodies List (PWL) was used as the starting point for the identification of individual surface water bodies. The NYSDEC PWL is "a statewide inventory of the waters of New York State that NYSDEC uses to track support (or impairment) of water uses, overall assessment water quality, causes and sources of water quality impact/impairment, and the status of restoration, protection and other water quality activities and efforts." As such, the PWL provides a logical organizational framework for Suffolk County's SWP, consistent with other state regulatory efforts. Through discussion with the NYSDEC and various workgroup members, it was determined that while the NYSDEC PWL represented a solid foundational starting place, various modifications were required to the individual NYSDEC PWL water bodies in order to align them more appropriately for the purposes of the SWP technical evaluations and wastewater management recommendations. A summary of these modifications may be found in the summary notes from the July 19, 2016 WPAC and the Modeling workgroup kick-off meetings (**Appendices A-1** and **A-2**). The primary modifications were based on the following:

- Aggregating hydraulically connected individual PWL identified stream systems and lakes into a single study area. For example, the Patchogue River system aggregated Patchogue River Upper and Tributaries, Canaan Lake, Patchogue Lake and tidal tributaries to Patchogue Bay.

- Modifying PWL administrative boundaries to facilitate a more accurate evaluation of a system's hydrodynamic residence time calculations;

- Modifying PWL administrative boundaries to facilitate wastewater management evaluations. For example, the Great South Bay, Middle-East boundary was modified to correspond to the boundary of the Southwest Sewer District; and,

- Disaggregating individual PWL water bodies where the PWL had several adjacent, but separate, water bodies grouped together as a single PWL.

During 2016, additional subwatersheds were added to the list, based on WPAC input, further review of water quality data and/or the occurrence of new harmful algal bloom (HAB) events. The final list of the 191 subwatersheds that were simulated and evaluated as part of the SWP is shown on **Table 2-1** (please see tables at the end of this section). The 191 subwatersheds are listed in alphabetical order, along with the towns in which they are located, and where applicable, the estuary to which they discharge. In addition, the table identifies an existing or modified PWL number for each subwatershed. Original PWL numbers have been modified in many cases, depending on whether the subwatershed was disaggregated from a larger water body or aggregated with an adjacent subwatershed. The rationale for aggregating or disaggregating specific subwatersheds is also noted in **Table 2-1.** The subwatershed numbers referred to in this SWP are identified as SWP PWL numbers.

The 191 subwatersheds include 27 subwatersheds contributing to Long Island Sound (LIS), 75 contributing to the Peconic Estuary, 74 contributing to the South Shore Estuary Reserve (SSER), and 14 other fresh or Coastal Ponds. Five of the 14 fresh water ponds were located within the Peconic Estuary or SSER watershed.

2.1.3 Project Water Quality Database Development

2.1.3.1 Water Quality Data

A first ever in Suffolk County, all readily available water quality data from a wide variety of sources was identified, acquired, and compiled into a single, seamless, Countywide water quality Excel-based database. The final database includes over 332,000 individual data points. The initial database was established using data obtained from the SCDHS' on-line portal:

https://gisportal.suffolkcountyny.gov/gis/home/group.html?id=cbd4d20b287d4ef79af28a9b56cea71a#overview

and data obtained from the United States Geologic Survey (USGS), Stony Brook School of Marine and Atmospheric Sciences (SoMAS), and the three estuary programs (Long Island Sound, Peconic Estuary and South Shore Estuary). The initial data inventory confirmed that many subwatersheds were characterized with extensive data sets, while no data was available to characterize others. SCDHS sought additional data through several outreach attempts from Towns, Villages and the NYSDEC, and identified additional in-house data sets to supplement the initial dataset. After determining that no data was available for over 70 subwatersheds, SCDHS collected and analyzed water quality samples from these water bodies to provide an initial assessment of existing conditions as described below in Section 2.1.3.4.

The searchable database was organized by subwatershed based on the subwatershed names and modified PWL numbers identified above in Section 2.1.2 and **Table 2-1**. Parameters that were included in the database organized for this project are:

- Water Clarity indicated as Secchi Depth
- Nitrogen species – Ammonia, Nitrite, Nitrate, Organic-N, and Urea
- Phosphorus species – Total/Dissolved Phosphorus, Phosphate, and Ortho-Phosphate
- Chlorophyll-*a*
- Dissolved oxygen
- Fecal coliform (pathogen indicator)
- Temperature
- Salinity
- Conductivity
- pH
- Carbon Dioxide
- Organic Carbon
- Total Suspended Solids

SCDHS Office of Ecology (OE) and Office of Water Resources (OWR) have monitored surface water quality throughout Suffolk County for decades and provided the majority of the water quality data used to characterize the subwatersheds as shown on **Figure 2-1** and **Table 2-2.** It should be noted that SCDHS screened the sampling stations included in the SWP database to eliminate those that were not representative of water quality conditions. For example, a surface water quality monitoring station that is explicitly monitored to track contaminants from an upgradient landfill would not be included because of its potential bias for various analytes that are not representative of typical land use in Suffolk County. In addition, in some cases, water quality sampling locations have not been randomly selected but may have been established to monitor known water quality impairments. In these cases, concentrations of specific parameters may be biased high, and provide a conservative representation of water quality.

Table 2-2 Data Sources Contributing to the Water Quality Database

Data Source	Number of Samples
Suffolk County Department of Health Services	276,549
Stony Brook University School of Marine and Atmospheric Sciences	31,095
United States Geological Survey	21,272
New York State Department of Environmental Conservation	2,529

Data Source	Number of Samples
Connecticut Department of Environmental Protection	473
Environmental Monitoring and Assessment Program	53
Other	57

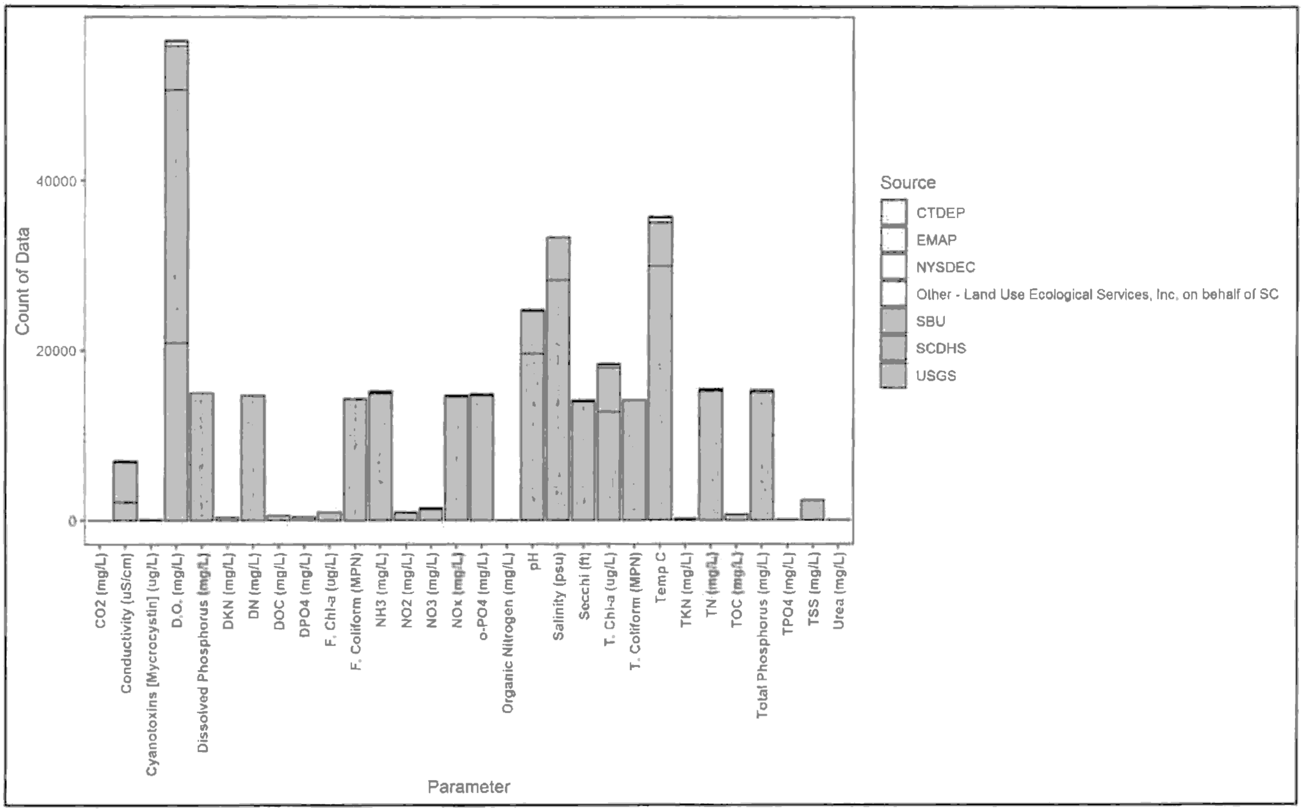


Figure 2-1 Surface Water Quality Samples by Data Source

2.1.3.2 Data Quality

After data was collected and inventoried, the data characterizing each subwatershed was assessed for adequacy based on:

- Reliability (source of the data),
- Quantity (count of data points), and
- Relevance (date data was collected).

Each entity that contributed data to the database has different quality assurance procedures. The vast majority of the data used for the watershed characterization was collected by SCDHS professionals in accordance with their own quality assurance procedures and/or study-specific Quality Assurance Project Plan (QAPP) and analyzed by SCDHS' own New York State Environmental Laboratory Approval Program (ELAP)-certified laboratory. The SWP QAPP recognized that exclusion of water quality data that is not generated by a laboratory with ELAP certification would significantly limit the team's ability to provide initial recommendations for a number of water bodies in Suffolk County. Because water quality data obtained from laboratories with ELAP certification is not available to characterize many of the subwatersheds, and because data measured directly in the field will be valuable to support first order water body characterization purposes, both will be used for this project as described in the QAPP. Data from laboratories that are not ELAP certified and from sources that cannot provide an approved QAPP was flagged due to potential less rigorous QA procedures.

Data measured directly in the field also provides valuable information to support first order water body characterization purposes; this data was also flagged and used for this project. For example, the characterization of diurnal and/or seasonal dissolved oxygen variation within a water body provides insight into data variability, the condition of a water body and the temporal response to loads and hydrologic events that quarterly or annual sampling and analysis by an ELAP certified laboratory cannot provide. This data was also incorporated into the subwatershed characterizations.

One of the intents of the subwatershed characterization process was to link nitrogen loads estimated at current conditions to current water quality. Therefore, the data was filtered so that only data collected during the most recent ten-year period was used for the water quality characterization used for subwatershed ranking, e.g., data collected prior to 2007 was not used, except as described below.

A subwatershed was identified as well-characterized if the results of ten samples within the past ten years were available. Availability of ten data points allowed determination of the 90th percentile and 10th percentile of water quality data characterizing each water body as described in Section 2.1.7. Data collected prior to 2007 was used as secondary data for those subwatersheds where no other data was available to characterize water quality, or if less than ten data points were available to characterize a water quality parameter. Before including samples collected prior to 2007, the data were screened further for relevance by confirming that major changes in land-use and/or wastewater management method (e.g., sewering) in the subwatershed had not occurred subsequent to the sample collection dates.

Figure 2-2 shows the total number of samples available to characterize each water quality data parameter and the number of samples available after screening was completed.

In addition, surrogate parameters were used in some cases when no data were available to characterize a selected indicator. For example, the sum of ammonia, nitrite and nitrate was used in place of, or to supplement, total nitrogen data for those subwatersheds with insufficient data. Even with the additional data collected by SCDHS Office of Ecology, data to characterize one or more parameters was not available for some of the subwatersheds. In those cases, the average concentration for all other subwatersheds was used as a place holder for ranking purposes, as described below in Section 2.1.7. The intent of using the Countywide average concentration was to make that particular parameter "neutral" for the purpose of priority ranking (e.g., no net benefit or disadvantage when compared to the Countywide average for the particular parameter).

The subwatersheds with limited datasets, and those subwatersheds where one or more parameters was characterized by an average value are illustrated on **Figure 2-3** and summarized on **Tables 2-3** and **2-4** (please see tables at the end of this section). The smaller estuaries, upper reaches of the fresh water streams, the ponds and the coastal ponds comprised the majority of the water bodies that were not well characterized.

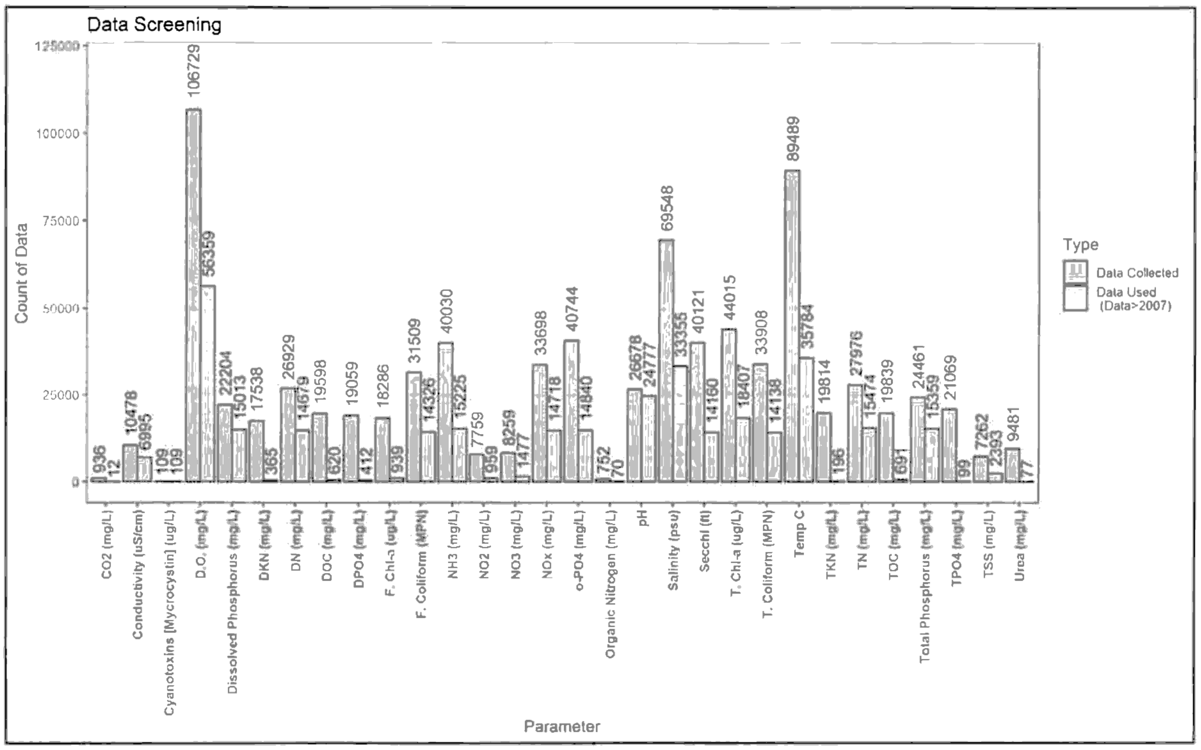


Figure 2-2 Total Number of Samples Collected and Samples Collected Since 2007

Overall, 35 percent of marine water bodies were poorly characterized, 84 percent of mixed water bodies were poorly characterized and nearly all, e.g., 88 percent of fresh water bodies, were poorly characterized. Recommendations for additional data collection, particularly to characterize the impacts of nitrogen loading on the poorly characterized fresh waters, may be found in Section 9.5.

2.1.3.3 Ecological Response Data - Harmful Algal Bloom (HAB) Database

Measures of the ecological response to water quality were also characterized for each subwatershed, including the presence or absence of harmful algal blooms (HABs). Another first of its kind in Suffolk County, a HAB database was developed in consultation with the SBU SoMAS. The HAB database incorporated all known HAB data including quantitative data characterizing HAB cell counts, toxins and other HAB-related analytes. HABs were subdivided into two categories, HABs causing primarily health impacts and HABs causing primarily environmental impacts, as well as plant and macroalgae overgrowth. HABs with human health impacts were comprised of:

- Blue green algae (cyanobacteria)
- Red Tide (Alexandrium fundyense, causes Paralytic Shellfish Poisoning, PSP)
- Red Tide (Dinophysis acuminate, causes Diarrhetic Shellfish Poisoning, DSP)

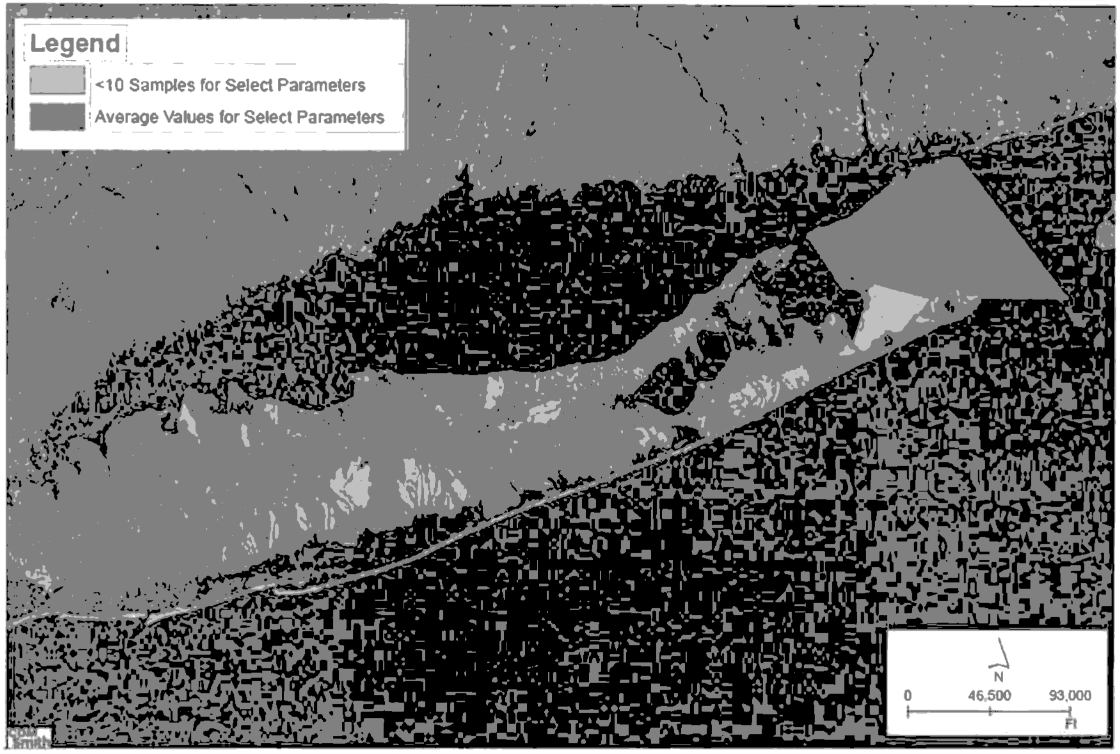


Figure 2-3 Subwatersheds with Less than 10 Data Points to Characterize One or More Parameters and Subwatersheds with One or More Parameters Characterized by an Average Value

HABs with environmental impacts were comprised of:

- Brown tide (Auerococcus anophagefferens)
- Rust tide (Cochlodinium polykrikoides)
- Other (unspecified species).

