SUFFOLK COUNTY
COMPREHENSIVE
WATER RESOURCES
MANAGEMENT PLAN

Section 8
WASTEWATER MANAGEMENT

Section 8
Wastewater Management

8.1 Problem Identification

In Suffolk County our economic prosperity, public health and safety, and quality of life rely upon a clean and sustainable supply of water. While all sources of water pollution are concerning, nitrogen pollution from septic systems has clearly emerged as the most widespread and least well addressed of the region's growing list of water pollutants.

Suffolk County New York is approximately 912 square miles and bounded by Nassau County to the west, the Atlantic Ocean to the east and south, and the Long Island Sound to the north. In 2013, the estimated population of Suffolk County was approximately 1.5 million (with 568,943 housing units), larger than the population of 11 states. The County's water resources are extremely valuable to residents, businesses, and visitors. The EPA designated sole source aquifer located directly underneath the County provides a source of fresh water to meet our potable drinking water, irrigation, and grey water needs. Surface waters resources provide recreational opportunities such as swimming and boating, a thriving tourist industry, fishing and shell fishing industry and coastal protection from storm surges.

The County's water resources are impacted by various pollutants contained in wastewater, storm water, fertilizers, and from atmospheric deposition. Portions of the Long Island Sound, Peconic Estuary, and South Shore Estuary have been listed on New York State's Draft Section 303(d) list of impaired water bodies.[1] One of the major water quality pollutants is nitrogen. Average nitrate concentrations in the same set of 175 upper glacial community supply wells that were sampled in 1987 and in 2013 have increased by approximately 1 mg/L, and average concentrations in the same set of 213 Magothy community supply wells increased by an of 0.76 mg/L from 1987 to 2013.

In Suffolk County, wastewater is one of the major contributors of nitrogen, which has significantly impacted ground and surface water quality. It is estimated that 69 percent (IBM Smarter Cities Challenge Report) of the nitrogen comes from onsite sewage disposal systems. Only 26 percent of Suffolk County is connected to a community sewage collection and treatment system capable of reducing nitrogen. The remaining 74 percent of the County utilizes onsite sewage disposal systems to meet their sewage disposal needs. These onsite sewage disposal systems are either systems consisting of cesspools (also known as leaching pools) or a combination of a septic tank and leaching pool (conventional onsite sewage disposal system). These systems typically have little nitrogen reduction capabilities. The wastewater effluent from these onsite sewage disposal systems discharges into the ground eventually impacting ground and surface water resources. Increased levels of nitrogen in drinking water can cause methemoglobinemia also known as "Blue Baby Syndrome".[2] Increased nitrogen levels in surface waters result in eutrophication. The higher levels of nitrogen in surface waters can spur hypoxia, harmful algal blooms, reduce coastal resiliency, and create a decline of sea and shell fisheries. As an example, increased nitrogen levels in surface waters can stimulate algal blooms followed by an algal die-off when the nitrogen nutrient is depleted causing dead algae to settle, which increases the biological oxygen demand (BOD) when the microorganism population expands to consume the dead algae. Excessive amounts of algae leads to increased algal metabolism and turbidity of water, decreased dissolved oxygen in the water, and changes in community structure of the ecosystem.[3]

Suffolk County contains the highest density of onsite septic systems within the tri-state area with approximately 360,000 homes currently utilizing onsite sewage disposal systems. Of particular concern are the onsite septic systems located in the groundwater contributing areas of potable supply wells and estuarine surface waters. The Suffolk County Department of Economic Development and Planning has identified that approximately 209,000 of these homes with onsite sewage disposal systems are located in areas considered to be high priority areas. High priority areas are as follows (**Figure 8-1**):

- Areas in the 0-50 year contributing zone to public drinking water wells fields
- Areas in the 0-25 year contributing zone to surface waters
- Unsewered parcels with densities greater than what is permitted in Article 6 of the Suffolk County Sanitary Code
- Areas located in an area where groundwater is less than 10 feet below grade

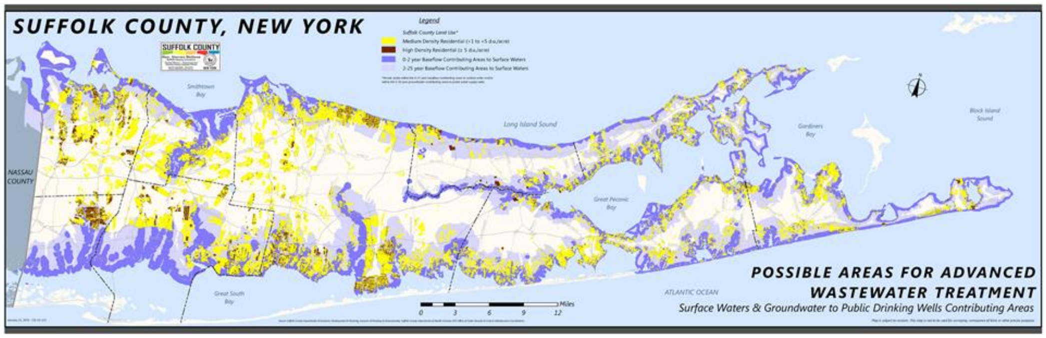


Figure 8-1 Map of Areas for Advanced Treatment

Suffolk County must maintain a balance between protecting the quality of water resources while maintaining the ability to dispose of wastewater to protect public health and stimulate development in order to promote economic growth and stability. This is accomplished by the implementation of a responsible wastewater management plan to limit the impacts of nitrogen from wastewater and other emerging wastewater constituents (personal care products, pharmaceuticals, etc.) on the County's water resources to preserve and protect these resources for future generations. The wastewater management plan should consist of connecting lots to community sewers by expanding existing sewer districts or creating new sewer districts where possible, upgrading cesspools to conventional onsite sewage disposal systems or innovative/alternative onsite sewage disposal systems, requiring new construction to install innovative/alternative sewage disposal systems in priority areas, developing/researching new technologies to better reduce nitrogen and other emerging wastewater constituents, and developing/providing funding sources to implement the wastewater management plan, etc.

8.1.1 The History of Wastewater Management in Suffolk County

8.1.1.1 Population Growth and Construction Trends

A review of population growth and construction trends becomes important when developing a responsible wastewater management plan to protect water resources. With population growth comes an increased need for potable water and wastewater infrastructure to serve the needs of the people. Suffolk County witnessed a population explosion between the 1950s and 1960s (See **Figure 8-2**) as the population increased from 276,129 in 1950 to 1,127,030 by 1970, according to U.S. census data. This was an increase of approximately 308 percent over a 20-year period. From the 1980s to 2010 the population of Suffolk County grew modestly with a population growth of 5.2 percent between 2000 and 2010.

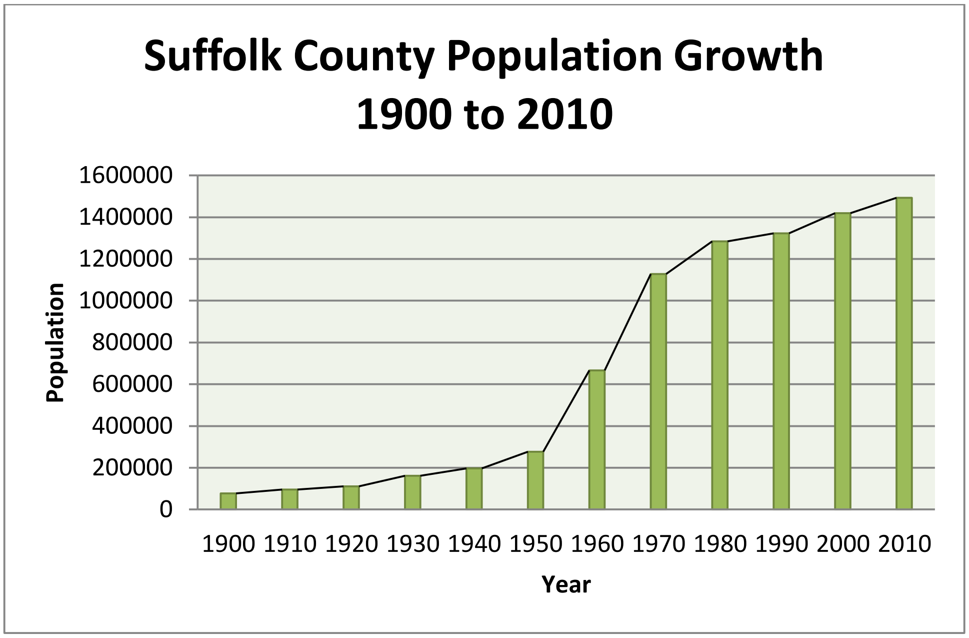


Figure 8-2 Suffolk County Population Growth

According to **The Suffolk County- Comprehensive Plan 2035**, the population of Suffolk County will continue to grow through 2045 reaching a population of 1.77 million.

Prior to 1950, much of Suffolk County was characterized by a network of small villages located along the Long Island Rail Road lines and supported by the fishing and agricultural industries. In the decade between 1950 and 1960, fueled by national housing and transportation policies that favored suburban tract development, the landscape of the County began to be transformed as the population of Suffolk County increased from 275,000 to 666,000 residents – an unprecedented growth of 140 percent. By 1970, after the population explosion during 1950s and 60s, the number of housing units within Suffolk County was 325,777 (See **Figure 8-3**). During the 43-year period after 1970 the number of housing units grew to 568,943.

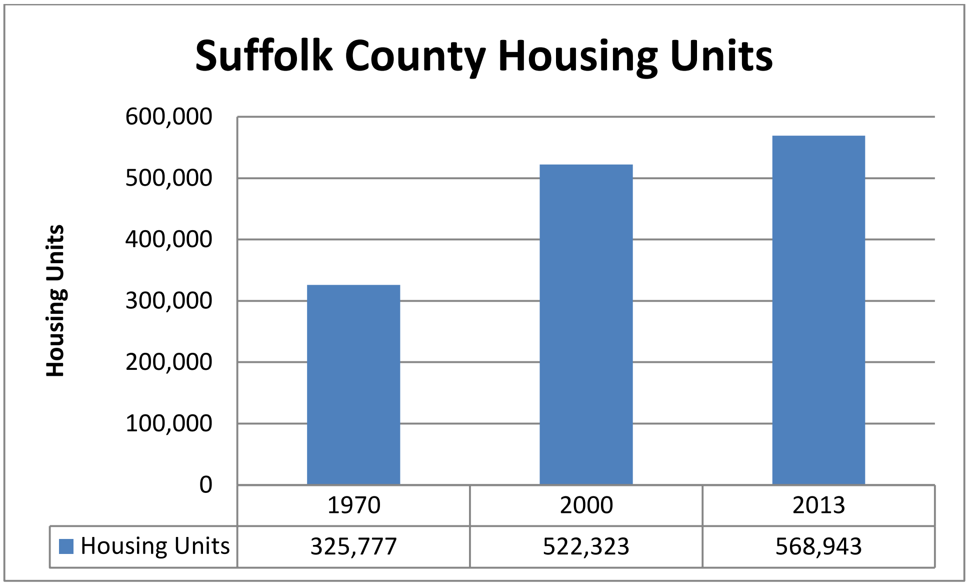


Figure 8-3 Suffolk County Housing Units

Currently, approximately 360,000 housing units use onsite sewage disposal systems that have limited nitrogen reducing capabilities as means of sewage disposal. The remaining units are connected to a community wastewater treatment system. In order to facilitate Suffolk County's continued population growth it is expected that development of remaining buildable undeveloped land will take place (other than the parcels sterilized for open space or development rights sold). In addition to the development of vacant parcels, previously developed parcels are being redeveloped. This includes infill development and redevelopment in and around train stations and transportation corridors and downtowns. One example of a blighted parcel is the redevelopment of the former United Artists Movie Theater previously located in Coram at the southwest corner of Middle Country Road and NYS Route 112. The vacant movie theater existed at the site for a number of years and was an eye sore to the community (See **Figure 8-4**).[4] In order to meet the growing housing needs of Suffolk County the site will be redeveloped with multiple workforce housing units and over 15,000 square feet of commercial space. Suffolk County played an active role assisting in the success of moving the workforce housing project forward and provided $1.5 million in funding for the construction of infrastructure components of the project.

Figure 8-4 Abandoned United Artist Movie Theater Located in Coram (Left) and Renderings of Proposed Residential-Commercial Buildings to be Constructed on the Site (Right)

8.1.1.2 Current Methods of Reducing/Limiting Wastewater Effluent Nitrogen Loading

8.1.1.2.1 Suffolk County Article 6 Density Standards and Groundwater Management Zones

Article 6 of the Suffolk County Sanitary Code outlines sewage disposal requirements for construction to help reduce the impacts of nitrogen loading to water resources. Per Article 6 of the Suffolk County Sanitary Code, property owners constructing a new building (including additions to existing buildings or changes of use of existing buildings with an onsite sewage disposal system) are required to obtain a permit from the Suffolk County Department of Health Services (SCDHS). The permit is usually for a proposed new onsite sewage disposal system conforming to current standards. In some cases where an addition or change of use is proposed, the permit may be to simply verify that the existing system meets current standards and is acceptable for the proposed addition or change of use.

A 208 Study was performed by SCDHS beginning in the early 1970s, to study the effects of building density on groundwater quality. The Long Island Comprehensive Waste Treatment Management Plan was based on the results of the 208-Study. Based on the study, eight Groundwater Management Zones, with differing recharge characteristics were identified. In addition the study showed that 1 acre zoning was needed to keep groundwater impacts acceptable and allow development to proceed. As a result, Article 6 was added to the Suffolk County Sanitary Code in 1981, which defined the means and methods for wastewater treatment in Suffolk County. Based on differences in regional hydrogeological and groundwater quality conditions, Article 6 delineated boundaries of the eight Groundwater Management Zones (GWMZ) for protection of groundwater quality (See **Figure 8-5**). The goal of creating the

GWMZ was to limit groundwater nitrogen to 4 mg/l in GWMZ III, V, and VI and to 6 mg/l in the remaining zones.

Figure 8-5 Suffolk County Sanitary Code Article 6 Groundwater Management Zone Map

Residential properties located within GWMZ III, V, and VI were required to have a minimum lot size of 40,000 square feet of land with the use of a conventional onsite sewage disposal system and public water or private wells. Residential properties located in the remaining zones are required to have a minimum 20,000 square feet of land when utilizing conventional onsite sewage disposal systems and public water (40,000 square feet with private wells).

Commercial/Industrial properties located in GWMZ III, V, and VI were limited to a total discharge of 300 gallons per day (gpd) per acre when using a conventional onsite sewage disposal system and public water or private well. The remaining zones were allowed 600 gpd/acre with public water (300gpd/acre with private well).

Since Article 6 was enacted in 1981 four (4) exemptions were permitted, as outlined below, for lots that existed prior to 1981. This permitted higher density development in certain areas when these exemptions where met.

1) Lots separately assessed on the Suffolk County Tax Maps as of January 1, 1981 and are buildable under current town or village zoning ordinances.
    a. (Applies to 4 or less lots owned by the same developer)

2) Subdivision previously approved by the New York State Health Department and have been filed in the Office of the Clerk of the County of Suffolk

3) Developments or other construction projects previously approved by the Department

4) 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

Projects that exceed the density requirements as stated in Article 6 of the Suffolk County Sanitary Code and do not meet one of the exemptions are required to provide advanced treatment capable of reducing effluent nitrogen to 10 mg/l. This is accomplished by connecting the site to an existing or proposed community sewage treatment plant.

Many areas of Suffolk County were built before the Article 6 density restrictions or prior to conventional treatment system requirements. It is these many homes and businesses that are contributing to the pollution of groundwater in Suffolk County as well as the surface waters and ecosystems of the County. The Suffolk County Department of Economic Development and Planning estimated that over 60 percent of the residential parcels in Suffolk County are less than or equal to one half acre. There are approximately 372,018 residential parcels less than or equal to ½ acre (See **Table 8-1**). Of the 372,018 residential parcels, 257,626 (52.9 percent of the parcels) are not sewered. Out of the 487,082 residential parcels there are 214,903 residential parcels less than ¼ acre including 129,947 unsewered parcels (26.7 percent, as shown on **Table 8-2**). **Table 8-3** depicts the number of sewered parcels versus unsewered parcels by town, which equates to 75.3 percent unsewered (366,693 residential parcels) and 24.7 percent sewered (120,389 residential parcels).

8.1.1.2.2 Expansion of Sewers

Alternatively to meeting the density requirement of Article 6 of the Suffolk County Sanitary Code to protect water resources, connection to community wastewater treatment systems is an acceptable method of reducing nitrogen. A feasibility Study was conducted to explore the construction of public sewers within Suffolk County in 1961, and in 1965 Suffolk County established the County Sewer Agency, which was responsible for sewage collection, conveyance, treatment and disposal.

By 1970, the County acquired its first sewage treatment plant, the already constructed 1.5 million gallon per day (MGD) plant, located in Port Jefferson known as Suffolk County Sewer District #1. Eventually in the late 1970s and 1980s the Southwest Sewer District (SWSD), known as Sewer District #3, was created and the Bergen Point wastewater treatment plant (WWTP) was built and went online in October, 1981 through funding from the federal Government and New York State.[5] Sewer District # 3 is the largest sewer district in Suffolk County consisting of an area of 57 square miles with of 950 miles of sewer lines and 14 remote pumping stations. The WWTP is currently designed for 30 MGD plus a scavenger waste flow of 0.5 MGD (**Figure 8-6**) serving an estimated population of 340,000 people.[6]

Table 8-1 Residential Parcels Less Than or Equal to ½ Acre

Residential Parcels Smaller Than or Equal to ½ Acre in Suffolk County Per Town					
Town	# of Parcels Less Than or Equal to ½ Acre	# of Unsewered Parcels Less Than or Equal to 1/2 Acre	# of Sewered Parcels Less Than or Equal to 1/2 Acre	Total Residential Parcels	Percent of Unsewered Parcels Less Than or Equal to ½ Acre
Babylon	58,377	15,291	43,086	59,485	25.71%
Brookhaven	119,535	92,253	27,282	151,672	60.82%
East Hampton	9,452	9,157	295	19,342	47.34%
Huntington	44,952	39,566	5,386	64,747	61.11%
Islip	78,796	47,143	31,653	88,138	53.49%
Riverhead	6,996	5,276	1,720	11,957	44.12%
Shelter Island	491	384	107	2,498	15.37%
Smithtown	28,181	24,985	3,196	37,643	66.37%
Southampton	17,776	17,114	662	37,365	45.80%
Southold	7,462	6,457	1,005	14,235	45.36%
Totals	**372,018**	**257,626**	**114,392**	**487,082**	52.89%

Table 8-2 Residential Parcels Less Than or Equal to ¼ Acre

Residential Parcels Smaller Than or Equal to 1/4 Acre in Suffolk County Per Town					
Town	# of Parcels Less Than or Equal to 1/4 Acre	# of Unsewered Parcels Less Than or Equal to 1/4 Acre	# of Sewered Parcels Less Than or Equal to 1/4 Acre	Total Residential Parcels	Percent of Unsewered Parcels Less Than or Equal to 1/4 Acre
Babylon	50,094	12,381	37,713	59,485	20.81%
Brookhaven	67,423	50,334	17,089	151,672	33.19%
East Hampton	3,479	3,186	293	19,342	16.47%
Huntington	27,373	22,608	4,765	64,747	34.92%
Islip	38,994	19,577	19,417	88,138	22.21%
Riverhead	4,064	2,926	1,138	11,957	24.47%
Shelter Island	128	53	75	2,498	2.12%
Smithtown	13,766	10,823	2,943	37,643	28.75%
Southampton	6,791	6,132	659	37,365	16.41%
Southold	2,791	1,927	864	14,235	13.54%
Totals	**214,903**	**129,947**	**84,956**	**487,082**	**26.68%**

Table 8-3 Sewered vs Unsewered Residential Lots

Sewered vs Unsewered Residential Parcels in Suffolk County Per Town					
Town	Total Unswered Residential Parcels	Total Sewered Residential Parcels	Total Residential Parcels	Percent of Unsewered Residential Parcels	Percent of Sewered Residential Parcels
Babylon	15,694	43,791	59,485	26.38%	73.62%
Brookhaven	122,984	28,688	151,672	81.09%	18.91%
East Hampton	19,046	296	19,342	98.47%	1.53%
Huntington	58,298	6,449	64,747	90.04%	9.96%
Islip	53,968	34,170	88,138	61.23%	38.77%
Riverhead	10,048	1,909	11,957	84.03%	15.97%
Shelter Island	2,348	150	2,498	94.00%	6.00%
Smithtown	34,411	3,232	37,643	91.41%	8.59%
Southampton	36,700	665	37,365	98.22%	1.78%
Southold	13,196	1,039	14,235	92.70%	7.30%
Totals	**366,693**	**120,389**	**487,082**	75.28%	24.72%

Figure 8-6 Aerial Photo of Bergen Point STP (Courtesy of Newsday)

Since the creation of the SWSD and extension of sewers to existing homes and commercial buildings located within the district there has not been a sewer project of its kind in Suffolk County in over 30 years. Evidence has shown that sewering can help reduce nitrogen loads to surface waters, for example the average nitrogen in the Carlls River in the 1970s was 3.2 mg/l and in the 2000s was reduced to 1.8 mg/l (See Section 5).

Suffolk County has recently started to evaluate the feasibility of sewering various areas throughout Suffolk County. In 2008, the Suffolk County Sewer District/Wastewater Treatment Task Force was established by the Suffolk County Legislature. The goals of the Task Force were to (suffolksewerstudy.cdmims.com):

1. Examine Suffolk's existing wastewater treatment facilities;

2. Educate the public as to the environmental and economic benefits of wastewater treatment facilities

3. Seek out public and private resources of funds to expand Suffolk County's wastewater treatment facilities to suitable areas in the County.

The unsewered areas to be studied were Bellport-North Bellport, Flanders Riverside Corridor, Lake Ronkonkoma Hub, Mastic-Shirley, NY 25 Corridor, Sayville, Southampton Village, and Yaphank.

In addition, the Task Force identified the following sewered areas for feasibility of potential expansion: Riverhead/Calverton, Patchogue, Port Jefferson and Sag Harbor.

Several additional feasibility study areas were later identified as separate projects: Deer Park-North Babylon-West Babylon-Wyandanch-West Islip, Center Moriches and Flanders-Riverside Corridor.

In 2014, Suffolk County was awarded $383 million from New York State to install sewers and connect approximately 10,000 properties to sewage collection and treatment systems. This will be the first major sewering based project within Suffolk County in more than 30 years. The goal of the project is to reduce nitrogen pollution to ground and surface waters to improve coastal resiliency against future storm events. The areas to be sewered, shown on **Figure 8-7,** the Suffolk County Coastal Resiliency Projects Fact Sheet, will be

(1) Mastic: Parcels in the Forge River area will be connected to a new sewer collection system that will flow to a new wastewater treatment plant located on municipal property near the Brookhaven Town Airport.

(2) North Babylon and West Babylon and Wyandanch: Parcels in the Carlls River area will be connected to the SWSD.

(3) Great River: Parcels in the Connetquot River and Nicolls Bay area will be connected to the SWSD.

(4) Patchogue: Parcels in the Patchogue River area will be connected to the Patchogue sewer system within the Patchogue Sewer District.

8.1.1.3 On-site Sewage Disposal Systems

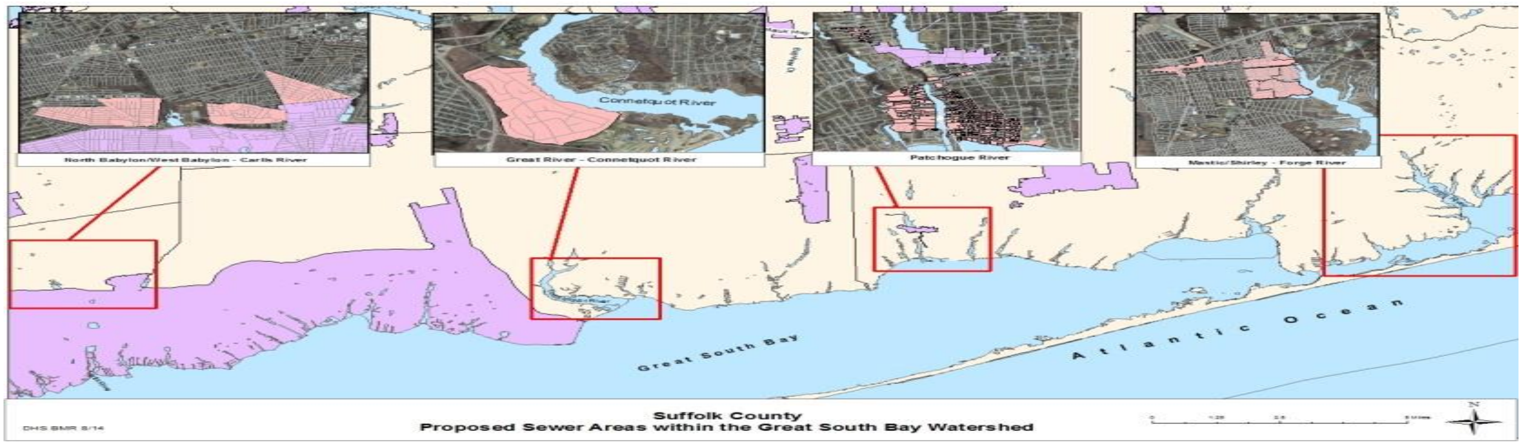
Seventy-four percent of Suffolk County residences use onsite sewage disposal systems as means of sewage disposal. The effluent from onsite sewage disposal systems are discharged into the ground. The sands, silts, gravels and clays that make up the unsaturated zone and the aquifer function as a large sand filter and help to limit the impact of contaminants contained in effluents to groundwater. In 1958 the first SCDHS Standards went into effect, requiring block cesspools for single-family homes. Up until 1972 these cesspools (AKA leaching pools) were permitted to be installed without a septic tank (**See Figure 8-8**). Leaching pools are defined as a covered pit with a perforated wall through which wastewater will infiltrate the surrounding soil. Today, leaching pools are reinforced precast concrete structures, but the original leaching

Great South Bay – Water Quality Initiative

10/21/14

Highest priorities: Sewer 4 sensitive sub-watershed areas of Great South Bay with small parcels, shallow groundwater, short travel time to groundwater and concentrated nutrient loads in sensitive stream corridors (Carlls River, Connetquot River, Patchogue River, and Forge River)

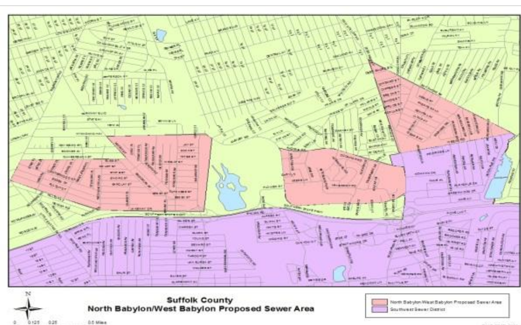
Sewer 10,647 Parcels ****Remove 860 lbs./day of Nitrogen*** ****Reduce Wasteater Nitrogen load by 15%***



These four projects will address the following circumstances:

- **High Nitrogen/Poor Flushing**
  - Residence time~100 days
  - Unsewered wastewater is ~70% of nitrogen load
- **Harmful Algal Blooms**
  - Recurring Brown Tide that obliterate shellfish habitat
  - *Cochlodinium p. "rust tide"* in 2011
- **Depleted Coastal Resiliency**
- **Wetlands loss**
  - *NYSDEC estimates 18-36% loss in GSB between 1974-2001
- **Seagrass loss**
  - 90% loss of since 1930
- **Shellfish loss**
  - 93% loss of hard clam harvest in past 25 years
  - Loss of more than 6,000 jobs
- **Low Dissolved Oxygen**
  - "Impaired water body" declaration by NYSDEC in 2008

Total sewering cost: $383 million. Grant request: $325 million (85% of total cost)



Carlls River (including Area In-District Connections)

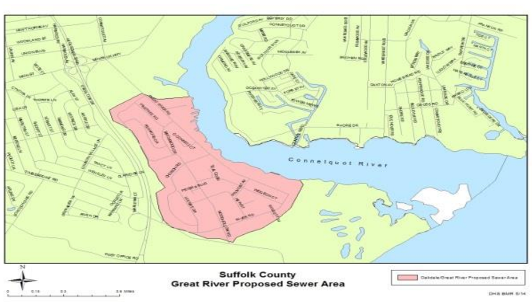
This project would:

- Sewer 6,606 parcels (2,106 w/in North and West Babylon & 4,500 w/in SD #3)
- Remove 543 lbs./day of nitrogen
- 25% reduction in existing Carlls River wastewater nitrogen load
- Remove ~100% of the remaining wastewater nitrogen load from 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: $112 million



Connetquot River

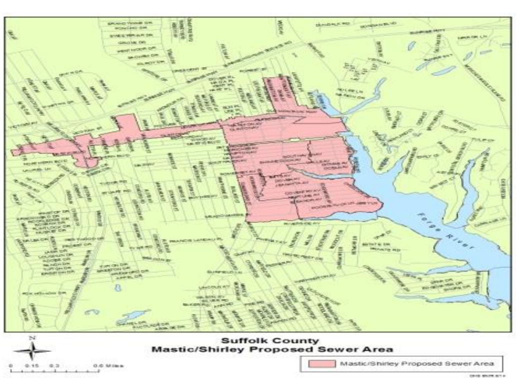
This project would:

- Sewer 500 parcels
- Remove 41 lbs./day of Nitrogen
- 8% reduction in Connetquot River wastewater nitrogen load

Key facts:

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

Cost: $27.2 million



Forge River

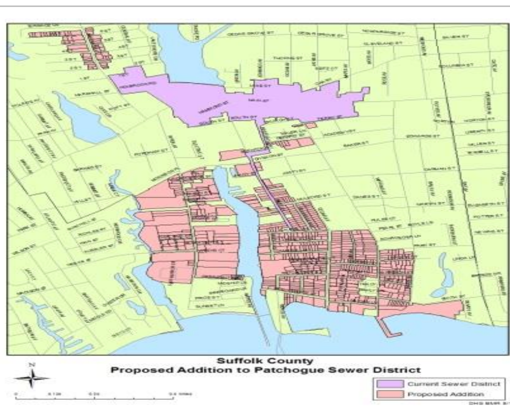
This project would:

- Construct a new Sewage Treatment Plant
- Sewer 2,893 parcels initially and allow for eventually sewering 10,500 parcels
- Remove 201 lbs./day of nitrogen
- 15% reduction of Forge River wastewater nitrogen load

Key Facts:

- Most eutrophic water body in Suffolk County
- 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: $170.3 million



Patchogue River

This project would:

- Sewer 648 parcels (Patchogue S.D.)
- 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: $15.5 million

pools known as cesspools were constructed from concrete blocks and are highly susceptible to collapse. There have been a number of news stories of individuals who have fallen into a cesspool which collapsed. Some individuals are lucky such as a farther, son and neighbor who fell into a cesspool that gave way in Huntington in 2006. They fell into a collapsed cesspool with sewage up to their necks but were rescued by police before they drowned. [7] Some are not so lucky; in September of 2001 a Huntington man who was practicing archery in his backyard died when his 18-foot deep cesspool caved in, taking him with it.[8]

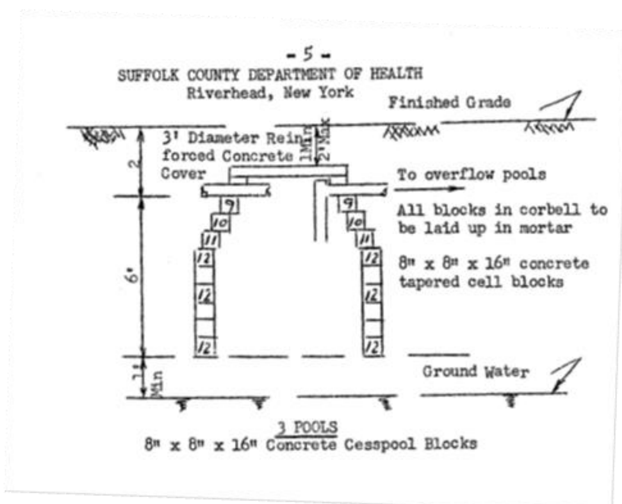


Figure 8-8 Block Leaching Pool Detail -SCDHS Residential Standards Prior to 1972

In 1972, the standards were revised to require basic treatment for single-family homes, consisting of a 900 gallon septic tank and precast leaching pools (also known as conventional onsite sewage disposal systems). **Figure 8-9** depicts the layout of a typical conventional onsite sewage disposal system and precast leaching pool rings respectively. Septic tanks are watertight chambers used for settling, stabilizing and anaerobic decomposition of sewage. Today all new construction including additions to existing buildings or changes of use of existing buildings are required to install a conventional onsite sewage disposal system when a community sewage disposal system is not available.

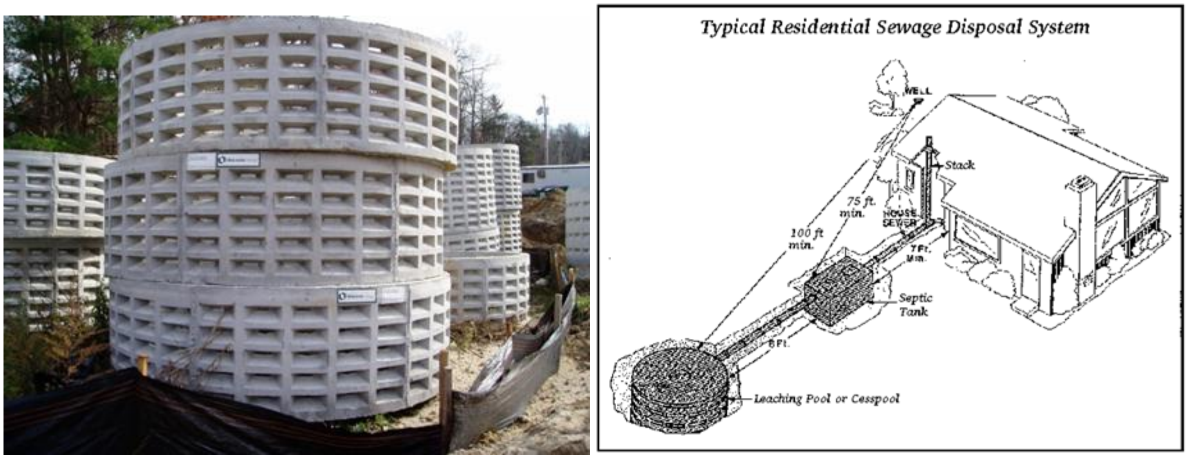


Figure 8-9 Precast Leaching Rings (Left) & Typical System layout (Right)

Currently, property owners with older onsite sewage disposal systems such as cesspools are not required to make an application to the SCDHS to upgrade their system to current standards. When either a cesspool fails or a conventional system fails the property owner has the right to re-install the system in kind without obtaining a permit from the SCDHS. However, as stated in the current residential construction standards, the SCDHS recommends property owners follow the standards as a guideline for re-construction of a failing system.

Based on 1970 census data there were 325,777 homes in Suffolk County that predate the Suffolk County Sanitary Code and construction standards requiring a precast septic tank and leaching pool to be installed at the time of construction. It is estimated that 252,530 homes out of the 325,777 homes in 1970 are not connected to sewers and do not have a sanitary system that conforms to current standards. **Table 8-4** shows the breakdown of number of houses per town that require sanitary upgrades assuming 80 percent of homes in Babylon and 33 percent of homes in Islip are on sewers. (**Suffolk County Decentralized Wastewater Needs Survey Final Report**, March 2012).

Most commercial buildings within Suffolk County are served by onsite sewage disposal systems. It has been estimated that there are approximately 39,318 active commercial properties within Suffolk County using onsite sewage disposal systems. Some of these sites have multiple onsite sewage disposal systems serving the building(s) located on the parcel. Similar to residential sewage disposal systems, commercial onsite sewage disposal systems that comply with current standards consist of a precast septic tank for primary treatment and precast leaching pool(s). Commercial buildings with any type of

Table 8-4 Estimated Sanitary Systems Pre-Dating Requirements for Septic Tanks

Estimated Number of Residential Parcels Pre-Dating Requirements for Septic Tanks		
Town	**Homes in 1970 (Census Data)**	**Homes Requiring Upgrade**
Babylon	58,359	11,672
Brookhaven	78,660	78,660
East Hampton	3,137	3,137
Huntington	56,996	56,996
Islip	79,680	53,120
Riverhead	5,402	5,402
Shelter Island	469	469
Smithtown	27,944	27,944
Southampton	10,329	10,329
Southold	4,801	4,801
Total	**325,777**	**252,530**

food service use also require the addition of a precast grease trap. The first commercial standards went into effect in 1961 and permitted the use of cesspools (block or precast) only or conventional sanitary systems. In 1984, commercial standards requiring precast septic tank and leaching pools went into effect known as “Standards for Approval of Plans and Construction for Sewage Disposal Systems for Other Than Single-Family Residences”. In addition to addressing the requirement for precast and septic tanks, the standards reference allowable sanitary flow permitted to be discharged from a commercial/industrial parcel. Therefore there are many sites constructed prior to 1984 that may exceed the current density requirements of Article 6 and may have cesspools as means of sewage disposal.

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). 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. It was followed by a dosing siphon or pump station that distributed flow to the downstream treatment units.