The number of samples analyzed for each type of HAB is summarized in **Figure 2-4**.

Macroalgae overgrowth was also characterized for the fresh subwatersheds based on readily available data provided in the NYSDEC PWL Fact Sheets. It should be noted that macroalgae overgrowth is generally not well characterized or documented in Suffolk County, particularly in marine waters.

The project-specific excel-database was linked to the subwatershed-specific mappings described in Section 2.1.4 below, and to mappings depicting the locations of the surface water sampling stations used to characterize the receiving water. **Figure 2-5** provides an example mapping showing the Napeague Harbor and tidal tributaries subwatershed and sampling stations.

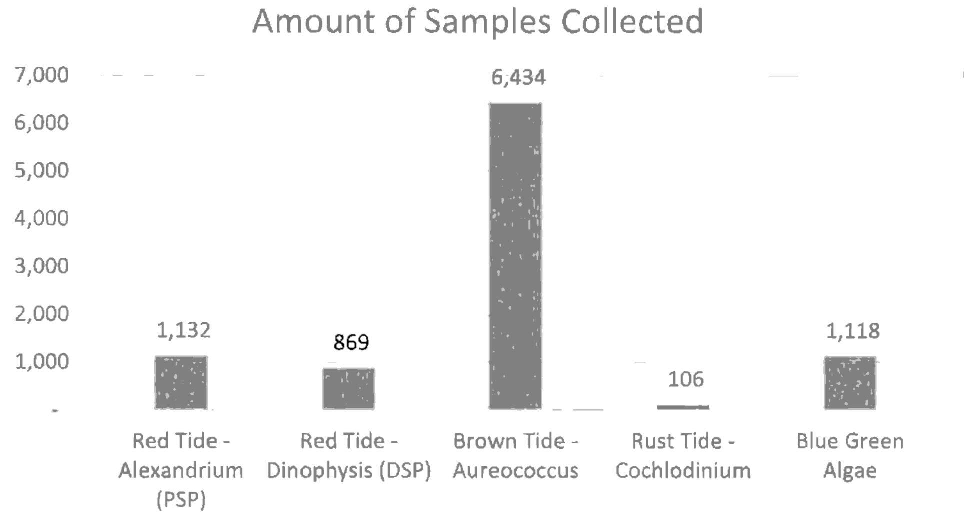


Figure 2-4 Number of Samples Analyzed for HABs

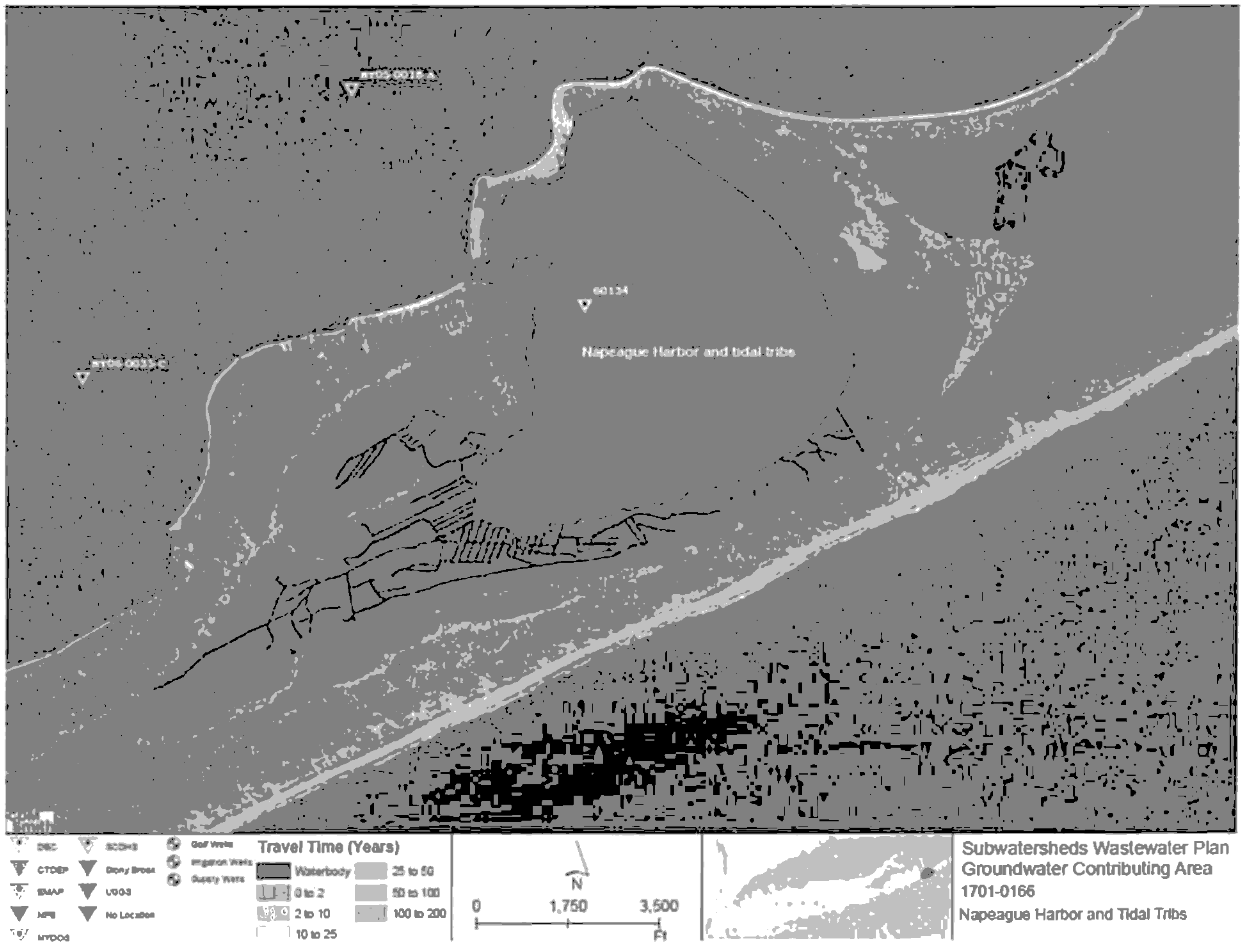


Figure 2-5 Napeague Harbor and Tidal Tributaries – Sampling Station Example

2.1.3.4 Supplemental Sampling

Despite the enormous quantity of existing surface water quality data in Suffolk County, more than 70 individual SWP water bodies were identified as having little or no water quality data. In addition, 10 water bodies were identified as having no existing bathymetry data for use in the Environmental Fluid Dynamics Code (EFDC) hydrodynamic model. A list of the surface waters with little or no water quality data and/or insufficient bathymetry data is provided in **Table 2-3** (please see tables at the end of this section).

In response to the data gaps, SCDHS Division of Environmental Quality staff collected a synoptic round of surface water quality samples and bathymetry data to characterize each of the water bodies listed in **Table 2-3**. Surface water samples were collected in accordance with the EPA-approved QAPP and procedures outlined in the Suffolk County Bureau of Marine Resources Standard Operating Procedures manual. All samples were submitted for laboratory analysis to the NYS ELAP certified Suffolk County Public & Environmental Health Laboratory (PEHL). Marine water quality samples were sampled during the last two hours of the outgoing tide from the top of the water column. Fresh water samples were also collected from the top of the water column. All samples were analyzed for total nitrogen, dissolved nitrogen, ammonia, nitrate, nitrite, total phosphorus, dissolved phosphorus, ortho-phosphate, chlorophyll-a, and total & fecal coliform. In addition, field parameters were recorded for bathymetry, secchi depth (where applicable), temperature, dissolved oxygen, salinity (marine only), conductivity (fresh only), turbidity (fresh only), oxidation-reduction potential (fresh only), and pH. While all 70 sampling locations were sampled at least once, a subset of 23 sampling locations was sampled twice. Supplemental water quality data was used for initial water quality characterization in the priority ranking of individual subwatersheds; however, consistent with the methodology described in Section 2.1.3.2 of the SWP, these water bodies were flagged as being poorly characterized to acknowledge that a single (or two) sample is insufficient to accurately characterize a water body's water quality and that additional data collection is recommended.

SCDHS collected additional bathymetry data in the winter of 2017 to characterize the following water bodies: Acabonack Harbor, Carmans River, Conscience Bay, Crab Meadow Creek, Flax Pond, Little Neck Run, Mecox Bay, Stillman Creek, Yaphank Creek, Nissequogue River, and Sunken Meadow Creek. Utilizing a canoe or motorized boat, depth and coordinate readings were recorded approximately every 150 feet, with the aid of a fiberglass measuring rod or depth sounder, and a cell phone with a mapping application. The additional bathymetry data was incorporated by HDR into the surface water hydrodynamic model discussed further in Section 2.1.6.

2.1.4 Subwatershed Delineation

Under predevelopment conditions, Suffolk County surface waters received over 90 percent of their baseflow from groundwater (Comp Plan, Rozel). Therefore, groundwater is of critical importance to maintaining both the flow and quality of the County's surface water resources. Understanding where surface water baseflow originates as recharge is key to surface water resource management. The four existing regional Suffolk County groundwater flow models (representing the Main Body, South Fork, North Fork and Shelter Island) were used to delineate the land surface area where recharging precipitation travels from the water table to discharge as baseflow or underflow to the surface water bodies within each subwatershed.

2.1.4.1 Existing Groundwater Model Overview

The existing, calibrated models have been utilized for nearly two decades to evaluate various water resources management strategies, contaminant transport and salt-water intrusion investigations throughout Suffolk County. The Suffolk County Main Body Flow Model was originally developed and calibrated as a cooperative effort with SCDHS, Suffolk County Department of Public Works (SCDPW) and Suffolk County Water Authority (SCWA) in 1996 and 1997, with guidance and input provided by NYSDEC and the Suffolk County Planning Department. Working together with SCDHS and SCWA, dual-density groundwater models were developed and calibrated in 2001-2002 for the North and South Forks and Shelter Island. The three dual-density models were developed using DYNSWIM, a dual-density three- dimensional finite element code that allows for the simulation of multiple salt-water interfaces. The dual-density models were later converted to freshwater models for use in the New York State Department of Health (NYSDOH) Source Water Assessment Program (SWAP) and the Suffolk County Comprehensive Water Resources Management Plan (2015). A detailed description of the development and calibration of each of these models can be found in CDM Smith (2003) and is not repeated here. The original Suffolk County model was calibrated to hundreds of water levels and to stream baseflows measured during two independent time periods representing different conditions of precipitation, recharge and development. The model was validated to a third set of water level measurements and stream baseflows. The model's ability to represent the aquifer's response to changing conditions of recharge and water supply pumping was further confirmed by a semi-transient simulation of the period from 1981 through 1994. The models' continued ability to represent observed conditions in response to changing water supply pumping and precipitation and recharge conditions has been evaluated through the years on a project-specific basis. The existing groundwater modeling framework (e.g., model stratigraphy, hydrogeologic properties) was not changed for this model application.

2.1.4.2 Updates and Refinements to Main Body, North Fork, South Fork and Shelter Island Models

The model computer codes were re-dimensioned for use in the SWP to allow for simulation of much more highly discretized flow and transport models that were required to provide the resolution needed to simulate detailed baseflow contributing areas (subwatersheds) to surface waters. The updates and modifications made to all four existing models are as follows:

- Additional discretization (e.g., thousands of additional model nodes) was added to allow more accurate representation of the coastline and surface water features;
- All models were converted to the horizontal datum of NAD 1983 State Plane New York Long Island (feet).
- Light Detection and Ranging (LiDAR) data representing the ground surface elevation was assigned to the top level of the groundwater flow model to allow for more accurate representation of groundwater discharges to surface waters and wetlands within the model domain;

- Boundary conditions were updated to represent contemporary conditions of precipitation, recharge, water supply pumping and sea level elevation. Estimated irrigation pumping from agricultural and golf course wells was also incorporated, and
- At least one model level was added to improve vertical model discretization within the upper glacial aquifer. Another model level was added to represent lakes simulated for SWP.

A detailed summary of the model refinements may be found in the Task 11a memorandum developed as part of the SWP project. A brief description of the primary refinements is provided below.

2.1.4.2.1 Additional Discretization

The models' computational framework is based on writing and solving the equations of groundwater flow at model nodes, the vertices of each finite element within the finite element grid, or model domain. For the SWP, additional detail was added to each model, particularly in coastal areas, to generate a more accurate representation of stream corridors, embayments and harbors and the freshwater ponds identified in Section 2.1.2. The additional detail also allowed for a better representation of water supply wells, as compared to the regional models as well as more discrete representation of the parcel-specific nitrogen loads described in Section 2.1.5. In general, node spacing in coastal areas was reduced to approximately 100 feet. The main body groundwater model was expanded to 511,247 nodes comprising 1,022,272 elements. The finite element grid for the Main Body SWP model is shown on **Figure 2-6**.

Similarly, the North Fork, Shelter Island and South Fork models were also refined with significant additional model discretization. The North Fork SWP model includes 169,969 model nodes comprising 339,698 elements. The Shelter Island SWP model includes 50,881 model nodes comprising 101,161 elements. The South Fork SWP model includes 153,691 model nodes comprising 307,131 elements. The finite element grids for the North Fork, Shelter Island and South Fork SWP models are shown on **Figures 2-7, 2-8** and **2-9**, respectively.

2.1.4.2.2 Incorporation of Light Detection and Ranging (LiDAR) Data

The groundwater models identify the presence of groundwater-fed surface water features (e.g., streams, ponds and wetlands) at model nodes where the groundwater table is simulated to intersect the ground surface.

A number of sensitivity analyses were conducted when the groundwater models were calibrated. Because the model-simulated groundwater-surface water interaction is sensitive to assigned stream bed elevations and to ground surface elevations in areas with high water tables, the ground surface elevation incorporated in the models was updated by incorporating more detailed elevation data. Ground surface elevations in the Suffolk County groundwater models were originally defined based upon the USGS five-foot contour mapping interval mappings available at the time that the models were developed. All four groundwater models were updated by incorporating more detailed ground surface elevation data using LiDAR data provided by Suffolk County. LiDAR data contain very detailed topographic data capable of reproducing 2-foot contours.

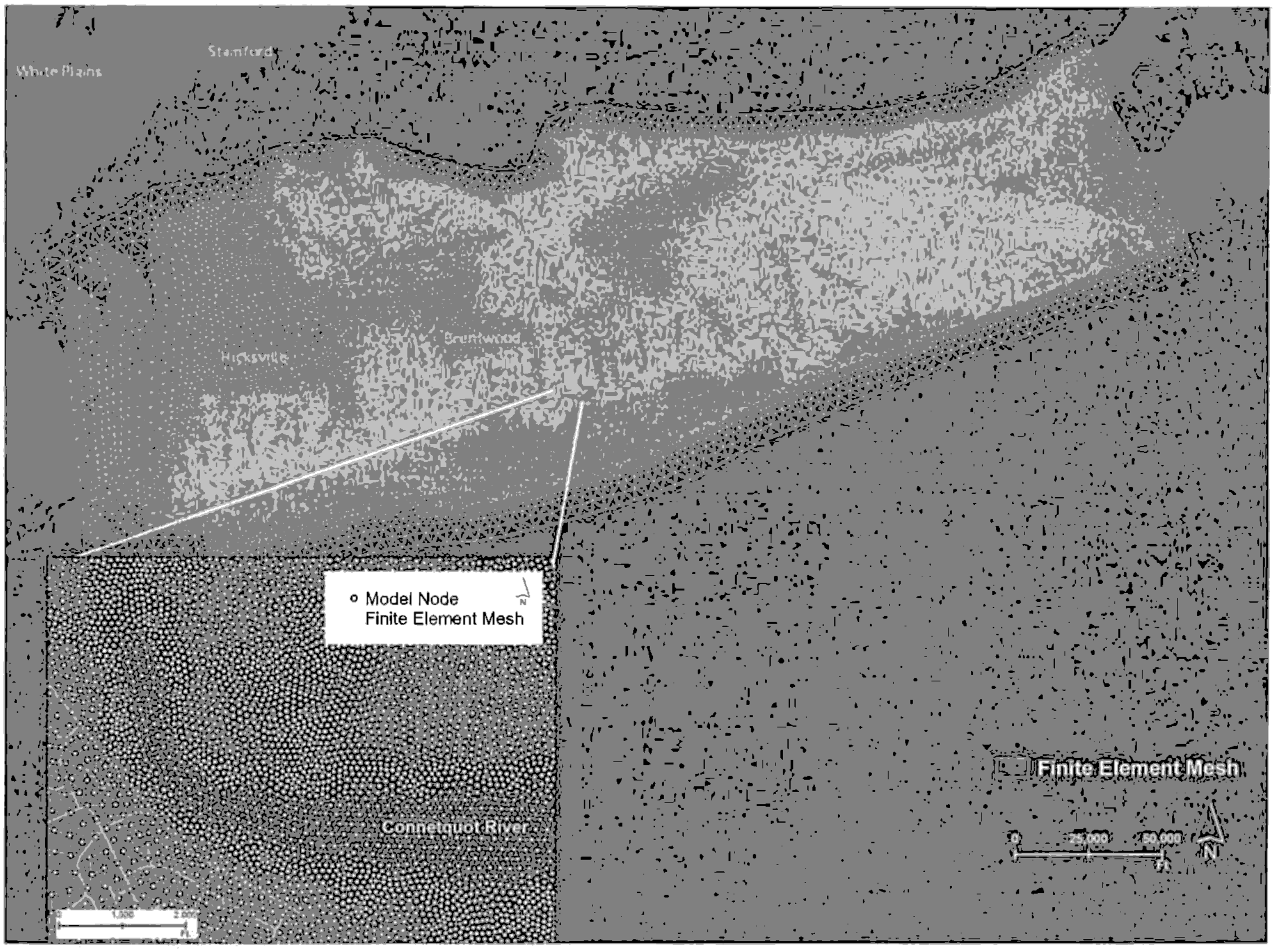


Figure 2-6 Main Body Groundwater Flow Model for SWP Finite Element Grid

2.1.4.2.3 Boundary Condition Update

Model boundary conditions were updated to incorporate a recent period representing long-term average annual conditions of precipitation and water supply pumping. The long-term average annual precipitation from January 1949 through October 2016 at the Brookhaven National Laboratory (BNL) gage of 48.84 inches was utilized in the Main Body model, average annual precipitation from the Riverhead gage was used to characterized recharge for the North Fork model, average annual precipitation from the Bridgehampton gage was used to characterize recharge for the South Fork model, and the Shelter Island model used the average of the BNL, Bridgehampton and Riverhead gages.