The treatment process was accomplished by two separate treatment units. The first unit consisted of a buried aerobic sand filter where nitrification would take place. The sewage was introduced to the top of the filter by a distribution manifold. As the sewage filtered down through the media, oxygen would be pulled down into the unit and mixed the sewage and the in-situ bacteria that attached to the sand. Both carbonaceous satisfaction and nitrification would occur in the filter before liquid was captured in an underdrain collection system.

The next treatment step consisted of 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.

Passive denitrification systems were installed between 1985 and 1994. There are approximately 450 of these systems installed throughout Suffolk County. This technology was thought to be advantageous because it provided developers the ability to exceed density with a much smaller footprint and significantly lower operating cost than a traditional decentralized onsite wastewater treatment plant. Unfortunately, permission to install these systems was ultimately suspended by the NYSDEC due to the fact the technology could not consistently meet the groundwater nitrogen discharge limit of 10 mg/l due to clogging of both the sand media and denitrification filter.

Over time, most of these systems failed hydraulically and were bypassed to conventional treatment systems. These systems originally operated under a State Pollution Discharge Elimination System (SPDES) permit 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 drop the effluent limitations and place the permittee on notice that additional treatment may be required in the future.

In 2009 Suffolk County began investigating innovative/alternative onsite wastewater treatment systems (I/A OWTS) capable of reducing effluent total nitrogen for residential use. A study by Holzmacher, McLendon & Murrell (H2M) on behalf of Suffolk County to evaluate “Alternative Onsite Wastewater Treatment Systems” was completed in 2012. The systems evaluated were required to produce a total effluent nitrogen of 10 mg/l or less consistently to meet NYSDEC requirements. The evaluation was broken into two categories as follows: (1) Systems between 300 gpd and 1000 gpd and (2) Systems between 1,000 gpd and 30,000gpd.

Based on the study, five new types of systems were found to be viable to meet NYSDEC total effluent nitrogen requirements for systems between 1,000 gpd and 30,000 gpd. These systems are now permitted to be installed in Suffolk County provided they meet the requirements of the Suffolk County Sanitary Code and separation requirements as stated in the SCDHS commercial standards. Only one system between 300 gpd to 1000 gpd (residential systems) that consistently met effluent total nitrogen of 10 mg/l or less was identified. The drawback of the system was cost, which could run a homeowner approximately $41,500 as compared to a conventional onsite sewage disposal system at approximately $5,080

The County has revaluated the need to require I/A OWTS for residential lots to meet an effluent total nitrogen of 10 mg/l or less. The County is exploring I/A OWTS that can reduce effluent total nitrogen to 19 mg/l at a lower cost. Based on the Suffolk County "Advanced Wastewater & Transfer of Development Rights Tour Summary" (Prepared April 2014), there are a number of systems existing that can meet these requirements.

In 2014, Suffolk County began its first demonstration project for I/A OWTS. The demonstration project is intended to provide field-testing and technology verification to determine if a particular I/A OWTS can function effectively in Suffolk County. The technologies and manufactures that have been selected to participate in the demonstration project are outlined in **Table 8-5**.

8.1.1.4 Sewage Treatment Plants and Sewering

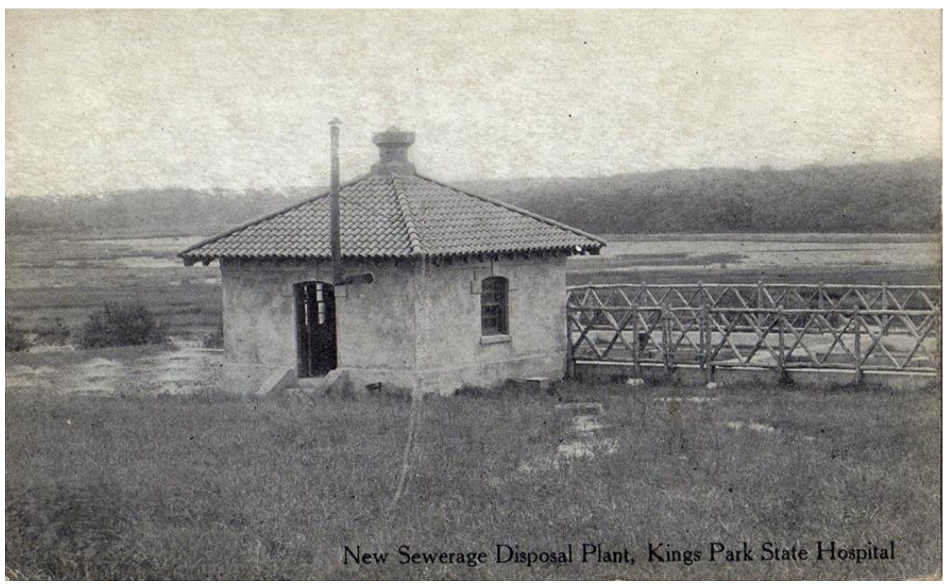
As of 2013, Suffolk County has 197 operational sewage treatment plants (STPs). 171 of the STPs are designed to remove nitrogen from the wastewater with typical effluent total nitrogen of 10 mg/l or less. These types of plants are considered "Tertiary Plants". The remaining 26 STPs are considered "Secondary Plants" capable of reducing biochemical oxygen demand (BOD5) and suspended solids (SS). Of the 197 sewage treatment plants, 15 sewage treatment plants discharge directly to surface waters. The 2013 average effluent total nitrogen for the tertiary plants in Suffolk County was 8.7 mg/l, which is less than the maximum allowed of 10 mg/l per SPDES permits.

Table 8-5 Suffolk County Demonstration Project I/A OWTS

I/A OWTS MANUFACTURER	SYSTEM	PROCESS
Norweco	Singulair TNT	Extended Aeration
Norweco	Hydro-Kinetic 600 FEU	Extended Aeration
Busse	Busse MF 400	Membrane Bioreactor
Orenco Systems	AdvanTex AX-RT	Attached Growth Textile Packed Bed Filter
Orenco Systems	AdvanTex AX20	Attached Growth Textile Packed Bed Filter
Hydro-Action	Hydro-Action	Extended Aeration

The sewage treatment plants in Suffolk County can be broken down into centralized and decentralized STPs. Centralized sewage treatment systems involve advanced collection and treatment processes that collect, treat and discharge large quantities of wastewater.[9] Municipalities usually own the centralized STPs. There are approximately 23 centralized STPs located in Suffolk County. Some of the major centralized sewer districts in the County are Bergen Point (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. Bergen Point is the largest treatment plant in Suffolk County with an operating capacity of 30 MGD and currently under construction to expand the plant to 40 MGD. Bergen Point is a secondary plant that discharges treated effluent 2 miles off of Fire Island into the Atlantic Ocean.

Most of the STPs located within Suffolk County are considered decentralized.



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, 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 (See **Figures 8-10** and **8-11**).

Figure 8-10 Kings Park State Hospital Sewage Disposal Facilities Circa 1935[10]

Figure 8-11 Aerial photo of Kings Park STP in 1978 (Left) and 2013 (Right)

Some of the types of sewage treatment plants utilized in Suffolk County are rotating biological contractor (RBC), sequence batch reactors (SBR), extended aeration systems with a denitrification filter, membrane bioreactor (MBR), and biologically engineered single sludge treatment (BESST) processes (See **Tables 8-6** and **8-7**).

.

Table 8-6 List of Suffolk County STPs (See Table 8-7 for Additional STPs)

Sewage Treatment Name	Sewage Treatment type	Tertiary or Secondary	Sewage Treatment Name	Sewage Treatment type	Tertiary or Secondary
Artist Lake	Extended aeration denite filter	Tertiary	Greens @ Half Hollow	SBR	Tertiary
Avery Village	SBR	Tertiary	Greenview Commons	SBR	Tertiary
Bellhaven Nursing Home	SBR	Tertiary	Greenview Court	Cromaglass	Tertiary
Birchwood @ Spring Lake	Extended aeration denite filter	Tertiary	Greenwood @ Oakdale	Extended aeration denite filter	Tertiary
Birchwood Glen	Extended aeration denite filter	Tertiary	Greenwood Village	Extended aeration denite filter	Tertiary
Birchwood Nursing Home	SBR	Tertiary	Gurwin Jewish Assisted Living	SBR	Tertiary
Birchwood On The Green	Extended aeration denite filter	Tertiary	Gurwin Jewish Geriatric Center	SBR	Tertiary
Blue Ridge	SBR	Tertiary	Hampton Rehab Center	SBR	Tertiary
Bretton Woods	SBR	Tertiary	Hawthorne (Concord) Village	MBR	Tertiary
Bristal East Northport	Cromaglass	Tertiary	Heatherwood @ Holbrook	BESST	Tertiary
Bristal @ Lake Grove	Cromaglass	Tertiary	Heatherwood @Lakeland	Extended aeration denite filter	Tertiary
Encore Atl Shores Bristal Est.	SBR	Tertiary	Heatherwood House @ Lake Ronk	Extended aeration	Secondary
Broadway Knolls	SBR	Tertiary	Heritage Gardens at Brentwood	BESST	Tertiary
Broadway West	Cromaglass	Tertiary	Hidden Ponds	Extended aeration denite filter	Tertiary
Brookhaven Hospital	SBR	Tertiary	Hilton Gardens	SBR	Tertiary
Brookhaven National Lab	Modular Aeration	Tertiary	Holiday Inn Express	Cromaglass	Tertiary
Brookhaven SD #2	BESST	Tertiary	Holiday Inn	Extended aeration denite filter	Tertiary
Brookhaven Town Hall	Extended areation denite filter	Secondary	Homestead Village	Extended aeration Susp. growth denite	Tertiary
Brookwood on the Lake	Bio disc denite filter	Tertiary	Huntington Town	SBR	Tertiary
Browning Hotel Marriott Courtyard	SBR	Tertiary	Inn @ East Winds	Cromaglass	Tertiary
Cabrini Gardens	Cromaglass	Tertiary	IRS	SBR	Tertiary
Calverton Enterprise Park	Extended aeration	Secondary	Island View	SBR	Tertiary
Calverton Hills	Extended aeration	Secondary	Islandia Center	Extended aeration denite filter	Tertiary
Cedar Lodge	Extended aeration	Secondary	Kensington Gardens st jamess NH	Extended aeration denite filter	Tertiary
Cenacle Manor	SBR	Tertiary	LA fitness	BESST	Tertiary
Chatham Holts RI Holt Hotel	SBR	Tertiary	La Quinta	Cromaglass	Tertiary
Chelmsford Weald Condo	Cromaglass	Tertiary	Lake Grove Apqartments	SBR	Tertiary
Country Pointe	SBR	Tertiary	Lake Pointe	Extended aeration denite filter	Tertiary
Country View Estates	SBR	Tertiary	Lakes @ Setauket	Biodisc denite filter	Tertiary
Country View @ Holtsville	BESST	Tertiary	Lakeview Woods Bayport	Cromaglass	Tertiary
Country View @ Smithtown	Cromaglass	Tertiary	Larkfield Gardens Atria	SBR	Tertiary
Courtyard at Southampton	Cromaglass	Tertiary	Lexington Village	Extended aeration	Secondary
Crescent Club	Extended Aeration	Secondary	DSW Plaza Loehmans Plaza	RBC denite filter	Tertiary
Dowling	RBC denite filter	Tertiary	Mac Arthur Plaza	Extended aeration denite filter	Tertiary
Eagles walk	Cromaglass	Tertiary	Medford multicare center for living	SBR	Tertiary
East Port Meadows	Cromaglass	Tertiary	Medford NH	SBR	Tertiary
Emanon Group	Cromaglass	Tertiary	Medford Ponds	BESST	Tertiary
Emerald Greens	SBR	Tertiary	Melville Mall	Biodisc denite filter	Tertiary
Exit 63 Development	SBR	Tertiary	Memorial Sloan Kettering	Cromaglass	Tertiary
Fairfield at Mastic	Cromaglass	Tertiary	Middle Island Co-op	Extended aeration	Secondary
Fairfield at Selden	SBR	Tertiary	Mill Pond Estates	BESST	Tertiary
Fairfield Inn by Marriott	Cromaglass	Tertiary	Montauk Manor	Oxidation ditch	Tertiary (Seasonal)
Fairfield Lk Ronk	Cromaglass	Tertiary	Nesconset NH	Extended aeration denite filter	Tertiary
Fairfield Village (Groton)	MBR	Tertiary	Newsday	Aerotor/MBR	Tertiary
Fairhaven Apts. @ Nesconset	Extended aeration	Secondary	North Isle Village	Extended aeration denite filter	Tertiary
Fairway Manor	Extended aeration denite filter	Tertiary	Northport VA	Extended Aeration w/ Suspended Growth D	Tertiary
Fox Meadows	Extended aeration denite filter	Tertiary	Northport Village	Extended aeration denite filter	Tertiary
Greenport Village	SBR	Tertiary	Oak Creek Commons	Cromaglass	Tertiary

Table 8-7 List of Suffolk County STPs (See Table 8-6 for Additional STPs)

Sewage Treatment Name	Sewage Treatment type	Tertiary or Secondary	Sewage Treatment Name	Sewage Treatment type	Tertiary or Secondary
Oak Creek Commons	Cromaglass	Tertiary	S-Hampton Commons	SBR	Tertiary
Oak HollowNH	Extended aeration upflowdenite filter	Tertiary	SHampton Hospital	Bio disc denite filter	Tertiary
Oak Ridge Hollow	Cromaglass	Tertiary	Shelter Island Heights	SBR	Secondary
Oakwood Care Center Affinity	SBR	Tertiary	Silver Ponds	RBC denite filter	Tertiary
Ocean Beach	Chemical Carbon Filter	Secondary	Smithaven Mall	SBR	Tertiary
Orchard @ Bulls Head Inn	Cromaglass	Tertiary	Smithtown Galleria	SBR	Tertiary
Patch NH	Extended aeration upflowdenite filter	Tertiary	Somerset Woods	Extended aeration	Secondary
Patch Senior Conifer 16128	SBR	Tertiary	Southern Meadows	SBR	Tertiary
Patchogue Village	Aerotor/mbr	Tertiary	Springhorn	Cromaglass	Tertiary
Paumanok	SBR	Tertiary	Spruce Ponds	SBR	Tertiary
Petite Fleur	Extended aeration denite filter	Tertiary	St Annes	Cromaglass	Tertiary
Pine Hills S Mirror Ponds	SBR	Tertiary	Stone Ridge at Dix Hills	Cromaglass	Tertiary
Pinewood Gardens	Cromaglass	Tertiary	Stonehurst	SBR	Tertiary
Plum Island	Extended aeration	Secondary	Stonington	SBR	Tertiary
Preserves	Cromaglass	Tertiary	Stony Hollow	SBR	Tertiary
Quail Run	SBR	Tertiary	Stratford Green	MBR	Tertiary
Radisson HotelBest Western	Extended aeration denite filter	Tertiary	Stratmore on the Green	Extended aeration denite filt	Tertiary
Residence Inn	Cromaglass	Tertiary	Sunrise assited living Smithto	Cromaglass	Tertiary
Riverhead Town	SBR	Secondary	Sunrise Dix Hills	Cromaglass	Tertiary
Rocky Point Apts.	Extended aeration	Secondary	Sunrise E. Setauket	Cromaglass	Tertiary
Ross Health Care	BESST	Tertiary	Sunrise Garden Apts.	SBR	Tertiary
Rough Riders Landing	Oxidation ditch	Tertiary	Sunrise Holbrook	Cromaglass	Tertiary
Saddle Brook	Cromaglass	Tertiary	Sunrise Village	Cromaglass	Tertiary
Sag Harbor	SBR	Tertiary	Tall Oaks	Extended aeration	Tertiary
Sagamore Hills	SBR	Tertiary	The Inn @ East Winds	Cromaglass	Tertiary
Sayville Commons	SBR	Tertiary	The Greens	SBR	Tertiary
SCC Riverhead	SBR	Tertiary	Timber Ridge @ Westhampton	Cromaglass	Tertiary
SCC Selden	Extended aeration denite filter	Tertiary	Towne House Village South	Extended aeration	Tertiary
SD # 1 Port Jefferson	SBR	Tertiary	Valley Forge	SBR	Tertiary
SD # 12 Birchwood	SBR	Tertiary	Victorian Gardens	SBR	Tertiary
SD # 13 wind Watch	SBR	Tertiary	Victorian Homes	SBR	Tertiary
SD # 14 Parkland	SBR	Tertiary	Village in the Woods 00130	Extended aeration denite filt	Tertiary
SD # 15 Nob Hill	Extended aeration Susp. Growth denite	Tertiary	Villages @ Lake Grove	SBR	Tertiary
SD # 18S Hauppauge Industrial Park	Extended aeration susp. growth denite	Tertiary	Fairfield Villas @ Medford	Cromaglass	Tertiary
SD # 2 Tallmadge	SBR	Tertiary	Villas @ Pine Hills	SBR	Tertiary
SD # 20W Leisure Village	SBR	Tertiary	Vinyards @ E. Morriches	Cromaglass	Tertiary
SD # 21 SUNY Stony Brook	Oxidation ditch	Tertiary	Walden Ponds	SBR	Tertiary
SD # 22 Hauppauge County Center	Cannabal	Tertiary	Waterways	Extended aeration denite filt	Tertiary
SD # 23 Coventry Manor	Bio disc denite filter	Tertiary	Waverly Park	SBR	Tertiary
SD # 28 Fairfield@St James	Extended aeration denite filter	Tertiary	West Hampton NH	Extended aeration denite filt	Tertiary
SD # 3 Bergen Point	Aeration	Secondary	Westhampton Pines	SBR	Tertiary
SD # 5 Strathmore Huntington	SBR	Tertiary	Whispering Pines	Extended aeration denite filt	Tertiary
SD # 6 Kings Park	SBR	Tertiary	Willow Ponds	SBR	Tertiary
SD # 7 Twelve Pines	Extended aeration susp. Growth denite	Tertiary	Windbrooke	SBR	Tertiary
SD # 7 Woodside	Extended aeration denite filter	Tertiary	Woodbridge	Cromaglass	Tertiary
SD # 9 College Park	Extended aeration susp. Growth denite	Tertiary	Woodcrest	SBR	Tertiary
SD #11 Selden	SBR	Tertiary	Woodhaven Manor	Extended aeration	Tertiary
SD 20E Ridgehaven	SBR	Tertiary	Woodhull	SBR	Tertiary
SD Gabreski Airport	SBR	Tertiary	Yaphank CC	Bio disc denite filter	Tertiary
SD Yaphank County Center	Bio disc denite filter	Tertiary	Yardarm	Bio disc denite filter	Tertiary
Setauket Meadows	SBR	Tertiary			

"Standards for Approval of Plans and Construction for Sewage Disposal Systems for Other Than Single-Family Residences" Appendix A and B outline the construction requirements for new sewage treatment plants. Appendix A is geared towards plants with flows less than or equal to 15,000 gallons per day while Appendix B is for plants with flows greater than 15,000 gallons per day. The major difference between the two appendixes is the setback requirements. **Table 8-8** outlines the differences in setbacks between Appendix A and B. Enclosed STPs with flows less than or equal to 15,000 gallons per day with the installation of an odor control system, usually carbon drum filters, have the least restrictive setback requirements. In certain cases, enclosed STPs with odor control with flows less than 15,000 gpd may qualify for reduced setbacks to property lines to a minimum of 25 feet when the property line boarders a major highway, railroad tracks, recharge basin, or areas designated as permanent open space.

Table 8-8 SCDHS STP Setback Requirements

Required Setback Distance of Sewage Treatment Plants (STP) of Suffolk County Department of Health Services Standards for Approval if Plans and Construction for Sewage Disposal Systems For Other Than Single-Family Residences Appendix A vs Appendix B			
	Distance to Habitable Structure	Distance to Non-Habitable Structure	Distance to property Lines
Enclosed STP w/ Odor Control (Less Than or Equal to 15,000 gpd – Appendix A)	75	50	75
Enclosed STP w/o Odor Control (Less Than or Equal to 15,000 gpd – Appendix A)	200	100	150
Enclose STP (Greater Than 15,00GPD - Appendix B)	200	200	150
STP Open to the Atmosphere (Greater Than 15,00GPD - Appendix B)	400	400	350

The types of systems installed meeting Appendix A requirements are normally considered to be package systems. Two systems, which have currently been installed in Suffolk County are the CromaFlow (formerly known as Cromoglass) treatment system and the biologically engineered single-sludge treatment processes (BESST) (See **Figure 8-12**). Both treatment systems are activated sludge processes. Other systems less than or equal to 15,000 gallon per day treatment capacity that are permitted to be installed in Suffolk County are sequence batch reactors, membrane bioreactors, Nitrex, AquaPoint, Inc. Bioclere and WesTech's STM-Aerotors.

Figure 8-12 CromaFlow (Left) and BESST (Right) Treatment Tanks

All of the tertiary treatment plants are designed specifically to remove nitrogen, but with the concern for emerging contaminants such as pharmaceuticals and personal care products some modifications may be required to some of the plants to remove these types of constituents in the future.

Sewer collection systems in Suffolk County consist mainly of gravity sewer lines with remote pump stations. In certain cases low pressure force mains have been utilized. The Village of Patchogue sewer district has been expanding in recent years through the use of low pressure force mains with Environmental One (E/One) pump systems such as the DH-152 model depicted in **Figure 8-13**. The advantage of installing low pressure force mains is the cost. They reduce the amount of major remote pump stations required, reduce the need for costly deep excavations to install gravity sewers, and lower dewatering costs. On the other hand, gravity sewers may be more expensive for developers/municipalities to install in certain cases but are less expensive for homeowners since the homeowner does not have to maintain and operate their own low pressure pump station located on their property.

Figure 8-13 E/One Low-Pressure Pump Station (Model DH-152)

8.1.2 Environmental Impacts due to Wastewater Effluent

Nitrogen in various forms can present a public health hazard in drinking water and impact surface waters. SCDHS samples for total nitrogen in wastewater effluent. Total nitrogen consists of organic nitrogen, ammonia (NH_4^+), nitrate (NO_3^-), and nitrite (NO_2^-). Tertiary wastewater treatment plants discharging into the ground in Suffolk County are required to have an effluent total nitrogen of 10 mg/l of less. The sources of nitrogen to Suffolk County's water resources are wastewater, storm water, fertilizers, and atmospheric deposition. It has been estimated that wastewater nitrogen contributes approximately 69 percent[11] of the total nitrogen to ground and surface water resources. The main source of wastewater nitrogen in Suffolk County is from the approximately 360,000 onsite sewage disposal systems utilized by the residents of Suffolk County to meet their wastewater needs. Sections 8.1.3.1 and 8.1.3.2 discusses the current nitrogen trends in Suffolk County's groundwater and surface water resources.

8.1.2.1 Status and Trends of Nitrogen in Suffolk County Groundwater

Early in 2014 SCDHS prepared an evaluation report of nitrates trends in Suffolk County supply wells (Appendix F). The evaluation of nitrates in groundwater is essential because it is a component of total nitrogen and is the primary contaminant in drinking water. When ammonia has contact with oxygen, the oxygen converts ammonia to nitrate via oxidation. After water containing nitrates is ingested, nitrate is converted to nitrite by bacteria conversion in the gastrointestinal tract. Nitrite then converts hemoglobin to methemoglobin, which reduces the bloods ability to transport oxygen causing methemoglobinemia (AKA "Blue Baby Syndrome"), which may cause death. Blue baby syndrome usually affects children less than 3-months old but may affect children up to six years of age.

The SCDHS evaluation report was an expansion of work previously completed by CDM in the Draft Comprehensive Water Resources Report which compared the 1987 and 2005 nitrate water quality data. SCDHS expanded CDM's work by including 2013 nitrate data. Suffolk County has approximately 1,000 public water supply wells and an estimated 45,000 private wells. Several public water supply wells in Suffolk County are approaching or exceeding the nitrate drinking water standard and must blend or treat to reduce nitrate concentrations. Public water suppliers on Long Island can spend an estimated $3.5 million in capital expenses for a nitrate removal system at a typical pump station and can spend an additional $125,000 per year in operating costs for electricity, disposal of waste streams, etc. [12]

Nitrate data was compared at public supply wells screened in the glacial and Magothy aquifers. The Lloyd aquifer was not evaluated since there are currently only a total of 5 public supply wells installed in the Lloyd aquifer and only one was sampled in 1987, 2005, and 2013.[12]

The nitrate results for the glacial aquifer wells were based on samples collected from the same 173 wells sampled in 1987, 2005, and 2013. Nitrate concentrations in the glacial aquifer wells rose over 41 percent from an average concentration of 2.54 mg/l in 1987 to 3.58 mg/l in 2013. This was an annual increase of 0.04 mg/l per year (see **Figure 8-14**).[12]

As with the glacial aquifer, the nitrate levels in the Magothy aquifer were based on samples collected from the same 190 public supply wells sampled in 1987, 2005, and 2013. Nitrate concentrations in the Magothy aquifer wells rose over 93.2 percent from an average concentration of 0.91 mg/l in 1987 to 1.76 mg/l in 2013. This was an annual increase of 0.03 mg/l per year from 1987 to 2005 and 0.04 mg/l from 2005 to 2013 (see **Figure 8-14**). [12]

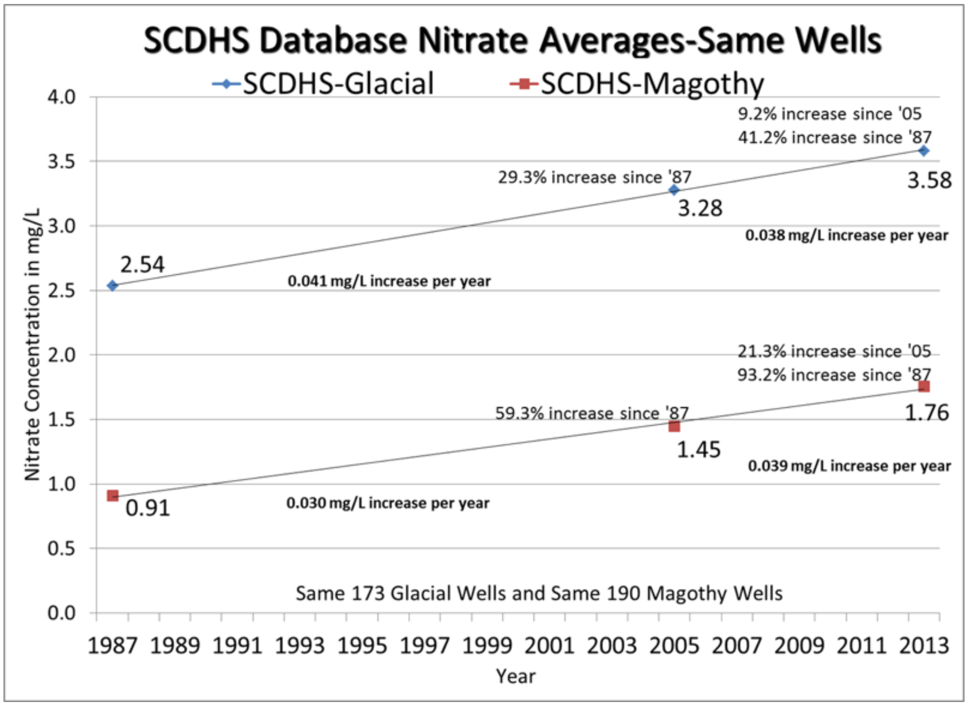


Figure 8-14 Average Nitrate Concentration of Same Wells Tested In 1987, 2005, and 2013

In addition, SCDHS compared the average nitrate concentration of all wells in the glacial and Magothy aquifers (**Figure 8-15**). From **Figure 8-15** the average nitrate concentration in the glacial aquifer increased from 3.01 mg/l to 3.34 mg/l or 11.0 percent from 1987 to 2013. During the same time period, the average nitrate concentration in public supply wells screened in the Magothy aquifer increased from 0.98 mg/l to 1.54 mg/l or 57.3 percent. It should be noted that the number of wells in the glacial aquifer decreased from 732 wells to 498 wells, which could be due to non-community water suppliers connecting to community water supplies and older supply wells being retired. In addition the number of Magothy wells increased from 260 to 390 which could be due to increased demand and/or Magothy well installed to replace a glacial well.[12]

To monitor the success of a wastewater management plan nitrate results should continue to be compared as part of the plan evaluation process. As stated in the nitrate evaluation report,

> *"Comparison of nitrate levels measured at the same set of wells over time provides the most reliable assessment of how nitrate levels in the aquifer are changing. As public supply wells continue to be abandoned or replaced, the pool of available data*

from the same subset of wells will continue to decrease resulting in a very limited assessment of overall quality in the aquifers. Public water supply wells are also generally installed in areas with better water quality, which may be biasing the data in an overall assessment of the aquifer. Alternative methods for compiling a database of consistent and reliable sampling points should be considered (e.g. monitoring well network)."

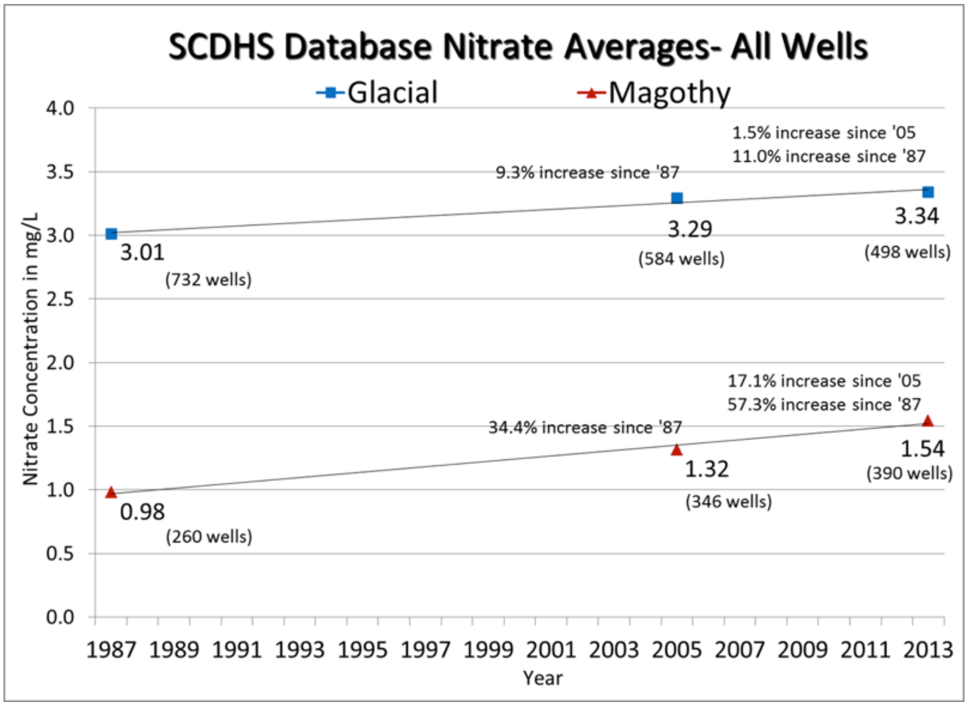


Figure 8-15 Average Nitrate Concentration of All Wells Tested In 1987, 2005, and 2013

8.1.2.2 Status and Trends of Wastewater Impacts to Suffolk County Surface Waters

Suffolk County has approximately 360,000 homes with septic tanks or cesspools contributing to surface waters with many systems in low lying areas that have less than 10 feet separating their systems from the water table. When flooded or submerged in groundwater, septic systems do not function as designed and they fail to adequately treat pathogens. In addition, the excess nutrient load from this wastewater via groundwater flow to our estuaries is impacting our valuable natural resources, natural coastal defenses and threatens our human health. In fact, recent studies by researchers Kinney and Valiela demonstrate that 69 percent of the total nitrogen load for the Great South Bay is from septic systems and cesspools.

All 3 major estuaries in Suffolk County are experiencing environmental and health impairments due to wastewater and nutrient over-enrichment. These impacts include impairments to fish and wildlife populations, oxygen depletion, beach closures, marsh and seagrass loss, shellfish harvest restrictions and recurrence of Harmful Algal Blooms, some of which are toxic to humans.

When algal blooms occur they can alter marine habitats by blocking light or killing marine life. When the algae eventually die off and decay, they deplete the dissolved oxygen in the water which results in uninhabitable dead zones (hypoxia). Since 1985, five distinct groups of harmful algal bloom have emerged in Suffolk County's coastal waters:

- Brown tide (Aureococcus anophagefferens) -a marine microalgae that when in bloom, turns waters coffee-brown and has been responsible for the decline in eelgrass beds in various locations, as well as the mortality of shellfish, particularly bay scallops.
- Red tide (Alexandrium fundyense) – causes paralytic shellfish poisoning (PSP) by the ingestion of shellfish that have been filter feeding on certain strains of algae which produce saxitoxin. Shellfish accumulate this toxin and can, when these contaminated shellfish are consumed by humans or another predator, cause sickness or even death.
- Dinophysis- causes Diaretic Shellfish Poisoning (DSP) by the ingestion of shellfish that have been filter feeding on certain strains of algae which produce the bio-toxin Okadaic acid. Shellfish accumulate this toxin and can cause sickness, when these contaminated shellfish are consumed by humans. In 2011, Dinophysis caused the first DSP event in Suffolk County waters (Northport Bay).
- Cochlodinium polykrikoides - Studies have demonstrated that this organism can have a serious impact on marine resources, as it causes the mortality of juvenile fish and shellfish.
- Toxic cyanobacteria (blue-green algae)-can produce powerful toxins that affect the brain and liver of animals and humans. Blooms of the organism have caused beach closures at various lakes in Suffolk County.

These algal blooms are not only unsightly and in some cases toxic, they block out valuable sunlight that seagrass needs to survive. Seagrasses stabilize bottom sediments, improve estuarine water quality, and provide critical habitat for a large number of varied species. However, thousands of acres have died off in Long Island's eastern and south shore estuaries. According to the NYS Seagrass Task Force, historic photography and records indicate that there may have been as much as 200,000 acres of seagrass in 1930 in Long Island Bays and harbors; only about 22,000 acres remain.

Salt marshes, or tidal marshes, are highly productive coastal wetlands that provide a wide array of important ecosystem services, including storm surge protection for coastal communities, nutrient removal, carbon sequestration, and habitat for numerous fish and wildlife species (Mitsch and Gosselink, 1993). Unfortunately, recent scientific studies have focused on excess nutrient nitrogen loadings from septic/cesspool systems, waste water treatment plants that do not treat for nitrogen, as a significant driver of marsh loss. What was once vegetated intertidal marsh is being converted to non-vegetated underwater lands/mud flats. In addition, high marsh vegetation is being converted to low marsh vegetation. This process is reducing our coastal resiliency as wetlands have been scientifically proven to reduce vulnerability from storm surge. They can greatly reduce wave height and energy over short distances as waves travel through vegetation1. Losses of healthy marshes have accelerated in recent decades. NYSDEC estimates that there was an 18-36 percent loss in tidal wetlands in the Great South Bay between 1974 and 2001.

The impacts of wastewater and nutrient over-enrichment to shellfisheries and fisheries have been negative and severe. In the past 25 years, the hard clam harvest in Great South Bay has fallen by more than 93 percent. In the 1970s, bay-scallop fishery on Eastern Long Island and hard clam fishery in the South Shore bays were the two largest in the U.S. However, due to recurring algal blooms, and to some extent over-harvesting, they have failed to recover. More recently, the NYSDEC has placed shellfish harvest restrictions due to marine bio-toxins caused by red tides of Alexandrium fundyense (PSP) at various locations within all three major estuaries in Suffolk County

8.1.2.3 Impacts and Trends of Other Wastewater Effluent Constituents

8.1.2.3.1 PPCPs

Since the 1987 Comp Plan was published, more advanced and sensitive analytical techniques have been developed that allow the detection of increasingly lower concentrations of contaminants in the environment. In recent years, very low levels of pharmaceuticals and personal care products (PPCPs), also sometimes referred to as pharmaceutically-active compounds (PhACs) or organic wastewater contaminants (OWC), have been detected in the environment. PPCPs include a broad range of products such as prescription and over the counter drugs, including antibiotics, veterinary and illicit drugs, fragrances, sun-screen products, cosmetics, some detergents, some food and drink additives, trace plasticizers that contaminate the consumer products and all of their respective metabolites and transformation products. Many are used and released to the environment in large enough quantities such that low levels are detected in wastewaters and receiving waters.

As most pharmaceuticals are designed to be water soluble, and to be persistent long enough to serve their designated therapeutic purposes, they can be present in dissolved form in receiving ground and surface waters. PPCPs are continuously introduced into the environment by sewage treatment plants and by on-site wastewater disposal systems (e.g., septic tanks and leach fields) in unsewered areas. Based upon estimated release rates to the environment and field surveys, the presence of PPCPs is expected to be at about the nanograms per liter (ng/l) or part per trillion (ppt) level in the environment and it is documented that many of these contaminants (e.g., nonylphenol, which mimics estrogen and is found in detergents, paints and cosmetics) are stable and persistent in the environment. SCDHS currently analyzes for thirty PPCPs; contaminants that have been detected in community, non-community, private or monitoring wells are summarized in **Table 8-9**.

Suffolk County has also participated in a study with USEPA; PPCPs in effluent from WWTPs with hospitals in their tributary area were studied. **Table 8-10** identifies the twenty contaminants that were detected during that study.

8.1.2.3.2 Pathogens

Pathogens are of potential concern for wastewater discharges to ground or surface waters, including onsite wastewater treatment systems (OWTSs). The highest risk is associated with ingestion when pathogens, including bacteria, viruses and protozoans, reach groundwater or surface waters where they can cause human disease through direct consumption, recreational contact, or ingestion of contaminated shellfish. Pathogen removal in OWTSs primarily occurs by die-off when microorganisms are detained by sorption to soil media. Thus, pathogen removal is most efficient when effluent from OWTSs is discharged into granular (sand) media than when non-porous media is present, for example, bedrock (e.g. basalt). Concerns over pathogens resulted in the implementation of travel time requirements for environmental buffers in systems where the disposal system may be hydraulically connected to drinking water supplies. Travel times are average values and some groundwater takes a faster path and arrives sooner than the average. Travel times are most accurately calculated for porous media aquifers. In non-porous media aquifers, travel times are best determined using site specific field tracer tests. For indirect potable reuse (IPR) systems in California, travel time requirements range from 6 to 12 months, depending on the percentage of

Table 8-9 PPCPs currently Analyzed by the Suffolk County PEHL and Maximum Concentrations Detected

Contaminant	Use	Detected by PEHL
Pharmaceuticals		
Acetaminophen	Pain Reliever	X
4-Androstene-3,17-dione	hormone	
Carbamazepine	anticonvulsant	X @ 17.8 μg/L
Carisoprodol	skeletal muscle relaxant	X @ 13.0 μg/L
Diethylstilbestrol	hormone	X
Dilantin (Phenytoin)	antiepileptic	X
4-Hydroxyphenytoin	metabolite of dilantin	X
Estrone	hormone	X
17 b Estradiol	hormone	
17 a Ethynylestradiol	hormone	
Gemfibrozil	lipid regulator	X @ 4.6 μg/L
Ibuprofen	anti-inflammatory	X @ 7.6 μg/L
Personal Care Products		
Benzophenone	fragrance	X
Chloroxylenol	antimicrobial	X
Dibutyl phthalate	plasticizer in nail polish	X
1,4-Dichlorobenzene	disinfectant	X
Diethyl phthalate	binds cosmetics & fragrances	X @ 59.8 μg/L
Dimethyl phthalate	used in insecticide repellents	X
Dimethyltoluamide (DEET)	insecticide repellent	X @ 69 μg/L
D-Limonene	deodorant	X
Picaridin	insect repellent	
Triclosan	antimicrobial	X
Other		
Benzyl butyl phthalate	plasticizer	X
bis-(2-ethylhexyl) adipate	plasticizer	X
bis-(2-ethylhexyl) phthalate	plasticizer	X
Bisphenol A	plasticizer	X
Bisphenol B	plasticizer	
Butylated Hydroxyanisole (BHA)	antioxidant; food additive	X @ 2.2 ppb
Butylated Hydroxytoluene (BHT)	antioxidant; food additive	X
Caffeine	stimulant	X

Table 8-10 Summary of PPCPs Found in Suffolk County WWTP Effluent

PPCP	Use	Detected
Acetaminophen	Pain reliever	X
Caffeine	Stimulant	X
Carbamzaepine	Anti-convulsant	X
Codeine	Pain killer	X
Cotinine	Pain killer	X
Cis-Diltiazem	Treats hypertension/angina	X
DEET	Insect repellant	X
Erythromycin	Antibiotic	X
Fluorosemide	Diuretic	X
Gemfibrozil	Lipid regulator	X
Hydrochlorothiazide	Diuretic	X
Ibuprofen	Anti-inflammatory	X
Meprobamate	Anti-anxiety agent	X
Metroprolol	Antihypertensive	X
Naproxen	Anti-inflammatory	X
Paraxanthine	Stimulant	X
Ranitidine	Inhibits stomach acid	X
Sufamethoxazole	Antibiotic	X
Tramadol	Analgesic	X
Triclosan	Anti-microbial	X

reclaimed water in the planned IPR system. In 2009, Massachusetts adopted a 6-month travel time requirement for environmental buffers in IPR systems. Although New York State does not currently have guidelines for water reuse, Subpart 5-1 'Public Water Systems' of the State Sanitary Code (November 2011) requires that all new and existing sewer discharges to groundwater systems must have a 60-day travel time or more from the point of discharge to the point of intake (NYCRR Title 10, 2011). The retention times required for environmental buffers ranges from 50 days to 12 months, which can have a major impact on design and implementation of OWTSs.

Bacteria

Extensive laboratory and field studies have been conducted on the survival of the bacteria, *Escherichia coli* (*E. coli*), which is generally a nonpathogenic indicator, although there are pathogenic strains that occur. A summary of studies on *E. coli* decay rates revealed that most researchers found decay rates of 0.1/day or greater when studying the decay of *E. coli* in sub-surface environments (Roslev et al., 2004). Many of these studies were conducted under controlled conditions in groundwater without the effects of straining and sorption (filtration). Therefore, decay alone may result in 5-log removal of *E. coli* in less than 20 days during sub-surface transport. Research conducted at the University of South Florida (John and Rose) found that the mean inactivation rate for coliform bacteria was 0.127 log/day, based upon eight studies, and that enterococci have a slighter longer survival time than do coliforms.

Viruses

Concern over viruses has prompted continued research on virus transport and survival in environmental buffers (AwwaRF, 2001a.). Soil saturation and aquifer flow type (porous or non-porous media), media composition, ground water pH, and virus strain all interact to affect the sorptive capacity and virus die-off rate in soils and aquifers. Because viral subsurface inactivation rates are estimates, a second barrier with reliable, effective disinfection is recommended if drinking water is potentially influenced by these discharges. Further, virus removal by sorption is an active research area and remains difficult to predict in field studies. Other parameters affecting efficacy of the soil-aquifer treatment (SAT) process include travel time, vadose zone depth, and wet/dry cycles (Drewes, 2011).

Because of their smaller size, viruses are less easily filtered than other pathogens; the most significant removal mechanism is adsorption onto soil particles. Finer soils with pH below 7.40 are more effective at adsorbing viruses. Higher silt and clay content, and lower ionic strength have also been reported to increase adsorption and removal. During groundwater transport, both irreversible and reversible attachment to particles, and increasing inactivation at increasing temperature has been documented (Harris, 1995, Yates and Gerba, 1985). Inactivation rates for viruses in New York groundwater at 12 degrees C, expressed in terms of $\log_{10}$ decline in the culturable organisms per day, ranged from 0.026 to 0.054 $\log_{10}$ per day, or about 90 percent inactivation in one month (Yates, et al, 1985; Yates, et al., 1990).

A recent study by Betancourt et al. (2014) focused on removal of enteric viruses from three managed aquifer recharge (MAR) projects in Arizona, Colorado, and California. Source water receiving treated wastewater and reclaimed water, and groundwater samples, were tested for the presence of select enteric viruses with polymerase chain reaction (PCR) methods to gauge the efficacy of soil-aquifer treatment. Results show that enteric viruses were only detected in one groundwater sample with a residence time of 5 days. A subsurface residence time of 14 days resulted in virus concentrations below the detection limit (1 to 5-log removal) (Betancourt et al. 2014). This study noted that virus removal is a function of both travel distance and residence time.

In 2014, Abel published 'Soil Aquifer Treatment: Assessment and Applicability of Primary Effluent Reuse in Developing Countries', and reported that travel distances for virus removal ranged from 0 to 5 meters. A tool for 'Soil Aquifer Treatment pre-screening' developed in this study revealed that the efficiency of soil aquifer treatment to remove viruses was a function of the type of wastewater effluent, the pretreatment processes provided, and travel distance (Abel, 2014). Abel et al. (2010) modeled a primary wastewater effluent (influent to soil aquifer treatment) virus concentration of 1.2 x 10^4 CFU/100mL and found that in 4.6 days, the travel distance was 0.8 meters and 4 percent removal of enteric viruses had occurred (Abel et al. 2014). Similarly, Rice and Bouwer (1984) measured 0.4 – 4 percent removal of enteric viruses in tertiary effluent from a WWTP that had traveled 0.1-4.6 days, a distance of 1.0 - 5 meters (Abel et al. 2014).

Protozoans

Similar concerns over protozoa have been raised because *Cryptosporidium* oocysts and *Giardia* cysts have been found in groundwater (Bridgman et al. 1995; Hancock et al. 1998) and in reclaimed water (Gennancaro et al., 2003; Huffman et al., 2006) including infectious *Giardia*. There have been *Cryptosporidium* and *Giardia* outbreaks, some associated with heavy rainfall (Bridgman et al. 1995; Curriero et al. 2001), with research revealing that *Cryptosporidium* oocysts and *Giardia* cysts can be transported in the subsurface soil under normal conditions, especially when preferential porous media flow paths exist (Darnault et al. 2003 and Park et al., 2012). Protozoa have been reported to be able to persist for months in groundwater. Although transport has not been extensively investigated, because they are relatively larger than other micro-organisms, and they have a higher propensity for grain surfaces, it has been hypothesized that their movement may be retarded in sand aquifers relative to bacteria (CDM Smith, 2003). Additional research into the transport of protozoan pathogens is needed (EPA, 2012).

The Long Island Source Water Assessment Program (SWAP) developed by New York State Department of Health (NYSDOH) in cooperation with Nassau County Department of Health (NCDH), Nassau County Department of Public Works (NCDPW) and SCDHS concluded that the relative persistence of bacteria, viruses and protozoa in Long Island groundwater is low, and that the relative mobility of bacteria and protozoa in Long Island groundwater is low, and the relative mobility of viruses in Long Island groundwater is moderate.

Based on this assessment, the SWAP identified supply wells with potential microbial sources located within a two year travel time as highly sensitive to microbial contamination and supply wells with potential microbial sources located within a two to five year travel time as having medium sensitivity to microbial contamination.

8.1.2.3.3 Other

Chromium is a naturally occurring metal that can occur as trivalent chromium (Cr-3) and hexavalent chromium (Cr-6). The presence of low levels of Cr-6 in groundwater can be naturally occurring, or can result from industrial processes. While there is no MCL for Cr-6, USEPA has established an MCL of 100 ppb for total Chromium. In 2013, the results of SCWA monitoring for Cr-6 ranged from non-detect to 6.06 μg/L. Cr-6 has a high mobility in groundwater due to its anionic nature.

1,4-Dioxane ($C_4H_8O_2$) is an organic solvent with numerous industrial and synthetic uses. It is highly water soluble and environmentally stable, but it is oxidizable by free radical chemical processes and slowly by Ultraviolet (UV) radiation. When found in water, it is at μg/L levels. It is not efficiently removed by most treatment processes due to its low molecular weight and chemical properties. Pretreatment and discharge controls are the best ways to prevent its presence in wastewater. It does not occur with sufficient frequency and concentrations to be useful in evaluating treatment trains. If present in a particular water source at concentrations well above the detection limit, it could be useful. The U.S. EPA current 10^{-6} lifetime risk value for 1,4-dioxane is 0.35 μg/L and the non-cancer lifetime Health Advisory (HA) is 200 μg/L based upon non-cancer effects (U.S. EPA, 2012). As a point of reference, California Department of Public Health has posted a notification level of 1 μg/L based upon an evaluation of new evidence of its carcinogenic activity in animals, and the limits of the current standard analytical detection.

8.1.3 Contaminants of Emerging Concern (CEC) Treatability Considerations

There are literally thousands of references on the environmental occurrence, fate and transport of various constituents of concern (CECs) that originate from wastewater (Wells et al., 2008, 2009, 2010; Bell, et al., 2011, da Silva et al., 2012, 2013, 2014). These CECs include groups of compounds such as pharmaceutically active compounds, personal care and consumer product additives, etc. and have been the subject of thousands of studies on their removal in various wastewater treatment processes (Wells et al., 2008, 2009, 2010; Bell, et al., 2011, 2012, 2013; Keen et al. 2014). **Table 8-11** illustrates the types of compounds that have been reported in treated wastewater effluents in many of these previous studies.

Research findings point to three major themes that should be considered when evaluating the treatability of these compounds. First, the compounds that are being detected reflect polar, poorly degradable compounds that occur frequently in wastewater effluents (Reemtsma, 2006). The occurrence of many of the CECs can be attributed to the fact that they are difficult to remove because they are very hydrophilic (tendency to mix with or dissolve in water) at the pH at which most treatment occurs, i.e. between pH 7 and pH 8; therefore, developing an understanding of appropriate measures of hydrophobicity/hydrophilicity of CECs is critical in understanding their removals by various treatment processes (Wells, 2006; 2007).

Secondly, there are significant differences in CEC removal among treatment processes, depending upon the mechanism of treatment. It is of note that the addition of advanced nutrient reduction and tertiary filtration to biological treatment systems is correlated with additional PPCP removal.

Finally, research reports on CECs only provide information about the parameters measured. As analytical technologies continue to advance and more chemicals enter commerce, it is a certainty that new chemicals will be discovered in water, and at even lower concentrations. According to Chemical Abstracts Services, more than 88 million organic and inorganic chemicals have been registered, more than 65 million chemical products are available commercially, and approximately 15,000 new chemicals are added per day (www.cas.org).

8.1.3.1 On-site Wastewater Treatment Systems

On-site wastewater treatment systems (OWTS) include a wide range of individual and cluster treatment systems that process household sewage. These systems are used by approximately 20 percent of all homes in the United States and by 74 percent of the homes in Suffolk County.

It has long been recognized that OWTSs are sources of contaminants, including nutrients and pathogens that can eventually enter both groundwater and surface waters. The EPA has published extensive guidance in *Onsite Wastewater Treatment Systems* (EPA, 2002) that provides detailed information on the background and use of onsite wastewater treatment systems, management of OWTSs, treatment performance requirements, and treatment processes and systems, including those that are aimed at achieving enhanced nutrient removal.

There are a wide variety of OWTSs that can be implemented; conventional (soil-based or subsurface wastewater infiltration) systems can include both gravity-driven and mechanized treatment processes. Sand filters (including other media) can be added onto conventional processes to improve treatment where soil conditions do not support adequate treatment. There are additionally, alternative treatment systems (e.g., fixed-film and suspended growth systems, evapotranspiration systems) that can also be used to provide enhanced treatment performance. But, in general there are three key components to OWTSs that are important in providing treatment. The three

Table 8-11 CEC Classes and Examples of Compounds in These Categories

Category	Compound(s)
Pharmaceuticals	Trimethoprim, Fluoxetine, **Carbamazepine,** Diltiazem, Cotinine, Caffeine, **Acetaminophen**, **Gemfibrozil, Ibuprofen**, Naproxen, Sulfamethoxazole, Primidone, Atenolol, Furosemide, Metoprolol, Meprobamate, Ofloxacin, Valsartan, Hydrochlorothiazide, Oxycodone, Sertraline, Verapamil
Sterols and Hormones	Coprostanol, cholesterol, β-sitosterol, β-stigmastanol, androstenedione, **estrone,** 17-α-ethynyl estradiol, 17-β estradiol
Flame retardants	Tris[2-chloroethyl]phosphate (TCEP), Hexabromocyclododecane (HBCD)
Perfluorinated compounds	Perfluorooctanesulfonic acid (PFOS), Perfluorooctanoic acid (PFOA), Perfluorononanoic acid (PFNA), Perfluorohexanesulfonic acid (PFHxS), Perfluoroheptanoic acid (PFHpA), Perfluorobutanesulfonic acid (PFBS)
Nonylphenols	Nonylphenol Diethoxylate, Nonylphenol Monoethoxylate, para-tert-Octylphenol, p-Nonylphenol
Disinfection byproducts (DBPs)	Trihalomethanes (THMs), Haloacetic acids (HAAs), Chloride, Bromate, Bromide, Chlorate, *n*-Nitrosodimethylamine (NDMA)
Volatile organic compounds (VOCs)	Methyl tert-butyl ether (MTBE), m- & p-Xylene, o-Xylene, 1,2,4-Trimethylbenzene, Naphthalene, Isopropylbenzene, Benzene, Ethylbenzene, Carbon tetrachloride, Toluene, 1,4-Dioxane, tert-Butyl alcohol, Acetone (2-propanone), and Tetrachloroethene (perc), 1,1,1,2-Tetrachloroethane and 1,1,2,2-Tetrachloroethane
Pesticides, herbicides, fungicides	Atrazine, Benzo(a)pyrene, Metolachlor, Simazine, Bentazon, 2,4-D, MCPA, Pentachlorophenol (PCP), Carbaryl, N,N-Diethyl-meta-toluamide (DEET), Chlordane
Consumer products and manufacturing additives	Bisphenol A (BPA), Triclosan, Triphenyl phosphate, Salicylic acid, Camphor, Anthraquinone, p-Cresol, 1, 4-dioxane
Contrast media	Iopromide
Wastewater tracer	Sucralose

primary components of a conventional system are the septic tank, the subsurface wastewater infiltration system (also called a leaching field or infiltration trench), and the soil in the unsaturated zone, which is a critical factor in providing aerobic conditions for treatment. The subsurface infiltration system is the interface between the engineered system components and the receiving ground water environment. It is important to note that the performance of conventional systems relies primarily on treatment of the wastewater effluent in the soil horizon(s) below the dispersal and infiltration components of the system.

Results from numerous studies have shown that well-operated, conventional systems can achieve high removal rates for most wastewater pollutants of concern, with the notable exception of nitrogen. Costa et al. 2002 estimated that 25 percent removal of total nitrogen could be assumed in cesspool systems and closer to 35 percent is removed when a conventional system including both the tank and the soil absorption or leaching field is considered. It is important to note that soil-aquifer treatment systems require unconfined aquifers, vadose zones free of restricting layers, and soils that are coarse enough to allow for sufficient infiltration rates but fine enough to provide adequate filtration (WRRF, 2012).Following pretreatment, biochemical oxygen demand (BOD), suspended solids (TSS), fecal indicators, and surfactants in septic tank effluent are effectively removed within 2 to 5 feet of unsaturated, aerobic soil.

Phosphorus and metals are removed through adsorption, ion exchange, and precipitation depending upon the retention capacity of the soil, which can vary substantially. While large microbial particles are effectively retained in soil treatment systems, the fate of viruses and trace organic compounds, however, has not been well documented. Field and laboratory studies do suggest that the soil is quite effective in removing viruses, but there are some types of viruses that are able to leach to groundwater. Additional information on recent research on pathogen removal via transport through soils systems is provided in **Section 8.1.2.3.2, Pathogens**.

8.1.3.1.1 Occurrence of Constituents of Emerging Concern in OWTSs

The impact of constituents of emerging concern (CEC) that originate from OWTSs has gained recent attention due to impacts on aquatic ecosystems and health risks to animals and potentially humans (Subedi et al. 2014; Schaider et al. 2010 & 2013; Swartz et al. 2006; Wilcox et al. 2009; Standley et al. 2008; Singh et al. 2010; Benotti et al. 2006; Rosen and Kropf 2009; Carrara et al. 2008; Godfrey et al. 2007; Katz et al. 2010; Zimmerman, 2005; Sima et al. 2014).

Cape Cod: An Illustrative Example of the Occurrence of CECs in OWTSs Linked to Groundwater Contamination

Standley et al. (2008) conducted a study that explored the connection between on-site septic system discharges and groundwater contamination leading to surface water quality impacts in Cape Cod, Massachusetts. The study investigated steroidal hormones, pharmaceuticals, and organic wastewater compounds from six aquifer-fed ponds in varying residential density areas with OWTSs. The study concluded that occurrence of these compounds in surface water ecosystems within unconfined aquifer settings results from OWTSs discharges. Additionally, increased concentrations of these organic wastewater compounds were found in the higher density residential areas of Cape Cod. The most commonly detected compounds were steroidal hormones such as androstenedione, estrone, progesterone, and pharmaceuticals such as carbamazepine, pentoxifylline, sulfamethoxazole, and trimethoprim (Standley et al. 2008). The highest concentration of any analyte measured was 19 ng/L (Ibuprofen); additionally, some estrogenic compounds reached concentrations that are known to trigger physiological impacts in fish species.

In 2009, Schaider et al. and Silent Spring Institute analyzed 20 public drinking water wells in 9 Cape Cod districts for 92 CECs. 75% of the drinking water wells sampled tested positive for the presence of CECs. Again in 2011, Silent Spring Institute measured CEC concentrations in 20 private drinking water wells in 7 towns across Cape Cod for 121 CECs; 85% of wells tested positive. Concentrations ranged from tens of nanograms per liter up to tens of micrograms per liter. Researchers concluded that Cape Cod wells impacted by septic systems are equally as contaminated as the 'most contaminated drinking water supplies so far reported in the United States' (Schaider et al. 2013).

Schaider et al. 2013 also modeled the loading of CECs into Barnstable County groundwater and found, similar to Standley et al. (2008) that the highest level of CEC discharges originated from densely populated residential areas with septic systems. This study concluded from loading estimates that effluent from septic systems and effluent from centralized WWTPs have similar concentrations of CECs.

In 2012, Heufelder published a report titled 'White Paper: Contaminants of Emerging Concern from Onsite Septic Systems' to assist in the investigation into the connection between OWTSs and CEC concentrations and CEC removal in Barnstable County (Cape Cod) Massachusetts, a sole-source aquifer reliant community. Approximately 350 studies were reviewed and summarized, lending way to an aggregate compilation of knowledge on the subject per the date of publication, and the proposal of three priority aspects relating CECs and OWTS treatment and disposal to animal/human health. The three priority concerns discussed were: endocrine disruption, antibiotic pharmaceuticals, and direct toxic effects of select CECs. Heufelder (2012) also reviewed literature pertaining to OWTS treatment technologies, including advanced treatment. This paper, along with one published in 2013 regarding a Cape Cod study by Schaider et al. (2011) and the Silent Springs Institute, assemble the majority of research that was performed through 2013 regarding CEC contamination in groundwater and surface waters as a result of OWTSs.

Suffolk County Approach to CECs

The Suffolk County Department of Health Services (SCDHS) has responded to reports of CECs in the groundwater by implementing a programmatic approach to understanding the potential impact of these compounds on local water resources. The plan (SCDHS, 2011)) dates back to 2001, and includes:

4. Implementation of a monitoring program incorporating analytical methodology development by the Suffolk County Public and Environmental Health Laboratory (PEHL);

5. A continuing literature review; and,

6. Discussions with other environmental and public health agencies.

8.1.3.1.2 CEC Treatment Performance in OWTSs

Many CECs are components of a broader group of organic compounds that are removed during sub-surface transport by a combination of filtration, sorption, oxidation/reduction, and biodegradation. Biodegradation is the key sustainable removal mechanism for organic compounds during sub-surface transport (Fox et al., 2005; AWWARF, 2001b.). Considering bulk organic matter components such as natural organic matter (NOM) and soluble microbial products (SMPs), these are reduced during sub-surface transport as high molecular weight compounds are hydrolyzed into lower molecular weight compounds and the lower molecular weight compounds then can serve as substrate for microorganisms (Drewes et al., 2006). Synthetic organic compounds that are present at concentrations too low to directly support microbial growth may be co-metabolized, as NOM and SMPs serve as the primary substrate for growth (Rausch-Williams et al, 2010, Nalinakumari et al, 2010). During sub-surface transport, the transformation of organic compounds may be divided into two regimes, one short-term regime where transformations are relatively fast and a long-term regime where transformations of recalcitrant compounds continue to occur at slower rates over time (Fox and Drewes, 2001). Easily biodegradable carbon is transformed within a time-scale of days and when transport paths are sufficiently long; providing longer retention times in the subsurface allows organic compounds to continue to be transformed.

The removal of constituents of concern in general tends to parallel the removal of organic carbon. Easily biodegradable CECs, such as caffeine and 17β-estradiol, tend to degrade on a time-scale of days while more refractory compounds, such as NDMA and sulfamethoxazole, tend to degrade over a time-scale of weeks to months (Dickerson et al., 2008). Persistent compounds, such as carbamezapine and primodone, can persist for months or years in the subsurface (Clara et al., 2004, Heberer, 2002). Schaider et al. (2013) confirmed, through the studies on Cape Cod septic systems, that CECs with high biodegradability such as acetaminophen, caffeine, and triclosan, tend to have the highest degree of removal (>99%) in OWTS leaching fields, while the lowest degrees of removal (<50%) tended to be correlated with persistent CECs such as sulfamethoxazole, carbamazepine, and TCEP (Schaider et al. 2013).The transformation of organic constituents of concern can also depend on the presence of biodegradable dissolved organic carbon (BDOC) because the concentrations of constituents of concern are very low and may not support growth (Rausch-Williams et al., 2010; Nalinakumari et al., 2010).

In general, concentrations of CECs in conventional OWTSs have been reported to be comparable to those measured in previous studies of municipal wastewater treatment plant (WWTP) influent, and concentrations in systems after “advanced” treatment were comparable to previously measured concentrations in WWTP effluent (Wilcox, 2009; Garcia et al. 2013; Du et al. 2013; Schaider et al. 2013).

Advanced treatment, as used herein, is a reference to on-site wastewater treatment systems that differ from conventional systems in several ways. Advanced treatment systems incorporate multiple treatment steps to facilitate a consistent and high degree of treatment prior to effluent discharge to the leach field. Many advanced treatment systems control flow through the system using pumps and timers to avoid overloading the treatment and final dispersal components during periods of high water usage, or “peak flow” conditions, which could occur during a morning rush of activity or when many guests are in the home. The treatment provided by advanced treatment systems that serves to reduce the “strength” of the wastewater may also contribute to reductions in pathogens, nutrients and CECs, depending on the design and configuration of the system. Systems that function to remove nitrogen prior to discharging effluent utilize alternating anoxic (or anaerobic) and aerobic treatment steps. These systems generally recirculate the effluent back to the septic tank or through a separate recirculation step, where raw effluent and treated effluent are mixed, creating conditions that facilitate denitrification, or actual removal of nitrogen by bacteria.

Advanced treatment systems that are designed as "treatment trains" or logical sequences of treatment components to achieve a certain level of treatment, may be specified by local, state, or regional governing agencies. In Rhode Island, the Department of Environmental Management (DEM), Coastal Resources Management Council (CRMC), and town governments may all have jurisdiction over a given area of land, and may impose differing regulations regarding wastewater treatment.

Technologies are initially chosen based on the level of treatment that is required; it is important to note that not all technologies will effectively achieve nutrient and/or pathogen reduction. Treatment technologies achieve the best results when receiving wastewater characteristics are evaluated and paired with the appropriate technologies. Site constraints may also dictate potential use of some technologies. For instance on small lots with existing homes and failed septic systems, advanced treatment technologies with the smallest footprints are most commonly used as replacement systems. Advanced treatment systems generally require annual or semi-annual maintenance activities in order to function properly; these maintenance activities should be performed by a trained and qualified service provider.

Available information indicates that advanced OSWTs that incorporate aerobic treatment (addition to oxygen to the wastewater to promote and support the growth of aerobic bacteria) can reduce CECs in treated effluent to similar concentrations as those observed in effluent from municipal WWTPs. This aerobic treatment process can be implemented by supplying air to the septic tank or through the use of an aerobic filter, such as a recirculating sand filter (Heufelder, 2012).

Further, Schaider et al. (2013) gathered from literature reviews and also from the Cape Cod study that median CEC concentrations in effluent from leaching fields, were comparable to those measured in WWTP effluent following conventional activated sludge processes (discussed in Section 7.1.3.2.1). The project was a synthesis of studies on various sites and sample depths ranged from 2 feet to 2-3 meters. In most cases, samples were collected from lysimeters that sampled vadose zone soils beneath leach fields. The cumulative information from these studies showed that seven of the nine CECs studied had median concentrations in leach fields within the same order of magnitude as their respective concentrations in WWTP effluent, indicating that the leaching fields provide additional treatment.

There were, however, discrepancies between median concentrations of caffeine, where a median concentration in WWTP effluent was 10 times higher than the median concentration in the leaching field. Prior to this study, Swartz et al. (2006) also concluded that caffeine was readily removed through soil infiltration following septic tank in Cape Cod sites. Conversely, nonylphenol, an endocrine disrupting compound, was found at 20 times the concentration in leaching field effluent than in WWTP effluent, and had the highest predicted total loading into the Cape aquifer of all CECs by an order of magnitude (Schaider et al. 2013). These results also demonstrate that some CEC compounds are readily degradable whereas some are more persistent.

In a recent publication, Subedi et al. (2014) discussed a pilot project in central New York focusing on the occurrence of organic chemicals such as PPCPs, perfluoroalkyl surfactants (PFASs) and polybrominated diphenyl ethers (PBDEs) in effluent from four enhanced aerobic OWTSs consisting of synthetic media and innovative dispersal units such as bottomless sand filters and drip irrigation, adjacent surface waters, and tap water samples of the four houses near Skaneateles Lake. Residents typically use lake water for drinking water purposes; one residence disinfected the lake water with UV disinfection, and one residence obtained drinking water from a well near the lake shore. Each of the ten PPCPs studied, including two antibiotics, two antimicrobials, an antihypertensive, an anti-seizure, an analgesic, a plasticizer, a UV filter, and a stimulant, were found both in OWTS effluent and in surface (lake) water samples. There was no significant difference between measured PPCP concentrations in lake water samples and drinking water (tap) samples. This study did not measure removal efficiencies, but rather confirmed the presence of PPCPs, amongst other organic contaminants, in wastewater plumes traveling from septic tank effluent to receiving surface waters and eventually into tap water.

Though there have been a considerable number of studies validating the presence of CECs in groundwater, less than 20 studies have investigated the level of treatment that septic systems provide with respect to CECs (CEC removal efficiency) (Schaider et al. 2013). An important note when discussing the treatment provided by OWTSs is the high variability of CEC concentrations (can differ by orders of magnitude) from sample to sample and from site to site, likely due to inconsistent and sporadic timing and frequency of the use of personal care products, pharmaceuticals, and other organic wastewater contaminants (Heufelder 2012; Carrara et al. 2008; Conn et al. 2010). While the concentrations of CECs in the influent to centralized wastewater treatment plants reflect a homogenized stream of wastewater from multiple sources, OWTSs can capture concentrations indicating a single discharge event has occurred (Heufelder 2012). The variability of influent water quality, complicated further by the vast range of site-specific conditions and soil characteristics, makes field studies and resulting recommendations for OWTS design difficult to generalize; therefore it should be noted that research and knowledge gaps on this topic are still prevalent and in need of further exploration. This literature review provides a summary of available information on the performance of various OWTSs with respect to CEC removal efficiency and transformation. **Table 8-12** summarizes broad conclusions with respect to OWTSs and CEC removal. **Table 8-13** summarizes removal efficiencies for select CECs compiled from relevant literature studies; the selection of CECs used in **Table 8-13** was governed by the literature. CECs included in the table were chosen for review because removal efficiencies had been calculated in more than one study providing data for comparison purposes. Additionally, CEC treatment removal mechanisms are discussed as well as recommendations for design parameters as gathered by researchers.

As noted previously, typical centralized WWTP influent wastewater quality is generally comparable to the wastewater quality in septic tanks. However, a study by Garcia et al. (2013) exemplified the need to distinguish treatment capabilities as they vary between municipal WWTPs, aerobic OWTS, and on-site septic treatment systems (STS). Although not entirely or specifically geared towards CECs, the study included endocrine disrupting compounds (EDCs) as a target contaminant in the Tier III group of an evaluation of effluent water quality from the three treatment types (municipal WWTP, aerobic OWTS and on-site septic treatment). Tier I and Tier II evaluations investigated select conventional water quality parameters (CBOD and TSS) and whole effluent toxicity, respectively. The results of the portion of the study pertaining to EACs illustrate the variability of concentrations of estrone (E1), 17β-estradiol (E2), 17α-ethinylestradoil (EE2), and testosterone (T), among municipal WWTPs, on-site aerobic wastewater treatment systems, and on-site septic wastewater treatment systems, with concentrations of the studied compounds ranging from 0.97 to 117 ng/L (Garcia et al. 2013). The most significant results show that concentrations of estrone, 17β-estradiol, and testosterone were significantly higher in advanced OWTS that incorporated aerobic treatment or municipal WWTPs. The study also concluded that the same general trends were observed regarding Tier I (CBOD and TSS) and Tier II (whole effluent toxicity) evaluation results, indicating that increased oxygen levels facilitate increased EDC removal (Garcia et al. 2013).

Table 8-12 General Conclusions from Literature Regarding CEC Removal and Treatment in OWTSs

Citation	Study Conclusions with respect to CEC Removal & Treatment in OWTSs
Wilcox et al. (2009); Stanford and Weinberg (2010)	Minimal CEC removal in anaerobic conditions of the septic tank
Swartz et al. (2006)	Minimal CEC removal in anaerobic groundwater, suggests significant aerobic biodegradation
Conn and Siegrist (2009), Heufelder (2012)	Significant CEC removal through sorption and aerobic biodegradation processes
Hinkle et al. (2005), Stanford and Weinberg (2010)	Significant CEC removal with advanced onsite treatment septic systems (trickling/packed bed filter, sequencing batch reactor, rotating biological reactor, aeration, forced aeration/attached growth media, aeration with carbon source, packed bed filter with carbon source, packed bed filter, trench with packed bed filter and carbon, attached growth media)
Heufelder (2012)	Significant CEC removal when leach fields were modified by hydraulic loading rates, vertical separation to groundwater, and horizontal setback distances from receiving water bodies.
Drewes et al. (2011)	Findings suggest that removal of DEET, diclofenac, ibuprofen, and meprobamate required at least one week of travel time to achieve 90% removal rates. Chlorinated flame retardants such as TCEP, TCPP, TDCPP were not well removed after 6 days, and antiepileptic compounds such as primidone, Dilantin, carbamazepine, sulfamethoxazole, and atrazine were not well removed after 5 days in either oxic or anoxic conditions.
Schaider et al. (2013)	High variability across removal efficiencies for various leach fields. Sulfamethoxazole had higher leach field effluent concentration than septic tank effluent concentration. Triclosan is well removed in septic treatment processes, but degradation products are persistent in the environment.
Berto et al. (2008)	Antimicrobials in hospital wastewater treated with an aerobic septic system could be degraded.
Garcia et al. (2013)	Aerobic on-site septic effluent was not statistically different than WWTP effluent. Anaerobic on-site septic effluent was of poorer quality than both ATS and WWTP effluent.
Teerlink et al. (2012)	Hydraulic loading was inversely related to CEC attenuation. Longer residence time may allow the microbial community to evolve to better transform CECs. Aerobic conditions facilitated better removal of acetaminophen and cimetidine than anaerobic conditions.
Roberts et al. (2014)	Direct relationship between organic carbon fraction and soil-water partitioning coefficient may exist, making estimation of CEC sorption to soil more accurate and useful.
Rosario et al. (2014)	Current horizontal setback distances from septic tanks to receiving surface waters are not enough to provide complete CEC attenuation.
Du et al. (2013)	Removal of CECs by aerobic on-site treatment systems was comparable to WWTP removal.

Table 8-13 Literature Reported Removal Efficiencies of Select CECs from OWTS Discharge

Citation		Du et al. (2013)		Schaider et al. (2013)	Teerlink et al. 2012	
CEC of Interest	**Use**	**Aerobic OWTS Leach Field Removal Efficiency**	**Septic (Anaerobic) OWTS Leach Field Removal Efficiency**	**Leach Field Removal Efficiency**	**Loading Rate in Packed Columns Representing Leach Field Removal Efficiency**	
					1 cm/ day	**12 cm/ day**
Caffeine	Pharmaceutical	89-99%	40-52%	50-99.9%	>99%	99%
Acetaminophen	Pharmaceutical	100%	28-65%	98-99.9%	>99%	99%
TCEP	Flame Retardant	-	-	0-80%	0%	0%
DEET	Pesticide	-	-	0 to >99%	48%	4%
Trimethoprim	Pharmaceutical	46-86%	12-20%	33->99.9%	87%	64%
Carbamazepine	Pharmaceutical	6-7.8%	5.9-7.4%	10-60%	6%	0%
Sulfamethoxazole	Pharmaceutical	17-31%	7.7-11%	0->95%	43%	45%

The studies referenced in **Table 8-12** provide valuable information regarding the treatment of CECs in OWTSs and the mechanisms by which treatment can likely be enhanced to better protect the integrity of the surrounding environment and human health. Upon review of available literature, conclusions have been compiled regarding attenuation of CECs with respect to removal mechanisms. Specifically, there are a suite of design parameters that ideally should be optimized to facilitate increased removal. Removal mechanisms and design parameters in OWTSs are discussed below.

8.1.3.1.3 Removal Mechanisms

Biodegradation and Oxidation-Reduction Conditions

Biodegradation is the key sustainable removal mechanism for organic compounds during sub-surface transport (Fox et al., 2005; AWWARF, 2001b). Aerobic microbial reactions that occur underground preferentially use oxygen, due to energy requirements, as the terminal electron acceptor. Higher levels of oxygen result in the growth of microbial communities that can then attenuate chemical contaminants (Teerlink et al. 2012). Anaerobic biodegradation can also occur, however, aerobic conditions have been shown to enhance CEC removal in past studies (Conn et al. 2010, Swartz et al. 2006, Carrara et al. 2008; Schaider et al. 2013; Teerlink et al. 2012). The ratio of BOD_5 to COD indicates the level of biodegradability of the wastewater; ratios exceeding 0.4 typically indicate a high biodegradability (Metcalf and Eddy, 1991). Berto et al. (2008) found that BOD_5 to COD ratios in hospital wastewater increased from 0.39 to 0.48 within 30 and 120 minutes of Fenton reaction treatment, respectively. The Fenton reaction utilizes iron and hydrogen peroxide at low pH values to generate hydroxyl radicals that serve as powerful oxidants. The BOD_5 to COD ratio increasing with time dynamic lends positively to the belief that parent pharmaceutical compounds present in raw wastewater are more hazardous than oxidized intermediate pharmaceuticals that have undergone Fenton treatment, or a comparable disinfection process (Berto et al., 2008).