As described in the Suffolk County Groundwater Model Report (CDM 2003), recharge to the aquifer system is comprised of recharge from precipitation and recharge from on-site wastewater treatment systems. Through the years, the models were modified to incorporate updated delineations of areas where sanitary wastewater is conveyed to major sewage treatment plants and wastewater discharges to groundwater. The flows for County and municipal wastewater plants that discharge to groundwater were incorporated into the flow model where they represented significant returns.

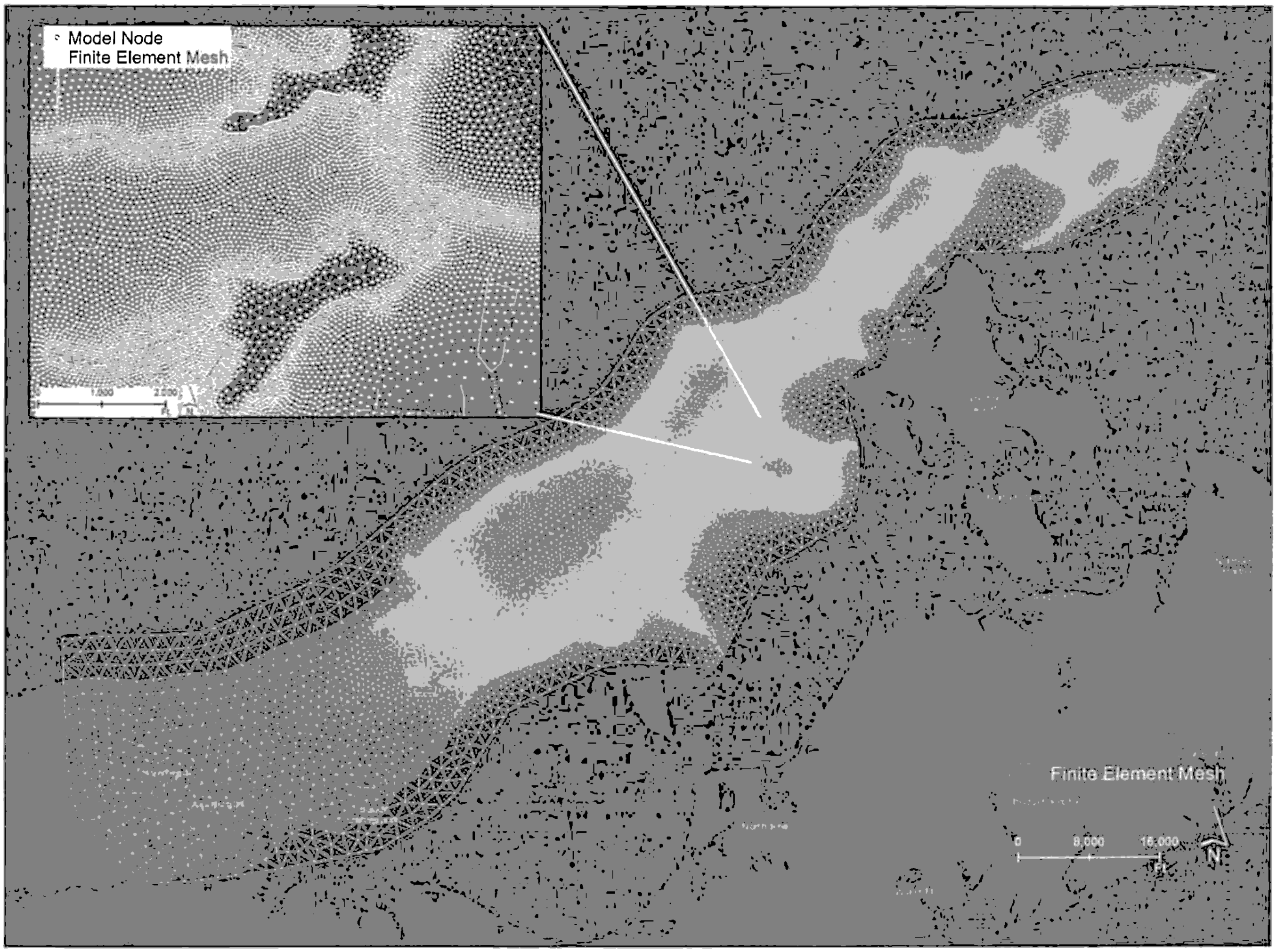


Figure 2-7 North Fork Groundwater Flow Model for SWP: Finite Element Grid

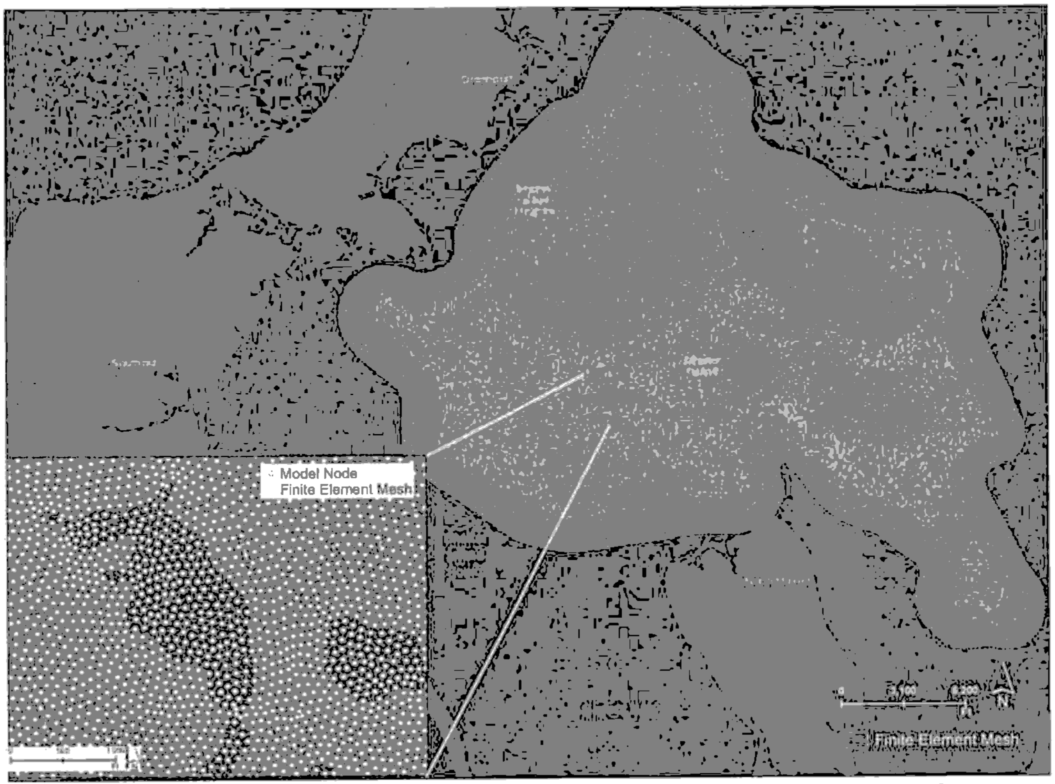


Figure 2-8 Shelter Island Groundwater Flow Model for SWP: Finite Element Grid

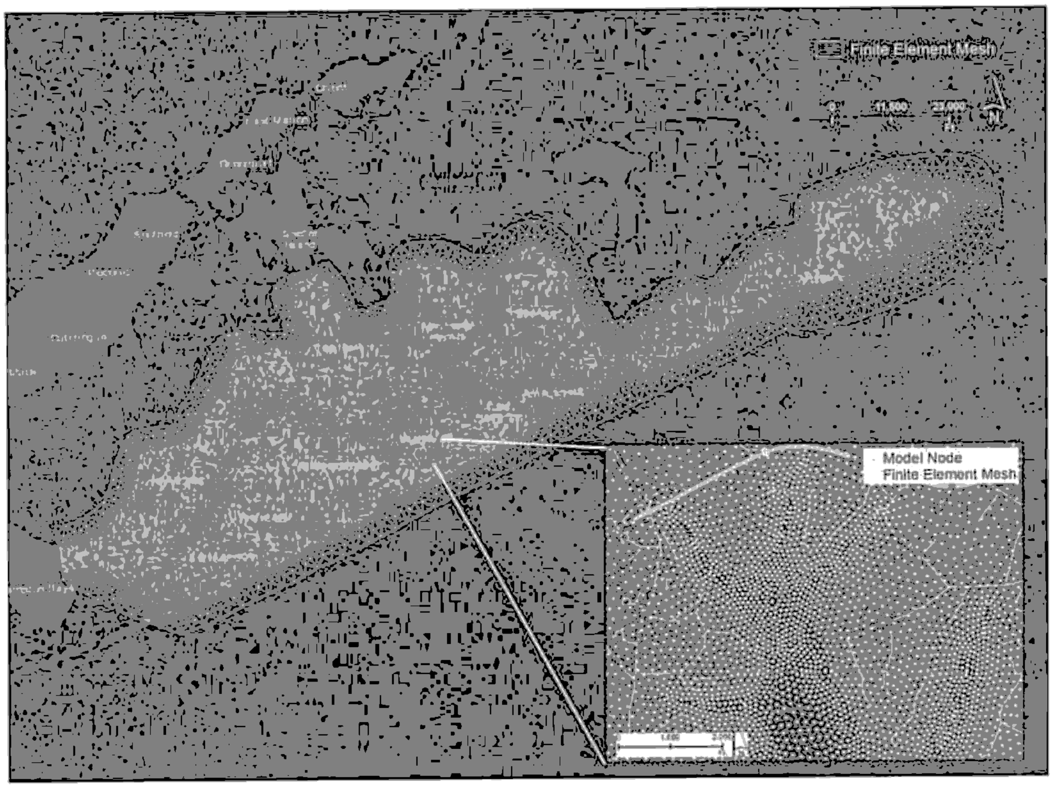


Figure 2-9 South Fork Groundwater Flow Model for SWP: Finite Element Grid

The average annual community supply well pumping rates from 2012 to 2013, which represent recent water supply pumping rates consistent with a period when precipitation was close to the long-term annual average were used for the SWP modeling. Recharge from on-site wastewater disposal systems (septic systems) was applied as 85 percent of the average non-growing season pumpage from November to March. Recharge from on-site wastewater disposal systems was applied to developed land uses within the County but not to open spaces or to areas served by County or municipal sewer systems.

Pumping from agricultural land use and golf courses was also incorporated into all four groundwater models. Because data documenting irrigation well locations, depths and pumpage is not readily available, irrigation wells were located at the centroids of golf courses and agricultural parcels and wells were screened approximately 80 to 100 feet into the water table for the model applications. Agricultural pumping locations were based on locations of irrigated parcels as published by the USGS Data Series 932: Geospatial Compilation and Digital Map of Center-Pivot Irrigated Areas in the Mid-Atlantic Region, United States (Finkelstein and Nardi, 2015). Pumping rates were assumed to be equivalent to an estimated irrigation depth of 8.26 inches per year based on the USGS Circular 1405 (Maupin et al, 2014). Because different crop types have different irrigation requirements, and crops are often rotated, 8.26 inches per year was applied to all irrigated parcels. Golf course irrigation was assigned based on an annual irrigation rate of 14.04 inches per year, based on published data from the USGS Circular 1405 (Maupin et al, 2014) and the National Water Information System golf course irrigation data for Suffolk County.

In addition, the mean sea level elevation used to define coastal and off-shore water levels was adjusted to reflect the increase in sea level rise over the past two decades. As the model is based in NVGD29, mean sea level elevation was adjusted to 0.83 feet, representing local sea level rise, using the Montauk NOAA Station. This sea level correction was applied throughout all models.

Changes to the boundary conditions described in the Suffolk County Groundwater Model Report are summarized in **Table 2-5**.

Table 2-5 Suffolk County Groundwater Model Boundary Condition Updates

Boundary Condition	Model Domain	Data Source	Notes
Recharge based upon long-term average precipitation	Main Body	BNL gage	Long term average conditions. Recharge estimated as documented in the Suffolk County Groundwater Model Report. 50 percent of annual average precipitation applied directly to simulated Lakes.
	North Fork	Riverhead gage	Long term average conditions. Recharge estimated as documented in the Suffolk County Groundwater Model Report.
	South Fork	Bridgehampton gage	Long term average conditions. Recharge estimated as documented

Boundary Condition	Model Domain	Data Source	Notes
			in the Suffolk County Groundwater Model Report.
	Shelter Island	Average of BNL, Bridgehampton and Riverhead gages	Long term average conditions. Recharge estimated as documented in the Suffolk County Groundwater Model Report.
2012-2013 Average Annual Water Supply Pumping (Community): Suffolk	All	SCWA, SCDHS, NYSDEC, NCDPW	Consistent with Comp Plan periods and period consistent with long-term average precipitation.
2012 Average Annual Water Supply Pumping (Community): Nassau			2012 pumping data were available from existing databases.
Agricultural Irrigation Pumpage	All (excluding Nassau County)	NYSDEC, SCDHS, USGS	Agricultural irrigation pumpage was estimated based on USGS documentation and estimates derived from agricultural land use, crop cover, and crop-specific irrigation requirements. As irrigation pumpage is not typically metered and varies significantly from year to year based upon weather and crop type, there is considerable uncertainty in the assigned pumpage locations and rates.
Golf Course Irrigation Pumpage	All (excluding Nassau County)	USGS	Golf course irrigation pumpage was estimated based USGS documentation and estimates derived-specific irrigation requirements. As irrigation pumpage is not typically metered and varies significantly from year to year based upon weather, there is some uncertainty in the assigned locations and pumpage rates.
Sewage Treatment Plant Service Areas	All	SCDPW, SCDHS, SCDEDP	Areas where sanitary waste is directed to sewage treatment plants; within the SWSD, wastewater from parcels that are not yet connected to the sanitary sewer system assumed to be

Boundary Condition	Model Domain	Data Source	Notes
			recharged via on-site systems.
Sewage Treatment Plant Discharge Rates (County and Municipal)	All	SCDHS/NYSDEC	County and municipal flows and 2015 nitrogen concentrations were incorporated where they represent a significant flux to the aquifer.
Sea Level Elevation	All	NOAA	Montauk Station (sea level rise trend)

2.1.4.2.4 Model Specific Updates

All four groundwater models had at least two model levels added to refine vertical discretization within the upper glacial aquifer and to incorporate lakes. Lakes were incorporated into the model by adding a surface layer of zero thickness in all areas with the exception of the lakes. Bathymetry data from the New York State Lake Contour Map Series (NYSDEC) were used to define lake bottom elevations in the groundwater models. Water in the lakes was represented as having a very high hydraulic conductivity relative to the surrounding formation, to allow for groundwater to pass through the lake freely. For lakes where bathymetry data were not available from NYSDEC, bathymetry was based on anecdotal data from the internet (fishing websites, etc.).

2.1.4.3 Model Application

The models were used to generate steady-state flow fields representing recent "average annual" conditions of water supply pumping, recharge and wastewater management. Suffolk County's aquifer system is constantly responding to changes in factors such as precipitation, recharge and water supply pumping, and is not in a steady-state condition, hence, the simulated flow field does not represent an observed flow field but an estimate of groundwater conditions that would result if the average conditions that were simulated remained constant for centuries.

The average annual flow fields established by the steady-state simulations were used to delineate the land surface (water table) area contributing groundwater recharge as baseflow or underflow to the County's surface waters, as well as an estimate of the time it would take recharging precipitation to travel from the water table to discharge at the downgradient surface water under the average conditions.

Figures 2-10, 2-11, 2-12 and **2-13** show the land surface area contributing groundwater baseflow to surface waters on the main body of Suffolk County, on the North Fork, Shelter Island and South Fork respectively. The figures show the areas where recharging precipitation travels from the water table to surface water discharge within two years in red, between two and ten years in orange, between ten and twenty-five years in yellow, between 25 and 50 years in green, between 50 and 100 years in light blue, and finally between 100 and 200 years in dark blue. Similarly, the areas where recharging precipitation is ultimately withdrawn by a community supply well or an irrigation well are also depicted, using the same color keys.

The figures highlight the areas where nitrogen introduced at the water table is carried down through the aquifer and discharges to surface waters via groundwater baseflow. Comparison of

Figure 2-10 with **Figures 2-11**, **2-12** and **2-13** also illustrates the differences between the deeper aquifer system on the Main Body of the island where it may take decades or even centuries for the recharging precipitation to discharge to coastal waters and the shallower aquifers on the Forks and Shelter Island. For example, **Figure 2-13** shows that nearly all of the precipitation that recharges Shelter Island will discharge to a coastal water body within 50 years, with most of the groundwater baseflow discharging in less than 25 years. This indicates that a reduction in the nitrogen introduced in this area will result in reduced nitrogen loading to Shelter Island surface waters relatively quickly, compared to areas in western Suffolk County where it may take decades to realize the benefit.

The groundwater models were used to delineate water body-specific groundwater contributing areas for each of the 191 water bodies identified. These 191 subwatersheds or groundwater contributing areas provided the framework for evaluation of nitrogen loads to each water body along with evaluation and development of nitrogen load reduction plans. Two example subwatershed delineations are shown here as **Figure 2-14** (Forge River and tidal tributaries) and **Figure 2-15** (Hallock/Long Beach Bay and tidal tributaries). **Figure 2-14** shows the extensive area contributing groundwater baseflow to the Forge River and its tributaries, extending over a mile north of the river headwaters where recharging precipitation can take over a century to discharge as baseflow. **Figure 2-15**, depicting a smaller water body on the North Fork, shows that most of the baseflow to Hallock/Long Beach Bay recharged the nearby shallow water table aquifer less than ten years ago.