Additionally, a significant theme in 'White Paper: Contaminants of Emerging Concern from Onsite Septic Systems' is that aerobic conditions enhance CEC removal, especially with respect to endocrine disrupting compounds of hormone and phenolic surfactants (Heufelder, 2012). Hydraulic loading rate variations (delivery of septic tank effluent to the leaching field or infiltration trench) can impact the diffusion of oxygen and hence the growth of microbial communities and respective treatment of CECs in OWTSs. Hydraulic loading rates and residence time are discussed as design parameters, below.

Sorption

Sorption is another key mechanism governing the attenuation of CECs by OWTSs. Septic tank effluent is typically discharged to a soil treatment unit (STU) where sorption occurs. Contaminants present in the septic tank effluent can be removed by sorption to soil particles (Teerlink et al., 2012). Roberts et al. (2014) completed a study concerning the sorption of CECs and OWCs to four different types of soils (sand, sandy loam, loamy sand, and loam) in order to deduce a relationship between the fraction of organic carbon in the soil and the soil-water partitioning coefficients of select OWCs. The OWCs studied included triclosan, 4-nonylphenol, bisphenol-A, estrone, 17β-estradiol, and 17α-ethynylestradiol. Research results show that accurately estimating the soil-water partition coefficient of a group of similar CECs could help in the modelling and estimation of how much sorption will occur in particular types of soil, thereby reducing the uncertainty associated with the level of treatment provided by soil treatment units.

Generally, sorption tends to increase with increasing fraction of organic carbon levels (Roberts et al., 2014). For example, soil-water partition coefficients were calculated for organic carbon fractions between 0.021 and 0.054. Triclosan was found to have soil-water partition coefficients of 75 and 260 at organic carbon fractions of 0.021 and 0.054, respectively; 17β-estradiol was found to have soil-water partition coefficients of 3 and 255 at organic carbon fractions of 0.021 and 0.054, respectively. (Roberts et al. 2014). Schaider et al. (2013) indicated that many factors affect the sorption of organic compounds to soil surfaces and therefore govern the attenuation of CEC concentrations from OTWSs. Factors noted include the importance of hydrophobicity of the CEC, the organic matter present in the soil, the acid dissociation constant (pKa), and the soil pH. The dynamics of these characteristics with respect to the soil and the CEC can provide valuable conclusions for the removal of CECs in OWTS leach fields. Among these conclusions include the confirmation that hydrophobic compounds undergo a higher degree of sorption.

Ion Exchange

Ion exchange is the soil's capacity to hold exchangeable ions at a given pH value. Ion exchange, in addition to biodegradation and sorption, is a mechanism of CEC removal from OWTS effluent. The acid dissociation constant and soil pH determine the ionization state of a given chemical which affects sorption levels. If a chemical has a net negative charge in soil, it is more likely to remain in solution because certain soil constituents (e.g. clay particles) also have a net negative charge (Schaider et al. 2013). Roberts et al. (2014) found that electrostatic repulsion between CEC anions and negatively charged soil constituents likely impact removal by resulting in less sorption. Siegrist et al. (2005) found that soils with a higher clay content exhibited slightly higher cation exchange capacity – or the ability to hold more positive ions at a given pH.

Temporal Variations

Hinkle et al. (2005) noted that variability of influent CEC concentrations to OWTSs could be temporally or seasonally dependent. The hypothesis when considering temporal variations and CEC removal is that increased biodegradation will occur with warmer temperatures.

One aspect of a recent study by Du et al. (2013) explored temporal seasonal variations in relation to CEC removal from advanced aerobic OWTS and septic tank OWTS. Although there was no observable correlation between the removal of total concentrations of all detected compounds between the fall and winter (October and January) seasons, there were select CEC compounds that experienced greater removal in October than in January. These compounds were caffeine, erythromycin, gemfibrozil, and sucralose. Standley et al. (2008) did not find any correlation between OWC concentrations in surface water bodies and temporal variations; however observed increased levels of steroidal hormones in surface waters during warmer months (Standley et al., 2008).

Stempvoort et al. (2011) studied the transport of artificial sweetener in OWTS discharge to groundwater and found that the degradation of saccharin in the soil was slower during the winter season, when temperatures were lower.

8.1.3.2 Conventional Wastewater Treatment Plants

8.1.3.2.1 Description of Activated Sludge Process (CAS) and Disinfection

The CECs listed in **Table 8-13** are present in wastewater from municipal sewer systems, just as they are present in OWTS effluent. The following section discusses the mechanisms by which CECs can be attenuated in centralized wastewater treatment plants employing conventional treatment processes. It is important to note that the treatability and removal of CECs in OWTS differs from centralized systems partly because centralized WWTPs receive a homogenized stream of wastewater from multiple sources. Flow equalization and the conveyance time within the collection system result in WWTP influent concentrations that are not as susceptible to concentration spikes (single-event impacts) as OWTSs. It is also important to note that unit processes which are already part of conventional WWTPs provide a certain level of CEC removal, even though the plants themselves were not initially designed to treat for these constituents (Rojas et al. 2013).

Conventional Activated Sludge

Conventional primary wastewater treatment consists of settling tanks where solids settle to the bottom of the sedimentation tank and lighter wastewater constituents float to the top. Typically a skimming process is used to remove floating materials before the wastewater flows to secondary treatment processes. The secondary treatment process is referred to as biological treatment or activated sludge. The activated sludge process, most simply defined, uses living microorganisms to degrade organic contaminants present in the wastewater stream (NSFC, 2003). Aeration tanks are used to provide beneficial bacteria with the oxygen they need to grow and consume the organic contaminants, thereby producing heavier particles (floc) that settle to the bottom of the clarifier tank. The settled layer at the bottom of the tank is known as activated sludge, and is utilized as a “seed” sludge for subsequent incoming wastewater to the plant. The activated sludge process produces a supernatant that is typically sent to a downstream disinfection process.

Disinfection

Disinfection is an important part of conventional wastewater treatment because it deactivates pathogens such as bacteria, protozoa, and viruses that can be a threat to human health. Chlorine is a common disinfectant used in conventional wastewater treatment; however, there are other chemical oxidants that are also capable of providing disinfection. Secondary benefits of using chemical oxidants such as chlorine, ozone or peracetic acid for disinfection include the oxidation of CECs. The degree of CEC oxidation depends on a number of factors, but is related to the reduction-oxidation (redox) potential for the chemical disinfectant. UV irradiation is also widely applied for disinfection.

Chlorine

Chlorine is the most widely used disinfectant in wastewater treatment today and although the exact mechanism of disinfection is yet unclear, it is believed that chlorine diffuses through cell walls and attacks enzyme groups, destroying the microorganism. Chlorine disinfection can be accomplished using various chemicals including gas, liquid sodium hypochlorite or solid calcium hypochlorite. However, when these are dissolved in water, disinfection occurs by common chlorine chemistry which is the combination OCl- and HOCl. The HOCl form is a more powerful oxidant than OCl- and the fraction of each is a function of pH (pKa for HOCl/OCl- is 7.5); which is reflected in higher pharmaceutical removals after hypochlorite addition at pH 5.5 (Westerhoff et al., 2005). It has been reported that ionized functional groups in CECs have a significant impact on chlorine reactivity (Gallard et al., 2002); generally deprotonated groups of compounds have second-order rate constants several orders of magnitude greater than those of protonated groups. For pharmaceuticals evaluated in these studies, most experiments were run at pH 5.5 to 8.2; therefore only weak acids would become protonated.

A research project by Lei and Snyder (2007) developed a quantitative structure-property relationship model for a wide range of CECs with respect to chlorine treatment and showed that degradation of compounds was, in fact, strongly inversely correlated with the ionization potential. As a result, the functional groups on a molecule strongly influence the compound's reactivity with chlorine which in these cases is predominantly by electrophilic substitution and addition (Lei and Snyder, 2007). A second mode of degradation is by oxidation, in which chlorine can promote ring cleavage, which usually has much slower reaction kinetics. A summary of recently reported removal rates of the selected pharmaceuticals by chlorine in various water matrices is shown in Table 8-14 along with the reference of the study.

While it has been demonstrated that chlorine addition to water can result in degradation of pharmaceutical compounds, Boyd (2005) found that the degradation products of some pharmaceuticals, in this work naproxen, produces degradation by-products that may be more toxic that the solutions of the original parent compound.

Table 8-14 Removal of Pharmaceutical Compounds with Chlorination

Compound	pKa	Chlorine Dose (mg/L)	Removal (% range)	Reference
Acetaminophen	9.7	3.5	> 70	Snyder, et al. (2008)
		1.2	98	Stackleberg, et al. (2008)
		2.8 - 6.75	96 - 98	Westerhoff, et al. (2005)
Caffeine	6.1	0.95 - 11.5	99 - >99	Huber, et al. (2005)
		1.2	88	Stackleberg, et al. (2008)
Carbamazepine	< 2	0.95 - 11.5	95 - >99	Huber, et al. (2005)
		3.5	< 30	Snyder, et al. (2008)
		1.2	85	Stackleberg, et al. (2008)
		2.8 - 6.75	93 - 98	Westerhoff, et al. (2005)
Clofibric acid		0.95 - 11.5	>99	Huber, et al. (2005)
Diazepam	2.4, 1.5, (3.3)	3.5	< 30	Snyder, et al. (2008)
		0.95 - 11.5	98 - > 99	Huber, et al. (2005)
		2.8 - 6.75	75 - 77	Westerhoff, et al. (2005)
Diclofenac	4.2	0.1 - 1	45	Huber, et al. (2005)
		3.5	> 70	Snyder, et al. (2008)
		2.8 - 6.75	93 - 96	Westerhoff, et al. (2005)
Dilantin	8.3	3.5	< 30	Snyder, et al. (2008)
		2.8 - 6.75	20 - 53	Westerhoff, et al. (2005)
Erythromycin	8.8	1	> 90	Snyder, et al. (2003)
		2.8 - 6.75	95 - 96	Westerhoff, et al. (2005)
		3.5	> 70	Snyder, et al. (2008)
		1.2	> 99	Stackleberg, et al. (2008)
Fluoxetine	[9.5]	3.5	< 30	Snyder, et al. (2008)
		2.8 - 6.75	15 - 50	Westerhoff, et al. (2005)
Gemfibrozil	4.7	0.95 - 11.5	59 - 93	Huber, et al. (2005)
		3.5	30 - 70	Snyder, et al. (2008)
		2.8 - 6.75	> 99	Westerhoff, et al. (2005)
Hydrocodone	[8.9]	3.5	> 70	Snyder, et al. (2008)
		2.8 - 6.75	95	Westerhoff, et al. (2005)
Ibuprofen	4.5 (4.9)	0.95 - 11.5	97 - > 99	Huber, et al. (2005)
		3.5	30 - 70	Snyder, et al. (2008)

Compound	pKa	Chlorine Dose (mg/L)	Removal (% range)	Reference
		2.8 - 6.75	30 - 75	Westerhoff, et al. (2005)
Iopromide	< 2 & > 13	0.1 - 1	97 - > 99	Huber, et al. (2005)
		3.5	< 30	Snyder, et al. (2008)
		2.8 - 6.75	3 - 32	Westerhoff, et al. (2005)
Meprobamate	< 2	3.5	< 30	Snyder, et al. (2008)
		2.8 - 6.75	12 - 26	Westerhoff, et al. (2005)
Naproxen*	4.5 (4.2)	1 - 10	61.5 - > 99	Boyd, et al. (2004)*
		0.95 - 11.5	53	Huber, et al. (2005)
		3.5	> 70	Snyder, et al. (2008)
		2.8 - 6.75	92 - 93	Westerhoff, et al. (2005)
Pentoxifylline	6 & < 2	0.95 - 11.5	98 - > 99	Huber, et al. (2005)
		3.5	< 30	Snyder, et al. (2008)
		2.8 - 6.75	73 - 81	Westerhoff, et al. (2005)
Sulfamethoxazole	2.1 & < 2 (5.7)	0.1 - 1	10 - 65	Huber, et al. (2005)
Trimethoprim	6.3, 4.0, < 2 (7.1)	1	> 90	Snyder, et al. (2003)
		3.5	> 70	Snyder, et al. (2008)
		2.8 - 6.75	97 – 98	Westerhoff, et al. (2005)

Ozone

Inactivation of bacteria by ozone is attributed to oxidation of cell membrane components; for virus inactivation, ozone appears to modify and break the protein capsid sites that the virus uses to fix on cell surfaces; for cysts, ozone is hypothesized to damage the cyst exterior, enabling inactivation. Analogous to chlorine, ozone disinfection efficacy likely depends on residual and reaction time. A number of parameters are used to monitor ozone disinfection: applied ozone dosage, transferred ozone dosage, and ozone residual. The oxidative power associated with ozone, also makes it a good candidate for removal of pharmaceutical compounds. Because of the potential applicability in wastewater treatment to provide disinfection, and potentially degrade emerging constituents such as pharmaceuticals, a number of studies have been conducted to evaluate the effectiveness of ozone disinfection on a wide range of compounds in wastewater. A summary of selected removal efficiencies in wastewater by compound for various ozone doses is shown in **Table 8-15**.

Table 8-15 Summary of Ozone Dose and Treatment Efficiencies for Select Pharmaceuticals

Compound	Wastewater		Reference
	Ozone Dose (mg/L)	Removal (% range)	
Caffeine	4.9 - 8.7	> 80	Lei, et al. (2007)
	32 – 34	19	Menapace, et al. (2008)
	2.1 - 8.7	34 - > 80	Snyder, Wert, et al. (2006)
Carbamazepine	4.75 - 53.8	80 - > 99	Andreozzi, et al. (2004)
	2 – 14	> 95	Bahr, et al (2007)
	1.5 – 4	89 - 99	Buffle, et al. (2006)
	4.9 - 8.7	> 99	Lei, et al. (2007)
	2.1 - 8.7	> 99	Snyder, Wert, et al. (2006)
Clofibric Acid	4.75 - 53.8	50 - > 99	Andreozzi, et al. (2004)
	2 – 14	> 95	Bahr, et al (2007)
	21.7 - 65	88 - 90	Gebhardt, et al. (2007)
	1	0.08	Ikehata, et al. (2006)
	10 - 15	34 - 51	Petrovic, et al. (2003)
Diazepam	1.5 – 4	< 1	Buffle, et al. (2006)
	21.7 - 65	53 - 95	Gebhardt, et al. (2007)
	41 – 46	28	Menapace, et al. (2008)
Dilantin	4.9 - 8.7	89 - > 99	Lei, et al. (2007)
	2.1 - 8.7	43 - > 99	Snyder, Wert, et al. (2006)
Diclofenac	4.75 - 53.8	72 - > 99	Andreozzi, et al. (2004)
	2 – 14	> 95	Bahr, et al (2007)
	1.5 – 4	> 95 - > 99	Buffle, et al. (2006)
	10 – 15	69 - 75	Petrovic, et al. (2003)
	2.1 - 8.7	> 98	Snyder, Wert, et al. (2006)
Erythromycin	4.9 - 8.7	> 98	Lei, et al. (2007)
	0.5 – 5	31 - 99	Huber, et al. (2005)
	47.5 - 48	56	Menapace, et al. (2008)
Fluoxetine	4.9 - 8.7	> 94	Lei, et al. (2007)
	2.1 - 7.1	> 93 - > 99	Snyder, Wert, et al. (2006)
Gemfibrozil	10 – 15	46 - 69	Petrovic, et al. (2003)
	2.1 - 7.1	> 94 - > 99	Snyder, Wert, et al. (2006)
Hydrocodone	4.9 - 8.7	> 99	Lei, et al. (2007)
	2.1 - 8.7	> 93 - > 99	Snyder, Wert, et al. (2006)
	1.5 – 4	< 1	Buffle, et al. (2006)
	4.9 - 8.7	94 - > 95	Lei, et al. (2007)
	10 – 15	65 - 90	Petrovic, et al. (2003)
	2.1 - 8.7	< 1 - > 94	Snyder, Wert, et al. (2006)
Iopromide	1.5 – 4	< 1	Buffle, et al. (2006)

Compound	Wastewater		Reference
	Ozone Dose (mg/L)	Removal (% range)	
	0.5 – 5	10 - 60	Huber, et al. (2005)
	4.9 - 8.7	72 - > 96	Lei, et al. (2007)
	2.1 - 8.7	14 - > 95	Snyder, Wert, et al. (2006)
Meprobamate	4.9 - 8.7	58 - 87	Lei, et al. (2007)
	2.1 - 8.7	31 - > 98	Snyder, Wert, et al. (2006)
Naproxen	2 – 14	> 95	Bahr, et al (2007)
	5	> 99	Ikehata, et al. (2006)
	10 – 15	45 - 66	Petrovic, et al. (2003)
	2.1 - 8.7	> 92 - > 96	Snyder, Wert, et al. (2006)
Sulfamethoxazole	4.75 - 53.8	90 - > 99	Andreozzi, et al. (2004)
	1.5 – 4	> 99	Buffle, et al. (2006)
	0.5 – 5	21 - > 99	Huber, et al. (2005)
	5	> 99	Ikehata, et al. (2006)
	2.1 - 8.7	97 - > 99	Snyder, Wert, et al. (2006)

The mechanisms of ozonation on various pharmaceuticals were also evaluated in the Lei and Snyder (2007) project that developed a model for explaining the mechanism of removal of CECs. This work showed that ozone was highly effective for removal of a wide range of compounds. Previous research has shown that ozone is a highly reactive, but selective electrophile that reacts with amines, phenols, and double bonds in aliphatic compounds (Snyder et al., 2006; Barron et al., 2006). Ozone also electrophilically attacks the sulfide, aniline, neutral tertiary amine, trimethoxytolyl and other electron-rich moieties that are commonly contained in antibacterial compounds (Dodd et al., 2006). As such, the model results that weakly polar surface area of a molecule is a good indicator of its ability to be oxidized by ozone is consistent with previous work.

Recent improvements in ozone technology, increased implementation of ozone disinfection systems, demonstrated effectiveness for addressing pharmaceuticals, and research indicating that the degradation products are less toxic than the parent solution (Andreozzi, et al., 2004) suggest that ozonation, at doses that are typical for meeting disinfection requirements, may be an effective treatment strategy for pharmaceuticals.

UV Based Disinfection Processes

Recent interest in addressing emerging contaminants, which include pharmaceuticals, has engineers looking toward potential treatment alternatives and one of these methods is UV disinfection. In addition to its disinfection effectiveness, UV can also degrade organic compounds by direct photolysis of photolabile compounds as a consequence of light absorption, or by indirect photolysis using hydrogen peroxide (H_2O_2), an advanced oxidation process (AOP), which will lead to the formation of highly reactive, unselective, and short-lived hydroxyl radicals (•OH).

There are however, issues with respect to UV disinfection systems traditionally employed for microbial inactivation in the treatment of pharmaceuticals. For any compound to be degraded by UV disinfection, it must have the capacity to absorb photons of the incident light and the probability that a given compound will absorb light at a particular wavelength can be determined by measuring its absorbance. In most wastewater treatment plants, UV systems typically used for wastewater disinfection are based on low pressure high output lamps that have output centered on 254nm. Because the output of these lamps overlaps with the wavelength that is absorbed by DNA, this results in inactivation of the organism by dimerization of adjacent thymine nucleotides in the molecule, preventing reproduction of the organism (Rauth, 1965; Linden et al., 2001).

Pereira et al., 2007 produced a plot of UV absorption of pharmaceuticals over a range of wavelengths showing that various pharmaceuticals, including carbamazepine, clofibric acid, and naproxen absorb at peaks that do not overlap the wavelength output generated by low pressure UV lamps as shown in **Figure 8-16.** Rather, the peak absorbances of these pharmaceutical compounds are in the range of 230 for clofibric acid and naproxen, with carbamazepine having a bimodal absorbance with peaks near 210 and 290 nm.

These other wavelengths can be obtained using medium pressure lamps which have a wider range of output; medium pressure lamps produce radiation at several wavelengths (polychromatic) and the output ranges from 200 nm to 700 nm. However, if the primary reason for use of UV is for disinfection, then a drawback to use of medium pressure lamps is that the UV output of a medium-pressure lamp is 50 to 80 times higher than the output of a low-pressure lamp but is not as efficient in the conversion of electricity to germicidal UV radiation.

While there are certainly drawbacks to use of medium-pressure UV systems, they do tend to have a lower capital cost; although they are usually associated with higher operation and maintenance costs. The use of a medium pressure/high intensity UV system can result in a significant reduction in the number of lamps required for the same UV dose. The major advantages of a medium pressure system are the ability to handle large swings in flow, abrupt changes in water quality and the potential for addressing emerging contaminants such as pharmaceutical compounds.

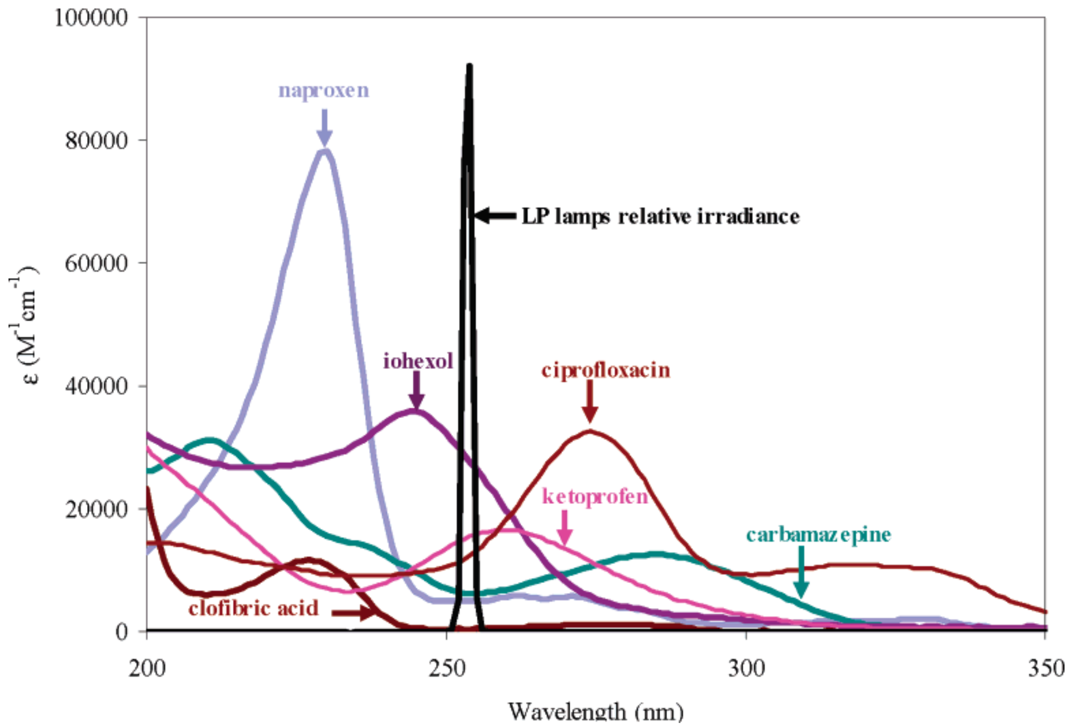


Figure 8-16 Plot of Absorption Coefficients of Pharmaceuticals over a Range of Wavelengths (reproduced from Pereira et al., 2007)

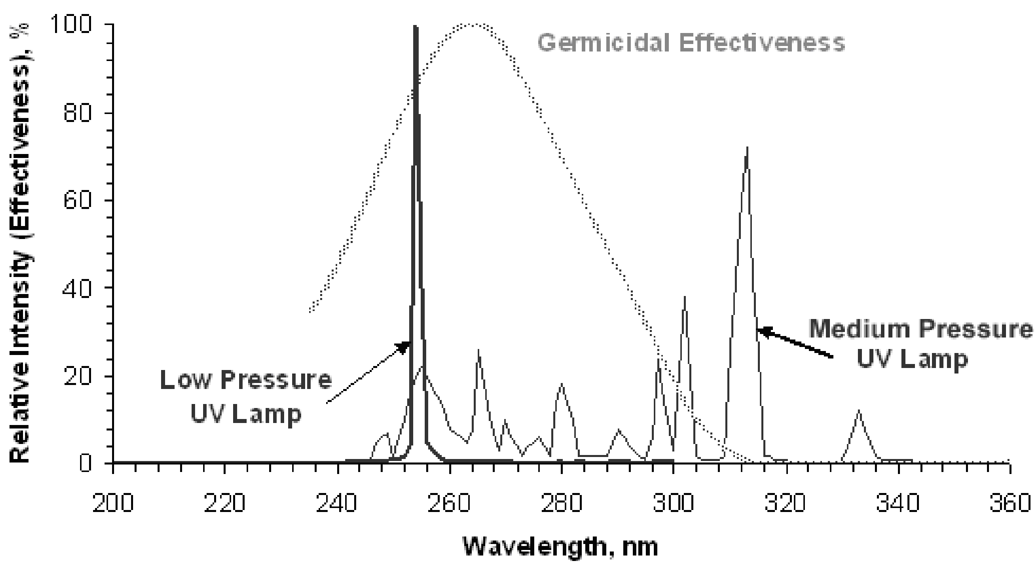


Figure 8-17 Output Wavelengths for UV lamps Shown with the Effective Germicidal Region for UV Disinfection; from http://www.americanairandwater.com/images/uv-lamp-output.gif

8.1.3.2.2 Mechanisms of Degradation of CECs and PPCPs in Conventional Activated Sludge Systems

The removal of CECs at municipal WWTPs is dependent upon a variety of factors, including the type of treatment employed, the solids retention times, levels of organic matter, and the properties of the chemical compounds (Schaider et al., 2013). During primary and secondary treatment, the attenuation of contaminants can be attributed to three removal mechanisms: **Biodegradation, sorption, and volatilization** (Khan and Ongerth, 2002). Biodegradation is believed to be the major elimination mechanism (Blair et al. 2013). Activated sludge processes have been shown to remove CECs, however the most persistent CECs display resistance to many types of treatment. Specifically, organophosphate flame retardants, fragrance compounds, pharmaceuticals, and perfluorinated chemicals tend to be the most persistent CECs and do not easily biodegrade during primary and secondary treatment (Schaider et al., 2013; Joss et al., 2006).

The mechanism for degradation of CECs and PPCPs in CAS systems can be summarized as “physical partitioning among liquid, gas, and solid phases with regards to biochemical transformation” (Rojas et al., 2013). Rojas et al. (2013) completed a study and literature review regarding CEC removal during conventional wastewater treatment processes for the 42 most common CECs discussed in literature and encountered in field studies, pilot studies, and laboratory experiments. The extensive literature review completed by Rojas et al. (2013) was a continuation of an assessment on CEC removal efficiency during wastewater treatment conducted by the EPA in 2010 (USEPA, 2010). In the EPA assessment, 246 compounds were surveyed using publications from 2003-2008. This study utilized two models, BIOWIN 2 and 6 and EPI Suites 4, to predict the biodegradability of each functional group present in the wastewater stream (USEPA, 2010). These models predict the removal of organic chemicals during secondary biological treatment (activated sludge) account for three mechanisms of removal: evaporation, biochemical degradation, and sludge sorption. The parameters utilized in the models to predict biodegradability include physical properties such as Henry’s law (H) and the octanol-water partitioning coefficient, however the actual biodegradation rate was hard to determine due to its dependence on a variety of treatment parameters and operating conditions (Rojas et al. 2013). Dickenson et al. (2010) also noted that biological degradation rate constants are not available for many PPCPs and need to be determined based on *in situ* testing rather than assuming them from typical chemical characteristics.

The octanol-water partitioning coefficient quantifies the concentration of a compound in the aqueous-phase in relation to the concentration of a compound in organic material that is part of the solid phase. Rojas et al. (2013)

studied the correlation between log octanol-water partitioning coefficients and the probability of a plant removing >75% of select CECs, and found that trends between the two were not apparent unless the readily biodegradable compounds (caffeine, acetaminophen, etc.) were excluded. When the readily biodegradable compounds were excluded from the evaluation, the relationship between the log octanol-water partition coefficient and probability of > 75% removal was more positively correlated, indicating that sorption to sludge is the main elimination mechanism of hydrophobic compounds (Rojas et al. 2013). Thompson et al. (2011) found that log octanol-water partitioning coefficients greater than 4 resulted in substantial hydrophobic interactions and sorption to solids.

The operating conditions of activated sludge processes where biodegradation, sorption to sludge, and volatilization may occur are also important when studying mechanisms of CEC removal in wastewater treatment. Gerrity et al. 2013 studied the solids retention time (SRT) and its impact on the removal of 33 trace organic constituents in conventional wastewater treatment after 5.5, 6, and 15 days. Gerrity et al. (2013) concluded that the optimal SRT for trace organic constituent removal is between 10-15 days and SRTs exceeding 15 days may be unjustifiable. Gerrity et al. (2013) observed >90% removal on an aggregate level with respect to all 33 compounds – and attributed removal to sorption and biotransformation. Additionally, Stephenson and Oppenheimer, 2007, studied the impact of SRT on the removal of 30 PPCPs from six different WWTPs. SRT values in the study varied from 0.5 days to 30 days amongst the six WWTPs and showed that the minimum SRT that should be implemented was dependent upon the compound, but overall ranged from 5 to 15 days. Strenn et al. found that both ibuprofen and bezafibrate removal efficiencies were clearly dependent upon the SRT and in yet another study, Cirja et al. 2008 found that SRT in WWTPs should be at least 8 days to facilitate enhance organic compound removal. In a comprehensive WERF study on *Trace Organic Indicator Removal during Conventional Wastewater Treatment* (WERF, 2012), laboratory studies were conducted to provide information on the threshold solids retention times (under aeration) that were required to achieve removal of 80% of several target compounds.

Table 8-16 Threshold (aerobic) SRTs Required to Achieve > 80% Removal of Targeted CECs

CEC	Days Required for > 80 Percent Removal
Acetaminophen	2
Caffeine	2
Ibuprofen	5
Naproxen	5
Bisphenol A	10
Triclosan	10
DEET	15
Gemfibrizol	15
Atenolol	15
BHA	15
Iopromide	15
Cimetidine	15
Diphenhydramine	20
Benzophenone	20
Trimethoprim	30

The previous study provides evidence supporting Drewes et al. (2006) previous conclusions that secondary treatment encompassing nitrification and denitrification processes was more efficient than conventional secondary treatment alone with respect to removal of estrogenic compounds. Miege et al. (2009) also concluded that nitrifying activated sludge and membrane bioreactors may be favorable regarding the removal of PPCPs (Miege et al. 2009).

8.1.3.2.3 Removal Efficiencies for Groups of Compounds

The removal efficiency of CECs and PPCPs in conventional wastewater treatment schemes is not completely understood with respect to the impact of different configurations of unit processes (Blair et al., 2013). However, there are a number of studies that have begun to compile the growing body of information on this topic. In a report by Miege et al. (2009), results from 117 publications on CEC presence in influent and effluent wastewater were gathered. Amongst the publication results, 70-99% of hormone compounds studied were removed during conventional wastewater treatment. Carbamazepine and diclofenac had removal efficiencies of <10%, and <25%, respectively.

The review by Rojas et al. (2013) calculated removal efficiencies for compounds based on influent and effluent concentrations that were measured in the cited studies to develop a database of on removal rates. Rojas et al. (2013) found that conventional secondary treatment removed less than 20 percent of carbamazepine and less than 50 percent of diclofenac, almost all of the caffeine and acetaminophen were removed in half of the WWTPs studied. The Rojas et al. (2013) review was very comprehensive, incorporating 657 references of previous work to calculate mean removal efficiencies of compounds. A summary of findings from that study, separated by group of CEC compound, follows.

Antibiotics

The efficiency of antibiotic removal by secondary treatment varied. Tetracycline displayed an average removal efficiency of 70%. Sulfamethoxazole, roxythromycin, nor-floxacin and ciprofloxacin had average removal efficiencies between 50 and 70%, and sulfamerazine and trimethoprim had removal efficiencies below 50%.

Estrogen and Estrogen Mimics

Removal efficiencies for hormonal compounds, specifically, estrogen and estrogen mimics, were uniformly greater than 75%.

Musks

Musks, though classified as nonbiodegradable, have removal efficiencies above 65%. One nito-musk, musk ketone, had removal efficiencies greater than 90%. A noteworthy comment with respect to musk removal was the hydrophobic nature of these compounds and the associated possibility that their removal could be attributed to sludge adsorption.

Plastics Additives

Benzophenone and DEHP displayed high removal efficiencies. Bisphenol A (BPA) and epoxy resins such as alkylphenols and alkylphenol ethoxylates had average removal efficiencies of 80-85%.

Perfluorinated Compounds

Compounds such as PFOS and PFOA showed removal efficiencies close to zero. This result was anticipated because perfluorinated compounds are both hydrophilic and nonbiodegradable.

8.1.3.3 Sequencing Batch Reactors & Membrane Bioreactors

8.1.3.3.1 Membrane Bioreactors

Unlike conventional activated sludge processes, membrane bioreactors (MBRs) do not include mechanical pretreatment or primary sedimentation. Instead, a microfiltration or nanofiltration membrane is used to separate liquid from the activated sludge that remains in the aeration basin. MBRs operate at much higher (typically five to eight times) mixed liquor suspended solids (MLSS) concentrations than CAS systems. Because of this, MBR systems produce high quality effluent with respect to nutrients, COD, microbial community growth, in a substantially smaller footprint for the physical system.

Treatment conditions such as SRT, temperature, pH, biomass concentration, and the class of CEC present in the wastewater determine the removal efficiencies of both CAS systems and MBR systems. SRT for MBRs is typically 25 to 80 days whereas SRT in CAS systems in considerably less, from 8 to 25 days (Cirja et al. 2008; Joss et al. 2006). Rojas et al. (2013) found that CEC removal efficiencies in membrane bioreactors were similar to those found in conventional wastewater treatment, however, compounds such as clofibric acid and naproxen were removed to a higher degree. Acetaminophen, diclofenac, ibuprofen, and ketoprofen seemed to exhibit more resistance during MBR treatment and had lower removal efficiencies than by conventional processes. BPA and p-nonylphenol were removed to similar extents between MBR and conventional activated sludge processes (Rojas et al. 2013).

Sipma et al. (2009) hypothesized that MBRs provide additional removal of refractory organic contaminants when compared to traditional activated sludge systems. The average removal efficiencies for 30 PPCPs that have been documented for MBR and CAS were compiled for this review. The authors found that due to sludge age and the formation of unique microorganism communities, MBRs outperform traditional activated sludge processes when removing poorly degradable PPCPs. However, easily degradable compounds such as acetaminophen, ibuprofen, and paroxetine were readily removed in both MBR and CAS systems. Compounds that were either barely or reasonably removed in CAS were more efficiently removed in MBRs. One example is sulfamethoxazole which exhibited removal efficiency of 33% in CAS systems, and removal efficiency of 73% in MBR systems (Sipma et al. 2009).

Cirja et al. (2008) found, in contrast to conclusions gathered by Sipma et al. (2009), that no real removal efficiency differences could be found between the MBR and CAS systems. Even though there were no conclusive overall differences, the paper noted that various operating conditions resulted in inconsistent performance from CAS to MBR. For example, CAS systems generally had consistent treatment performance even during temporal variations from 10-25 degrees Celsius. This can likely be attributed to the larger surface area in CAS as opposed to MBR; larger surface areas may protect microbial communities from temperature shock. MBRs were strongly influenced by changes in temperature and season (Cirja et al 2008). Higher temperatures in the MBR systems resulted in an 80-100% increase in removal rates. High temperature operating conditions in MBR systems likely enhance removal of persistent organic compounds. Cirja et al. 2008 concluded overall that conventional wastewater treatment plants in locations with average temperatures between 15 and 20 degrees Celsius may be more effective at removing micropollutants when compared to locations with an average temperature less than 10 degrees Celsius (Cirja et al. 2008).

8.1.3.3.2 Sequencing Batch Reactors

A sequencing batch reactor is an activated sludge process that operates under non-steady state conditions. Both aeration and sedimentation occur in the same basin in a time sequence and therefore the system operates as a batch reactor. Because the reactions, sedimentation process, and decanting process occur in the same tank, there are no secondary clarifiers needed and there is no recycled sludge process employed.

Studies regarding CEC removal in SBRs focus on the microorganism community within the reactor, and its ability to degrade pollutants (Keen et al. 2014). Toyama et al. 2013 studied the removal efficiency of endocrine disrupting compounds in SBRs and found that two particular rhizobacteria of *Phragmites australis* effectively degraded EDCs to below detection limits within 12 hours (Toyama et al. 2013). Mohan et al. (2004) found that suspended growth SBR systems may facilitate increased removal of complex chemical constituents, when compared to traditional CAS systems, because short term non-steady state conditions can be enforced in combination with fluctuating "feast and famine" periods. Essentially, it was observed that microbial communities may be able to store substrate during "feast" periods and reuse the substrate for growth during "famine" (withdrawal) periods. This dynamic is believed to enhance removal (i.e. substrate uptake) and allow better settling of the biomass (Mohan et al. 2014). Performance of the suspended growth SBR system was measured by percentage of BOD and COD removal. When operating at an organic loading rate of less than 1.7 kg COD/m^3/day, COD removal was approximately 66% and BOD removal was 92%; when operating at or above 1.7 kg COD/m^3/day, COD removal dropped to 47% and BOD removal reduced to 72%. When the organic loading rate was increased to 3.5 kg COD/m^3/day, COD removal was 57% and BOD removal was 35%. Therefore, Mohan et al. 2014 concluded that ideal organic loading rates are less than 1.7 kg COD/m^3/day whereas performance inhibiting conditions begin when the organic loading rate is increased past 3.5 kg COD/m^3/day. Additionally, Mohan et al. 2014 found that the SBR was stabilized within 2-5 days of initial start-up which is typically shorter than a conventional activated sludge reactor needs (Mohan et al. 2014).

Gonzalez et al. (2009) studied the combination of aggressive pretreatment by chemical oxidization followed by SBR treatment for the removal of antibiotic sulfamethoxazole and found that 76% removal of TOC concentrations occurred over an 8-hour period. Gonzalez et al. concluded that powerful oxidation processes, can be applied successfully as pretreatment steps to SBR systems for the removal of recalcitrant PPCPs (Gonzalez et al. 2009).

8.1.3.4 Advanced Treatment Options

Subedi et al. (2014) studied advanced on-site wastewater systems in the vicinity of Skaneateles Lake in central New York for the removal of PPCPs and PFASs. Originally, advanced systems were installed in homes to limit nutrients entering receiving surface water bodies. In this instance, advanced systems incorporated synthetic media such as textile filter, peat fiber, and textile/peat along with innovative dispersal technologies such as drip irrigation and bottomless sand filters (Subedi et al., 2014).The designs chosen for installation were shown to be effective at reducing total nitrogen load to the subsurface which was the initial goal. Results from numerous past studies have shown that well-operated, conventional systems can achieve high removal rates for most wastewater pollutants of concern, with the notable exception of nitrogen. Costa et al. 2002 estimated that 25 percent removal of total nitrogen could be assimilated in conventional soil absorption systems. Commercially available advanced OWTSs evaluated in the Subedi et al. (2014) study included aerobic systems utilizing synthetic media (textile filter, peat fiber, and textile/peat) and dispersal units such as a sand filters with no bottom (Subedi et al. 2014). Subedi et al. (2014) found significant concentrations of sulfamethoxazole subsequent to textile/peat treatment in comparison with effluent concentrations from the other systems. Additionally, concentrations of atenolol were found to be tenfold lower when treated with the biofilter treatment unit. Overall, exact removal efficiencies between the four systems were not within the scope of study, however the textile/peat filter was found to be the most effective advanced OWTS in terms of removing total coliform, E. coli, enterococci, and all of the measured PPCPs. It is of note, however, that effluent from the textile/peat filter had PFOS concentrations 2 to 4 times higher than the other advanced OWTSs.

Stanford and Weinberg (2010) conducted a study on the use of advanced OWTS processes for removal of steroid estrogens and nonylphenols; five different systems were tested and all systems were in locations where >25 people reside. The systems utilized a variety of pretreatment methods such as aerobic wetlands, anaerobic wetlands, sand filters, vegetated sand filters, greenhouse irrigation beds, and UV disinfection or chlorination prior to release (Stanford and Weinberg, 2010). Stanford and Weinberg concluded that advanced pretreatment methods such as aerobic sand filtration or aerobic wetlands are likely needed to ensure removal of EDCs before effluent reaches groundwater. When these particular pretreatment methods were utilized, TOC, NH_3-N, BOD, steroid estrogens and nonylphenols, and total estrogenic activity were substantially reduced. On the other hand, when aerobic pretreatment methods were not utilized, high estrogenic activity, TOC levels, and high levels of endocrine active substances were observed. Where aerobic processes are not used prior to discharge to leaching fields, it is important to be aware of the possibility of increased levels of these constituents in groundwater, especially when the soil is particularly sandy and the groundwater table is shallow (Stanford and Weinberg, 2010).

Du et al. (2014) found that a septic tank system coupled with subsurface flow constructed wetlands performed far better than a septic tank alone; however, the coupled system did not outperform aerobic OWTS or municipal WWTP treatment. The septic tank system studied did not include soil treatment (traditional septic systems utilize a leaching field) and was used to represent a septic system that does not properly function; 10 to 20 percent of septic systems in the United States malfunction every year (USEPA, 2002).The study conclusions highlighted the potential of constructed wetlands for enhanced CEC removal when soil absorption leaching fields are not possible (space restrictions, etc.). In a constructed wetland, mechanisms for removal of CECs are primarily biodegradation, sorption, sedimentation, and vegetation uptake. In this study, constructed wetlands performed similar to municipal wastewater treatment plants with respect to CEC removal with the exception of diclofenac, gemfibrozil, and benzoylecgonine (Du et al. 2014). For example, in this study caffeine had a removal efficiency of 100% in the WWTP, 99% in the aerobic OWTS, 100% in the septic tank system paired with the constructed wetland, and 52% in the septic tank alone (Du et al. 2014).

Mechanisms of treatment that are employed in advanced on-site wastewater treatment systems are discussed below, though the list is not intended to be exhaustive. These types of processes could be added to conventional OWTSs to enhance CEC removal. If CEC removal is enhanced, it is also likely that the overall water quality of the effluent will be enhanced with respect to nutrients and the suite of conventional water treatment parameters. It is important to emphasize that metabolites or disinfection by-products can be the result of some treatment processes, and further attention needs to be placed on the linkage between unit processes, class of CEC, and the potential formation of unwanted, harmful, products or intermediate compounds.

8.1.3.4.1 Sorption

There are two types of activated carbon: powdered activated carbon (PAC) and granular activated carbon (GAC) (NRC, 2012). Activated carbon can be used to enhance adsorption of contaminants, such as organic wastewater chemicals, on a solid phase material and therefore remove them from the water. PAC is most commonly utilized in the activated sludge process to increase solids contact, whereas GAC is a common component in pressure and gravity filters (NRC, 2012).

8.1.3.4.2 Biofiltration

Biofiltration is a process that relies upon the growth of microbial communities on filter media in order to facilitate microbial degradation of organic matter (Kandasamy et al. 2002). A biofilter can be any type of filter that has developed a biological film on the filter media; examples include trickling filters, GAC filters, and sand filters (Kandasamy et al. 2002). The microbial community transforms organic material into both energy and cell mass. Operating parameters such as the pH, temperature, and hydraulic loading rates can impact the performance of the microbial community (Kandasamy et al. 2002).

8.1.3.4.3 Ion Exchange

Ion exchange incorporates a solid phase material to substitute ions in the aqueous phase for an ion in the solid phase (Asano et al. 2007). The most common application of this process is in water softening, where the hardness of the water is reduced by removing magnesium and calcium ions from the water and replacing them with sodium ions from the solid phase exchange material such as polymeric resin, kaolinite, or montmorillonite (Asano et al. 2007). Essentially, the exchange materials have fixed charge functional groups attached to the material itself; oppositely charged ions, known as counter ions, uphold the electroneutrality of the exchange material and the aqueous solution, allowing removal of select ions from the water by replacement (Asano et al. 2007). Ion exchange can be used to remove a variety of constituents such as barium, radium, arsenic, perchlorate, chromate, Na+, Cl^-, SO_4^{2-}, NH_4^+ and importantly for systems that discharge to groundwater for the purposes of indirect potable reuse, NO_3^- (Asano et al. 2007).

8.1.4 Recommendations for Suffolk County: Planning for the Future

In Suffolk County, CECs are not the only concern when planning for future OWTSs. About 70 percent of the nitrogen load in Suffolk County is estimated to originate from OWTSs; this is a very high percentage when compared to other regions. Effluent nitrogen levels from traditional OWTS are an estimated 38 mg/L. Barnstable County, MA requires effluent nitrogen concentrations to be between 19 and 25 mg/L whereas the State of Maryland requires effluent nitrogen concentrations to be 30 mg/L. Of the 19 pilot advanced OWTS systems investigated on the 'Suffolk County Septic Road Show', only one is permitted in all four studied jurisdictions for the adequate reduction of nitrogen. The system, known as Bio Microbics FAST, is an Integrated Fixed Film Activated Sludge (IFAS) process. Busse GT and Bio Microbics Bio Barrier are OWTSs that likely enhance removal of both nitrogen and CECs (Bellone, 2014).

As discussed in previous sections, enhanced aerobic conditions (i.e. extended aeration), MBRs, and biofiltration are methods that have been shown to slightly or modestly increase removal of CECs from wastewater – but research gaps inevitably exist, particularly with respect to how each specific system performs. Further investigation is, without doubt, a crucial component of making educated decisions about the long-term selection and implementation of processes to provide treatment for these compounds.

Thus, both practical recommendations for design and implementation of OWTSs as well as further investigation are provided. These recommendations are provided based on the cumulative information that is available, but specifically leverages information that is documented for centralized systems that have similar treatment processes and removal mechanisms as the proposed advanced OWTSs. Finally, it is worth considering how monitoring information can be used to inform risk assessment and risk management from CEC contamination of groundwater supplies; a brief discussion of how CEC data currently being collected can be used to inform this process.

8.1.4.1 Design Parameters for OWTSs

Recommendations for design of OWTSs have been extracted from literature with respect to optimizing treatment performance, which also includes the treatment that occurs in the aerobic vadose zone into which effluent is discharged.

8.1.4.1.1 Separation Distances

Carrara et al. (2008) reported that removal of pathogens is typically the governing factor when setting criteria for separation distances between a water supply well and the tile bed (or leaching field) of OWTSs, and these criteria do not account for the transport or effective removal distances for CECs (Carrara et al. 2008). Moving forward, separation distances should be adequate to ensure both pathogen removal and CEC removal. While there is not clear guidance in the literature on ideal or minimum separation distances that are necessary to achieve CEC removal, it is known that researchers have reported higher observed concentrations of PPCPs at sample locations that are closer to the OSWTs discharge. Rosario et al. (2014) theorized that the limited separation distance in some OTWSs result in higher concentrations of PPCPs in down-gradient samples, such as groundwater or stream samples. Additionally, Heufelder (2012) recommended maximizing vertical separation of OWTSs from groundwater in efforts to increase residence time within the soil aquifer system to provide better CEC removal, however the authors noted that this needs to be studied further.

Current SCDHS requirements for septic systems require a minimum of three feet below the bottom of the leaching pool and the highest recorded groundwater elevation for conventional OWTS. In addition, the County requires a minimum of 100 to 150 foot distance between a leaching pool and the nearest private well (depending upon the well depth) and a minimum of 200 feet to a public supply well (SCDHS, 1995). SCDHS guidance for siting new or expanded WWTPs advises that WWTPs should not be located within the zero to two year contributing area to public supply wells as identified by the 2007 source water assessments, based on the NYSDOH's assessment of the sensitivity of microbial contaminants. In addition, the County advises that the siting of WWTP discharges within the two to 50 year groundwater travel time should be minimized to the extent feasible; if a WWTP is located within this zone, an advanced treatment process shall be provided (SCDHS, 2014). The separation distances proposed by SCDHS are consistent with providing some level of CEC removal, particularly when the OWTS is an advanced treatment system that includes aerobic treatment.

8.1.4.1.2 Horizontal Setback Distances from OWTS to Receiving Surface Waters

The Rosario et al. (2014) study proposed increased horizontal setback distances between OTWS and surface waters in order to increase treatment of CECs and PPCPs. In soils predominantly characterized by sandy clay loam, PPCPs migrated up to 15 to 18 m from the drain field to the nearby stream. Current SCDHS guidance for siting new or expanded STPs advises that siting of STPs within the zero to twenty-five year contributing area to sensitive surface waters should be minimized to the extent feasible; if an STP is located within this zone, an advanced treatment process shall be provided (SCDHS, 2014).

8.1.4.1.3 Hydraulic Loading Rates and Residence Time

Drewes et al. (2011) made conclusions regarding soil-aquifer treatment operations from findings of field monitoring efforts at five field sites. The main findings suggest that removal of DEET, diclofenac, ibuprofen, and meprobamate required at least one week of travel time to achieve 90% removal rates. Chlorinated flame retardants such as TCEP, TCPP, TDCPP were not well removed after 6 days, and antiepileptic compounds such as primidone, Dilantin, carbamazepine, sulfamethoxazole, and atrazine were not well removed after 5 days in either oxic or anoxic conditions.

In the laboratory column study published by Teerlink et al. (2012), CEC attenuation was explored as a function of hydraulic loading rates. The majority of CECs did not show a significant difference in removal as a function of loading rates however readily biodegradable CECs seemed to exhibit better removal at lower loading rates (Teerlink et al. 2012). One study suggested an increase of residence time by decreasing the hydraulic load. Recommendations include a loading rate of 0.74 gallons per square foot per day (Heufelder et al. 2012).

8.1.4.1.4 Vents

Heufelder (2012) recommended that in order to promote increased air exchange and enhance the resulting treatment benefits of sufficient levels of oxygen with respect to aerobic organisms, at least one vent should be required in all SAS systems. Heufelder (2012) also noted that ideal design of soil-absorption systems would incorporate minimal coverage because less coverage promotes air exchange.

8.1.4.1.5 Distribution of OWTS Effluent

Heufelder (2012) has been testing OWTS in Massachusetts for 20 years – in his work, he makes recommendations for design features for OWTS that are thought to optimize CEC removal. One of the key recommendations is pressurizing the treated effluent to optimize oxygen transfer and produce consistent unsaturated flow conditions. In gravity fed systems the majority of the soil aquifer system soil interface area is not used and effluent percolates over time under saturated flow conditions through less soil volume. Low-pressure distribution of septic tank effluent results in higher levels of oxygen transfer due to the effluent being exposed to increased surface area of soil particles. This design modification is recommended so that OWTS effluent is distributed to the soil treatment unit via low pressure distribution in order to utilize the most surface area within the soil absorption system (Heufelder 2012).

8.1.4.2 Monitoring Indicators for CECs Treatment Performance

The core purpose of wastewater treatment is focused on reducing the organic and nutrient load in wastewater. Biological treatment processes are the predominant type of treatment in the U.S. and other parts of the world. These processes have been designed in many different configurations depending on the level of treatment required. Although not originally designed for this purpose, conventional treatment processes (both centralized and OWTSs) can remove a variety of CECs. There are a number of factors which have been identified in previous works to affect the attenuation of CECs in various treatment systems (both centralized and OWTSs), among them solid retention time (SRT), pH, and temperature. Quantitative relationships between these factors and CEC removal have not yet been systematically established for centralized systems; less is known about CECs in OWTSs. Therefore, our ability to predict CEC removal during treatment is currently limited.

However, with the thousands of chemicals contained in wastewater, comprised of pharmaceuticals, personal care products, food additives, and other high production volume chemicals with a wide range of physical and chemical properties, many CECs have been detected in groundwater supplies. As we can only monitor a very small fraction of all CECs that are present in environmental samples, strategies are needed to describe and predict removal efficiencies for representative CECs. Therefore, a strategy based on performance indicators selected by considering key removal mechanisms and compound properties could be used to inform the process of evaluating OWTSs.

Considering that the major removal mechanisms in OWTSs include sorption and biotransformation, researchers have identified a key group of indicator compounds that can be grouped into nine bin categories that represent a larger group of CECs with similar sorption and biotransformation characteristics (WERF, 2012). Each bin category can be described in terms of anticipated range of removal efficiency and the accuracy and reliability of predicting fate during activated sludge treatment using current fate models. As previously noted, solid retention time (SRT) was found to drive the biotransformation of indicator compounds that are moderately biotransformed and threshold SRTs were defined for each indicator that exhibited more than 80% removal as previously described while characteristics such as hydrophobicity drive removals by sorption onto solids.

Based on research published by WERF (2012), the parameters identified in **Table 8-17** can be used as indicators with respect to evaluating biological treatment performance in conventional systems, and these may also be useful in assessing the performance of OWTSs being piloted in Suffolk County.

Table 8-17 Indicators Recommended for Assessing Biological Treatment Performance

		Biotransformation (k_b, L/g-d)		
		Slow <0.1	**Moderate 0.1 - 10**	**Rapid > 10**
Sorption (log K_d)	**Low <2.5**	Carbamazepine Meprobamate Primidone TCEP Sucralose	DEET Sulfamethoxazole Gemfibrozil Iopromide Trimethoprim	Acetaminophen Caffeine Naproxen Ibuprofen Atenolol
Sorption (log K_d)	**Moderate 2.5 – 3**	TCPP	Cimetidine	Benzophenone Diphenhydramine Bisphenol A
Sorption (log K_d)	**High > 3**	Tricolcarban		Triclosan Fluoxetine

Twenty-two compounds that could be used as performance indicators were selected from a database of over 240 compounds evaluated based on the occurrence levels and detection frequency in wastewater influents and effluents, their properties and ability to be measured by current analytical techniques. Toxicological relevance was a secondary selection criterion. The compounds were classified into different bin groups based on their biotransformation kinetics as sorption characteristics during biological treatment processes.

8.1.4.3 Research on Emerging Monitoring Tools

As noted above, ultimately, effluent limits for CECs are impractical for individual compounds or even groups of compounds and other endpoints will need to be identified to manage the risk imposed by these compounds on the environment and public health. Thus researchers have focused on identifying new methods for identifying wastewater impacts on the receiving environment.

While there have been significant advances in the number of compounds that can be measured, at increasingly lower detection limits, the approach to linking the detection of CECs to human health or ecological effects is not clear cut. For example, many pharmaceuticals, steroids, and biogenic and anthropogenic hormones are chemically changed by human or animal digestive tracts by formation of glucuronide or sulfate conjugates (Berg et al., 2007). The pharmaceuticals ingested by mammals are often excreted as the unaltered parent compound to only a small degree., Thus in addition to studying the parent compound, it is necessary to examine the metabolic by-products of these compounds, which may be radically different than the parent compounds from a treatment perspective. The formation of conjugates is a mechanism by which certain chemicals are rendered more water soluble and thereby more excretable. Organic weak acids, including alcoholic, phenolic, and carboxylic acid functional groups, react with glucuronic acid *in vivo* to form glucuronide conjugates (Berg et al., 2007). For example, gemfibrozil, a lipid regulating pharmaceutical, is excreted mostly as the glucuronide conjugate, with less than 2% excreted as unchanged gemfibrozil; it is also of note that approximately 76% of the actual administered dose is excreted (RxList, 2014). When the hydrophobicity–ionogenicity profile for the parent compound is compared to the glucuronide conjugate, it can be concluded that the conjugate is more hydrophilic than the parent compound, indicating that it is more challenging to remove from wastewater by sorption processes (Wells, 2006).

Considering the number of possible chemicals and their degradates that could be analyzed, our historical and current paradigms for evaluating occurrence, fate, and toxicity cannot keep pace with chemical development and commercialization, let alone regulatory evaluation. The objective of identifying all of the constituents and their degradation products that may be of concern in wastewater effluent is an impossible task. Thus, many researchers have focused on developing an understanding of the bulk characteristics of the residual organic carbon that remains in treated wastewater and the biological effects of the mixtures of compounds that exist in these waters (Snyder, 2014).

8.1.4.3.1 Characterization of Bulk Organic Matter

Residual organic carbon is of interest because it is associated with a broad spectrum of potential concerns. Three groups of residual organic chemicals require attention (Drewes and Jekel, 1998):

- Constituents of emerging concern added by consumers or generated as disinfection by-products (DBPs) when chlorine-based oxidizing agents are applied, or during the disinfection of water and wastewater, and
- Soluble microbial products (SMPs) formed during the wastewater treatment process and resulting from the decomposition of organic compounds.
- Natural organic matter (NOM), if present in water supplies will be present in wastewater.

In addition to traditional methods for measuring organic carbon content in samples, emerging methods such as UV fluorescence excitation/emission matrix (EEM) spectroscopy can be used to provide characterization of organic constituents in water samples. This allows indirect measurement of changes in water quality through a treatment train. Spectra or "maps" are generated in which specific spectral signatures or "fingerprints" of organic matter can be localized. EEM, or 3D fluorescence, is a technique that can be used to characterize the organic matter present in waters from diverse sources. When organic matter present in wastewater is excited at a particular wavelength, only part of the organic matter emits light, fluorescence. Fluorescence occurs when a molecule absorbs energy in the form of electromagnetic radiation (ultraviolet and visible light) and re-emits that energy as light. Most molecules do not fluoresce, but re-emit the light energy absorbed in the form of motion (kinetic energy) or heat (thermal energy). Therefore, the technique is limited to molecules containing fluorophores (sub-parts of molecules that have the ability to re-emit energy in the form of light). Many naturally-occurring organic compounds (humic and fulvic acids, amino acids, proteins, and microorganisms) and anthropogenic organic compounds will fluoresce.

Water samples are excited at certain wavelengths (200–600 nm), and fluorescence intensity emitted is collected in a certain range (200–650 nm), resulting in a three-dimensional map: an excitation, emission, and fluorescence-intensity matrix. By this representation, it is possible to localize fluorescence centers related to particular groups of fluorophores, or fingerprints (*i.e.* Yan et al., 2000; Baker, 2001; Chen et al., 2003; Christensen et al., 2006; Stedmon and Markager 2000; Sierra et al. 2005). In a typical river water sample, discrete fingerprints have been identified: tryptophan (λEX, 275; λEM, 350 nm); fulvic-like (λEX, 320–340 nm; λEM, 410–430 nm); and humic-like (λEX, 370–390 nm; λEM, 460–480 nm) (Baker, 2001). In addition, it is possible to distinguish different sources such as sewage dominated by tryptophan-like proteins (Baker, 2002).

Therefore, an innovative mapping procedure for a subset of surrogates or representatives of important chemical classes of potential contaminants has been developed based on fluorescence spectroscopy. Spectra or "maps" are generated in which specific spectral signatures or "fingerprints" of organic matter can be localized. Visualizing a 3D EEM map is similar to looking down on elevations of a mountain in a topographic map. A 3D EEM spectrum can be represented as a contour map just as many topographic maps are, but in these data the height of the elevations (intensity of fluorescence) is denoted by variations in color (**Figure 8-18**).

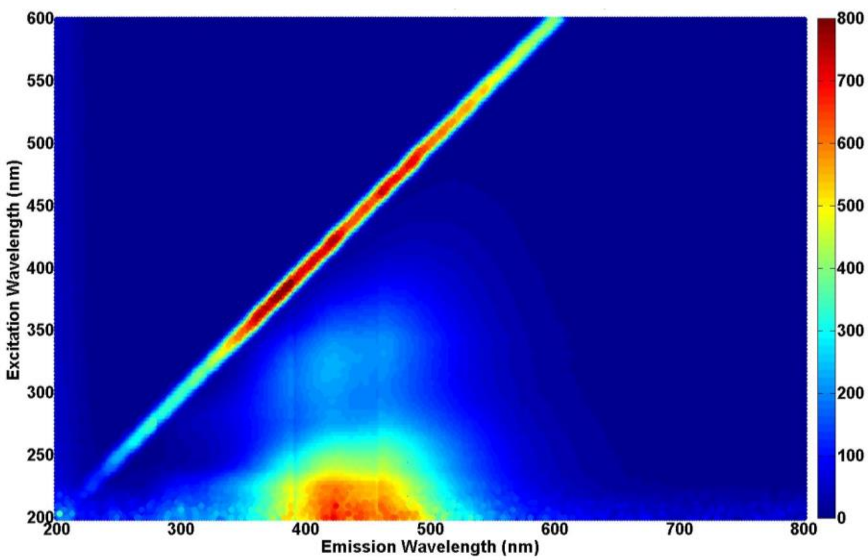


Figure 8-18 Example of a 3D EEM Map Obtained in a Recent Study Tracking Effluent Organic Matter in an Environmental Sample

In the 3D EEM maps presented in **Figure 8-18**, the x-axis represents the emission wavelengths, the y-axis represents excitation wavelengths and the zaxis (represented by the color bar, and coming out of the plane of the page toward the viewer) indicates the intensity of the corrected fluorescence at a specific excitation-emission wavelength pair (x,y data point). The intensely colored diagonal stripe in the 3D maps, located where the excitation wavelength is equal to the emission wavelength, is not due to fluorescence but results from scattering of light (by atoms, molecules, particles) and is referred to as first-order Rayleigh scattering. Of note is the importance of data processing which should include corrections for 2nd order Rayleigh scatter, the Raman spectrum of water, and the inner filtering effect when environmental samples are evaluated.

8.1.4.3.2 Potential Toxicity Impacts

With respect to monitoring for potential biological impacts we can utilize biological sentinels, such as the canary in the coal mine which was relied on for more than 100 years by miners who used these birds to ensure that air within mines was suitable for humans to breathe. The use of biological surrogates has had a long history in protecting human health and, in fact the current risk assessment framework includes testing using *in vivo* animal models to extrapolate endpoints that can be translated to regulatory limits (http://www.epa.gov/riskassessment/) for risk assessment method, e.g., MCL for drinking water. However, with the number of chemicals and mixtures of chemicals and chemical transformation products, this approach is limited and high-throughput screening methods are being evaluated to provide information on the mechanisms of biological toxicity at a relatively small cost (Snyder, 2014).

In the United States, bioassay monitoring is already required by the USEPA for wastewater discharge through whole effluent toxicity testing requirements (http://water.epa.gov/scitech/methods/cwa/wet/). And, researchers are investigating analogous approaches to using assays and endpoints appropriate for human health. Thus, even with the limitations of extrapolation from a cellular response to human health outcomes, high throughput assays could provide a more comprehensive view of chemical constituents present in water as well as an assessment of their cumulative (mixture) toxicity.

Equipment to perform most *in vitro* cellular bioassays is significantly less expensive than those required for mass spectrometric techniques used for targeted analyses. Although many cell bioassays, such as the Ames test or Microtox®, are available commercially, EPA continues to develop a wide array of assays that could be made publically available for very little cost to water agencies. Cell culture equipment is already available in many water laboratories, and plate-scanning spectrophotometers can be procured at reasonable costs that are at least an order of magnitude less than commonly employed liquid chromatography tandem mass spectrometer equipment. The proliferation of 384 well-plate assays along with robotics for liquid handling also will continue to decrease labor and supply costs while simultaneously increasing reproducibility. These types of high throughput assays will continue to be developed and applied for water quality evaluations, allowing for rapid and relatively inexpensive characterization of the mixtures of chemicals that may occur in water (Snyder, 2014).

Recently, a comprehensive survey of bioassay tests that are indicative of a wide range of responses has been published (Escher et al., 2014) along with the results of an interlaboratory study investigating a range of bioassay methods. This research evaluated bioassays that have been identified to be sensitive to induction of specific modes of toxicity such as: mutagenicity and genotoxicity, xenobiotic toxicity, reactive toxicity, cytotoxicity, endocrine disruption, among other modes of action. The conclusions of the study show that while there are currently limitations to bioassay techniques, they are a valid tool for water quality assessment that complements chemical analyses. Additionally, it may be that a battery of bioassays may be necessary to represent the various pathways that are related to evaluating relevant to human health and more research in this area is needed.

8.1.4.3.3 Risk Assessment for CECs in Water

There are a number of federal agencies (e.g., United States Food and Drug Administration [U.S. FDA]) or even other regulatory programs within the USEPA (e.g., the Office of Pesticides Programs [OPP]) that establish risk-based guidelines for various chemicals. Many of these programs establish limits based on the same data that the U.S. EPA Office of Drinking Water utilizes, but usually focus on a reference dose (RfD) so the actual value of a compound would need to be converted to a drinking water equivalent level (DWEL). The acceptable daily intake (ADI) or the margin of exposure (MOE) used by OPP, and the minimum risk level (MRL) used by the Agency for Toxic Substances and Disease Registry (ATSDR) are similar approaches. These approaches may not consider relative source contribution (RSC) that is usually routinely applied by the Office of Drinking Water when establishing maximum contaminant levels (MCLs) or health advisories (HAs).

Researchers have proposed that these numbers can be brought into line with a DWEL by distributing the ADI into 2 L of water. The RSC values for drinking water are usually in the 20- to 80-percent range, with 20 percent being the most common default value for noncarcinogens, if there is not adequate data to assign another value. The RSC default is effectively an additional safety factor on the RfD; RSCs are not used in the risk calculations for carcinogenic chemicals where incremental risk is the metric. 2-liter-equivalent values are sometimes used, especially for volatile organic compounds (VOCs) where exposure contributions for inhalation and dermal exposure from bathing and showering may be incorporated in arriving at a benchmark drinking water value (WRRF, 2013).

Thus identifying *de minimis* risk associated with various pharmaceuticals that are used safely in therapeutics, cannot be approached in the same way as the risk benchmarks described above. Reference doses for pharmaceuticals are developed based upon clinical experience in humans, and the data are frequently derived from controlled clinical trials. The lowest therapeutic dose as a benchmark for estimating “safe levels” for pharmaceuticals in drinking water is one approach that has been used. The adverse effects that are identified in standard texts may be based upon clinical trials and good incidence data may be available for these effects. However, adverse drug reactions that have been reported over the history of the drug's therapeutic use form a substantial portion of the assembled database and the nature of these side effects needs to be taken into account when assigning additional uncertainty factors (Bull et al., 2011).

Several publications (e.g., Physicians' Desk Reference, Drug Information Handbook, Facts and Comparisons) are based primarily upon the U.S. FDA database on drugs in use, but do provide some evaluation of the primary literature. Bull et al. (2011) proposed that the lowest therapeutic dose be considered the equivalent of a Lowest Observed Adverse Effect Level (LOAEL) and that appropriate uncertainty factors be applied to adjust for the frequency and severity of the adverse effects associated with the drug's use. This literature also specifically identifies drugs that have been shown to be developmental toxins in animals, as well as humans. It identifies the adverse effects of compounds with some summary evaluation of the strength of evidence. As a LOAEL taken from human studies, uncertainty factors as low as 100 could be applied, but greater uncertainty factors should be applied to adjust for drugs with short-term clinical courses (usually the case with antibiotics and antimicrobials), and those identified as teratogens or developmental toxins. Those compounds identified as carcinogens should be assessed using linear extrapolation, if the data are available. If not, it has been suggested that dividing the lowest therapeutic dose by 500,000 (Bull et al., 2011), which would produce a cancer risk estimate at approximately the 10-6 lifetime risk (this assumes that the lowest therapeutic dose might have produced a 50-percent response, which is a conservative assumption because, with the exception of chemotherapeutic agents, most often cancer data are from animals and the doses in cancer studies in animals are generally higher than the therapeutic dose).

Finally, while there are standard approaches for developing risk assessments of various CECs, these do not account for the multitude of metabolic products that may occur along with these compounds, nor do they address the complexities of mixtures of compounds. Thus, it is important to continue to evaluate other means of assessing bulk toxicity, such as through the cellular bioassay methods as indicators of risk, as described in 8.1.4.3.2.

8.1.5 Impacts of Rising Sea Level on Wastewater Treatment

Recent sea level rise projections indicate that sea level is projected to rise between 24 and 34 inches by the end of the century with a 95 percent uncertainty range of 36 to 45 inches (Zhang et al, 2014) as shown by **Figure 8-19**. Sea level rise has significant implications regarding on-site wastewater treatment systems for parcels within low-lying coastal areas.

As published in the Suffolk County Standards for On-Site Wastewater Disposal Systems (SCDHS, 1995), the minimum separation distance from the bottom of a leaching pool system to the highest groundwater elevation recorded at the site is 3 feet to ensure adequate treatment in the unsaturated zone prior to discharge to groundwater. In some instances, the minimum separation distance may be reduced to 2 feet for alternative treatment systems, as approved by SCDHS. As per the Standards, for a single-family household with 4 or fewer bedrooms, a minimum depth to water of 9 feet is required or an alternative system must be designed. For larger residences (5 to 6 bedrooms), the minimum depth to water is 11 feet due to the increased wastewater flow.

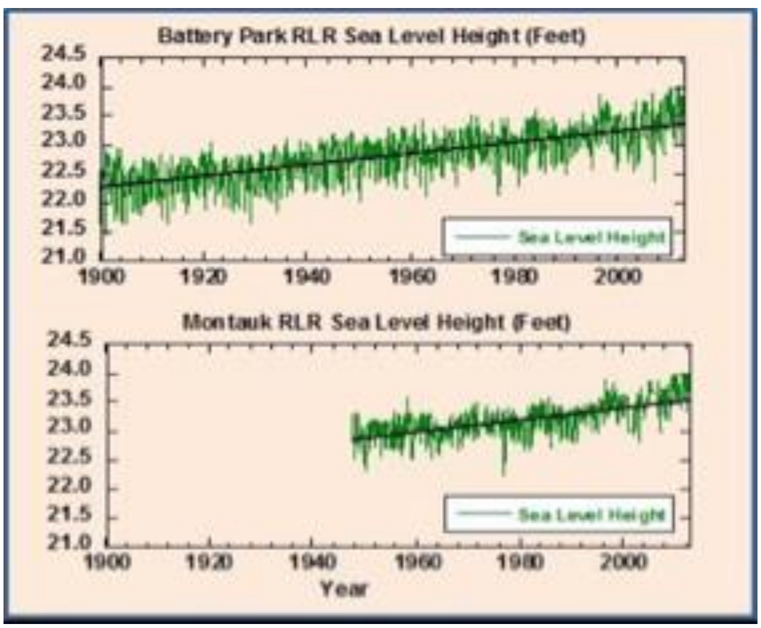


Figure 8-19 Monthly Sea Level Height over Time (Relative to the Revised Local Reference (RLR); from Zhang et al, 2014)

As described in Section 3, sea level rise may result in water table increases of more than 3 feet in coastal areas. This rise in the water table may result in a reduced treatment capability for systems installed within the 9 foot depth to groundwater range or may in fact cause flooding in older systems installed prior to the development of the 1995 Standards. This would result in a direct discharge of sanitary effluent to the groundwater with minimal or no treatment from travel through the unsaturated zone.

8.1.5.1 Groundwater and Sea Level Trends

As discussed in Section 3, the regional groundwater models that were developed for Suffolk County were used to simulate projected sea level rise to the year 2100. Using the "business as usual" scenario outlined in Zhang et al (2014), a sea level rise of 34 inches was projected. The groundwater model simulations incorporated a monthly increase in sea level assuming a linear increase to 2100. The simulated water table position was saved out over time and subtracted from the surface elevation to estimate the resulting depth to groundwater. Areas where depth to water is less than 9 to 11 feet (outside of currently sewered areas) are at risk of having a reduced treatment efficiency from the septic tanks/leaching pools and would be target areas for enhanced wastewater treatment.

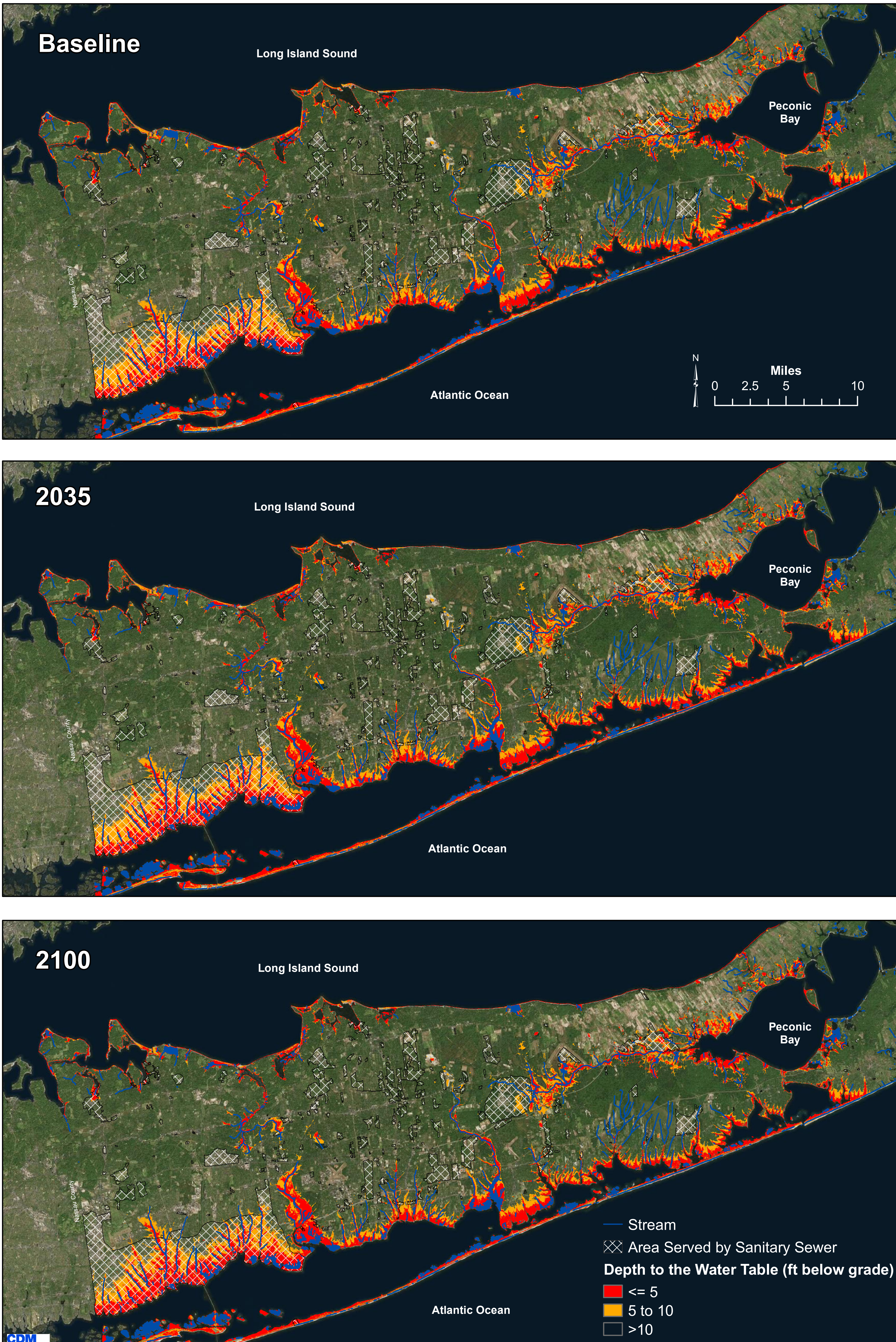
8.1.5.2 Groundwater Model Simulation Results

8.1.5.2.1 Main Body

Simulated depth to water under baseline (2013), 2035 and 2100 conditions is shown on **Figure 8-20**, highlighting areas where the depth to water is less than 10 feet from the surface As shown on the figure, much of this area is along the south shore or along the shoreline of the Peconic Bay. It should also be noted that there are large portions of the coastline that are developed and currently have a depth to water of 10 feet or less. It is likely that these areas were developed long before the establishment of Suffolk County Sanitary Code Article 6 or the standards for wastewater treatment. These areas currently have a reduced treatment capability, which would be even further reduced following any increase in the water table elevation.