The subwatershed delineations for each of the 191 subwatersheds were coupled with GIS coverages of 2016 Suffolk County land use data, as provided by Suffolk County Department of Economic Development and Planning (SC DEDP). These land use mappings, along with planning criteria such as areas where the average depth to groundwater is less than ten feet and Sea, Lake and Overland Storm Surges from Hurricanes (SLOSH) delineations provided further information that could potentially be used to guide wastewater planning. The land use mappings also provided the basis for the nitrogen load assignment and modeling described in Section 2.1.5 below.

Figures 2-16 and **2-17** illustrate the land use mappings for the Forge River and Hallock/Long Beach Bay within the 25 year contributing areas, respectively. Land use mappings for all 191 subwatersheds may be found in **Appendix D**.

2.1.4.3.1 Groundwater Baseflow Compilation

The groundwater baseflow contributions to each water body, based on the land surface area contributing recharge to the water body within each travel time interval simulated, were also compiled. These travel time baseflow percentages support the SWP by identifying the areas that contribute the most groundwater baseflow and associated nitrogen load to each of the surface water bodies studied in the plan. The percentages are based on the total baseflow discharged to the surface water body over the 200-year simulation period. For some of the coastal water bodies (e.g., Long Island Sound) the complete contributing area is not delineated by a 200-year simulation. In these cases, additional centuries would need to be simulated to capture the complete contributing area. However, the 200-year simulations do capture the majority of the contributing area, and as noted provide a reasonable framework for nitrogen management planning. In addition,

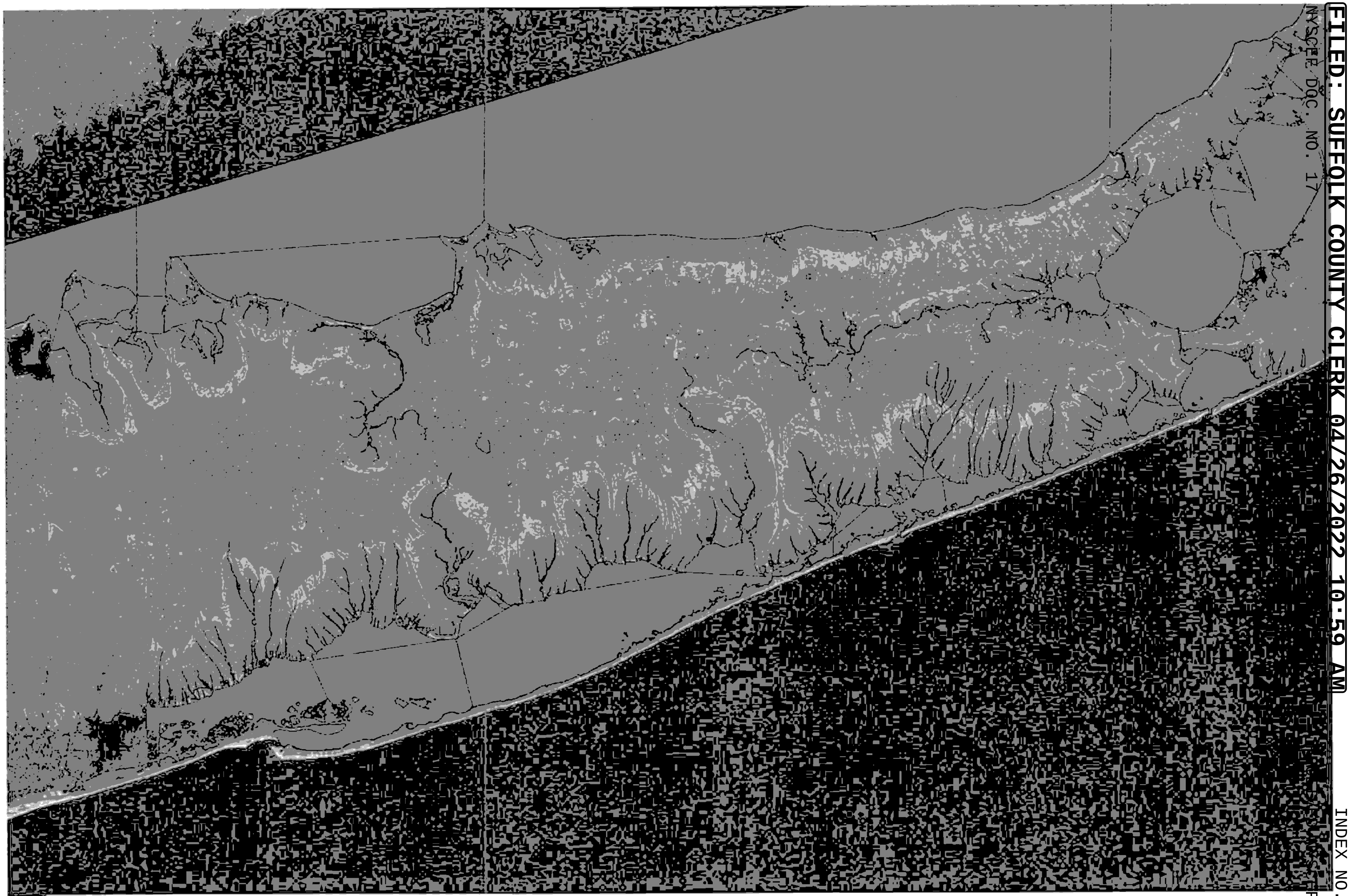


Figure 2-10 Area Contributing Groundwater Baseflow to Suffolk County Surface Waters – Main Body

Travel Time (Years)

▨	Waterbody	▨	25 to 50
▨	0 to 2	▨	50 to 100
▨	2 to 10	▨	100 to 200

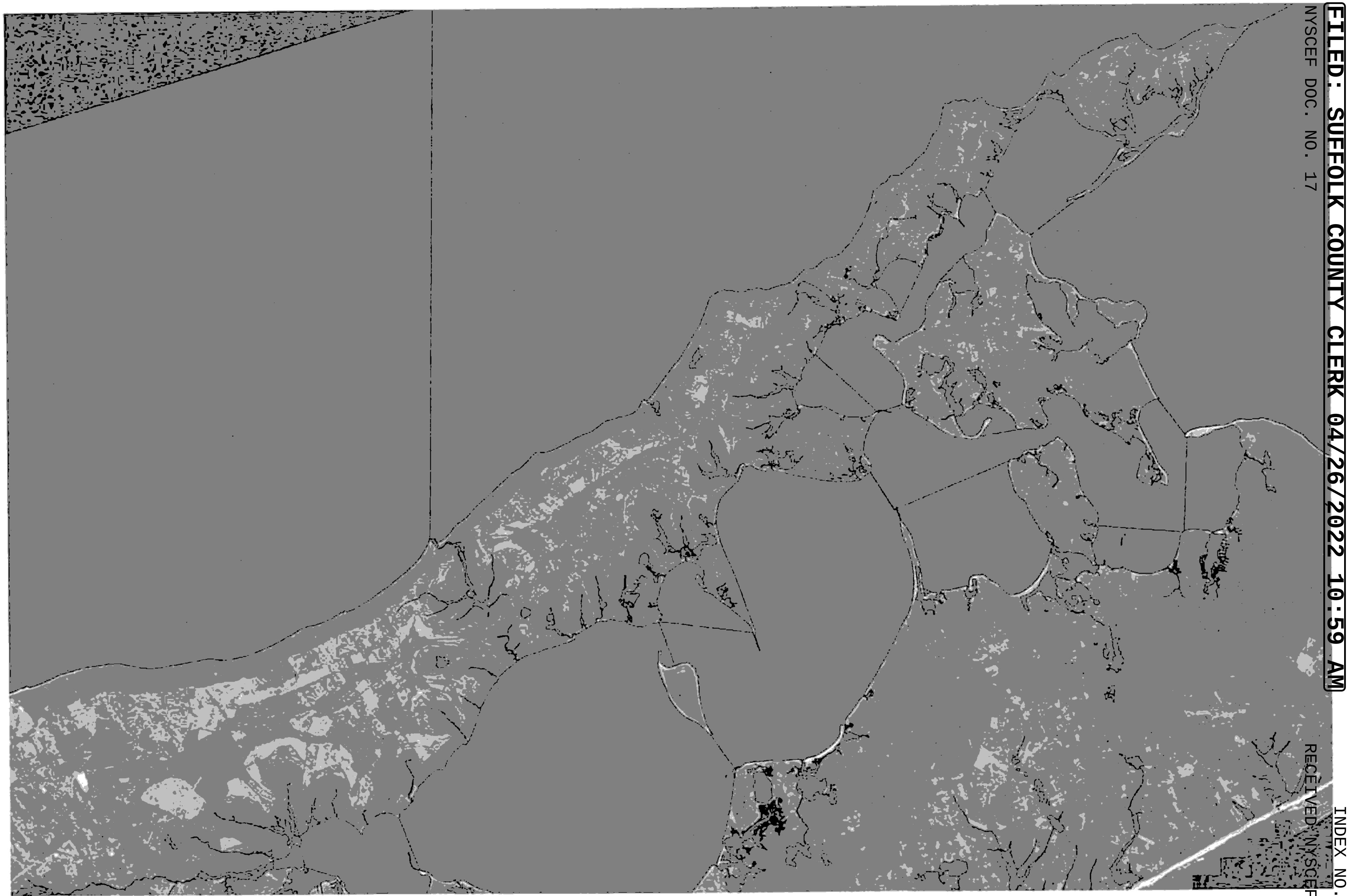


Figure 2-11 Area Contributing Groundwater Baseflow to North Fork Surface Waters

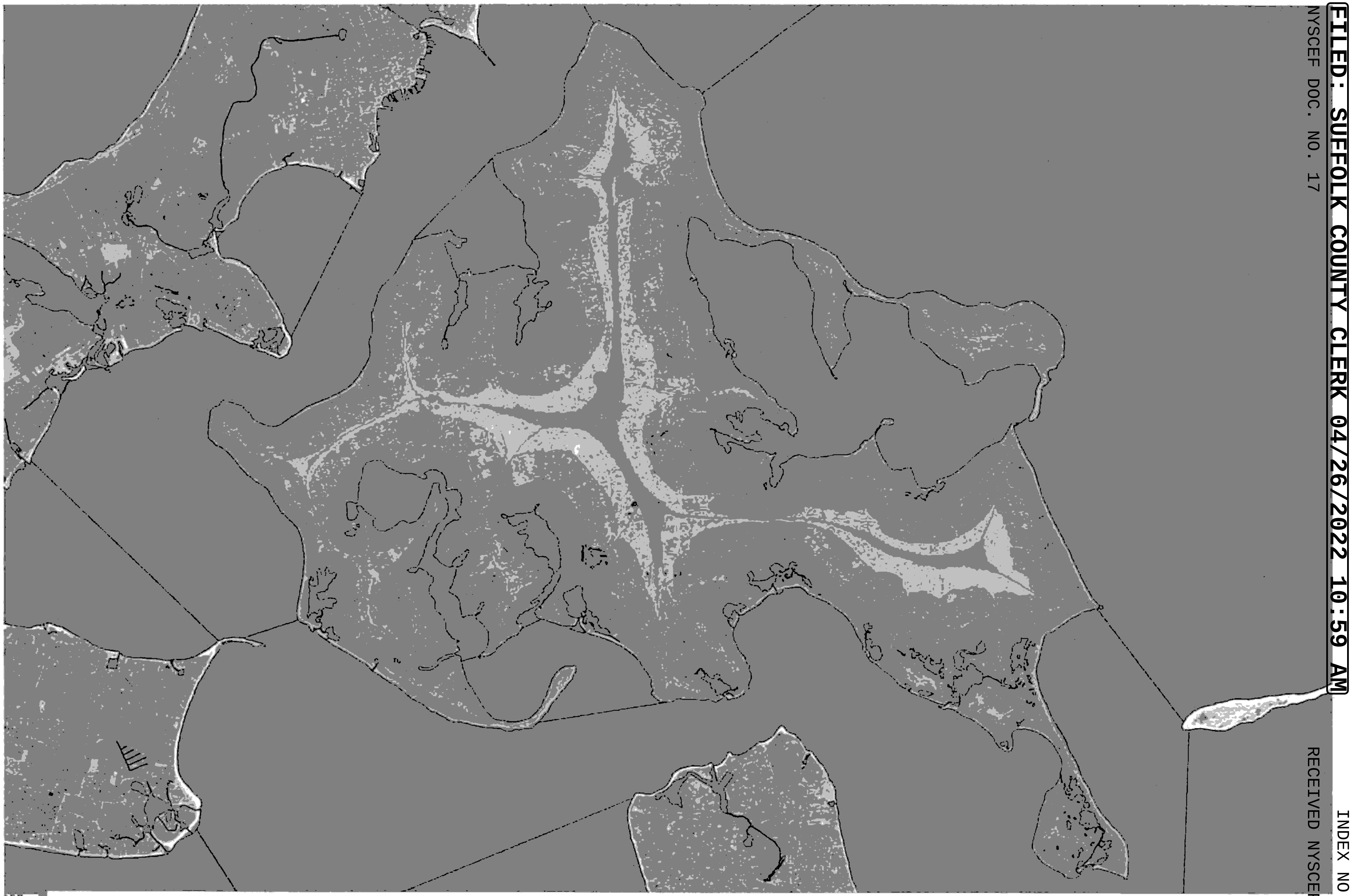


Figure 2-12 Area Contributing Groundwater Baseflow to Shelter Island Surface Waters

Travel Time (Years)

▇	Waterbody	▒	25 to 50
▒	0 to 2	▨	50 to 100
░	2 to 10	▓	100 to 200

N

0 9,000 18,000

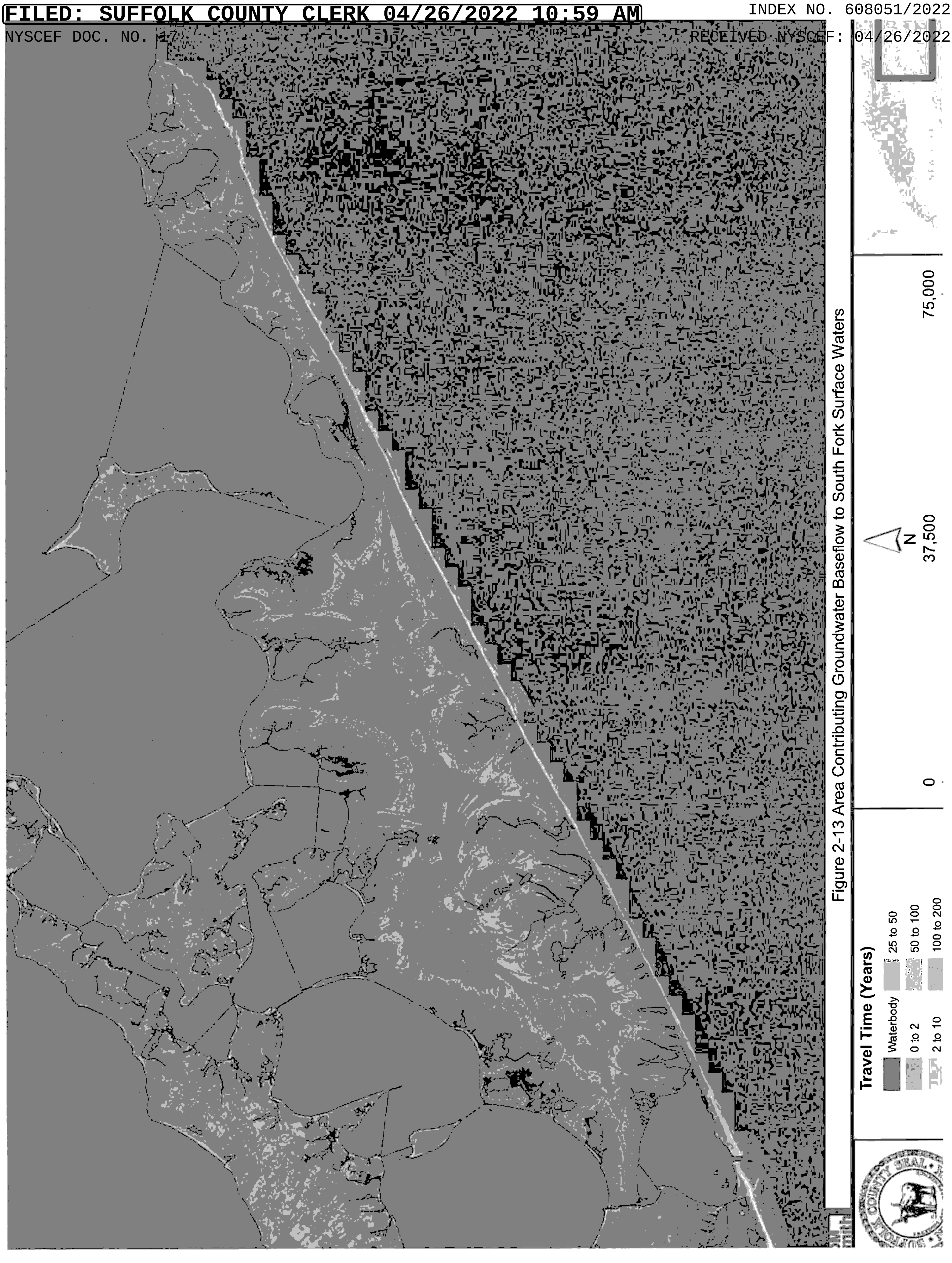


Figure 2-13 Area Contributing Groundwater Baseflow to South Fork Surface Waters

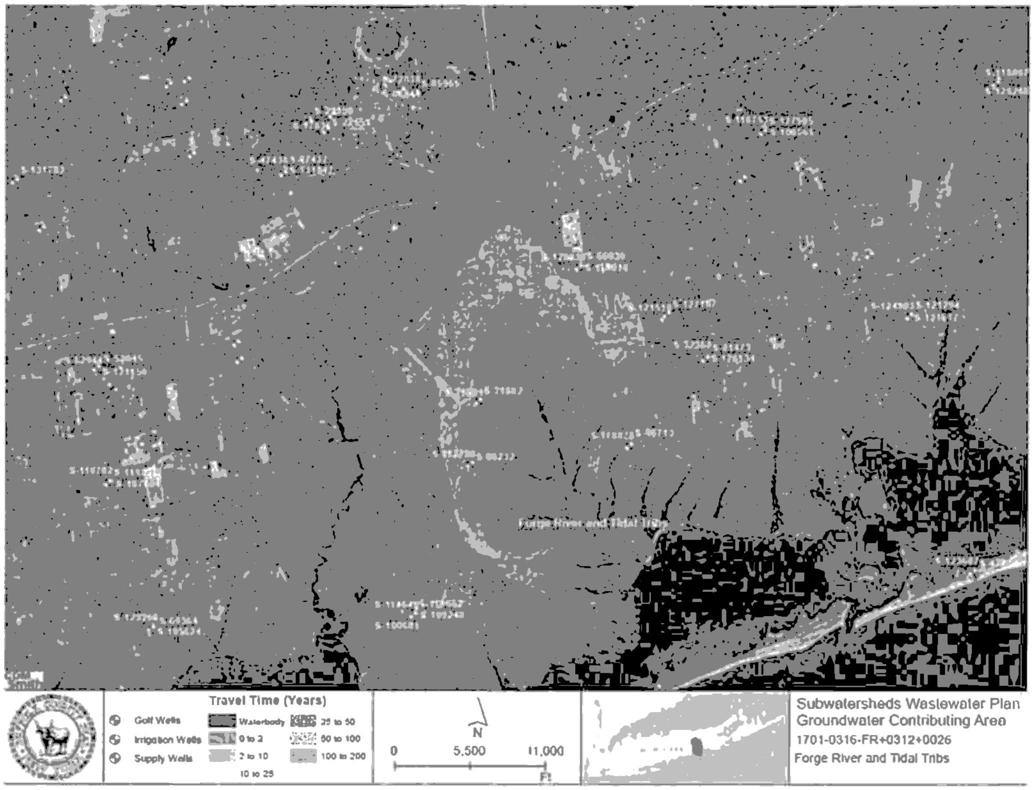


Figure 2-14 Example Subwatershed Contributing Area Forge River and Tidal Tributaries