As discussed in Section 3, streams act as a flow relief valve and a control to the rising water table. Although it appears from **Figure 8-20** that there isn't a significant difference between areas that have a depth to water of less than 10 feet under baseline conditions to 2100, the water table does rise in these areas (see Section 3) and therefore, treatment effectiveness of on-site wastewater disposal systems would be even further reduced than it currently is.

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community



Simulated Depth to the Water Table
Sea Level Rise of 34 Inches by 2100

Suffolk County Comprehensive Water Resources Management Plan

Figure 8-20

As sea level continues to rise, the barrier island communities are at risk of significant flooding. If the water table is simulated to intersect the ground surface elevation in the groundwater model, the model will simulate a discharge (baseflow or groundwater seepage) at the surface at that point. As shown on **Figure 8-21**, most of these discharge nodes occur along the streams. The sum of this discharge would equal the baseflow of a particular stream. Looking at the baseline condition, there are only a couple of these discharge nodes along the barrier island. However, as sea level rises, additional discharge nodes begin to appear. In 2035, these nodes are primarily located along the immediate coastline, as the groundwater seepage face adjusts in response to the rising sea level. However, note that by 2100, discharge is simulated to occur within currently developed communities along the barrier island, this is anticipated to result in flooding, not only of the septic systems, but at the surface as well.

8.1.5.1.2 North Fork

Similar to the results of the main body flow model, the projected 34-inch sea level rise results is simulated to result in an increased groundwater elevation of approximately 3 feet on the North Fork. As discussed in Section 3, this increase results in some encroachment of the saltwater interface. From a wastewater treatment perspective, the increase results in various areas that are at risk of reduced treatment from the septic systems, particularly on the peninsulas and Orient Point. Simulated depth to water maps for baseline, 2035 and 2100 conditions are shown on **Figure 8-22**. The model results for the North Fork provide a good opportunity for use as a planning tool and can highlight the areas on the North Fork that could be prioritized for sewering or the installation of alternative systems. Evaluating **Figure 8-22** at a small scale, it is difficult to see which areas in particular are impacted. However, when evaluating on a larger scale, impacts are more apparent. As shown on **Figure 8-23**, developed (residential, commercial, industrial, institutional land uses) parcels near Jamesport and Aquebogue currently have a depth to groundwater greater than 10 feet or between 5 and 10 feet. However, as sea level rises, those parcels ultimately become at risk for reduced wastewater treatment as the depth to water at many of these parcels is less than or equal to 5 feet by 2100.

8.1.5.1.3 South Fork

Simulated depth to groundwater on the South Fork is shown on **Figure 8-24**. Similar to results from the other models, depth to water is currently fairly low near the coast and along water bodies. However, these areas become further impacted due to sea level rise. This is clearly shown around the vicinity of Mecox Bay and just west of Napeague State Park. In addition, the area where depth to water is less than or equal to 5 feet below grade clearly expands in North Haven.

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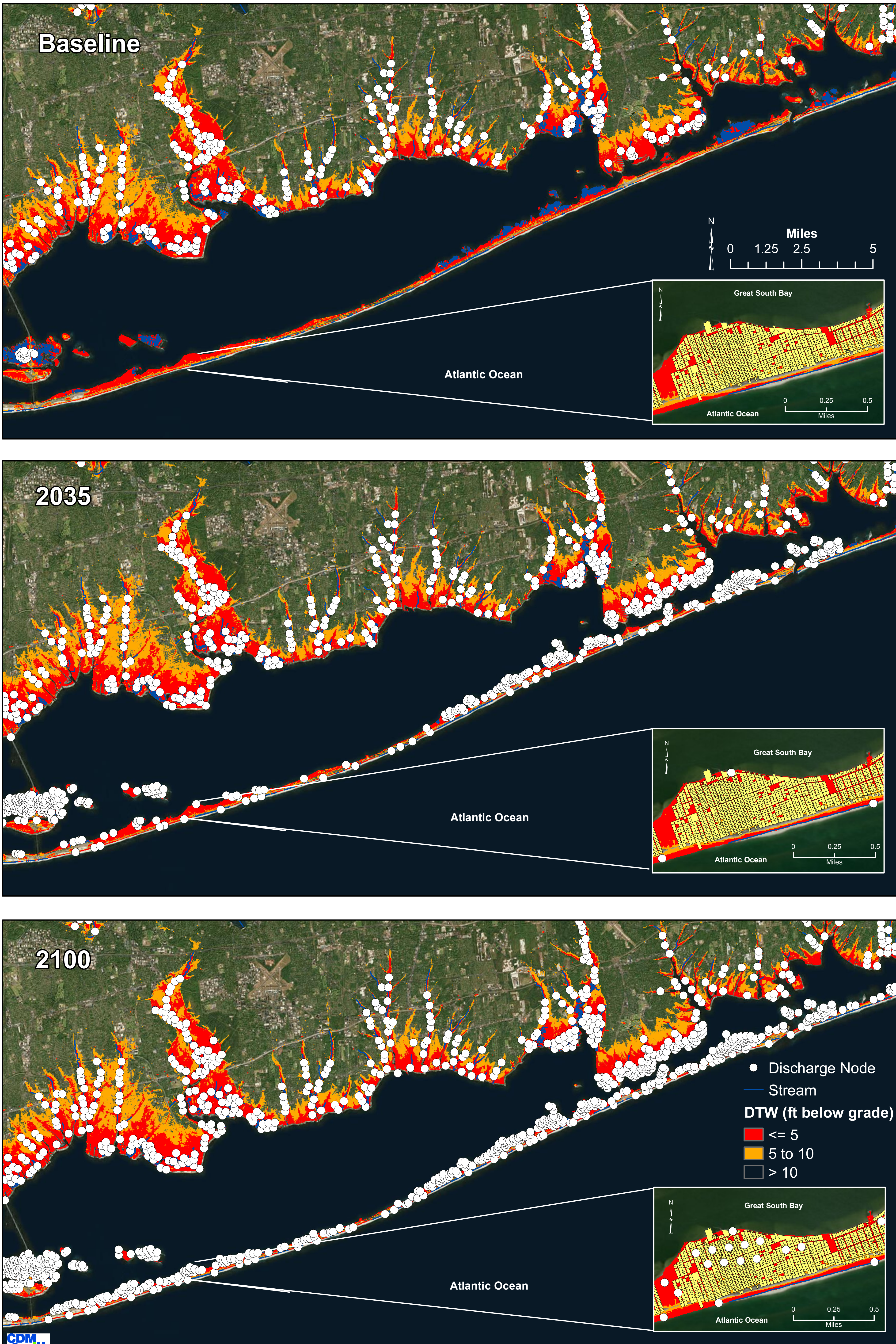
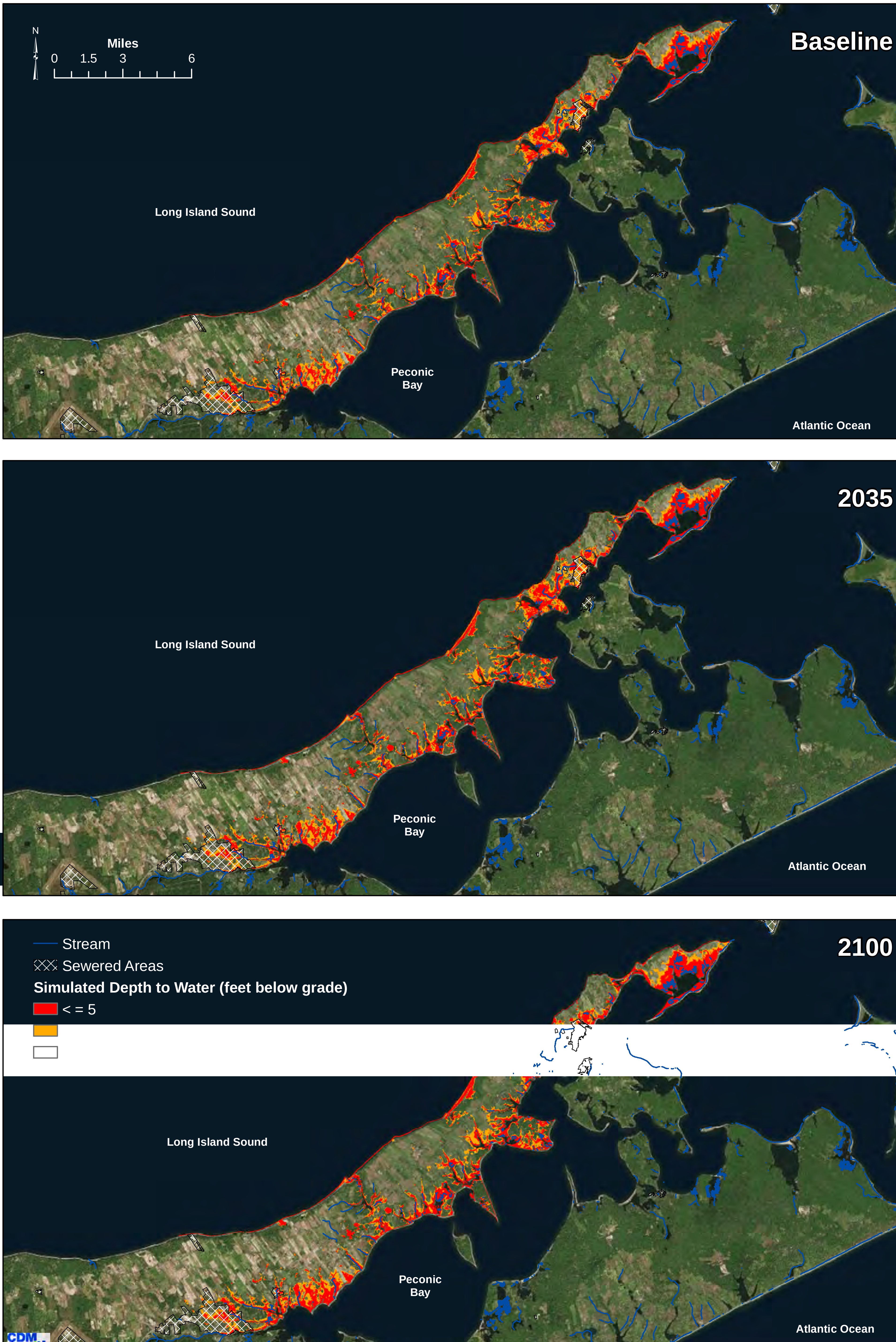


Simulated Discharge Nodes at Surface
Sea Level Rise of 34 Inches by 2100

Suffolk County Comprehensive Water Resources Management Plan

Figure 8-21

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community



Simulated Depth to Groundwater on the North Fork
Sea Level Rise of 34 Inches by 2100

Suffolk County Comprehensive Water Resources Management Plan

Figure 8-22

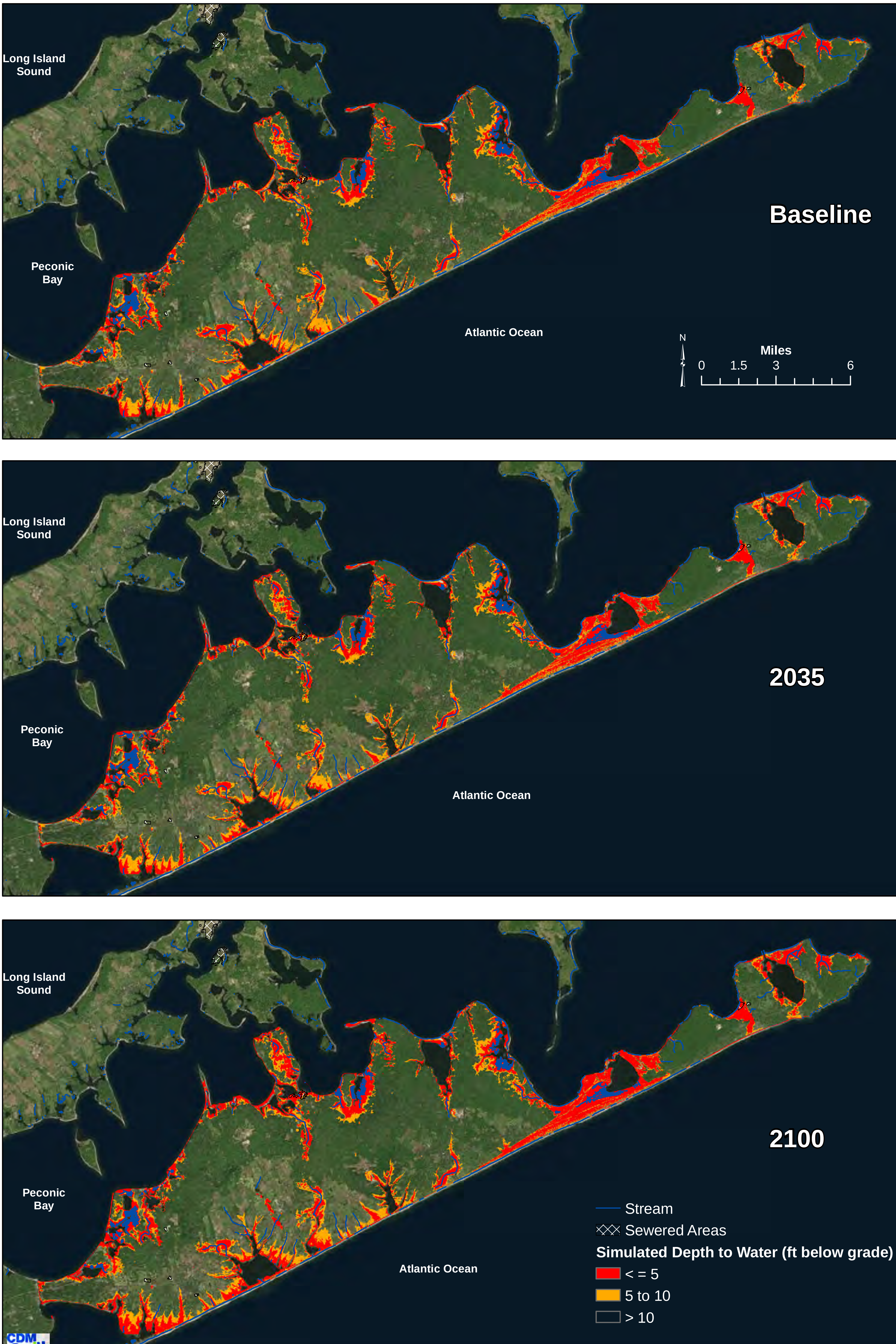
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Impact of Rising Sea Level on Select Parcels on the North Fork
Sea Level Rise of 34 Inches by 2100

Suffolk County Comprehensive Water Resources Management Plan

Figure 8-23

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community



Simulated Depth to Groundwater on the South Fork
Sea Level Rise of 34 Inches by 2100

Suffolk County Comprehensive Water Resources Management Plan

Figure 8-24

8.1.5.1.4 Shelter Island

The simulated depth to groundwater on Shelter Island during sea level rise simulations is shown for baseline, 2035 and 2100 conditions on **Figure 8-25**. The Ram Island peninsula and areas surrounding West Neck Bay currently have a shallow depth to water in numerous locations, but these areas expand as sea level rises. By 2100, the depth to water throughout much of Little Ram Island and West Neck have is less than 10 feet. The area between the West Neck Bay channel and Menantic Creek as well as the western shore of Coecles Harbor near Congdons Creek are also at risk for shallow water table.

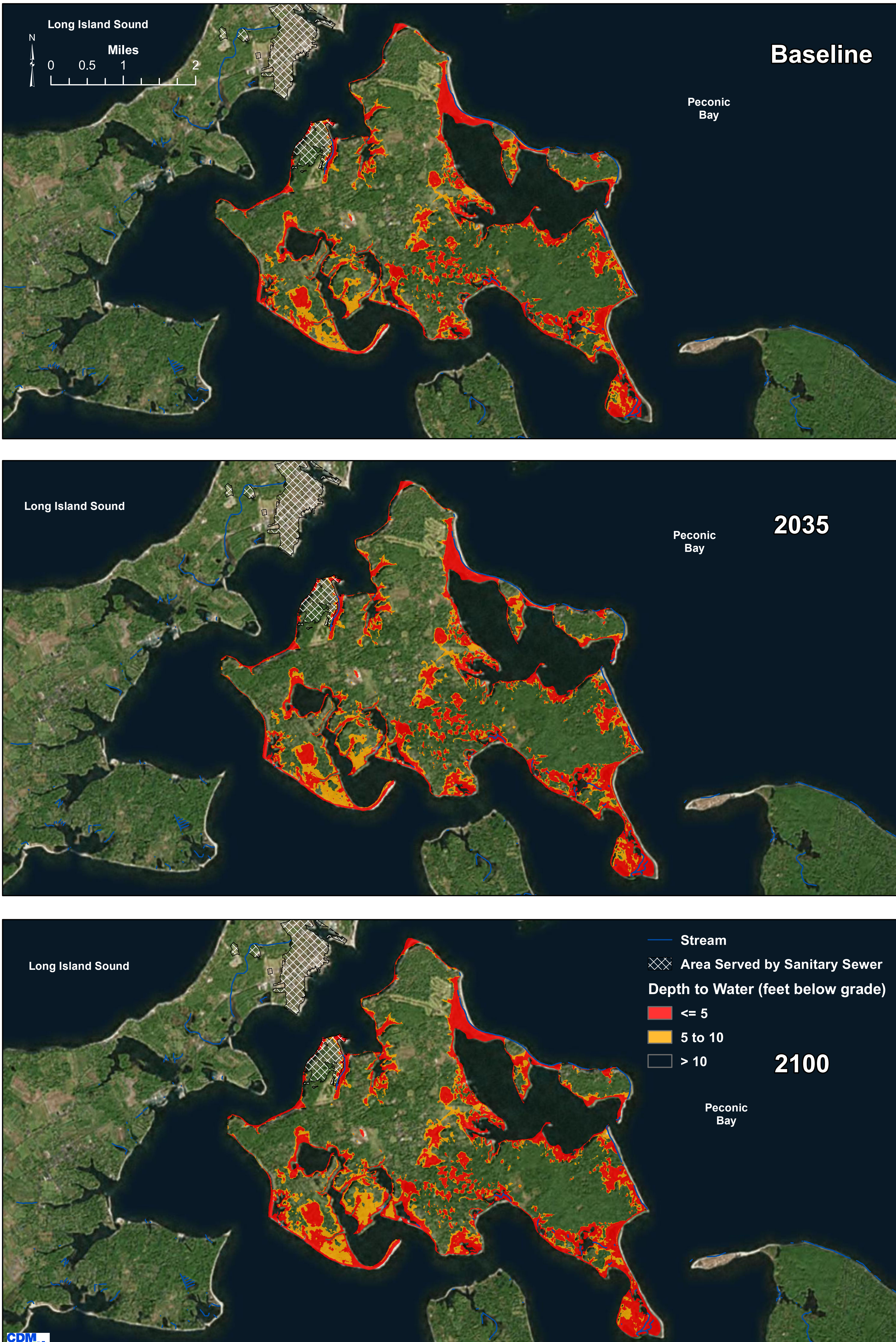
8.1.5.3 Summary

There are many areas along the coast that are currently developed where the existing depth to groundwater is less than 10 feet below grade. These areas also generally correspond with areas that are projected to be further impacted by rising sea level. It is possible that many of the systems within these areas are currently just above the seasonal high water table and may become flooded as sea-level rises in the future. This would not only reduce treatment capability of existing on-site treatment systems, but could completely eliminate the functionality of the system(s).

At greatest risk to elevated sea level are the communities along the south shore barrier island. Not only does the water table rise significantly, but much of the land area becomes flooded, similar to a wetland as the groundwater system adjusts to the rising sea level.

The groundwater table was simulated using long term average rates of precipitation and recharge and current (2013) conditions of water supply pumping. Considering that pre-1972 Suffolk County standards identified a minimum distance of one foot from the bottom of a cesspool to groundwater (providing nine feet from ground surface to the water table), and current standards identify a minimum distance of three feet (providing eleven feet from ground surface to the water table), the number of unsewered parcels where the depth to groundwater is less than ten feet were estimated, based on the simulated water table. On a County-wide basis, it is estimated that over 80,000 of the existing 360,000 unsewered parcels, or over 20%, are currently located in areas where groundwater is less than ten feet deep. These areas should be prioritized for evaluation of appropriate wastewater management alternatives. Shallow depth to groundwater that potentially compromises septic system effectiveness will be exacerbated with increasing sea level rise. Based on recent mid-range projections of sea level rise, it is projected that over 10,000 additional unsewered parcels (total of more than 90,000 parcels) may be located in areas where the depth to groundwater will be less than 10 feet by the turn of the century.

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community



Simulated Depth to the Water Table on Shelter Island
Sea Level Rise of 34 Inches by 2100

Suffolk County Comprehensive Water Resources Management Plan

Figure 8-25

These estimates are based on mid-range estimates of sea level rise resulting from climate change models incorporating the greenhouse gas emissions resulting from "business as usual" and reasonable assumptions regarding precipitation and recharge. It is not reasonable to expect that sea level rise can be predicted to the turn of the century, as estimates of climate change and sea level rise are being re-evaluated and updated as new information becomes available. In addition, some climate change models predict increased precipitation over this part of the world, which will also affect these projections. Nonetheless, the information presented in this section is helpful in identifying the areas of potential concern, as well as the order of magnitude of change that could be expected in the decades to come.

8.1.6 Section Summary

Approximately 69 percent of the total nitrogen affecting our ground and surface water supplies emanates from wastewater, specifically onsite sewage disposal systems. Approximately 74 percent of Suffolk County is unsewered utilizing onsite sewage disposal systems with limited ability to reduce wastewater nitrogen. There are approximately 360,000 onsite sewage disposal systems located in Suffolk County with approximately 209,000 of these systems located in identified priority areas and an estimated 252,530 of the 365,00 pre-dating the requirement for a septic tank. Suffolk County has been experiencing population growth and is expected to reach 1.77 million residents by 2045.

Currently, nitrogen discharge from onsite wastewater treatment systems is regulated by lot size through the implementation of the Suffolk County Sanitary Code Article 6. Based on differences in regional hydrogeological and groundwater quality conditions, Article 6 delineated boundaries of the eight Groundwater Management Zones (GWMZ) for protection of groundwater quality. The Goal of creating the GWMZ was to limit groundwater nitrogen to 4 mg/l in GWMZ III, V, and VI and to 6 mg/l in the remaining zones. Many areas of Suffolk County were built before the Article 6 density restrictions or prior to conventional treatment system requirements. It is these many homes and businesses that are contributing to the pollution of groundwater in Suffolk County as well as the surface waters and ecosystems of the County.

Alternatively to meeting the density requirement of Article 6 of the Suffolk County Sanitary Code to protect water resources, connection to community wastewater treatment systems is an acceptable method of reducing nitrogen. Unfortunately only 26 percent of Suffolk County is connected to sewer systems. The last major expansion of sewers was the creation of the Southwest Sewer District and extension of sewers to existing homes and commercial buildings located within the district. This project was completed in the early

1980s and there has not been a sewer project of its kind in Suffolk County in over 30 years. Evidence has shown that sewering can help reduce nitrogen loads to surface waters, for example the average nitrogen in the Carlls River located by the SWSD was 3.2 mg/l in the 1970s and in the 2000s dropped to 1.8 mg/l. After Super Storm Sandy impacted structures along our coastline in 2012, the need for increased wastewater treatment to reduce nitrogen was realized to improve our valuable water resources. The first major sewer expansion in Suffolk County will occur through a funding reward of $383 million from New York State to install sewers and connect approximately 10,000 properties to sanitary sewer systems.

Innovative/alternative onsite sewage disposal systems, which have been proven in other jurisdictions to reduce wastewater nitrogen to 19 mg/l or less are currently being evaluated to reduce nitrogen discharges from on-site wastewater treatment systems. These types of systems would replace conventional onsite sewage disposal systems. In 2014, Suffolk County began its first demonstration project for I/A OWTS. The demonstration project is intended to provide field-testing and technology verification to determine if a particular I/A OWTS can function effectively in Suffolk County. In addition to nitrogen removal, anticipated rising groundwater and sea level elevation are of concern. Leaching pools are required at a minimum to be 2 feet above the groundwater table. Updated sea level rise projections indicate sea level will rise approximately 24 to 34 inches by the end of the century. Therefore, Suffolk County should review the separation distance between the bottom of leaching structures and groundwater by investigating shallow leaching systems, which may also provide additional nitrogen removal.

In addition to nitrogen, PPCPs are becoming additional contaminants of concern in wastewater discharges based on their potential impacts to ground and surface water resources. In recent years, very low levels of PPCPs, also sometimes referred to as pharmaceutically-active compounds (PhACs) or organic wastewater contaminants (OWC), have been detected in the environment. As most pharmaceuticals are designed to be water soluble, and to be persistent long enough to serve their designated therapeutic purposes, they can be present in dissolved form in receiving ground and surface waters. PPCPs are continuously introduced into the environment by sewage treatment plants and by on-site wastewater disposal systems (e.g., septic tanks and leach fields) in unsewered areas. Advanced treatment units whether sewage treatment plants or I/A OWTS have shown evidence of removing emerging contaminates of concern but further research is required.

In order to combat against the wastewater nitrogen impacting our water resources and maintaining a balance between protecting our water resources while maintaining our ability to dispose of wastewater to protect public health and stimulate development in order to promote economic growth and stability, Suffolk County must implement a responsible wastewater management plan to limit the impacts of nitrogen from wastewater and other emerging wastewater constituents (personal care products, pharmaceuticals, etc.) on the County's water resources to preserve and protect these resources for future generations.

8.2 Goals and Objectives

In order to reverse the degradation of our water resources and to create a process to improve and protect our groundwater and surface water quality for future use over an anticipated timeline, Suffolk County must develop a well-defined and organized wastewater management plan. The wastewater management plan shall address wastewater pollution emanating from the approximately 360,000 onsite sewage disposal systems and handful of remaining secondary sewage treatment plants located within Suffolk County. The basis of the plan shall be to address the goals and objectives outlined in this section.

8.2.1 Goals to Meet Water Quality Initiatives

8.2.1.1 Direct Wastewater Effluent Discharge Goals

Goal 1: Improve groundwater quality to maintain a potable water supply to serve existing and future populations by reducing effluent nitrogen loads from existing and future onsite sewage disposal systems and sewage treatment plants.

Goal 2: Improve surface water quality to increase coastal resiliency and rehabilitate and maintain a vibrant coastal ecosystem by improving dissolved oxygen levels, reducing harmful algal blooms, and controlling nutrient levels through the reduction of effluent wastewater nitrogen loads from existing and future onsite sewage disposal systems and sewage treatment plants.

Goal 3: Reduce and/or eliminate the impacts of pharmaceuticals and personal care products from wastewater effluent for increased public health and marine life protection.

8.2.1.2 Indirect Goals Attributed to Direct Wastewater Effluent Discharge Goals

Goal 4: Provide development opportunities for continued economic growth to support future population growth while limiting wastewater nitrogen discharge.

Goal 5: Improve operations and maintenance of onsite sewage disposal systems and sewage treatment plants to maintain compliance with effluent nitrogen limits and achieve more stringent discharge goals where feasible and appropriate to protect ground/surface waters.

Goal 6: Provide funding sources to the residents of Suffolk County to permit affordable upgrades to existing onsite sewage disposal systems or connection to community sewers.

***Goal 7**:* Promote the reuse of effluent wastewater for irrigation and grey water uses to preserve the volume of potable groundwater water supply to serve anticipated future population growth.

8.2.2 Objectives to Meet Water Quality Initiatives

8.2.2.1 Wastewater Management Plan Implementation Timeline to Meet Goals

Objective 1: Suffolk County shall follow the subsequent proposed timeline to meet the wastewater water quality goals

> 2015 – 2017: Initiate development and implementation of a wastewater management plan to reduce nitrogen loads to ground and surface waters
>
> 2018-2035: Full-scale implementation of the wastewater management plan to reduce nitrogen loads via upgrading onsite sewage disposal systems to I/A OWTS or connecting parcels to sewers.
>
> 2035 and beyond: Continue on-site sanitary system upgrades and/or parcel connections to community sewers in the high priority areas. The total nitrogen load to ground and surface waters is reduced as onsite sewage disposal systems are upgraded or connected to sewers.

As the Plan is implemented, the County shall re-evaluate the wastewater management plan to refine and update the plan to meet the water quality goals and objectives (e.g. 5 year evaluation, 10 year evaluation, etc.)

8.2.2.2 Sewering Objectives to Meet Wastewater Goals

Objective 2: Suffolk County shall clearly identify and prioritize tax parcels to be connected to community sewers (centralized or decentralized) to reduce the nitrogen load to ground and surface waters.

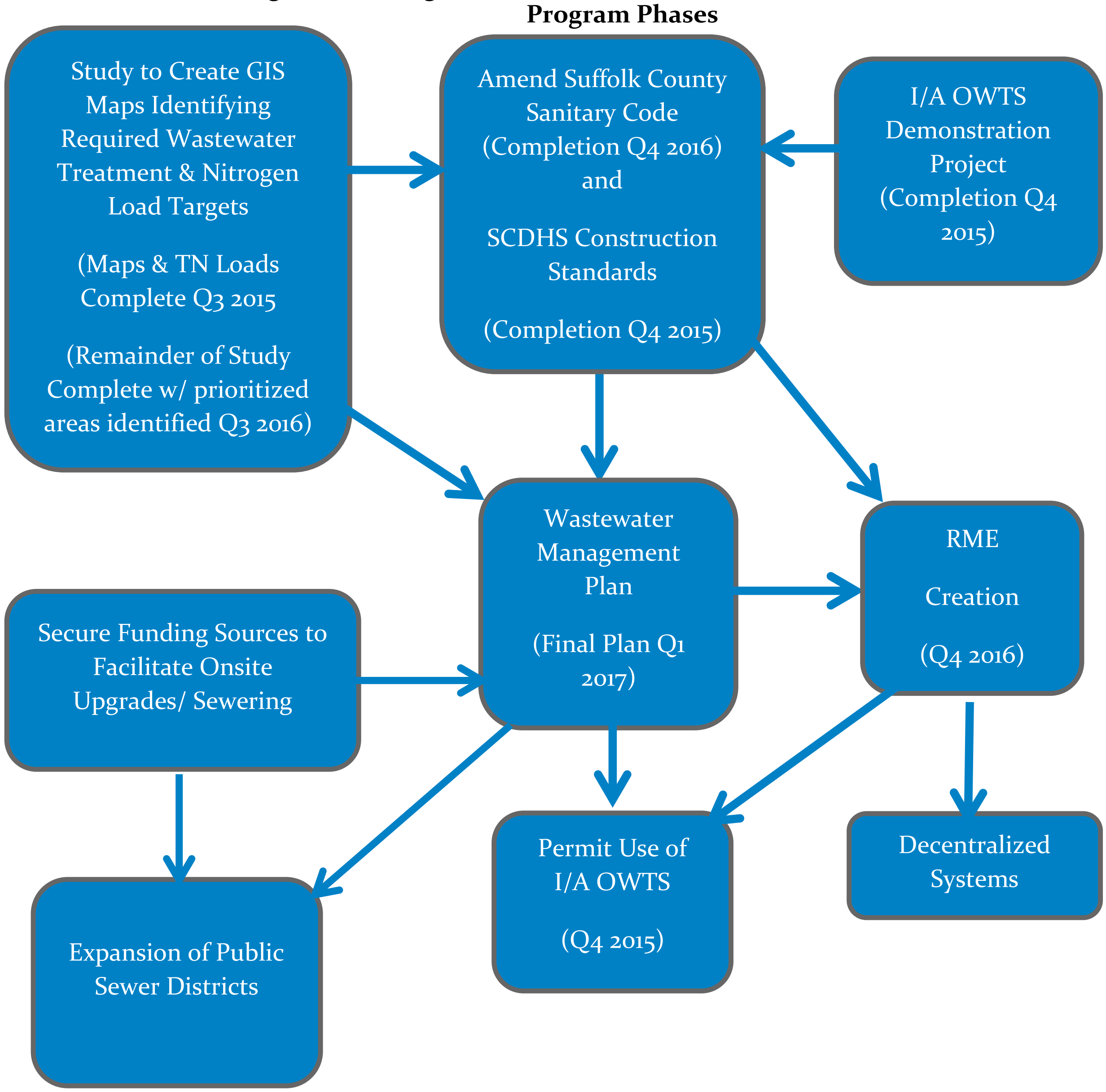
Objective 3: Suffolk County shall determine the sewage treatment plant capacity requirements to permit the connection of identified parcels to an existing, expanded, or new sewage treatment plants/districts.

Objective 4: Suffolk County shall continue to identify and implement new sewage treatment technologies to improve wastewater effluent quality to reduce impacts to ground and surface water resources and for permitting water reuse.

Objective 5: Suffolk County shall create and/or determine funding sources and costs associated with meeting sewering objectives:

i. To expand and/or create new sewer districts (e.g. sewer extensions, construction of new sewage treatment plants, expansion of existing sewage treatment plants, etc.)
ii. To improve existing sewage treatment plant technologies
iii. For staffing, permitting, enforcement, and operations and maintenance of sewer districts

Figure 8-26 Diagram of Timeline and Interconnections between Program Phases



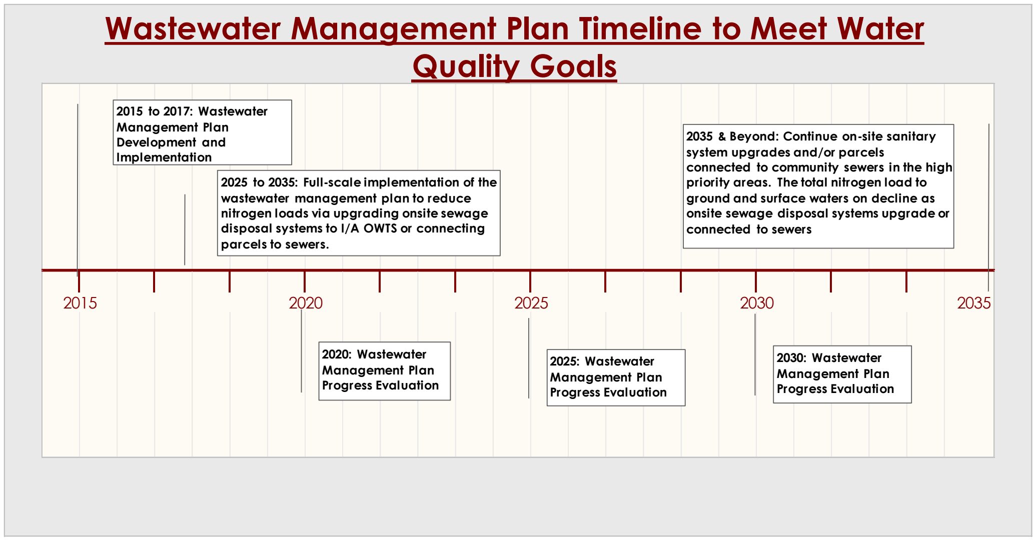


Figure 8-27 Wastewater Management Timeline

8.2.2.3 On-Site Wastewater Treatment System Objectives to Meet Wastewater Goals

Objective 6: Suffolk County shall clearly identify and prioritize tax parcels that shall be required to install an I/A OWTS to reduce the nitrogen load to ground and surface waters.

Objective 7: Suffolk County shall adopt regulations and standards to permit and/or require the use of I/A OWTS capable of reducing effluent wastewater nitrogen to 19 mg/l or less.

Objective 8: Suffolk County shall create and develop an onsite sewage disposal system technology evaluation program to simplify the approval process of various on-site sewage treatment technologies for use within Suffolk County to reduce wastewater impacts to water resources. Such systems for evaluation shall be, but not limited to, treatment systems, leaching systems, water reuse systems, etc.

Objective 9: Suffolk County shall evaluate the feasibility of adopting rules and regulations requiring the upgrading of existing onsite sewage disposal systems to conventional onsite sewage disposal systems or I/A OWTS under an established schedule based on location within Suffolk County to promote the protection of public health and marine life.

Objective 10: Suffolk County shall evaluate amending the Suffolk County Sanitary Code Article 6 to revise Groundwater Management Zone 4 density requirements to conform to Groundwater Management Zones 3, 5, and 6 to improve groundwater protection in the zone and improve surface water quality in the Peconic Estuary.

Objective 11: Suffolk County shall determine a required pump-out schedule for I/A OWTS to ensure the proper operation of the system to meet effluent nitrogen parameters. In addition, Suffolk County shall determine the required scavenger plant capacity to permit system pump-outs based on an established schedule.

Objective 12: Suffolk County shall create a Wastewater Management District with a Responsible Management Entity (RME) to oversee the financing, operation, maintenance, and enforcement of I/A OWTS and decentralized sewer system programs.

Objective 13: Suffolk County shall create and/or identify funding sources and costs to meet onsite sewage disposal system objectives:

i. To create financing/funding options for the upgrade or repair existing onsite sewage disposal systems
ii. To review and approve new onsite sewage disposal system technologies to enhance wastewater treatment
iii. For the creation and operation of a Responsible Management Entity
iv. To provide the Suffolk County Department of Health Services Office of Wastewater Management with staffing and equipment required to facilitate the wastewater management plan

8.2.3 Section Summary

With approximately 360,000 onsite sewage disposal systems located in Suffolk County the nitrogen emanating from these systems must be addressed to protect the County's valuable water resources. Nitrogen from onsite sewage disposal systems has been identified as one of the culprits degrading our water resources. The County established Suffolk County Sanitary Code Article 6 to control nitrogen discharge from onsite sanitary systems by requiring minimum lot sizes when building residential or commercial structures. The implementation of the Suffolk County Sanitary Code Article 6 has been mostly effective in cases where the minimum lot size requirements have been followed. Unfortunately there are many smaller parcels that predate the enactment of the Suffolk County Sanitary Code Article 6, which utilize onsite sewage disposal systems that negatively impact our water resources.

Suffolk County has prioritized the reduction of nitrogen from wastewater impacting ground and surface water resources. In order to tackle this problem, a set of goals and objectives have been established to guide Suffolk County in the preparation of a wastewater management plan to address excess nitrogen from onsite sewage disposal systems and the handful of secondary sewage treatment plants that remain in the County. These goals require the County to reduce wastewater effluent nitrogen from onsite sewage disposal systems and sewage treatment plants to preserve and protect our ground and surface water resources for its existing residence and future population growth. To attain these goals a set of objectives have been defined for sewering and onsite sewage disposal systems with a hypothetical timeline for development, implementation, and reversal of nitrogen trends. Some of these objectives included prioritizing areas for sewering or installation of I/A OWTS, evaluation and implementation of new technologies for sewering and onsite sewage disposal systems, development of a responsible management entity to oversee an I/A OWTS program, and revising the Suffolk County Sanitary Code Article 6 to amend the requirements for groundwater zone IV. These goals and objectives shall be the basis for formulating a responsible wastewater management plan to address nitrogen impacts (and other wastewater effluent constituents) to Suffolk County's water resources.

8.3 Recommendations

To create an effective wastewater management plan for Suffolk County based on the goals and objectives outlined in Section 8.2 four major areas must be addressed. These areas are:

- Establishment of nitrogen loads for watersheds,
- Improvement of onsite sewage disposal system technologies,
- Expansion and/or creation of new Suffolk County operated sewer districts, and
- Creation of privately-run decentralized sewer districts.

8.3.1 Establish Wastewater Nitrogen Load Targets for Sub-Watersheds and Public Water Supply Well to Maintain and Improve Water Quality

The Suffolk County Sanitary Code Article 6 was implemented for the primary purpose of groundwater protection. The intent of Article 6 was to limit groundwater nitrogen concentrations to 4 mg/l in groundwater management zones 3, 4, and 5 and 6 mg/l in the remaining groundwater management zones. This was to be accomplished by requiring minimum lot sizes in each groundwater management zone, as stated in section 8.1, when utilizing an onsite sewage disposal system. Unfortunately there are many lots that predate the enactment of Article 6, which are the major cause of the degradation of ground and surface water quality. In addition, Article 6 did not directly address maintaining surface water quality.

It is recommended that Suffolk County establish specific nitrogen load targets for each of the sub-watersheds and public water supply wells located in and around the County in addition to maintaining the minimum lot size requirements established under Article 6. The creation of these targets shall take into account the need to improve drinking water quality, improve coastal resiliency, decrease harmful algal blooms, revitalize fin and shell fisheries while supporting future population growth. These load targets shall provide the basis for the County to determine the specific level of wastewater nitrogen reduction required for maintaining and improving the water quality of ground and surface water resources. The nitrogen load reduction targets will enable the County to determine the types of wastewater treatment required to be installed to meet these targets such as connecting unsewered lots to community sewage disposal system capable of reducing nitrogen to 10 mg/l or less, installing I/A OWTS capable of reducing nitrogen to 19 mg/l, or permitting the use of conventional onsite sewage disposal systems. In conjunction with determining required wastewater treatment, Suffolk County should review the minimum lot size requirements for Groundwater Management Zone 4.

8.3.1.1 Create a GIS Based Wastewater Treatment Map Defining Wastewater Treatment Options for Suffolk County Based On Established Nitrogen Load Targets

After the nitrogen load targets have been established for each of the sub-watersheds and public water supply wells, boundaries of each area should be created defining the acceptable means of wastewater treatment to meet the established nitrogen load targets, considering effluent nitrogen requirements, distance to existing sewer districts, depth to groundwater, soil conditions, distance to surface waters, SLOSH zones, and FEMA flood zones. As an example, the methods of wastewater treatment could be grouped into six categories based on required effluent nitrogen limits according to **Table 8-18**. Categories A1, B1, and C are minimum wastewater requirements to meet effluent nitrogen target loads. Categories A2, A3, and B2 are increased treatment requirements due to high groundwater conditions, location within SLOSH or FEMA flood zones, distance to sewers, etc.

A GIS map should be created depicting each area with recommended category rating to enable property owners and Suffolk County to ensure the proper type of wastewater treatment is proposed and installed for existing or new construction to reach the desired nitrogen target loads to meet water quality goals.

Table 8-18 Example of Wastewater Treatment Categories Based on Future Study to Establish Nitrogen Load Targets

Category	Minimum Effluent Nitrogen Requirement	Minimum Wastewater Treatment Option
A1	Wastewater Nitrogen Effluent > 30mg/l	Conventional Onsite Sewage Disposal System
A2		Innovative/Alternative Onsite Sewage Disposal System
A3		Community Sewage Treatment (Centralized or Decentralized)
B1	Wastewater Nitrogen Effluent <30mg/l & >10mg/l	Innovative/Alternative Onsite Sewage Disposal System
B2		Community Sewage Treatment (Centralized or Decentralized)
C	Wastewater Nitrogen Effluent <10mg/l	Community Sewage Treatment (Centralized or Decentralized)

8.3.2 Implement an On-Site Sanitary System Upgrade Program and Sewage Treatment Plant Upgrade Program

There are approximately 360,000 onsite sewage disposal systems located within Suffolk County, which contribute approximately 69% of nitrogen load to ground and surface waters in the County. It has been estimated that over 250,000 residential onsite sewage disposal systems pre-date the requirements for septic tanks and precast leaching pools, which means there are many existing onsite sewage disposal systems within Suffolk County consisting of a cesspool, which provides the bare minimum wastewater treatment. In addition, block cesspools are prone to collapse under certain conditions such as during periods of heavy rain. For example, during a period of heavy rain, soils around a cesspool swell and may place unwanted pressure on the walls of a cesspool, if the cesspool is empty and constructed of block or precast cesspool without steel reinforcement then the pressure can cause the cesspool to collapse as shown on **Figure 8-28**.

Figure 8-28 Picture of a Collapsed Cesspool

Another issue with onsite sewage disposal systems installed prior to the enactment of standards requiring precast reinforced septic tanks and leaching pools is that early residential construction standards (prior to 1972) permitted cesspools to be placed a minimum of 1 foot above ground water elevation. Since the implementation of these standards groundwater elevations in Suffolk County have risen and are predicted to rise approximately 3 feet by the end of the century, therefore placing cesspool originally installed 1 foot above the groundwater table in groundwater. This creates a direct flow path of contaminants such as pathogens into groundwater impacting drinking water and surface water resources.

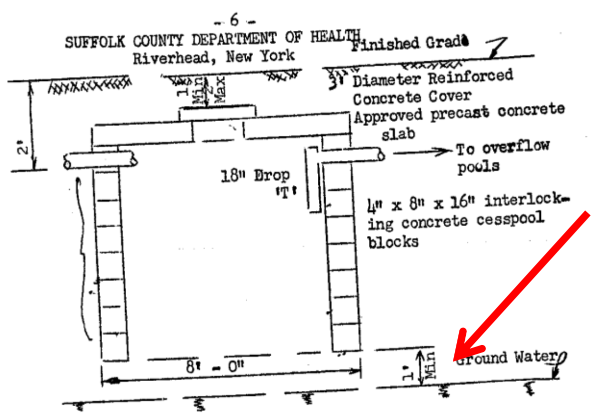


Figure 8-29 SCDHS Leaching Pool Detail with Requirement to Maintain 1 ft above Groundwater Prior to 1972

One final issue with cesspools and conventional onsite sewage disposal systems is that they provide minimal wastewater nitrogen reduction. These types of systems are major contributors to the nitrogen load impacting our water resources in areas where they are utilized on small lots that pre-date the enactment of the Suffolk County Sanitary Code Article 6.

To protect and improve our water resources, it is recommended that Suffolk County assess the feasibility of adopting an onsite sewage disposal upgrade program to expedite the upgrading of existing onsite sewage disposal systems to protect public health from injury due to a collapsed cesspool, to improve public health, and to improve and protect our water resources. A number of jurisdictions throughout the United States have implemented these types of programs. A team from Suffolk County visited leaders from the Maryland Department of Environment, New Jersey Pinelands Commission, University of Rhode Island New England Onsite Wastewater Training Program, and Barnstable County Department of Health Massachusetts Alternative Septic Systems Test Center. Each of these areas have onsite sanitary system upgrade programs, which are outlined in the "Advanced Wastewater & Transfer of Development Rights Tour Summary" report issued by the Suffolk County Departments of Economic Development & Planning, Health Services, and Public Works included in Appendix G.

One type of upgrade requirement, which is already in place in Suffolk County, is the requirement to upgrade a sanitary system when additions to dwellings are proposed. Based on the previous five years of applications, if Suffolk County were to solely depend on this requirement to upgrade sanitary systems there would be only approximately 242 sanitary upgrades to I/A OWTS per year based on addition applications processed by the SCDHS (See **Table 8-19**). This would reduce total nitrogen in Priority Areas by 12.1 lbs./per day assuming 300 gpd/property based on SCDHS standards and 39 mg/l effluent from a conventional system compared to 19mg/l total nitrogen effluent from an I/A OWTS.

The most common upgrade program instituted in the jurisdictions visited were upgrades of onsite sewage disposal systems at the time of property transfer. New Jersey requires sanitary systems with cesspools to be upgraded at the time of property transfers to a conventional septic system. An area not visited, Macomb County, Michigan requires an evaluation report to be submitted to the Health Department prior to property transfer. If the Department determines the system is failing then the property owner must submit a remedial action plan to bring the system into compliance.[13] Bringing a system into compliance could be a minor repair, complete replacement of the system to conforming system, or connection of the property to public sewers.

Table 8-19 Predicted SCDHS I/A OWTS Applications for Additions to Existing Dwellings

<table>
<tr><th colspan="7">Estimated SCDHS Sanitary Upgrade Applications Due to Addition to a Dwelling</th></tr>
<tr><td>Year</td><td>2009</td><td>2010</td><td>2011</td><td>2012</td><td>2013</td><td rowspan="5">Notes:
Estimated % Priority Systems [209000/360000]- = 0.58 or 58%

Estimated % of Applications that are not constructed =0.55 or 85%</td></tr>
<tr><td>Number of Upgrade Applications Submitted to SCDHS</td><td>496</td><td>522</td><td>500</td><td>456</td><td>484</td></tr>
<tr><td>Yearly Average</td><td>491</td><td colspan="4" rowspan="2"></td></tr>
<tr><td>Adjusted Average For I/A OWTS Upgrades in priority Areas</td><td>242</td></tr>
<tr><td colspan="6">(491 average addition applications per year) x .85 x .58 = 242 (See Notes)</td></tr>
</table>

A second common onsite sewage disposal system upgrade program is the requirement to upgrade an onsite sewage disposal at the time of failure. Another jurisdiction not visited is Oneida County, Wisconsin, which requires inspection of onsite sewage disposal systems every three years. Per their "Oneida County Private Onsite Wastewater Treatment Systems Ordinance" they define minor repairs, which do not have to be approved by the department, and major repairs, which have to be reviewed by the department. Major repairs can range from connecting a property to sewers, replacing a leaching field, or complete upgrade of a system. [14]

A third type of program is a cesspool phase out program mandating that sites utilizing existing cesspools be upgraded. Rhode Island enacted a Cesspool Phase-Out Act in 2007 requiring all existing parcels utilizing cesspools to be upgraded with a new onsite wastewater treatment system or connected to a sewer system by 2014. Cesspools located within the Special Area identified by Rhode Island's Coastal Resources Management Council were required to be upgraded to nitrogen reducing system.

Suffolk County should investigate the feasibility of implementing our own onsite sewage disposal system upgrade program to expedite the upgrading of systems to protect and improve ground and surface water resources. Upgrade programs should be a combination of the programs above. This will enable properties not located in an identified priority area to be upgraded from cesspools to conventional onsite sewage disposal systems to meeting current standards, and accelerate the upgrading of properties located in priority areas to be upgraded to an I/A OWTS or connected to sewers. For example, **Table 8-20** estimates the number of upgrades of existing sanitary systems in priority areas to I/A OWTS at the time of Property Transfer. Based on the figure, there could be approximately 2,573 I/A OWTS installed at the time of property transfers per year reducing the total nitrogen load in priority areas by 129 lbs./per day assuming 300 gpd/property based on SCDHS standards and 39 mg/l effluent from a conventional system compared to 19mg/l total nitrogen effluent from an I/A OWTS.

Table 8-20 Predicted SCDHS I/A OWTS Applications for Existing Dwellings at the Time of Property Transfer

Example of Number of Onsite Sewage Disposal System in Suffolk County That May Be Required to be Upgraded Per Year in Priority Areas at Property Transfer				
SC Home Sales (non-Condo)	**2011**	**2012**	**2013**	**Notes:** Estimated % Priority Systems [209000/360000]- = 0.58 or 58% Estimated % Sub-Standard Systems (from Fig. x) [252530/360000] =0.70 or 70% Estimated % Unsewered = 74% SCDHS Final 3 Year Avg. (1397 + 1200 + 1328)/3 = 1308 (Includes Condo's and therefore 1308 is an overestimate)
	9,460	10,735	9431	
Average Home Sales for 3 Year period	9875			
Average SCDHS Residential Construction Permits Issued Final During the same 3-year period	1308			
Number of Homes In Priority Areas Requiring Sanitary System Upgrade At the Time of Transfer Per Year		2573 (See Below)		
Assumes 74% parcels unsewered, 58% systems priority systems, 70% systems are sub-standard – See Notes				
[9875-1308] x .74 x .58 x .70 = 2537 upgrades per year				
Housing data from www.tax.ny.gov				

If upgrades of sanitary systems at the time of an addition of bedrooms and property transfer were both used to upgrade onsite sewage disposal systems to I/A OWTS then approximately 2,815 systems would be upgraded. This would result in a total reduction of nitrogen loading of 140.8 lbs./per day assuming 300 gpd/property based on SCDHS standards and 39 mg/l effluent from a conventional system compared to 19mg/l total nitrogen effluent from an I/A OWTS.

8.3.3 Onsite Wastewater Treatment System Technologies

There are many existing onsite sewage disposal system technologies that have been modified over the years and new onsite sewage disposal system technologies that have been brought to market to improve wastewater treatment. These types of systems will enable Suffolk County to combat against wastewater nitrogen pollution, treat for emerging contaminants of concern in wastewater, and protect against sea and ground water level rise. These systems include advanced treatment units and leaching systems. Historically the main components of an onsite septic system were the septic tank and leaching field. Septic tanks are designed to reduce suspended solids and provide a small degree of BOD reduction. Leaching systems provide the means for septic tank effluent to be disposed into the ground. Newer types of treatment systems have been designed to increase the reduction of BOD and nitrogen. These types of systems are considered advanced treatment units. Advanced treatment units combined with septic tanks (if required) and leaching systems are considered to be innovative/alternative onsite sewage disposal systems. It should be noted that some types of leaching fields are under investigation for nitrogen removal capabilities, which will be discussed in section 8.3.3.2. It is recommended that Suffolk County develop an active program as part of their wastewater management program to begin requiring I/A OWTS in identified priority areas.

8.3.3.1 Develop an Innovative/Alternative Onsite Wastewater Treatment System Program

As part of the wastewater management plan Suffolk County should implement an I/A OWTS program to promote the use of nitrogen removing sewage disposal systems to serve single-family, multi-family, and commercial buildings where community sewers are not available in identified priority areas or for property owners wishing to install them in non-priority areas. These types of systems usually are mechanical systems containing pumps and/or blowers to assist in the treatment of wastewater to reduce suspended solids, BOD, and nitrogen. Evidence indicates that some advanced treatment systems also reduce and/or remove some contaminants of emerging concern.

Maintenance of I/AWTS is essential in ensuring their continued ability to reduce nitrogen.

Suffolk County should take the following action steps to develop an I/A OWTS program:

1. Develop a pilot program to evaluate I/A OWTS systems on an experimental basis in Suffolk County to gather information on effluent quality, installation, and operation, and maintenance requirements before full scale implementation of these types of systems are permitted. Many jurisdictions that permit the installation of I/A OWTS such as Maryland and Rhode Island have piloting programs in place.

   The Maryland Department of Environment (MDE) established the Best Available Technology (BAT) Verification Program to review proposed I/A OWTS. An application is submitted to Maryland Department of Environment. The BAT Review Committee, comprised of the Bay Restoration Fund (BRF) chair, the division chief of MDE and county represented, evaluates 3rd party evaluation/certification's test methods, independent performance evaluations and test results to verify the vendors' claim. If the Committee accepts the claims then provisional technologies enter a Field Verification Process. Twelve systems plus three reserve systems may be installed during the field verification process and must be sampled four times each year with a minimum of 1 winter sample. The average total nitrogen concentration in the effluent must be below 30 mg/l. After passing the Field Verification Process a final report with sample results is submitted to the BAT review committee for evaluation. If the committee accepts the report then the system is classified as "Best Available Technology, Field Verified".[15]

   Rhode Island implemented the Rhode Island Onsite Wastewater Demo Projects, 1996 to 2005, conducted by the New England Onsite Wastewater Treatment Center (NEOWT). The knowledge gained from the project was transferred to the Department of Environmental Management (DEM), which helped with policy/rule revisions. The demonstration project was a series of five demonstration projects in seven communities. They installed 58 demonstration systems on sites with failed septic systems. Sites were selected using a lottery for homeowners that had failed septic systems. The program provided reduced costs or no costs to owners for a 3-year access period, to allow staff to install, test, and maintain systems. Labor was provided gratis as means of developing expertise in the installation of new technologies. Today alternative treatment systems are approved for use by the RI DEM. New alternative treatment systems can be approved by the RI DEM as nitrogen reducing systems per the DEM Onsite wastewater treatment (OWTS) rules governing pilot systems.[15]

Suffolk County is in the process of conducting an I/A OWTS demonstration project for single-family dwellings. Suffolk County initiated the demonstration program by issuing a Request for Expressed Interest (RFEI) in April, 2014. The demonstration permits the installation of two types of I/A OWTS. The first type of system are those certified by the USEPA Environmental Technology Verification Program ("ETV") or the National Sanitation Foundation/American National Standards Institute (NSF/ANSI) Standard 245 testing program ("NSF 245") to be demonstrated on a limited number of private residential properties. The second type of system includes systems not yet certified by ETV/NSF 245 for testing on County municipal property which will require the authorization of the County Legislature.

The demonstration program is intended to provide field-testing and technology verification to determine if a particular alternative technology can function effectively in Suffolk County. A technology may only be approved when the SCDHS has determined, based on relevant technical data, that the proposed alternative is capable of a level of environmental protection at least equivalent to that of a system designed in accordance with the Suffolk County Sanitary Code Article 6, and other applicable state or local provisions.

Suffolk County accepted four manufacturers to participate in the demonstration program. These manufacturers and systems are provided in **Table 8-5.** The manufacturers have committed to installing a total of 19 demonstration systems on residential properties located throughout Suffolk County through a lottery setup by the County. Suffolk County selected the nineteen properties in 2014 and expects installation of the demonstration systems by the spring of 2015. The treatment systems to be installed are the Norweco Singulair TNT (**Figure 8-33**), Norweco Hydro-Kinetic 600 FEU (**Figure 8-34**), Busse MF 400 (**Figure 8-35**), Orenco Systems AdvanTex AX20 (**Figure 8-36**), Orenco Systems AdvanTex AX-RT (**Figure 8-37**), and Hydro Action

(**Figure 8-38**). Each of these treatments systems has submitted data to Suffolk County with their applications indicating they can achieve target effluent total nitrogen of 19 mg/l or less.

Suffolk County has developed an anticipated timeline of the approval process of I/A OWTS as depicted in **Figure 8-30**. The figure depicts two timelines: Standard approval model and RFEI accelerated approval model. The manufacturers who participate in the demonstration project with NSF 245 or ETV certifications are permitted to fast track the standard approval model, provided results of their sampling during the demonstration meet total nitrogen effluent requirements and other factors are deemed satisfactory. The County should continue to provide demonstration opportunities to manufacturers in order to provide more treatment options to property owners.

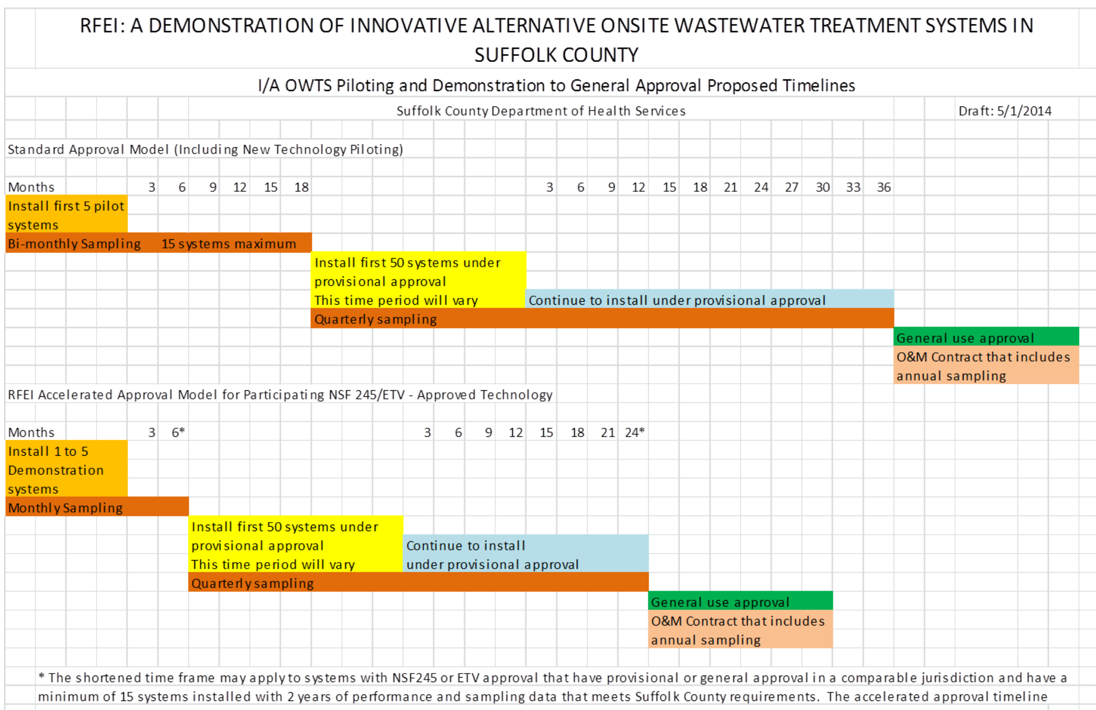


Figure 8-30 Example of I/A OWTS Approval Timeline

The USEPA has recently started to promote the creation of a means of sharing I/A OWTS data between jurisdictions. Some of the Chesapeake Bay states are in the process of implementing their own data sharing program for I/A OWTS. This will allow jurisdictions to use data from other states to prove the effectiveness of a system. For example, if

Suffolk County implemented the standard approval model depicted in **Figure 8-29**, during the pilot phase a manufacturer would be required to install five systems and sample them for 18 months within Suffolk County before moving to provisional approval. If Suffolk County joined a cooperative program with other jurisdictions such as the Chesapeake Bay States program, then instead of a manufacturer installing five pilot systems the County could review the systems installed in the Chesapeake Bay States and evaluate the data of the systems. If the data is found to be acceptable then the system could move directly to the provisional approval stage without a manufacturer installing a single system within Suffolk County.

2. Creation of a Responsible Management Entity (RME) to oversee an I/A OWTS program. The SCDHS maintains the authority over the location and means of sewage disposal systems and water supplies. According to the EPA "**Voluntary National Guidelines for Management of Onsite and Clustered (Decentralized) Wastewater Treatment Systems**", March 2003, a responsible management entity is a legal entity responsible for providing various management services with the requisite managerial, financial, and technical capacity to ensure the long-term, cost effective management of decentralized onsite and/or cluster wastewater treatment facilities in accordance with applicable regulations and performance requirements. RMEs can be operated by private companies, public utility companies, or Government agencies.

   In the EPA's guide overview of five management models are presented. EPA Management Model 4 is the RME operation and maintenance model which resembles the kind of RME required in Suffolk County. Model 4 is acceptable where there are large numbers of onsite sewage disposal systems and decentralized systems that must meet water quality requirements to protect the environment and the systems are maintained in private ownership. In Suffolk County there are approximately 360,000 onsite sewage disposal systems and over 150 decentralized STPs that are privately owned. SCDHS already monitors the operation and maintenance of the privately owned sewage treatment plants located within the County. With the proposal to upgrade many of the existing onsite sewage disposal systems located within high priority areas to I/A OWTS to meet water quality goals a RME is required to ensure that the systems are maintained and function properly to produce effluent with reduced nitrogen.

The RME's responsibilities in Suffolk County would be to provide financing options for property owners to permit them to install or repair an I/A OWTS or decentralized STP's in an affordable manner, oversee the operation and maintenance of I/A OWTS and STP's, participate in the technology piloting process for I/A OWTS, and enforcement.

During Suffolk County's Septic Tour, the team gathered information about each jurisdiction's funding sources to provide grants and/or low interest loans to property owners to upgrade existing onsite sewage disposal systems. Suffolk County would also need to provide funding opportunities to property owners to upgrade their onsite sewage disposal systems; this would be managed by the established RME. The jurisdictions had robust involvement, commitment, and investment from state agencies to fund the installation of I/A OWTS. Rhode Island, with the most number of systems installed, provides low interest loans to homeowners to upgrade their septic systems to I/A OWTS through the use of a portion of their "big pipe" Federal Clean Water Act Revolving Fund to the State, that were then loaned to local government agencies at low to zero interest rates. The local government would then issue a loan to homeowners with an interest rate of 2% [RI] to 5% [MA] at a 10 or 20 year term. The Maryland Department of Environment provides grant funding to pay for I/A OWTS only (excludes the cost of leaching field and septic tank) through a State bill creating the Bay Restoration Fund (BRF). The BRF is funded through a fee assessed to the property and added as a property tax or part of a separate bill depending on municipality. The State of Massachusetts offers a tax credit for repair or replacement of failed cesspools or septic systems for 40% of the cost up to $6000, spread over 4 years at $1500 per year. **Table 8-21** summarizes the financing opportunities for property owners in each jurisdiction.[15]

Table 8-21 Summary of I/A OWTS Available Funding for Installation

Region	Loan	Grant	Tax Incentive
Maryland	--	Bay Restoration Fund Provides grants for total cost of treatment unit. Funded by $60/year fee assessed to onsite septic system owners	--
NJ Pinelands	NJ Environmental Infrastructure Financing Program can provide funding to replace failing systems. The local governing body or utilities authority must form a septic management district to receive financing.	---	---
Rhode Island	RI Clean Water Finance Agency issues loan to local community (w/ plan) at 0% which issues to the borrower @ 2% for 10 years with at a max of $25,000	---	---
Barnstable County, MA	Barnstable Community Loan Program 5% for 20 years. 0% loan for composting unit	---	tax credit for 40% for repair or replacement of failed cesspools or septic systems up to $6000, spread over 4 years @ $1500/year

In addition, the established RME must have the capabilities to track operations and maintenance of I/A OWTS installed within the County. For example, Barnstable County, MA deployed a tracking database designed by Carmody Data Systems. All maintenance and sample results must be entered into the tracking system. The system identifies failure rates and pumping rates to determine if a system is failing. Alerted to operation and maintenance contract expiration, the County calls the owner and sends a letter notifying the homeowner. Upon a 2nd alert, a certified letter is issued and the homeowner may be called into a hearing. Local Boards of Health can fine (approximately $250) homeowners if operation and maintenance contract is not maintained. The Carmody System also provides the ability to generate graphs depicting the sample data for public view.

Figure 8-31 depicts a sample graph of nitrogen data for 449 BioMicrobics FAST systems installed in Barnstable County. BioMicrobics FAST is a type of I/A OWTS. It should be noted that some of the data falls outside the average effluent nitrogen ranges required, which may be due to system downtime due to maintenance or fluctuations in water usage, nitrogen and BOD loading, and temperature.[15]

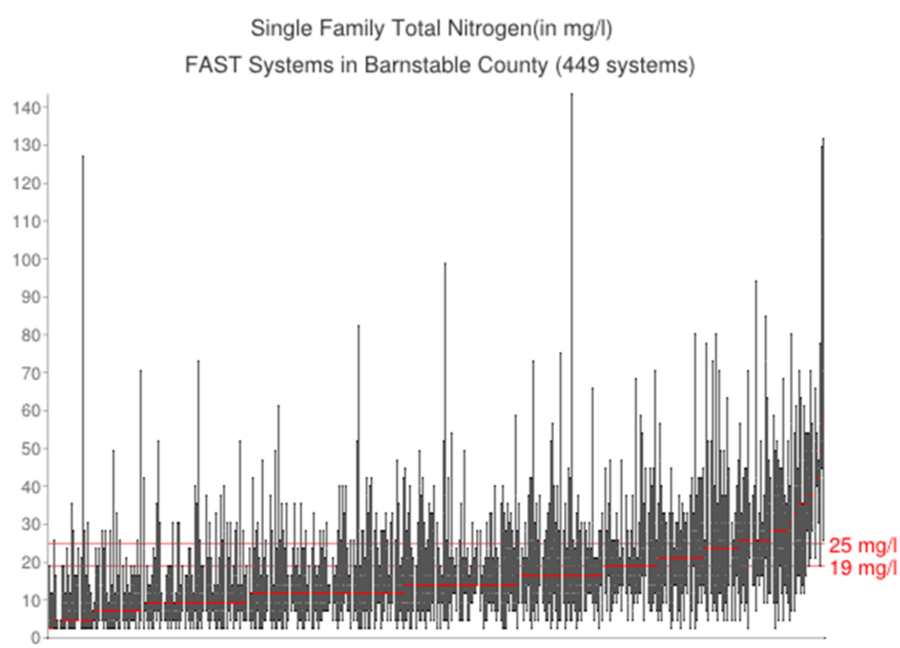


Figure 8-31 Barnstable County BioMicrobics FAST Total Nitrogen Effluent Data Graph

3. In order to implement an I/A OWTS and an onsite sewage disposal systems upgrade program some existing codes and standards must be amended. SCDHS enforces Suffolk County Sanitary Code Article 6 which defines the means and methods for wastewater treatment requirements in Suffolk County with respect to new construction (including additions to existing buildings or changes of use of existing buildings), but does not provide the authority to Suffolk County to enforce upgrading of existing onsite sewage disposal systems to a conventional onsite sewage disposal system or innovative/alternative onsite sewage disposal system when no new construction is proposed. In addition, SCDHS has developed and implemented the "Standards Approval of Plans and Construction – Sewage Disposal Systems for Single-Family Residences" (Residential Standards) issued November 13, 1995 and "Standards for Approval of Plans and Construction for Sewage Disposal Systems for Other Than Single-Family Residences" (Commercial Standards), issued July 15, 2008 which do not require property owners to make an application to the SCDHS to upgrade or repair their onsite sewage disposal system and do not permit the use of I/A OWTS.

   There are many codes/standards/regulations already on the books pertaining to I/A OWTS, which SCDHS could use as models such as Massachusetts Tile 5 Septic System Regulations, which outlines the requirements for I/A OWTS to be permitted to be installed in the States. The Macomb County, Michigan "Regulations Governing On-Site Sewage Disposal and On-site Water Supply System Evaluation and Maintenance" is another example that defines requirements for system evaluations at the time of transfer, maintaining operations and maintenance contracts, and when failed systems are required to be upgraded.

   Suffolk County should add a new article to the Suffolk County Sanitary Code and update existing articles of the Suffolk County Sanitary Code to address the following:

   i. Define when a property owner will be required to have their existing onsite sanitary system inspected by a licensed inspector and report submitted to SCDHS for review with included exemptions (e.g. property transfer, failure, etc.);

ii. Define the license requirements for individuals permitted to inspect onsite sewage disposal systems and submit an inspection report to SCDHS or RME for review;

iii. Define when an existing onsite sanitary system must be upgraded or repaired;

iv. Define a minor versus major repair (major repairs would require an application to the SCDHS;

v. Define the type of onsite sanitary system upgrade required (connection to sewers, new conventional system, new I/A OWTS, repair of existing system);

vi. Define operation and maintenance requirements for I/A OWTS (O&M Contracts, Sampling, RME, I/A OWTS operating permit, etc.);

vii. Address enforcement by SCDHS or RME; and

viii. Requirement for SCDHS to maintain a database of existing onsite sewage disposal systems.

The SCDHS Residential and Commercial should be revised to address:

i. Inspection requirements and upgrade requirements of onsite sewage disposal systems and

ii. Provide I/A OWTS construction standards;

Legislation may be required to implement the recommended changes to the Sanitary Code.

8.3.3.2.1 Innovative/Alternative Onsite Wastewater Treatment Systems Capable of Reducing Total Effluent Nitrogen

Innovative/alternative onsite wastewater treatment systems (I/A OWTS) are considered treatment systems that have the ability to reduce effluent total nitrogen. Multiple technologies that have been used for large-scale wastewater treatment systems to reduce nitrogen have been scaled to serve as treatment units for individual residential lots. These types of processes consist of sequencing batch reactors, extended aeration, membrane bioreactors, and recirculating filters, among others. Many of these treatment systems provide some degree of wastewater nitrogen removal. A few of these technologies, such as membrane bioreactors, have also shown some ability to remove personal care products and pharmaceuticals. **Table 8-22** lists a number of I/A OWTS products capable of reducing wastewater nitrogen.

Innovative/alternative onsite wastewater treatment systems can be broken into non-proprietary and proprietary I/A OWTS. Non-proprietary I/A OWTS are systems that are not mass produced by a company who has exclusive rights to the system. Two non-proprietary I/A OWTS are recirculating sand filters

(RSF) and recirculating constructed wetlands systems (also known as recirculating gravel filter). When properly designed these systems have the capability of reducing effluent total nitrogen to levels less than a conventional onsite sewage disposal system. **Figure 8-31** depicts an example of a RSF. Flow from the house enters the septic tank where solids settle then the septic tank effluent is discharged by gravity to a pump chamber. Per **Figure 8-32**, the pump chamber has two functions. The first function is to transport septic tank effluent to the sand filter. The second function is to act as an anoxic tank were denitrification occurs with the assistance of facultative bacteria and septic tank effluent as a carbon food source (See section 8.3.5 overview of the nitrogen reduction process). The flow from the pump chamber is discharge to the top of the sand filter were aeration occurs and bacteria help in the nitrification process. When the flow reaches the bottom of the sand filter, a portion of the flow is discharged to the leaching structures and a portion is returned to the pump chamber.