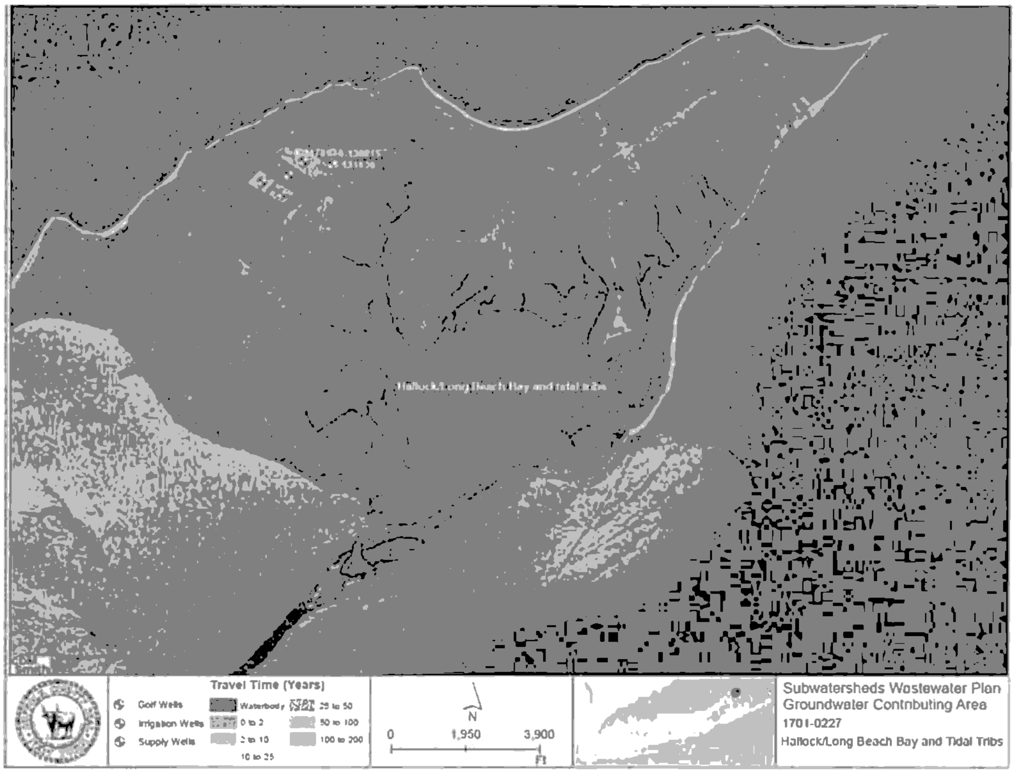


Figure 2-15 Example Subwatershed Contributing Area Hallock/Long Beach Bay and Tidal Tributaries

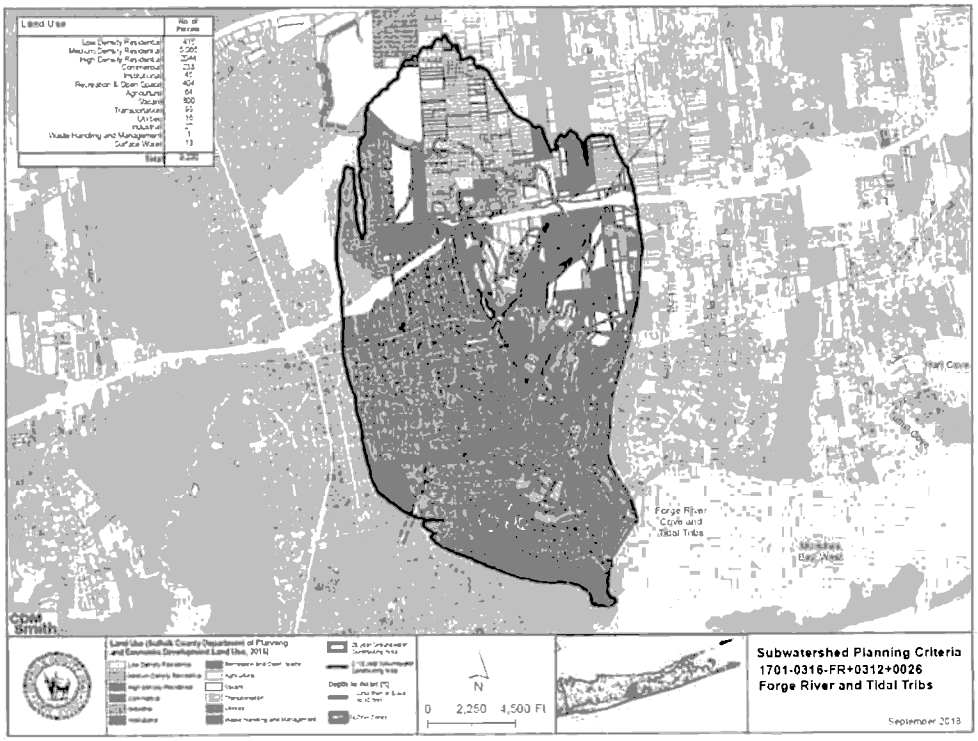


Figure 2-16 Land Uses and Planning Criteria within the Forge River 25-Year Contributing Area

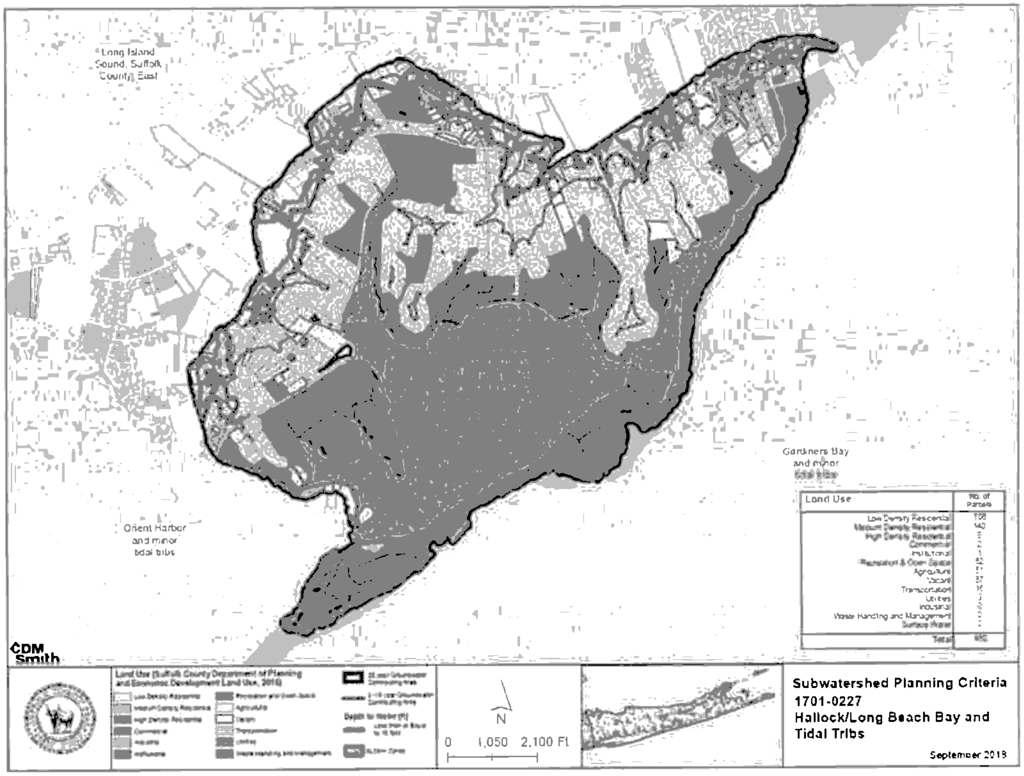


Figure 2-17 Land Uses and Planning Criteria within the Hallock/Long Beach Bay 25-Year Contributing Area

when combined with the contributing areas to public supply wells, there is very little remaining land surface area that is not accounted for in either the predicted surface water contributing areas or public supply well contributing areas, particularly in the developed areas of Suffolk County.

Over ninety percent of the groundwater baseflow to water bodies located in the East End towns (such as Shelter Island) is less than 25 years old; that is, it has taken less than 25 years for most of the recharging precipitation to travel from the water table to discharge to water bodies such as Coecles Harbor, Dering Harbor and Shelter Island Sound. Groundwater baseflow from the North Fork and South Fork to subwatersheds of the Peconic Estuary in general is comprised of groundwater that is only decades old, with over ninety percent contributed from the zero to 25-year contributing areas. In general, the water table on the East End is much shallower than areas to the west and the fresh groundwater system is relatively limited due to the salt-water interface.

Over ninety percent of the groundwater baseflow contributing to subwatersheds that are tributary to the Great South Bay, on average, is less than fifty years old. In areas along the County's north shore within the Long Island Sound watershed where the aquifer system is deeper, over eighty-three percent of the groundwater baseflow is less than fifty years old. It takes longer for recharging precipitation to travel down through the aquifer system to discharge in areas of the main body of the island where the aquifer system is deeper than on the forks, and it will take longer before the benefits of management actions can be observed than on the East End.

A summary of the groundwater baseflow contributions to each subwatershed based on the direct groundwater recharge area from each travel time interval is provided by **Figure 2-18** and **Table 2-6** (please see tables at the end of this section). On an average annual basis, over 75 percent of groundwater baseflow has travelled from the water table to surface water discharge in less than 25 years, and over 85 percent of groundwater baseflow to surface waters has travelled from the water table to surface water discharge in less than 50 years.

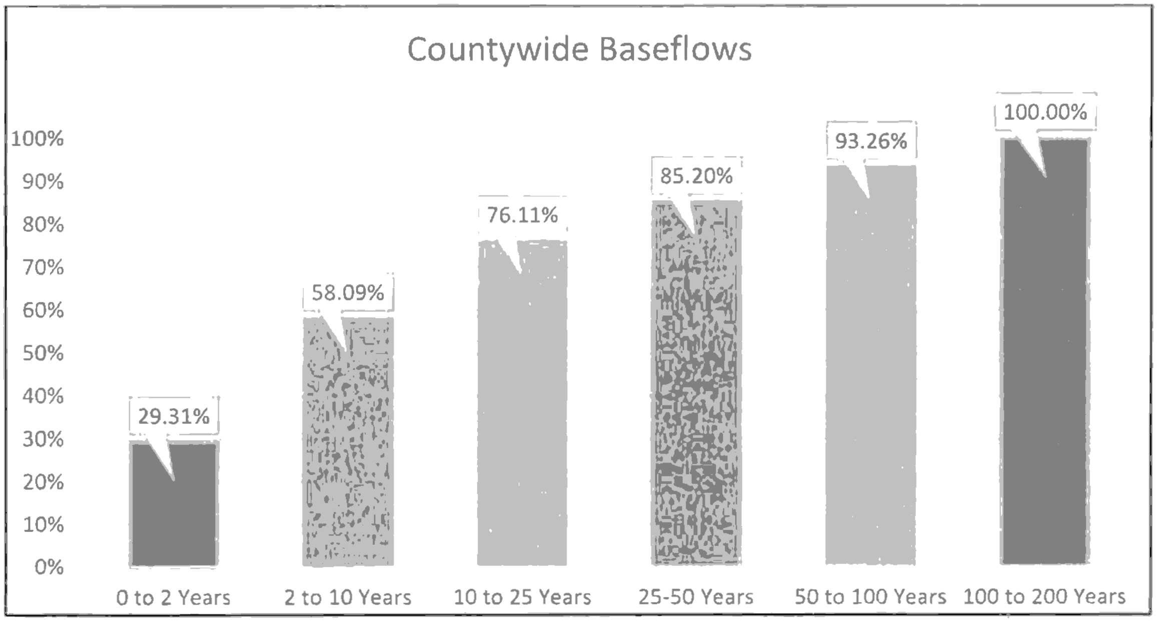


Figure 2-18 Groundwater Baseflow Travel Times

2.1.4.4 Seasonal Sensitivity Evaluation for the Peconic Estuary & Lake Ronkonkoma

Initial steady-state model simulations for the SWP showed contributing areas to the Peconic River subwatersheds that were smaller than expected or were absent in areas, particularly within the Upper Peconic subwatershed. Similarly, for Lake Ronkonkoma, the simulated contributing area did not include some wetland areas upgradient of the lake within Lake Ronkonkoma County Park. As the water table varies seasonally with changes in recharge and pumping, so does the length of flowing stream and groundwater discharge to streams. Therefore, a sensitivity simulation was conducted to evaluate the subwatersheds of Lake Ronkonkoma and the Peconic River (both included in the "main body" groundwater flow model) under transient conditions, incorporating seasonal recharge and pumping.

The model was updated in two ways for the sensitivity evaluation. The SWP "main body" model was run for a period of 200 years using time steps of 90 days to represent seasonal variations in recharge from precipitation and variations in water supply pumping. The model calculates the average pumping and recharge over each 90-day period and these quarterly average recharge and pumping rates based on 2012-2013 conditions were cycled through a period of 200 years. Assigned recharge rates were highest during the non-growing season months when losses to evapotranspiration were low. During the non-growing winter season months, public water supply pumping was lowest. During the growing season, recharge rates from precipitation were reduced, while water supply pumping rates increased.

A second change based on SCDHS field work completed during the winter of 2018 was also incorporated into the transient simulations along the Peconic River. As described above, SWP groundwater models utilize elevations depicted by LiDAR data to define the top of the model. Areas where the groundwater table is simulated to rise to the ground surface defined by the elevation of the top of the model identify the locations where groundwater discharge to a surface water is simulated to occur. During the winter of 2018, Suffolk County conducted a field survey of stream depth and flow at various locations in the upstream portions of the Peconic River. Stream depths ranged from less than a foot to more than four feet. Average depths from these observations were incorporated into the model, and the depths were interpolated and/or extrapolated to characterize the remainder of the River as shown by **Figure 2-19.** Lake Ronkonkoma bathymetry had already been incorporated into the Main Body model for the steady-state simulations based upon available information.

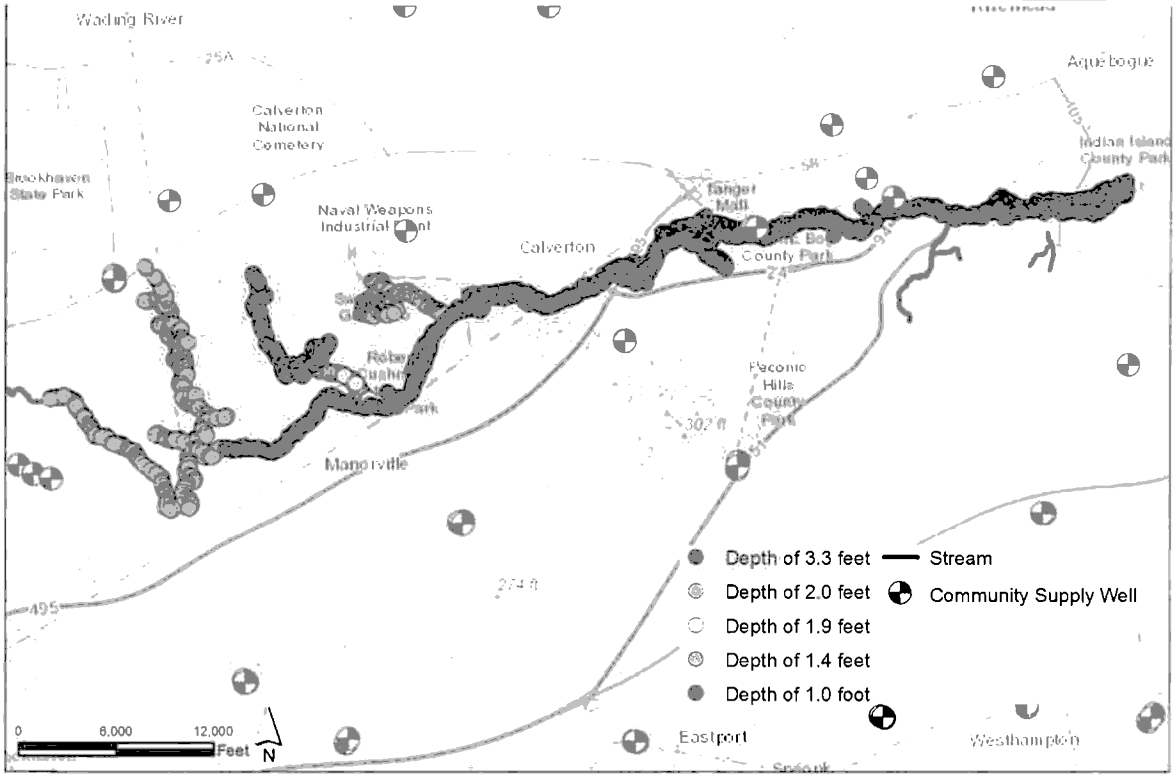


Figure 2-19 Assigned Peconic River Depths Based on 2018 SCDHS Field Surveys

The simulated flow field was used by the accompanying solute transport model to simulate the 200-year transient contributing area to the Peconic River and Lake Ronkonkoma. At the beginning of the subwatershed simulation, particles were spread at 50-foot intervals over an area much larger than the subwatersheds and then were tracked through the aquifer system. The resulting simulated contributing areas (e.g., subwatersheds) for the Peconic River and Lake Ronkonkoma are shown on **Figures 2-20** and **2-21**, respectively.

Incorporation of the seasonal sensitivity in recharge and water supply pumping, along with the updated depth information provided by SCDHS results in a larger simulated subwatershed for the Peconic River, particularly for the Upper Peconic River subwatershed. Prior simulations under average annual steady-state conditions indicated that although the simulated water table approached the ground surface, little if any flow discharged to the Upper Peconic River. However, seasonal sensitivity results including the increased recharge during the winter months provide a much better match to SCDHS' winter observations, with subwatershed delineations extending much further upstream than the original average annual simulations suggested. The transient simulation depiction of the larger subwatershed was used as the basis for the nitrogen loading calculations described below in Section 2.1.5 and other SWP evaluations.

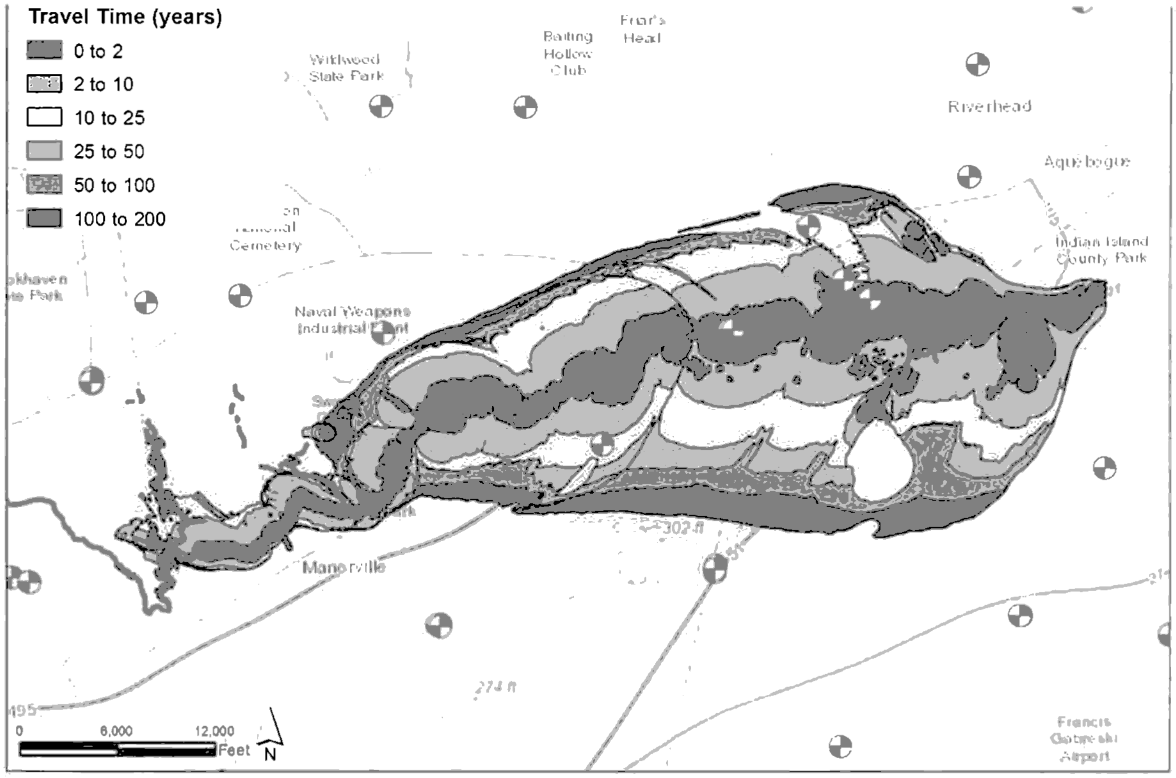


Figure 2-20 Seasonal Groundwater Contributing Area to the Peconic River Subwatersheds

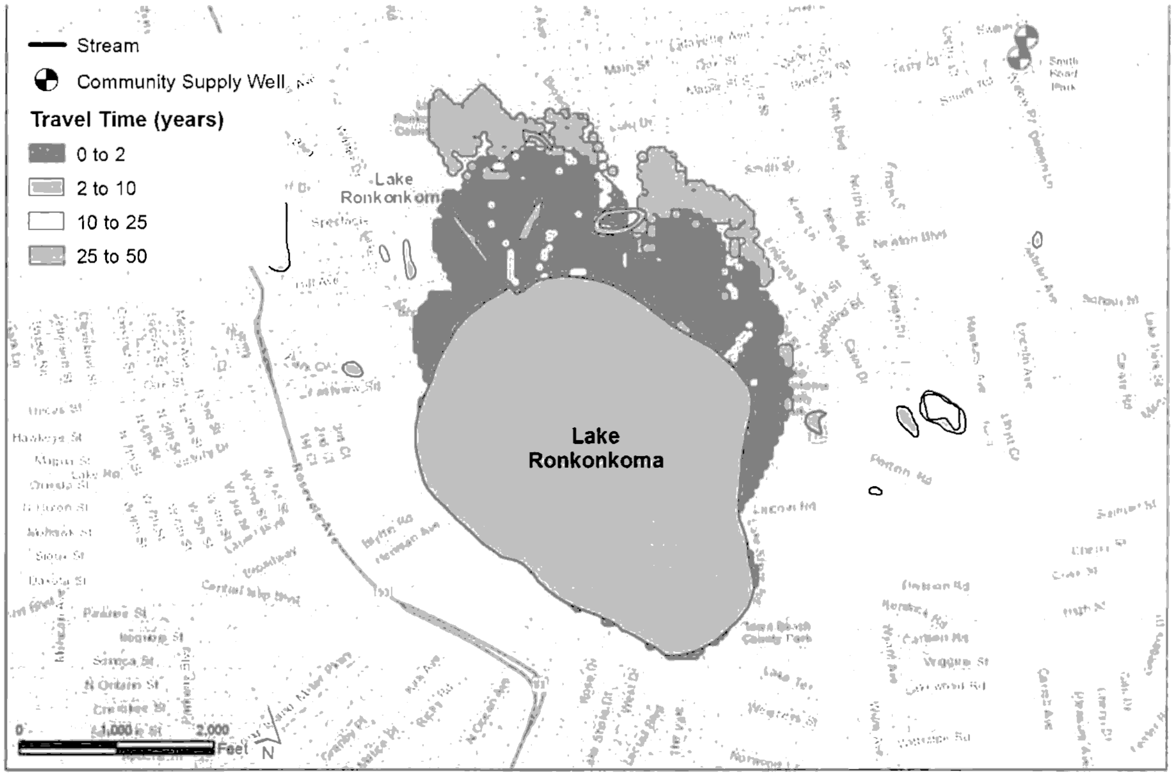


Figure 2-21 Seasonal Groundwater Contributing Area to Lake Ronkonkoma

The subwatershed defined by the transient simulation for Lake Ronkonkoma is similar to the original subwatershed and is somewhat smaller than the steady-state simulation. The intent of this simulation was to capture the wetlands within Lake Ronkonkoma County Park, but the transient simulation only extends slightly further west than the original simulation. Furthermore, the upgradient extent of the subwatershed does not extend as far north as the steady-state simulation. This could be due to large changes in seasonal pumping that result in deeper flow paths to downgradient supply wells, therefore limiting discharge to Lake Ronkonkoma, as recharge to the area directly west of the Lake is captured by two downgradient community supply wells. The original, steady-state subwatershed was utilized as the basis for the nitrogen load calculations.

The results show the subwatershed delineation sensitivity to the assumed conditions of recharge and water supply pumping selected to define the flowfield.

2.1.5 Nitrogen Load Estimation

Parcel-specific nitrogen loading was incorporated into the three-dimensional solute transport models to simulate groundwater nitrogen concentrations and nitrogen migration throughout the aquifer system and to:

- Estimate nitrogen loading to each of the 191 subwatersheds;
- Estimate the nitrogen concentrations in the shallow upper glacial aquifer, and
- Estimate the nitrogen concentrations in community supply wells.

The development of the parcel-specific nitrogen loads under both existing (2016) conditions and projected future build-out conditions is described in the following pages.

2.1.5.1 Baseline/Current Conditions

To calculate parcel-specific nitrogen loads for existing conditions, parcel-specific land uses were defined by the up-to-date information designated by the 2016 land use coverages provided by Suffolk County Department of Economic Development and Planning. Potential nitrogen sources, nitrogen loading rates and nitrogen attenuation factors were developed in cooperation with the Nitrogen Loading Model Focus Area Work Group convened by SCDHS.

Nitrogen from the following sources was incorporated into the nitrogen loading model:

- Sanitary wastewater
- Fertilization
- Pet Waste
- Atmospheric Deposition

Nitrogen loading rates from sanitary wastewater, fertilizer and pet waste were based on each parcel's land use. Nitrogen loads from atmospheric deposition was applied uniformly across all land use types in the County. Incorporation of nitrogen loads conveyed to surface waters via direct stormwater runoff was considered, but not included for this first order assessment. HDR (**Flushing**

Time Calculations for Suffolk County Water Bodies, 2019) found that surface runoff amounted to approximately five percent of the groundwater baseflow to the surface waters. The components of nitrogen in stormwater runoff; e.g. nitrogen from fertilizer, atmospheric deposition and pet waste were primarily captured in the groundwater baseflow assessment. In addition, storm sewer collection catchment area delineations were not readily available for incorporation into the evaluation.

Nitrogen contributions from wildlife and avian populations were considered but could not be incorporated into the current nitrogen loading model as described further below.

The assumptions used to characterize each component of the parcel-specific nitrogen loads are summarized in the following pages.

2.1.5.1.1 Nitrogen from Sanitary Wastewater

Nitrogen loads from sanitary wastewater were based on land uses and loading estimates used in previous studies conducted in Suffolk County and elsewhere in the country.

Nitrogen from sanitary wastewater generated by approximately 1.5 million Suffolk County residents includes the nitrogen introduced to groundwater via on-site wastewater systems in unsewered residential areas and direct discharges from sewage treatment plants (STPs) that discharge to groundwater or surface water in sewered areas. Nitrogen loads from sanitary wastewater contributions in unsewered commercial areas, downtown areas where residential units exist above commercial establishments, Suffolk County and New York State parks, and mobile home parks were also estimated.

Nitrogen from On-Site Wastewater Systems in Unsewered Residential Areas - As approximately 74 percent of Suffolk County is unsewered, nitrogen introduced to the aquifer system by on-site sanitary systems represents the most significant component of nitrogen load throughout much of the County. Per capita nitrogen load was assigned as an average of 10 pounds-nitrogen/person/year. This value is consistent with values used in the literature and other regional studies.

Based on consensus of the Nitrogen Load Model Focus Area Work Group, this wastewater load was reduced by two attenuation factors, assuming:

- Six percent removal of nitrogen in the septic tank (consistent with Valiela (1997), Lloyd (2016), Vaudrey (2016) and Stinnette (2014)).
- Ten percent removal of nitrogen as the wastewater is recharged to the unsaturated zone (e.g., loss through biologically active areas of aged leaching pools and/or through the vadose zone).

In addition, 15 percent additional nitrogen removal was assumed in the aquifer for unsewered residential parcels located above morainal deposits (supported by Young et al., 2013), which, in general, have a higher organic carbon fraction that can support denitrification when compared to the sands of the glacial outwash deposits (coastal plain). No denitrification through the coastal plain sediments was included; however, additional nitrogen attenuation was included through the hyporheic zone as discussed further below.

The datasets used to develop the nitrogen load from sanitary wastewater in residential unsewered areas are summarized in **Table 2-7.**

Table 2-7 Data Used to Estimate Nitrogen Load from Sanitary Wastewater in Unsewered Residential Areas

Data/Assumptions Required	Data/Estimate Used	Data Source
Parcel-specific Land Use	2016 Land Use coverages for Babylon, Brookhaven, East Hampton, Huntington, Islip, Riverhead, Shelter Island, Smithtown, Southampton, Southold	Suffolk County Department of Economic Development and Planning
Household Size*	2010 Population Data and Number of Households	Suffolk County Planning Department, 2010 U.S. Census
Unsewered Parcel Locations	Sewer District Coverages and unconnected parcels in SWSD coverages	Suffolk County Department of Economic Development and Planning, SCDHS and Suffolk County Department of Public Works coverages
Nitrogen Loading Rate	10 pounds/capita/year	New Jersey Nitrate Dilution Model (Hoffman and Canace, 2009), Vaudrey (2016), Valiela (1997)
Nitrogen Attenuation	6% attenuation in septic tank, 10% attenuation in the unsaturated zone	Valiela (1997), Lloyd (2016), Vaudrey (2016) and Stinnette (2014), Desimone and Howes (1998), Chesapeake Bay Partnership (2014) recommendations of Nitrogen Load Modeling Focus Area Work Group

* Adjusted for seasonal population for East Hampton, Riverhead, Shelter Island, Southampton and Southold

Nitrogen from On-Site Wastewater Systems in Unsewered Non-Residential Areas - Nitrogen from sanitary wastewater is also introduced to the aquifer in non-residential areas, including parcels with commercial, industrial and institutional uses. No nitrogen from sanitary wastewater was assumed to be generated at parcels identified as recreational and open space (including golf courses and with the exception of County and State parks as identified further below), agricultural, transportation, utilities, vacant or surface water.

Nitrogen loads from sanitary wastewater discharges generated by parcels with commercial, industrial or institutional land uses vary significantly. For example, both wastewater flow and the associated nitrogen load generated by a restaurant or bar would be significantly higher than the wastewater flow and nitrogen load generated by a jewelry store. Because sanitary wastewater generated by commercial facilities varies so widely, and because the occupants of leased commercial properties can change from year to year, a typical effluent nitrogen concentration was utilized to characterize all commercial properties. Furthermore, County land use coverages do not specify business type, so an average countywide loading rate was generated using the design flowrates for commercial sanitary systems provided in the **Standards for Design and Construction of Other than Single Family Residences** (SCDHS, 2017) and using data obtained from the SCDHS Office of Wastewater database.

For purposes of this study, parcel-specific nitrogen loads for unsewered commercial properties were estimated based upon flow generation rates compiled in SCDHS' Standards for Approval of Plans and Construction for Sewage Disposal Systems for Other than Single-Family Residences. Specifically, the average design flow rate for commercial projects that received final approval in the SCDHS OWM database between the years 2011 and 2016 was calculated, and the average flow rate was multiplied by a factor of safety of 1.5. The factor of safety was included to provide an initial allocation for grandfathered parcels which can have actual flows significantly greater than permitted by Article 6 of the Sanitary Code. The average design flow rate was than multiplied by parcel-specific building footprint areas and a representative effluent nitrogen concentration of 60 mg/L. Building footprints for all land uses were obtained from Suffolk County Real Property and each parcel-specific building footprint for non-residential land uses was multiplied by a land use specific wastewater flow rate (based on Suffolk County Sewerage Standards) and the 60 mg/L effluent nitrogen concentration to estimate the parcel-specific nitrogen load from sanitary wastewater. The nitrogen load was assigned at the parcel centroid. Unit sanitary wastewater flow generation rates and representative nitrogen concentrations for each non-residential land-use type are summarized in **Table 2-8.** The flow rate for commercial is conservative and was based on a blended average of various commercial uses.

Table 2-8 Unit Sanitary Wastewater Flow Rate and Nitrogen Concentrations for Non-Residential Areas

Land Use Type	Flow Rate (gpd/ft2)	Nitrogen Concentration (mg/L)
Commercial	0.07	60
Industrial	0.04	60
Institutional	0.06	60
Waste Handling and Management	0.04	60

Calculated nitrogen loads were attenuated by the same attenuation factors used for the residential wastewater loads as described above.

Additional Nitrogen Load in Downtown Areas - Because second-floor residential apartments are located above commercial parcels in some Suffolk County downtown areas, the nitrogen loads from sanitary wastewater in these areas were increased to include both the commercial and residential components. Downtown areas and the associated estimated percentage of two-story buildings with residential apartments, estimated using Google street view are summarized on **Table 2-9.**

Table 2-9 Downtowns with Residential Units above Commercial Establishments

Town	Percent Commercial Buildings with Second Story Residences
Amagansett	50%
Bellport	60%
Bridgehampton	70%
Center Moriches	40%
East Hampton	50%
Hampton Bays	70%
Huntington Station	80%
Mattituck	40%
Montauk	50%
Sayville	50%
Smithtown	50%
Village of Southampton	70%
Village of Westhampton Beach	70%

Residential loads from the second-floor apartments were calculated as single-family homes, using the same methodology as described for residential areas above. Commercial and residential sanitary load components were then added together and applied to each parcel. The total calculated nitrogen loads were attenuated by the same attenuation factors used for the residential wastewater loads.

Nitrogen from Sanitary Wastewater in Unsewered Parks - To avoid underestimating the nitrogen load from sanitary wastewater generated at popular Suffolk County and New York State parks with restrooms, but no wastewater treatment facilities, sanitary loads were estimated for thirty-one parks, based upon data and guidance provided by SCDHS.

SCDHS provided data on the average number of visitors to each park per year. For County Parks, the number of annual visitors was based on parking fees, number of camping reservations, and number of nights stayed. The average number of visitors to State parks per year was also provided.

The nitrogen load for each park was estimated based upon the calculated number of visitors per day and an average nitrogen load of 0.0274 pounds per person per day. Septic system and leaching ring removal factors are also applied. The resulting nitrogen loads were assigned to building locations, assuming that restrooms are located in the major building structure of the park.

Nitrogen from Sanitary Wastewater Generated at Mobile Home Parks - Nitrogen load from sanitary wastewater generated at mobile home parks was included based on a list of 40 mobile home parks received from SCDHS. The total daily nitrogen load for each mobile home park was calculated based on the number of units for each mobile home park and the population housing density from U.S. Census data.

Nitrogen Loads from Sanitary Wastewater in Sewered Areas - There are approximately 200 sewage treatment plants providing sanitary wastewater treatment in Suffolk County. Nitrogen introduced to the aquifer from treated sanitary effluent recharged to groundwater was included in the nitrogen load estimates based upon 2013 wastewater flow rates provided in the 2013 SCDHS STP Annual Report and average annual effluent nitrogen concentrations provided by SCDHS and NYSDEC for 2016. Nitrogen loads were applied at the centroids of each parcel where the sewage treatment plants were located, and no sanitary loads were applied to the residential parcels located in each sewage treatment plant's sewer service area. The 2,271 parcels that are located in the Southwest Sewer District that have not connected to the sewer collection system were identified by Suffolk County Department of Economic Development and Planning and sanitary wastewater loads generated at these parcels were included in the groundwater model estimate. Nitrogen loads from sewage treatment plants discharging to surface waters are not included in the groundwater model but were included in the subwatershed-specific nitrogen load totals.

2.1.5.1.2 Nitrogen from Fertilizer

Nitrogen load from fertilizer was applied to each of the following land use types:

- Residential;
- Golf courses;
- Parks and recreation and
- Agriculture

The nitrogen load from fertilizer was based on previous studies and assumptions vetted through the County's Nitrogen Load Model Focus Area Work Group. Much of the nitrogen that is applied as fertilizer does not travel down to the water table and into the aquifer but remains within the root zone and is utilized by the plants. To account for this, a leaching factor is applied to the nitrogen load from fertilizer; the leaching factor is dependent on the type of ground cover. The fertilizer leaching rates incorporated into this evaluation are summarized on **Table 2-10.** The leaching rate for golf courses was based on the Massachusetts Estuary Project and is similar to rates calculated using data provided by The Bridge Golf Course in Southampton. The leaching rate was increased slightly for residential parcels as the turf is not as robust and typically does not have the benefit of management by turf professionals who are typically hired to manage golf course turf.

Table 2-10 Leaching Rates Applied to Nitrogen Loading from Fertilizer

Ground Cover	Leaching Rate (%)
Turf (Residential, Parks and Rec).	30
Golf Courses	20
Agricultural Fields	40

Fertilizer on Residential Parcels - For residential fertilizer load, it was conservatively assumed that fertilizer is applied to all residential parcels. In reality, fertilizer application rates vary significantly on any given residential parcel and while many residents do not apply fertilizer at all, some apply much more than the average.

The assumed nitrogen fertilizer application rate for residential parcels was 2.04 lbs. per 1,000 square feet per year based on average values used by Vaudrey (2016). Fertilizer is assumed to be applied to a percentage of each residential parcel. Using the building footprint layer provided by Suffolk County Department of Economic Development and Planning, the building areas were removed from the residential parcels. Fertilizer was then assumed to be applied uniformly to a percentage of the remaining area to account for unfertilized areas such as patios, landscaping, driveways, wooded buffers, etc.). The percentage of residential parcel (minus buildings) to which fertilizer was applied in the model is as follows:

- Low density residential – 25%
- Medium density residential – 60%
- High density residential – 20%

Nitrogen from fertilizer is then attenuated by the 30 percent leaching rate, and an additional 15 percent attenuation was applied in areas where till materials were present.

Fertilizer on Golf Courses - Nitrogen from fertilizer was applied to golf courses at a rate of 3.89 lbs.-N per 1,000 square feet per year based on Vaudrey (2016). Fertilizer was applied to a portion of the total golf course parcel, estimated to be greens and fairways. The percentages of the golf courses representing greens and fairways were estimated using aerial surveys. A leaching rate of 20 percent was applied, and an additional attenuation of 15 percent was applied in areas underlain by till.

Fertilizer on Parks and Recreational Areas - Nitrogen from fertilizer was also applied to parks and recreational fields, assuming that 50 percent of all parks are fertilized. If a park was dominated by vegetation or forest based on the United States Department of Agriculture (USDA) 2016 CropScape data, fertilizer was not applied.

A loading rate of 0.92 lbs.-N per 1,000 square feet per year was applied to all parks. This represents 50 percent of the load used by Vaudrey (2016) for fertilizer nitrogen load at parks and athletic fields. It is assumed that 75 percent of the parcel area is fertilized and a leaching rate of 30 percent was applied.

Fertilizer on Agricultural Parcels - Fertilization application rates in agricultural areas vary widely. Fertilization varies by crop type; crop type can also change from year to year and crop type data can be inconsistent. The assumed fertilizer loads for the SWP were based on best available data, including fertilization rates based on data provided by Cornell Cooperative Extension (**Table 2-11**), and land use data obtained from the Nature Conservancy and the Peconic Estuary Program (PEP) that was used to assign crop types to agricultural parcels. Agricultural parcels from the 2016 County land use database were selected, crop type was assigned initially from the PEP data and subsequently confirmed or assigned using the USDA CropScape 2016 database. Vineyards were subsequently verified and/or incorporated using a vineyards database developed by CDM Smith using aerial photography and roadside surveys.

Table 2-11 Agricultural Nitrogen Use (from CCE, dated October 3, 2016).

Crops	Acreage	Nitrogen Use (lb. N/acre/year) (1)	Comments
Mixed Vegetables	7,500	80-160	Split applications, 95%, 85%, sweet corn growers CRNF
Potatoes	2,200	150-200	Split applications 80%; CRNF about 500 acres
Nurseries (field and container)	5,000	50-200(2)	Multiple applications; estimated 75% using some CRNF
Vineyards (vinifera grapes)	2,200	0-40 (10-20 most common)	Foliar and/or ground applications
Sod	2,800	200-300 (3)	Five to seven applications; estimated 80% using CRNF
Small fruit-berries	200	30-120	Split applications
Greenhouse	700	60-350 (2)	Multiple applications
Small Grains	1,000	0-60	Split applications
Field Corn	1,200	120-150	Split applications 100%
Pasture/hay	2,800	0-40	

(1) N rates – references Cornell Guidelines for small fruit, field crops and vegetables
(2) Area does not include aisles and/or roadways
(3) Amount over an 18-month cropping period

Based on the information included in the table, nitrogen loading rates were specified for broad ranges of crops as summarized by **Table 2-12**. The "other crops" category represents crops that are not listed in the table above and uses a weighted average of nitrogen use for other crops as specified by CCE. Greenhouses were not included in any calculations because fertilizer is applied indoors.

Table 2-12 Nitrogen Applications to Agricultural Land Use from Fertilizer

Crop Type	Nitrogen (lbs.-N/1,000sf/yr.)
Pasture / hay	0.46
Orchards	1.61
Vineyards	0.34
Sod	5.74
Other Crops	2.91

Nitrogen loads from fertilized agricultural parcels were calculated based on application to 90 percent of each agricultural parcel and a 40 percent leaching rate. The 40 percent leaching rate was agreed upon by the Nitrogen Load Model Focus Area Workgroup and considered published leaching rates from studies which appeared to have soil conditions consistent with Suffolk County. Studies considered in the determination of average 40 percent leaching rate are provided below in **Table 2-13.**

Table 2-13 Summary of Studies used for Establishment of Agricultural Leaching Rates

Study	Leaching Rates
Hochmuth, et. al. 2003 - Potatoes in Florida	47% - 70%
Prasad & Hochmuth, 2016 - Potatoes & Corn in Florida	32% - 35%
Hermanson, et. al. 2000 - Agriculture Literature Search	30% - 70%

It should be noted that based upon the available literature, the agricultural leaching rates utilized in the SWP were reduced significantly from the 60 percent leaching rate used in the original NLM work completed by Valiela (Valiela et. al, 1997) and subsequently used in most regional nitrogen loading studies. However, these assumptions were further supported by comparison of model predicted concentrations in the upper glacial aquifer to actual monitoring well data collected by the SCDHS which showed an overall excellent correlation. Nonetheless, actual parcel specific leaching rates likely vary significantly based upon crop type, irrigation practices, actual application rates, and other parcel specific factors and consideration should be given to completion of a long-term leaching rate study using actual parcel specific application rates and observed water quality.

2.1.5.1.3 Nitrogen from Animal Waste

Based upon input from stakeholders, the potential to quantitatively assess the nitrogen load from pets, birds and wildlife was also considered. Further investigation confirmed that nitrogen load from pets was the only additional source that could be quantified based upon existing information. Additional data collection is necessary to quantify nitrogen loading from birds and wildlife.

The potential to estimate the nitrogen loads contributed by pets and wildlife (specifically, geese) was carefully considered based on:

- The estimated net nitrogen load generated by each population;
- The percentage of nitrogen generated that could migrate to groundwater and
- The ability to quantify each population on a parcel-specific basis.

While some literature reported that nitrogen from wildlife (e.g., deer, geese and other waterfowl) was largely recycled (e.g., the population ingested plants containing nitrogen and excreted nitrogen in the same vicinity), it was agreed that pet waste should be considered as a potential external load to the groundwater system. An estimate of the nitrogen excreted by dogs and by cats was available from **Nitrogen on Long Island Sources and Fates**, Porter, 1978. The nitrogen load produced by each dog was estimated as 4.29 lb.-N/dog/year and the load produced by each cat as 3.22 lb. N/cat/year. For modeling purposes, it was estimated that fifty percent of the nitrogen load was lost to volatilization and does not reach the water table, and the remaining fifty percent was applied. The nitrogen loads from pet waste were assigned to residential parcels only and were applied at the centroid of each residential parcel.

According to the **U.S. Pet Ownership & Demographics Sourcebook** (American Veterinary Medical Association, 2012), there were an average of 1.4 dogs per household and an average number of 1.9 cats per household in New York in 2011. Because many cats spend their lives indoors, the nitrogen load from their waste is not released to the environment and was not included in this nitrogen loading assessment. One New York City veterinary practice that tracked the fraction of cats that resided completely indoors versus the population of outdoor cats (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2603649/) concluded that 61 percent of the domestic cat population is confined indoors, and 39 percent may spend some time outdoors. Attempts to obtain Town-specific breakdowns of the assumed Suffolk County dog, cat and outdoor cat populations were not successful. None of the veterinary practices consulted were able to provide additional insight into the pet population or fraction of outdoor cats.

Based on the New York City estimate, only the nitrogen load for the 39 percent of the pet cats that spend some of their time outside (e.g. 0.74 cats/household) was included in the nitrogen load from pet waste estimates. The pet waste loading assumptions are summarized in **Table 2-14.**

Table 2-14 Assigned Nitrogen Load from Pet Waste

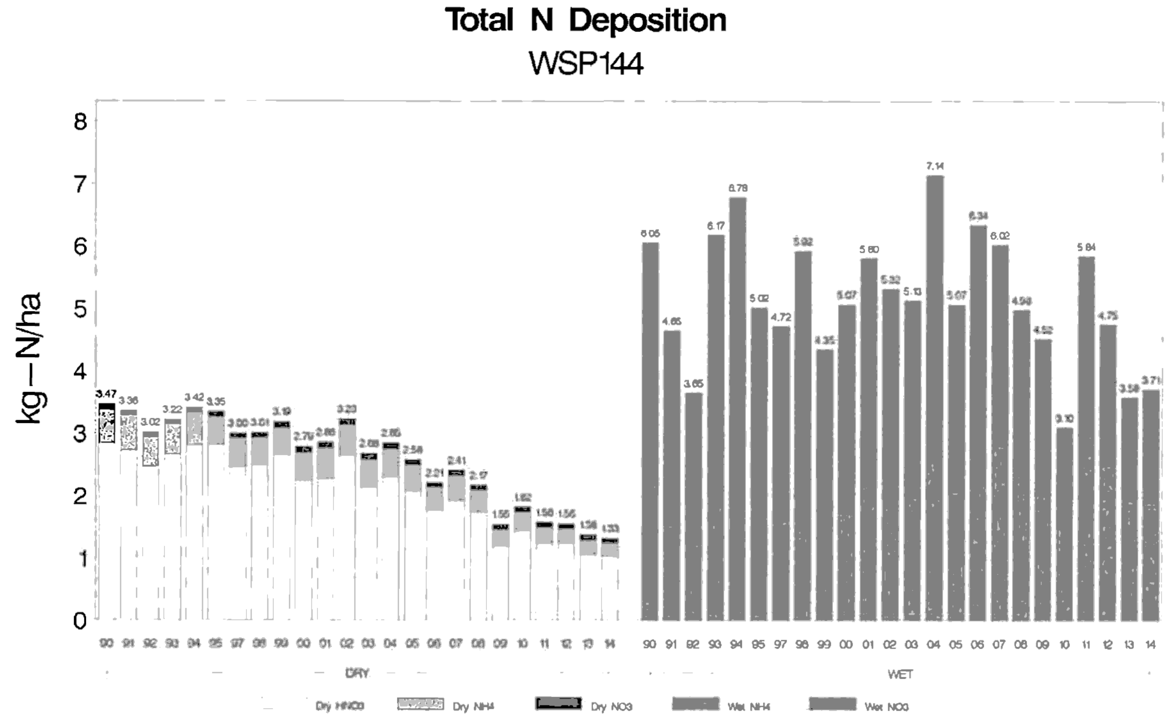
Pet Type	Number of Pets per Household	Annual Nitrogen Load per Pet (lbs./yr.)	Percent Lost to Volatilization
Dogs	1.4	4.29	50
Cats	1.9	3.22	50
Outdoor Cats	0.74	3.22	50
Indoor Cats	1.16	0	N/A

2.1.5.1.4 Nitrogen from Atmospheric Deposition

Atmospheric nitrogen deposition also contributes both to the nitrogen load to the aquifer system and directly to each surface water body's nitrogen load. Nitrogen load from atmospheric deposition is comprised of both wet (via rainfall) and dry deposition. Nitrogen load from wet deposition was calculated based on data collected at the rainfall/deposition monitoring station at Cedar Beach in Southold, which is part of the National Atmospheric Deposition Program's (NADP) National Trends Network (NTN). The station provides average nitrogen concentration in rainfall on an annual basis (wet deposition). The data from 2010 to 2014 were used to calculate the wet atmospheric nitrogen deposition.

Total nitrogen deposition was calculated by scaling the wet deposition data using a regional station that is part of the USEPA Clean Air Status and Trends Network (CASTNET; **Figure 2-22**). Wet deposition that was calculated using data collected at the Southold station was scaled up to total deposition using data collected over the same time period (2010-2014) from the CASTNET station.

Atmospheric deposition is applied to all parcels within the County using 100 percent of the parcel area. As mentioned above in Section 2.1.5.1.2, nitrogen can attenuate as it infiltrates through the ground surface. Leaching factors were also applied to the atmospheric nitrogen load. The leaching rates (TNC,2016) and calculated nitrogen load from atmospheric deposition are shown in **Table 2-15.** Total nitrogen deposition was calculated by scaling the wet deposition data using a regional station that is part of the USEPA Clean Air Status and Trends Network (CASTNET; **Figure 2-22**).



Source: CASTNET + Interpolated NADP—NTN/PRISM Only complete years are shown 03MAR16

Figure 2-22 Nitrogen from Atmospheric Deposition

Table 2-15 Assigned Nitrogen Load from Atmospheric Deposition

Ground Cover	Leaching Rate (%)	Nitrogen Load (lbs.-N/1,000 sf/yr.)
Natural Vegetation	25	0.103
Turf	30	
Agriculture	40	

2.1.5.1.5 Denitrification Effect of Coastal Wetlands and the Hyporheic Zone

The hyporheic zone is a zone of saturated sediment within the bed of a surface water body where discharging groundwater mixes with surface water. Denitrification through the hyporheic zone has been documented in the literature (Wexler et al, 2011; Peyrard et al, 2011; Pinay et al, 2009; Puckett, 2008). As nitrogen discharges through this zone, biological respiration and vegetation uptake may utilize some of the nitrate and promote denitrification. Denitrification through the hyporheic zone is highly variable and site specific. While data was not available to quantify the potential for denitrification throughout the County, denitrification through wetlands discharge areas was included in the nitrogen load estimates based on values documented in the literature. Hamersley (Hamersley, 2001) completed a study in New England documenting that salt marshes can remove about 15 percent of the total nitrogen discharging from groundwater flow to estuary shorelines. Based on similar conditions, nitrogen loss through the hyporheic zone and wetlands was considered as subwatershed-specific nitrogen loads were compiled.

Nitrogen and Pathogen Loads from Birds and Wildlife

Nitrogen *- Nitrogen loads from animals and the avian population were identified by stakeholders as potentially significant loads for consideration. Avian and wildlife generated nitrogen loads were not incorporated into the SWP evaluation for two reasons. First, the available literature indicated that in general, nitrogen excreted by wildlife such as deer, geese and other water fowl was largely recycled; e.g., the populations ingested plants containing nitrogen and excreted nitrogen in the same vicinity. For example, Clarke and Meredith (2014) reported that goose/waterfowl droppings did not significantly increase nutrient concentrations in the water column. Swanson, et al (2010) referenced Valiela's (1997) conclusion that the net nitrogen contribution to a waterway from resident birds such as swans is zero because they remove as much nitrogen as they excrete. Swanson, et al concluded that even if the swans did not consume nitrogen but only excreted it, it would be a very small component of the total nitrogen load to that water body, amounting to 0.03 percent of the total nitrogen load to the Forge River, based on an estimate of 150 resident swans. Other studies referenced in the literature (Unckless and Makarewicz 2007, Pettigrew et al 1998, Scherer et al 1995, Brandvold et al 1976) also concluded that the addition of goose/waterfowl droppings did not significantly increase water column nutrient concentrations based on experimental systems.*

In addition to available literature indications that geese do not introduce a net nitrogen load, a second challenge was identifying the data required to estimate location-specific populations. Location-specific population estimates were not available from the resources that were checked including:

- *The Audubon Society;*
- *Cornell Lab of Ornithology;*
- *Ducks Unlimited;*
- *Goosewatch;*
- *Long Island Goose Control;*
- *New York State Department of Environmental Conservation (on-line, 2016), and*
- *The Nature Conservancy.*

Based on the limited information available to quantify net nitrogen loads generated by geese and other wildlife and the inability to reliably quantify subwatershed-specific populations upon which to base an estimate, they could not be incorporated into this evaluation.

Additional study and data collection are required to develop this parameter for incorporation in future evaluations.

Pathogens *- Unlike nitrogen loads, pathogen loads from birds in particular are significant sources to surface waters. Pathogens, including the results from bacterial source tracking studies documenting avian and wildlife impacts on surface waters are described in Section 2.2.6. Recommendations for additional pathogen evaluations in collaboration with NYSDEC who is currently completing a bacteria source tracking study in support of a revised pathogen TMDL for Suffolk County waters are included in Sections 2.2.6 and 8.4.7.*

Table 2-16 Nitrogen Removal from Wetlands

Wetland Type	Percentage of Nitrogen Removal
Littoral Zone.	10
Fresh Marsh	15
Intertidal Marsh	15
Coastal Shoals, Bars and Mudflats	15
High Marsh	15

2.1.5.1.6 Summary and Results

Parcel-specific nitrogen loads were compiled for each parcel in the County, comprised of one (atmospheric deposition) to all four of the potential nitrogen load components. Parcel-specific nitrogen loads were applied to the centroid of most parcels. For parcels larger than two acres, however, sanitary waste and pet waste loads (if applicable) were applied at the centroids, while fertilizer and atmospheric deposition of nitrogen were distributed across the area of the parcel using model nodes for source locations.

The nitrogen loads identified for each parcel were introduced as hundreds of thousands of point sources to the three-dimensional solute transport models to simulate nitrate migration through the aquifer system for a period of 200 years, assuming average annual precipitation, recharge and water supply pumping remained constant over this period.

The solute model transport was used to generate three types of results used in the development of the SWP:

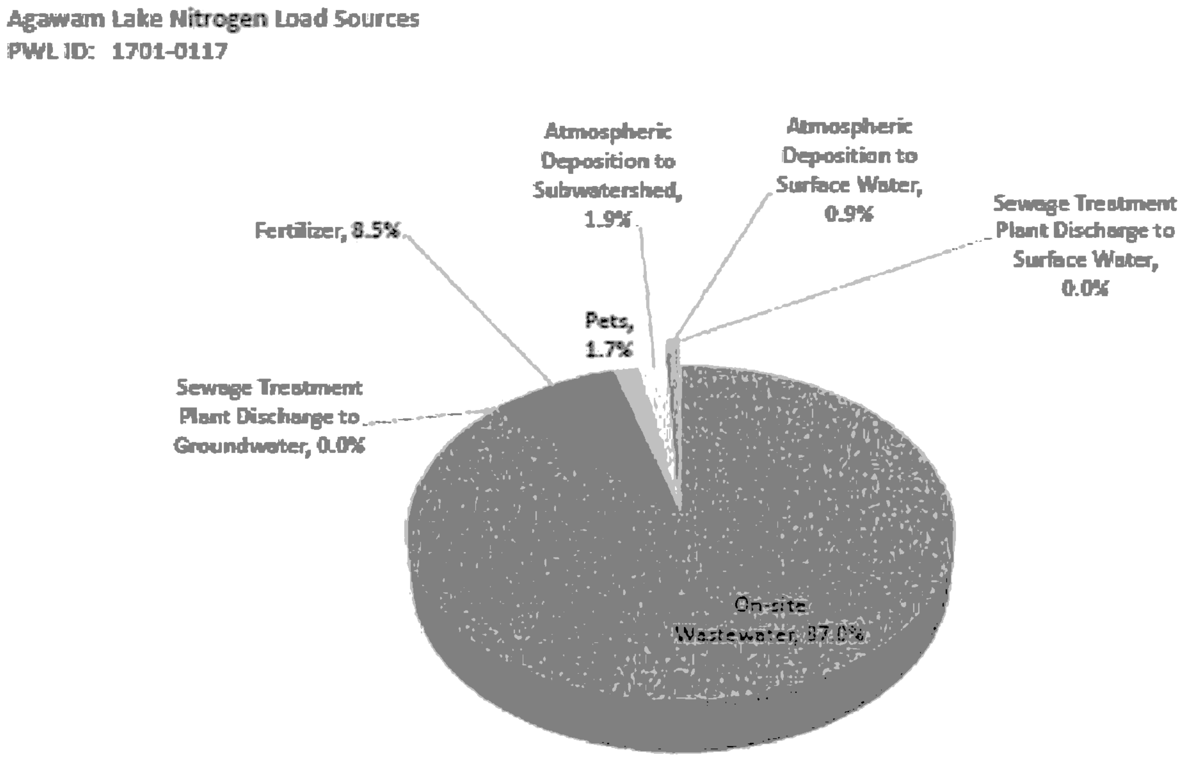
- Nitrogen load from groundwater discharged to each of the 191 surface water bodies;
- Nitrogen concentrations in the shallow upper glacial aquifer (described in Section 3), and
- Nitrogen concentrations in community supply wells (also described in Section 3).

These model-simulated nitrogen levels represent the nitrogen concentrations and loads that would be anticipated to occur after 200 years of existing land use, precipitation and recharge, water supply pumping locations and rates and wastewater management.

2.1.5.2 Subwatershed Nitrogen Loads Based on Baseline/Current Conditions

2.1.5.2.1 Nitrogen Loads to Individual Subwatersheds

Subwatershed-specific nitrogen loads were compiled in a series of charts and tables depicting the simulated pounds of nitrogen introduced to each subwatershed on an annual basis. Each component of the nitrogen load contributing to each subwatershed was identified in the Task 4A deliverable, as illustrated by **Figure 2-23**, which summarizes the nitrogen loading to Lake Agawam. The graphic shows that 87 percent of the nitrogen load to the lake originated from on-site wastewater disposal; fertilizer is the second highest nitrogen load contributing 8.5 percent, followed by atmospheric deposition to the subwatershed at 1.9 percent, nitrogen from pets at 1.7 percent and atmospheric deposition directly to the Lake at 0.9 percent.



Nitrogen Load Sources (without Hyporheic Zone Attenuation)*

Nitrogen Source	Nitrogen Load (lbs/day)	% Contribution
Groundwater Sources		
On-site Wastewater	76.5	87.0%
Sewage Treatment Plant Discharge to Groundwater	0.0	0.0%
Fertilizer	7.5	8.5%
Pets	1.5	1.7%
Atmospheric Deposition to Subwatershed	1.6	1.9%
Surface Water Sources		
Atmospheric Deposition to Surface Water	0.8	0.9%
Sewage Treatment Plant Discharge to Surface Water	0.0	0.0%
Total N Load (without Hyporheic Zone Attenuation)	87.9	100%

*Attenuation reduces the nitrogen load from groundwater baseflow as it travels through the hyporheic zone to surface water discharge. The hyporheic zone reduces the total nitrogen load to 83.4 lbs/day

Figure 2-23 Example Summary of Nitrogen Loads to Agawam Lake

The nitrogen loads contributing to each subwatershed are summarized on **Table 2-17** (please see tables at the end of this section). The nitrogen load contributed by each potential component of the total load varies considerably among the subwatersheds, with the contribution from on-site sanitary loads varying from zero (Big Reed Pond) to 87 percent (Agawam Lake). **Figure 2-24** shows the percentage of each component of the nitrogen loads from groundwater sources within the 200-year contributing area to the 191 subwatersheds. The nitrogen contribution from on-site wastewater discharge to groundwater amounts to 63.6 percent of the nitrogen load from groundwater and is the most significant nitrogen source to the subwatersheds, followed by fertilizer at 26.9 percent, atmospheric deposition to the subwatershed at surface water at 4.4 percent and pets at 3.9 percent.

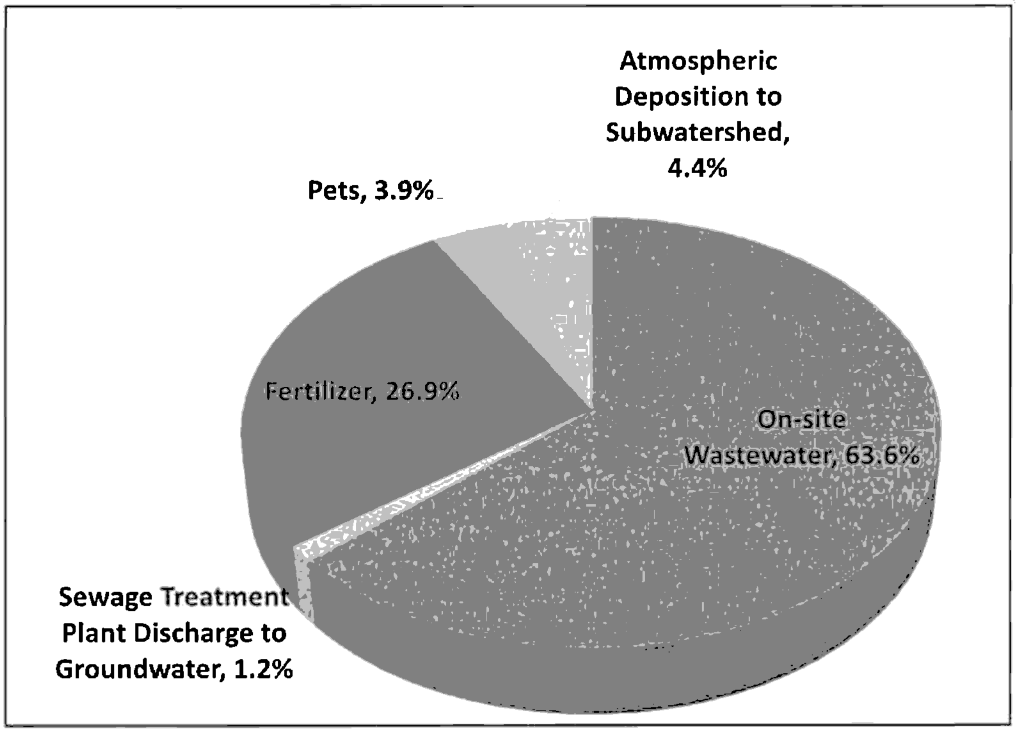


Figure 2-24 Nitrogen Loads from Groundwater to All 191 Subwatersheds

Figure 2-25 shows the percentage of each component of the nitrogen loads from the 200-year contributing area to the 191 subwatersheds. At 47.7 percent, the nitrogen contribution from on-site wastewater discharge to groundwater was the most significant source to the subwatersheds, followed by direct atmospheric deposition to surface water at 23.7 percent and fertilizer at 20.2 percent. Nitrogen from atmospheric deposition to the subwatersheds, pets, and sewage treatment plant discharges directly to the surface waters or to the contributing areas all contributed a very small percentage of the total nitrogen load on a Countywide basis.

Subwatershed-specific nitrogen loads may be found in **Appendix D** of this SWP.

2.1.5.2.2 Nitrogen Loads to Aggregated Subwatersheds

The total nitrogen loads that contribute to water bodies that are connected to upgradient draining streams, lakes, tributaries, and sub-embayments include nitrogen from the direct subwatershed groundwater contributing area, nitrogen to the surface water body itself (e.g., deposition and STP effluent, where applicable), and the nitrogen from upstream connected water bodies as groundwater baseflow and direct discharge to the surface water. The total nitrogen loads for these water bodies were compiled by aggregating the loads from each upstream water body as shown by **Figures 2-26** and **2-27** which show the individual subwatershed for Patchogue Bay and the aggregated subwatershed including upstream subwatersheds Abets Creek, Corey Lake and Creek and tributaries, Dunton Lake, Upper and Tributaries and Hedges Creek, Howell's Creek, Mud Creek, Robinson Pond and tidal tributaries, the Patchogue River, Stillman Creek, Swan River, Swan Lake and tidal tributaries and Tuthills Creek.

Patchogue Bay, in fact receives the total nitrogen load contributed to all of the upstream subwatersheds, hence the nitrogen loads to all of the upstream subwatersheds were aggregated. Aggregated loads were used as the basis for the subwatershed rankings and identification of nitrogen load reduction targets described in Section 2.1.9.

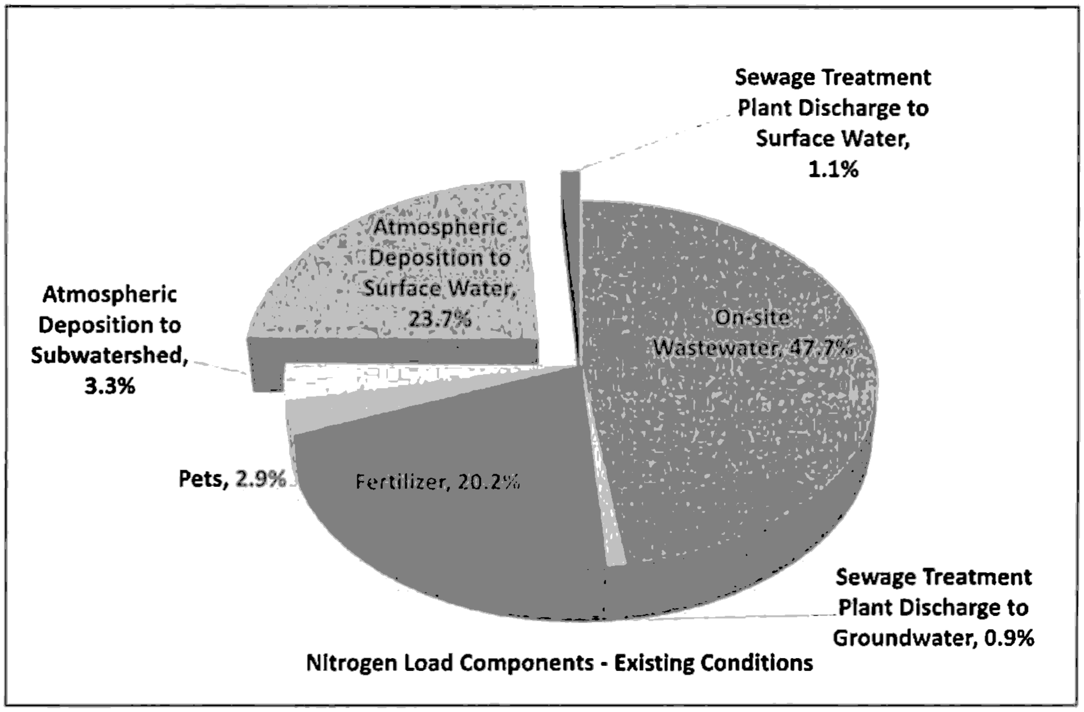
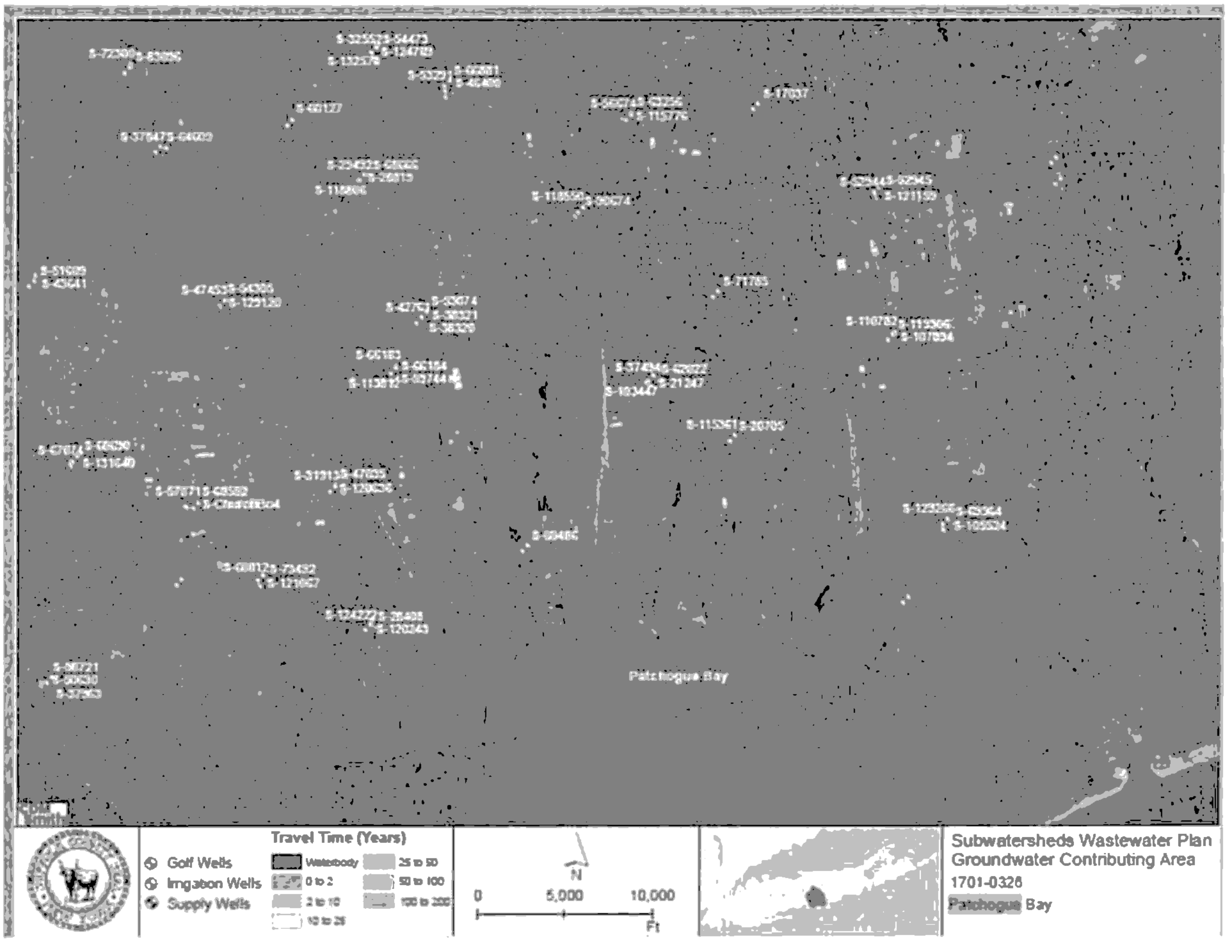


Figure 2-25 Nitrogen Load Components to the 191 Subwatersheds

In all, a total of 55 water bodies were identified for nitrogen aggregation as shown in **Table 2-18**. For all evaluations in this SWP (e.g., priority area establishment, load reduction goals, etc.), the aggregated nitrogen loads were used for each of the 55 water bodies identified.

Nitrogen loads for aggregated subwatersheds along with select freshwater or coastal ponds were also normalized per unit acre of applicable land use to satisfy the requirements of NYSDEC's Nine Elements Watershed Plans. **Table D-1** in Appendix D provides a list of the Nine Elements subwatersheds and the individual water bodies that constitute each Nine Element subwatershed. **Table D-2** presents a summary of the Nine Elements Plan nitrogen loads. In addition, **Table D-3** presents a summary of the individual STPs and their respective nitrogen loads for each of the Nine Elements Watershed Plans water bodies.



Nitrogen Source	Nitrogen Load (lbs/day)	% Contribution
Groundwater Sources		
On-site Wastewater	186.8	60.6%
Sewage Treatment Plant Discharge to Groundwater	49.9	16.2%
Fertilizer	32.0	10.4%
Pets	8.8	2.9%
Atmospheric Deposition to Subwatershed	4.7	1.5%
Surface Water Sources		
Atmospheric Deposition to Surface Water	25.9	8.4%
Sewage Treatment Plant Discharge to Surface Water	0.0	0.0%
Total N Load (without Hyporheic Zone Attenuation)	**308.1**	**100%**

Figure 2-26 Individual Patchogue Bay Subwatershed