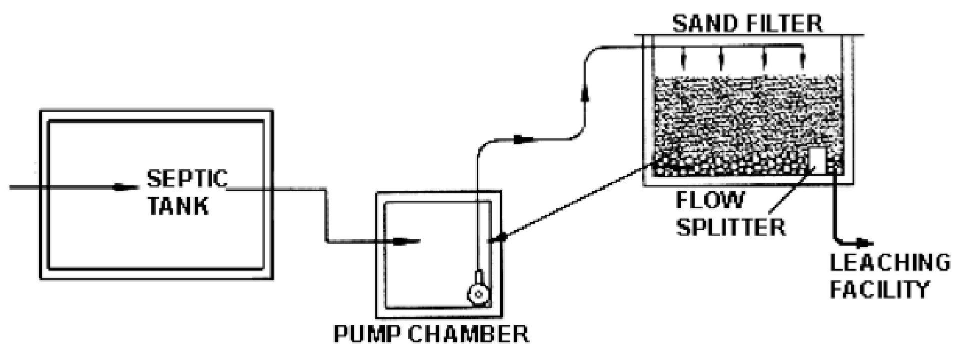


Figure 8-32 Example Recirculating Sand Filters (RSF)

Recirculating constructed wetlands are another type of non-proprietary I/A OWTS. They can either be horizontal flow where the flow moves horizontally across the system or vertically where the flow moves from the planted layer down. **Figure 8-33** is an example of a recirculating vertical flow constructed wetlands system. Flow from the septic tank enters the bottom portion of the wetlands system which is an anoxic environment. Flow travels across the gravel section to a pump pit. From the pump pit flow is either discharged or recirculated to the top section of the wetlands and dispersed so it flows down towards the gravel section. The top section of the wetlands is where aeration and some evapotranspiration occur.

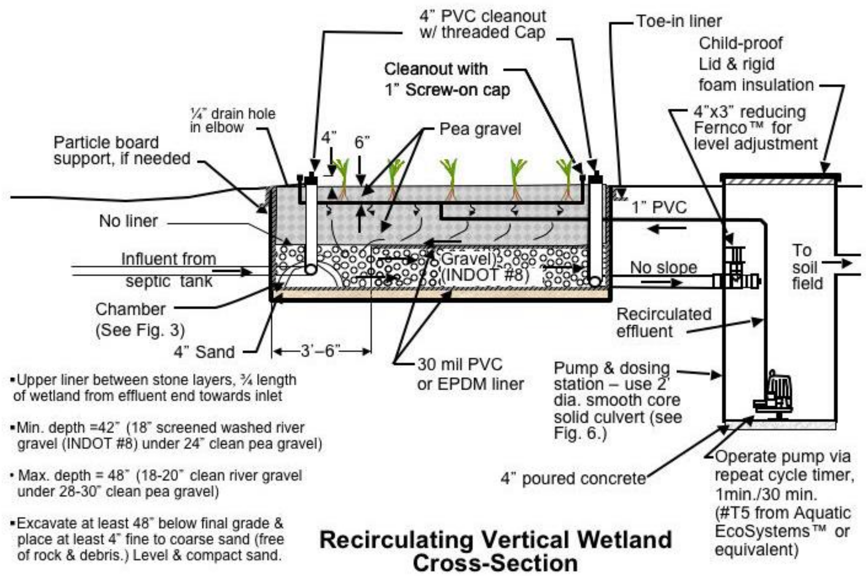


Figure 8-33 Recirculating Constructed Wetlands Systems (AKA recirculating gravel filter)

There are many proprietary I/A OWTS that are capable of reducing total nitrogen as listed in **Table 8-22**. These systems are extended aeration, SBR, MBR, and fixed film processes.

Below are some brief descriptions of the systems selected for the Suffolk County demonstration project. It is essential for the County to continue reviewing other onsite treatment options, besides the demonstration systems, to determine which systems would meet operation, maintenance, and effluent nitrogen requirements to provide I/A OWTS selection flexibility to property owners.

(1) *Norweco Singulair TNT (***Figure 8-34***)*
Based on the Norweco website the Singulair TNT reduces total effluent nitrogen by 68 percent. Treatment in the Singulair TNT is accomplished by an extended aeration process. The system consists of one precast treatment tank containing a pretreatment chamber, aeration chamber, and clarifier chamber. Flow enters the pretreatment chamber which acts as an equalization tank. Flow is transferred from the pretreatment chamber to the aeration section via a transfer tee. Aeration in the aeration chamber is supplied by a mechanical aerator. Flow from the aeration chamber flows under a baffle wall into the clarifier chamber. Solids from the clarifier chamber are returned to the aeration chamber via the company's

Bio-Static Sludge Return system. Effluent flow from the clarifier is discharged to leaching pools via the Bio-Kinetic System.[18]

Table 8-22 Types of Nitrogen Reducing Systems (IFAS – Integrated Fixed Film Activated Sludge Process, SBR – Sequence Batch Reactor, MBR – Membrane Bioreactor)

Nitrogen Reducing Innovative/Alternative Onsite Wastewater Systems		
Amphidrome	F.R. Mahony & Assoc	Fixed Film SBR
Bioclere	Aqua Point Inc	Modified trickling filter
Cromaglass	Cromaglass Corp	SBR
Fast	Bio-Microbics, Inc	IFAS
MicroFAST	Bio-Microbics, Inc	IFAS
Bio Barrier	Bio-Microbics, Inc	MBR
Busse GT	Busse Green Tech.	MBR
Hoot ANR	Hoot Systems, LLC	Extended Air
SeptiTech	SeptiTech, LLC	IFAS
Singulair TNT	Norweco	Extended Air
Singulair Green	Norweco	Extended Air
AdvanTex AX20	Orenco	Packed bed textile-recirculating filter
AdvanTex AX100	Orenco	Packed bed textile-recirculating filter
Advantex AX-RT	Orenco	Packed bed textile-recirculating filter
RUCK	Innovated RUCK	
Waterloo Biofilter	Waterloo biofilter	Attached growth Trickling Filter
Recirculating Sand Filters		Recirculating Sand filter
Nitrex	Lombardo Associates	Trickling Filter

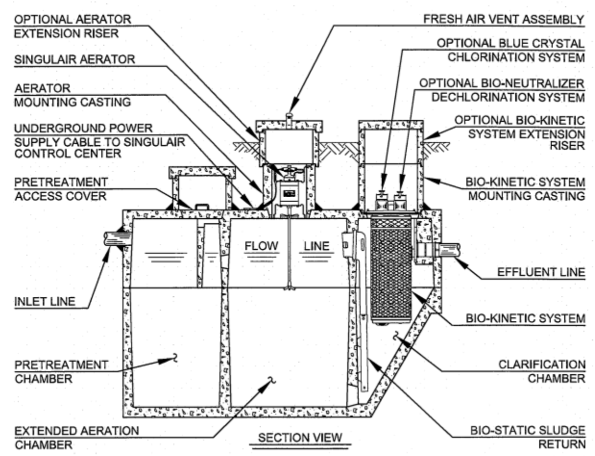


Figure 8-34 Norweco Singulair TNT

(2) *Norweco Hydro-Kinetic 600 FEU* (**Figure 8-35**)

According to Norweco's website the Hydro-Kinetic system achieved results of 7.9 mg/l total nitrogen during their NSF 245 tests. The Hydro-Kinetic system uses an extended aeration and attached growth process to treat wastewater. The treatment occurs within two pre-cast concrete tanks. The first tank contains the pretreatment chamber, anoxic chamber, aeration chamber, and clarification chamber. The second tank contains the influent chamber and hydro-kinetic FEU filter. Flow enters the pretreatment chamber where some solids settle. Flow from the pretreatment overflows into the anoxic tank through a drop tee. Denitrification will occur in the anoxic chamber. The flow from the anoxic chamber enters the aeration chamber for denitrification and BOD reduction. After the aeration chamber flow enters the clarifier chamber through the inlet zone, which reduces turbulence in the clarifier. A portion of the flow is recirculated to the anoxic chamber and a portion is moved forward towards the influent chamber. Flow than travels from the influent chamber to the Hydro-Kinetic filter for further reduction in organic matter before discharging to the leaching field. The system can also be fitted with a UV unit for additional treatment.[19]

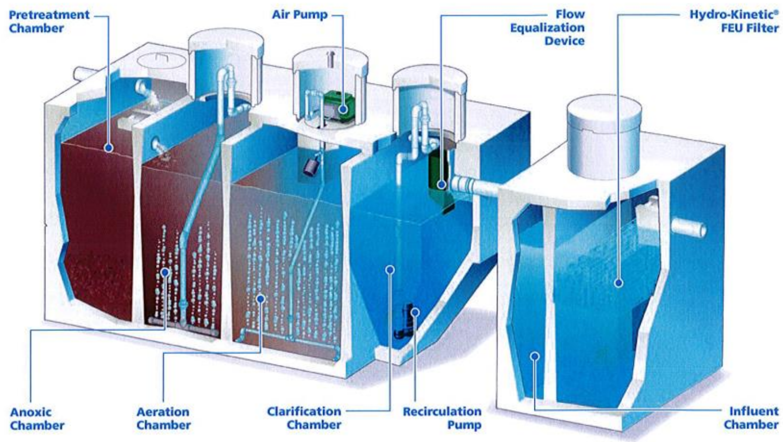


Figure 8-35 Norweco's Hydro-Kinetic System

(3) *Busse Green Technologies, Inc. BUSSE MF 400* **(Figure 8-36)**
The BUSSE MF is membrane bioreactor, which uses Kubota flat sheet membranes. The unit can be installed in a basement or above grade after an existing septic tank in a storage shed or garage. As an example, the BUSSEMF-440, which can be installed in a basement prior to an existing sanitary system, utilizes two balance tanks and two MBR tanks. Flow is transferred between balance tanks and to the MBR tanks via airlifts. Balance tank 1 is the primary sedimentation tank to remove settleable and floating coarse matter. Flow is transfered from Balance tank 1 to Balance tank 2 via an airlift. Balance tank 2 is used to store surplus activated sludge. Flow is transferred to the two MBR tanks from Balance tank 2 via an airlift. From the MBR tanks flow is discharged to the leaching field.[20]

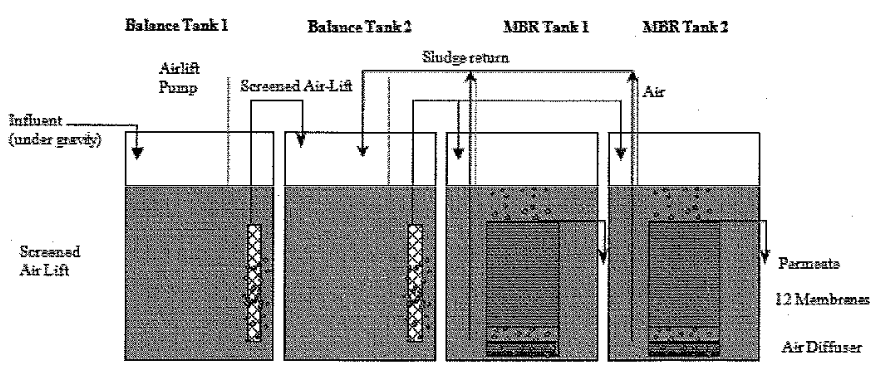


Figure 8-36 Busse Green Technologies, Inc. BUSSE MF 400

(4) *Orenco Systems AdvanTex AX20* (**Figure 8-37**)
Orenco systems has a document located on their website with the heading `"AdvantTex Performance Summary #2 Nutrient Reduction: TN, NH3, TP, Rev 1.4, 3/12" which indicates the AX20 and AX-RT units can produce effluent total nitrogen of less than 19 mg/l. Both units can be fitted with a UV unit for additional treatment. The AdvanTex AX20 is a packed bed textile-recirculating filter. The AX-20 works in conjunction with a septic tank. The septic tank can be modified to become a processing tank with the addition of the Biotube pumping package and additional piping. Flow enters the processing tank where scum, sludge, and liquid effluent are separated. The filtered effluent is dosed to the filter pod via the Biotube pumping package. Effluent is then sprayed over the textile sheets. The effluent then percolates down through the textile sheets and is distributed between the recirculation and discharge to the leaching field.[2]

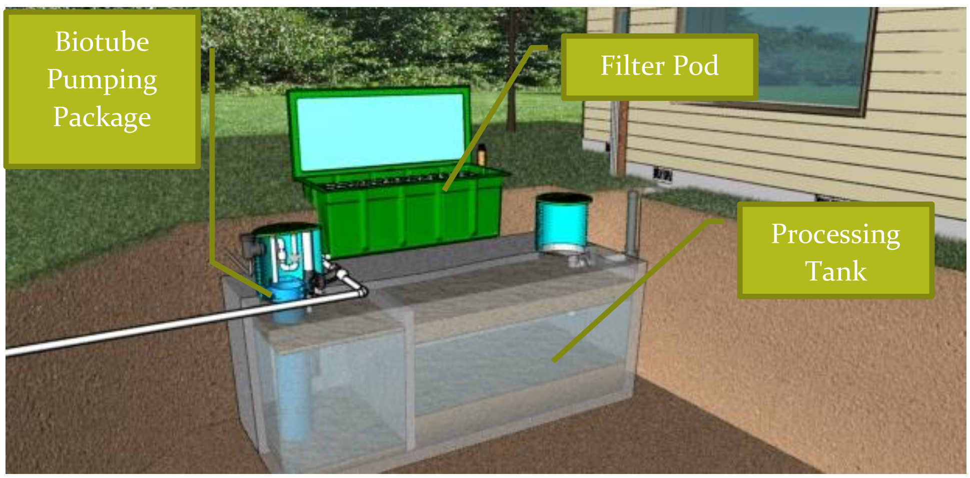


Figure 8-37 Orenco Systems AdvanTex AX20

(5) *Orenco Systems AdvanTex AX-RT* (***Figure 8-38***)
Orenco's AdvanTex AX-RT is the same process as the AX20 unit and has the ability to reduce effluent total nitrogen to less than 19 mg/l. A septic tank precedes the AX-RT unit. Flow enters the septic tank where scum, sludge, and liquid effluent are separated. Flow then exits the septic tank through the Biotube effluent filter discharging to the AX-RT recirculating section of the tank, which contains the Biotube pump package. Effluent is then sprayed over the textile sheets. The effluent then percolates down through the textile sheets and is distributed between the recirculation and

discharge chambers by means of the AX-RT baffle. Periodically, a pump in the discharge chamber doses effluent to the leaching field.[21]

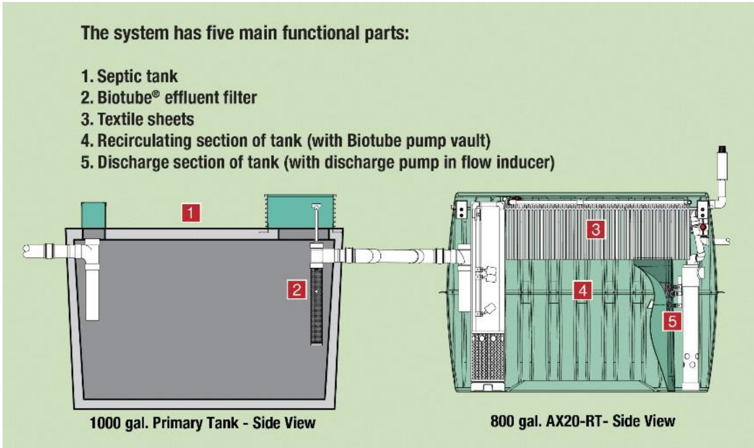


Figure 8-38 Orenco Systems AdvanTex AX-RT

(6) *Hydro-Action Industries, Hydro Action AN Series*
Prior to treatment in the Hydro-Action tank effluent must undergo pretreatment in a septic tank to remove solids. Then flow enters the hydro-action treatment system to complete the treatment of wastewater to reduce nitrogen.

8.3.3.2.2 Leaching system

Suffolk County currently uses leaching pools, leaching galleys, and infiltrators for leaching systems. Leaching galleys and infiltrators are normally used on sites with high groundwater conditions. There have been some claims of properly designed leaching fields having the capability of reducing nitrogen. The types of leaching systems are usually shallow systems located approximately 1 foot below grade. These shallow systems take advantage of contact with organic soils to enhance oxygen transfer, increase plant uptake, and retention of nutrients. One of these systems is a geomat flat with pressure dosing (Figure 8-39) by Geomatrix. Due to plant uptake these systems can help with irrigation of home lawns. Suffolk County should investigate the use of alternate types of shallow leaching systems to increase nitrogen removal and protect against rising sea and groundwater levels due to the increased separation between the bottom of the leaching system and groundwater.

Figure 8-39 Geomat Flat leaching system by Geomatrix

The Wasteflow dripline with rootguard by Geoflow, Inc is a subsurface drip system, another shallow drainfield manufactured product. The Dripline piping is flexible 1/2" polyethylene tubing coated on the inside with an anti-bacterial lining to inhibit bacterial growth. There are emitters installed and spaced evenly along the tubing. The dripline is placed 6-10 inches below the surface, directly into the biologically active soil horizon. Effluent cycles through a self-cleaning filter out to the dripfield, providing slow, even application of effluent. The system returns back to the pump tank or treatment tank in a closed loop, and is kept clean with regular flushing (See **Figure 8-40**). The Massachusetts Alternative Septic Test Center tested the product performance and also tested the nitrogen reducing capabilities of the shallow system. Nitrogen entering the leaching system had an average total nitrogen concentration of 33.91 mg/l and the system was found to reduce total nitrogen in the range of 25% to 47%.[22] When using a shallow system, effluent filters on the septic tank are required.

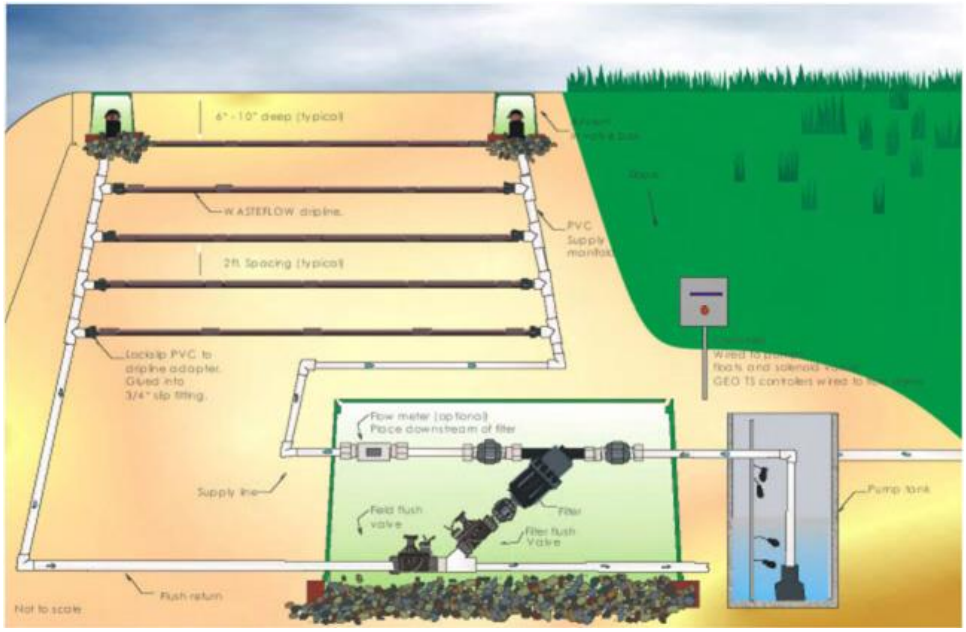


Figure 8-40 Wasteflow Dripline with Rootguard by Geoflow Example Layout

8.3.4 Expanding and/or Creating New Sewer districts (Centralized or Decentralized)

One of the means of improving water quality is to extend sewers to lots currently utilizing onsite sewage disposal systems. Sewering helps to reduce nitrogen loads impacting drinking water wells as well as increase coastal resiliency. This has been known for years but funding to extend sewers to unsewered areas has been lacking for approximately 30 years until SuperStorm Sandy. After SuperStorm Sandy impacted structures along our coastline in 2012, the need for increased wastewater treatment to reduce nitrogen was realized to improve our valuable water resources. The first major sewer expansion in Suffolk County will occur through a funding award of $383 million from New York State to install sewers and connect approximately 10,000 properties to these sewers.

Suffolk County must continue to promote expansion or creation of community sewage systems whether by municipalities creating centralized sewer systems or individual property owners joining together to create a decentralized sewer system. Per Article 6 of the Suffolk County Sanitary Code community sewer systems are defined as a system utilized for the collection and disposal of sewage or other waste of a liquid nature, including various devices for the treatment of such wastes, serving more than one parcel, whether owned by a municipal corporation, private utility, or otherwise. The major components of a community sewage system are the wastewater treatment plant and the collection system used to transport wastewater to the treatment plant. The wastewater treatment plants are designed to reduce suspended solids, BOD, and Nitrogen to meet applicable discharge standards. The collection system is the network of sewer pipes, structures and devices installed for the purpose of collecting and transporting sewage to the wastewater treatment plant. Collection systems may be compromised of gravity sewers or pressure sewers or the combination of both.

Suffolk County has already embarked on the path to create or expand community sewerage systems by performing sewer feasibility studies throughout the County. These studies include expansion of sewers into Wyandanch, Deer Park, West Babylon, North Babylon, and West Islip as depicted in **Figure 8-41**. In addition, the feasiblity of sewering areas of Mastic-Shirley, Sayville, Bellport, North Bellport, Flanders, Southampton Village, and Lake Ronkonkoma HUB was also studied, as depicted in **Figure 8-42**.

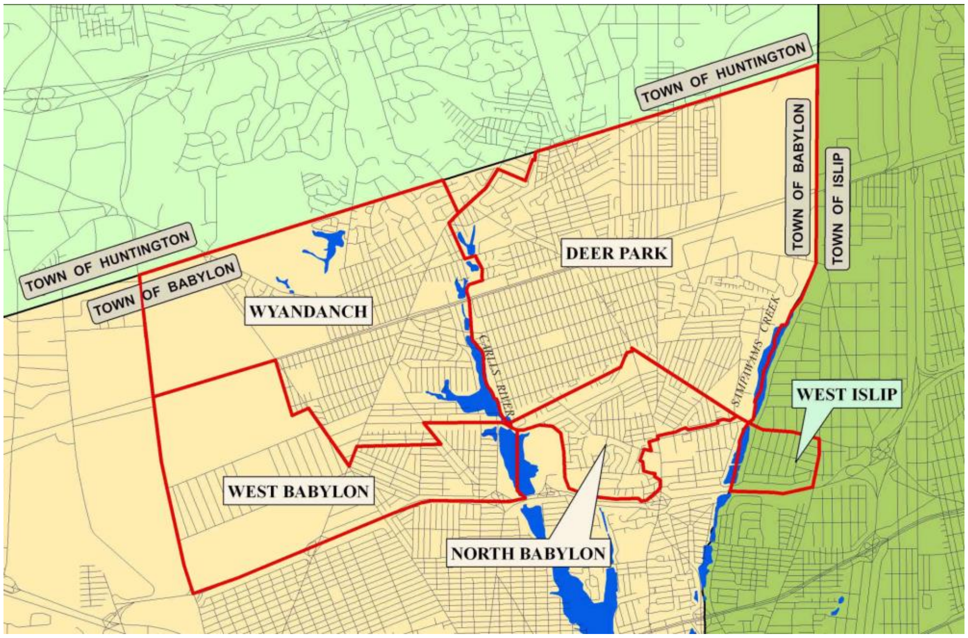


Figure 8-41 Map of Wyandanch, Deer Park, West Babylon, North Babylon, and West Islip Sewer Feasibility Study Area

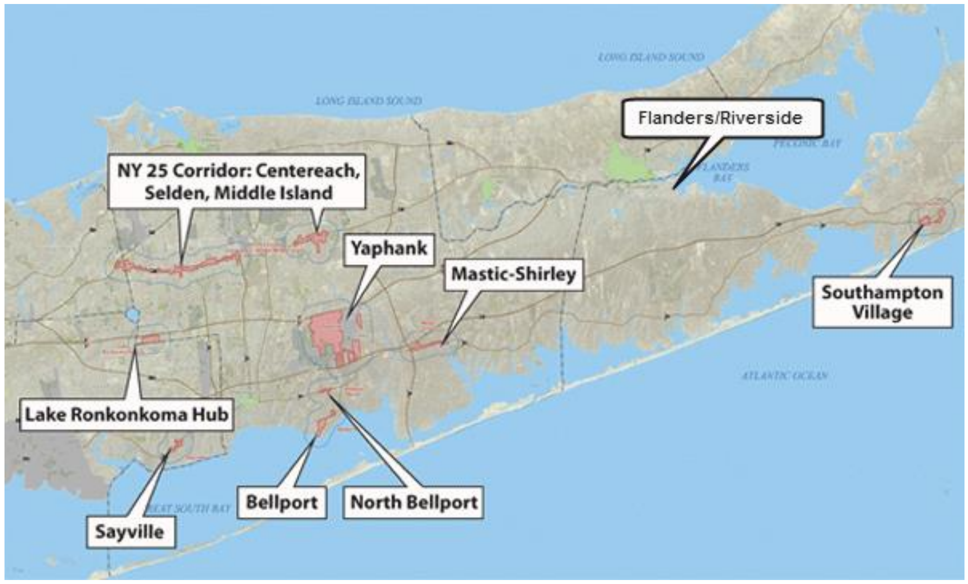


Figure 8-42 Map of Yaphank, Mastic-Shirley, Sayville, Bellport, North Bellport, Flanders, Southampton Village, Lake Ronkonkoma HUB, and NY 25 Corridor Sewer Feasibility Study Areas

8.3.4.1 Bellport Feasibility Study

The Bellport Feasibility Study considered a 56 acre area consisting 131 parcels located in two geographically distinct areas; (1) Bellport Village downtown area and (2) properties surrounding the Long Island Railroad Bellport Station located in North Bellport on Montauk Highway. The Final study was completed in June 2014.

These areas were selected for a feasibility study due to groundwater impacts to surface waters down gradient of Bellport Village, the Town of Brookhaven's desire to improve the local economy of the area, and to establish a transit oriented development. The projected wastewater flow from the study area was estimated to be 160,000 gpd. The study proposed using a combination sewer collection system consisting of gravity sewers and low-pressure sewers.

It was recommended that the North Bellport portion of the project be serviced by gravity sewers while the Bellport Village portion would be serviced by low-pressure sewers due to the elevation of the groundwater table. The study recommended that the wastewater flow from the North Bellport area be transported by gravity sewers to a pump station located by the train station and wastewater flow from the Village of Bellport be transported to the same pump station via low-pressure. From the pump station by the train station the wastewater flow would be transported to the Village of Patchogue STP. The

Village of Patchogue STP was selected to process the wastewater from the study area since it was found to be the most viable solution.

The report estimated if the project was approved it could be implemented in six to seven years at an estimated cost of $38,907,000. The proposed project would reduce nitrogen loading to area groundwater from existing conditions by approximately 2 pounds per day.[23]

Concurrently, as part of a separate study, an additional option of sending the flow to the County's Sewer District 7 – Woodside STP was made available by the Town of Brookhaven by providing additional land for potential expansion of the effluent recharge area; this option was evaluated by the Town and its consultant in a separate study in coordination with SCDPW.

8.3.4.2 Flanders Riverside Sewering Feasibility Study

The Flanders Riverside corridor feasibility study was performed based on the anticipated opportunities to improve the local economy, housing, and improve water quality due to the close proximity of the study area to the Peconic River, Flanders Bay, and Pine Barrens. The study evaluated an 85 acre area including 89 parcels for sewering with a total estimated wastewater flow of 160,000 gpd. In addition, the study evaluated the sewering of a smaller portion of the study area known as the Phase 1 area with a proposed flow of less than 15,000 gpd.

Collection of wastewater for the overall area was recommended to be via gravity lines with seven remote pump stations to minimize operation and maintenance requirements. However to reduce capital costs for Phase 1 a low-pressure system was recommended. Treatment of the wastewater would occur at a new treatment plant built for the study area. To treat the 160,000 gpd flow scenario a MBR was recommended to reduce effluent total nitrogen in the range of 3 mg/l to 5 mg/l. For the 15,000 gpd Phase 1 scenario an alternative systems such as a Nitrex system was recommended.

Two more alternatives described below were identified as a result of an April 2014 stakeholder meeting facilitated by Suffolk County and attended by representatives from both Southampton and Riverhead.

One additional alternative for the Phase I area would include construction of a low pressure collection system to convey wastewater from the Phase I area to the existing Riverhead STP for treatment. This alternative would require each property owner to purchase and maintain a grinder pump station, and the existing Riverhead Sewer District would be extended into Southampton to include the Phase I redevelopment area.

Another alternative for treating 160,000 gpd flow would be construction of a gravity collection system, pump stations and treatment at the Town of

Riverhead's Calverton STP. This alternative would require that the existing Calverton Sewer District be extended into Southampton to include the area to be sewered.

If approved, the project would take approximately five to six years to implement. The cost to sewer the overall study area (160,000 gpd scenario) with an MBR plant would be approximately $33,827,000, and the cost to sewer the Phase 1 (15,000 gpd scenario) with an alternative system such as a Nitrex plant would be $3,746,000. It is estimated that sewering the overall study area would reduce the nitrogen load to the groundwater by approximately 2 pounds per day, over the nitrogen loading that would had occurred if the area were to be developed in accordance with existing zoning, but remain unsewered.[24]

8.3.4.3 Mastic/Shirley Sewering Feasibility Study

The Mastic-Shirley area was selected to allow the implementation of the "Montauk Highway Corridor Study and Land Use Plan for Mastic Shirley" and to improve the quality of the groundwater base flow to the Forge River. The study evaluated a 1,400 acre area with a total estimated wastewater flow of 1.36MGD.

The study proposed using a combination collection system consisting of gravity sewers and low-pressure sewers. Low-pressure sewers would be used in areas where groundwater is less than 10 feet below grade based on USGS mapping. Treatment of the wastewater would occur at a new treatment plant built for the study area located on a 14.9-acre parcel located at the Town of Brookhaven Calabro Airport. Since water quality of the Forge River was a major reason for undertaking the sewer feasibility study, an MBR STP was recommended to reduce effluent total nitrogen down to the range of 3 mg/l to 5 mg/l.

If approved, the sewering program could be fully implemented within 13 years at a cost of $315,009,010. Under existing conditions, the estimated nitrogen load reduction to local groundwater would be approximately 167 pounds per day. This would provide significant improvement in shallow groundwater quality and in the groundwater baseflow to the Forge River.[25]

8.3.4.4 Sayville Feasibility Study

The Sayville Study includes an area of 71 acres with 167 tax lots generally located along a one mile stretch along Montauk Highway and Railroad Avenue in Sayville. The study area was identified as a critical area in need of sewers to provide environmental, economic, and/or social benefits to the area.

The wastewater flow of the area is estimated to be 130,000 gpd. Collection of the wastewater would be through a low pressure system due to the high groundwater and the area being an already established Main Street Business District. The wastewater would ultimately be conveyed to the Village of Patchogue STP. If approved, the sewering program could be implemented in 6 to 7 years to complete at a cost of $35,301,000. The sewering would help reduce nitrogen to groundwater by a small measurable amount, which was not defined in the report.[26]

8.3.4.5 Southampton Village Feasibility Study

The Southampton Village study includes an area of 62 acres with 151 tax lots within the Village's business district. The study area was identified as in critical in need of sewers to provide environmental, economic, and/or social benefits to the area. Meetings with Village stakeholders identified the two most significant factors for upgrading sanitary sewage infrastructure in the business district as groundwater impacts to Lake Agawam and the Village's desire to implement their own vision plan.

The wastewater flow of the area is estimated to be 145,052 gpd. Collection of the wastewater would be through a low-pressure system due to the high groundwater and the area being an already established Main Street Business District. Treatment of the wastewater would occur at a new treatment plant built for the study area. Based on the desire to reduce impacts to Lake Agawam an MBR STP was recommended to treat the 145,052 gpd wastewater flow to a total effluent nitrogen in the range of 3 mg/l to 5 mg/l.

If approved, the sewering program could be implemented in 5 years to at a cost of $29,300,000. It is estimated that sewering would reduce the nitrogen load to area groundwater by approximately 20.6 pounds per day and reduce the groundwater nitrogen concentration beneath the Southampton Study area to approximately 2.6 mg/l.

8.3.4.6 Deer Park, North Babylon, West Babylon, Wyandanch, Wheatley Heights, and West Islip Feasibility Study

The sewering feasibility study encompassed the communities of Deer Park, North Babylon, West Babylon, Wyandanch, Wheatley Heights and West Islip. The study area was identified as a critical area in need of sewers to help address environmental and health concerns associated with on-site wastewater disposal systems, potential to encourage business investment, and increase workforce-housing opportunities.

The wastewater flow of the area is estimated to be between 4.1 to 5.5 MGD to sewer approximately 18,000 parcels. Collection of wastewater for the overall area was recommended to be via gravity lines with remote pump stations. The wastewater would ultimately be conveyed to the Bergen Point STP. If approved, the cost to sewer the entire study area would be approximately $2 billion.[6]

One overarching issue identified during each study is the cost. Costs ranged in the millions to billions of dollars to sewer the studied areas. If the annual debt service for the cost of installation of the sewers was required to be paid by the property owners then they would incur significant annual debt for connecting to sewers above current annual property tax payments. As an example, **Table 8-23** depicts the annual cost to homeowners in the proposed Sayville sewer study area of approximately $5,947/year based on a 30 year loan. Therefore, these projects would become economically feasible for residential property owners only if significant grant funding was provided or some other type of established funding stream was created to fund these and future sewer extension projects.

Table 8-23 Annual Costs for Property Owners Located in the Sayville Sewer District

Annual Costs for Typical Property Owners (Sayville Sewer District Created)						
Property Type	"Typical " Assessed Value ($)	Annual Debt Service (Sewer Assessment)	Annual Electricity Cost & Service Contract	Annual O&M	Village of Patchogue Sewer User Fee	Total Annual Amount
Sayville Commercial Property	$45,000	$4,677	$1,850	$1,500	$8,270	$16,297
Sayville Residential Property	$45,000	$4,677	$375	$150	$745	$5,947

8.3.5 Improvements to Sewage Treatment Plant Technologies

In 2013, there were 197 sewage treatment plants (STP) operating in Suffolk County. 171 STP's are designed to remove total nitrogen below 10 mg/l (tertiary STP), and the remaining 26 STP's are designed to remove suspended solids and BOD (secondary plants). The life expectancy of a STP is approximately 30 years. Many plants in Suffolk County have been in operation for approximately 25 to 40 years. Many of these STPs undergo upgrades or modifications periodically to replace aging parts or to improve process. Modifications include separating blowers for aeration to improve process control or converting an entire treatment process to a new process.[28]

SCDHS monitors the performance of all STPs located within the County. In addition, SCDHS has been actively requiring older STPs that are underperforming and/or lacking nitrogen removal capability, to undertake major renovations or replacement by a new STP. SCDHS and/or an established RME should continue these duties into the future. During the past 15 years 20 existing STPs were constructed to replace aging/underperforming STPs. In 2013 there were 26 tertiary plants that were non-compliant with their SPDES permits and undergoing upgrades and/or repairs. Thirteen of the 26 existing secondary plants were in the process of transitioning to tertiary treatment to provide nitrogen removal. Two additional secondary treatment plants were completely abandoned and replaced by pump stations to transport untreated wastewater to a municipal plant.

Secondary plants are designed to reduce total suspended solids and biochemical oxygen demand (BOD). A common measurement method of BOD is the five-day BOD, or BOD_5, which is the quantity of oxygen consumed by microorganisms during a five-day period to measure the amount of biodegradable organic material in, or strength of, sewage. BOD has traditionally been used as a measure of the strength of effluent released from conventional sewage treatment plants to surface waters or streams. High effluent BOD can deplete oxygen in receiving waters, causing fish kills and ecosystem changes. New York State SPDES Permits require secondary plants to have a maximum effluent suspended solid of 30 mg/l and BOD of 30 mg/l. **Figure 8-43** depicts a conventional extended aeration process capable of reducing suspended solids and BOD.[29] Reduction of BOD occurs in the aeration tank and reduction of suspended solids occurs by the screen, grit separator, and secondary clarifier. Unfortunately most secondary plants lack the ability to appreciably reduce nitrogen to required standards. Therefore, most secondary plants are upgraded to include the capability of reducing nitrogen to 10 mg/l or less with the exception of Bergen Point WWTP that discharges 2 miles off Fire Island into the Atlantic Ocean.

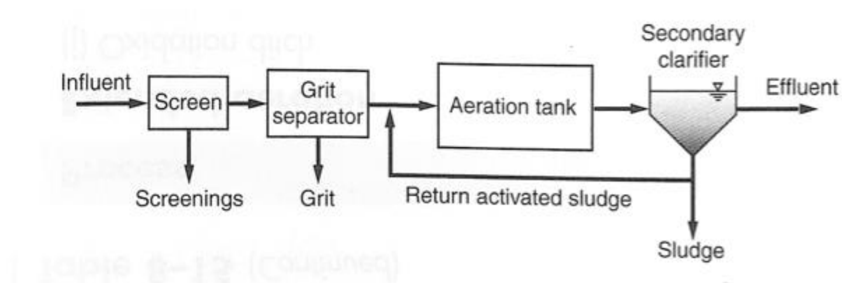


Figure 8-43 Conventional Extended Aeration Process

The basic principle of removing nitrogen in tertiary wastewater plants (in addition to reducing BOD and suspended solids) is to nitrify then denitrify the wastewater converting ammonia to nitrogen gas. Nitrification is competed by the addition of oxygen and aerobic bacteria (Nitrosomonas and Nitrobacter) to convert ammonia (NH_4) to nitrite (NO_2^-) to nitrate (NO_3^-).

Nitroso-bacteria

$2NH_4^+ + 3\ O_2 \rightarrow 2NO_2^- + 4H^+ + 2H_2O$

Nitro-bacteria

$2NO_2^- + 2\ O_2 \rightarrow NO_3^-$

Denitrification occurs under anaerobic conditions (oxygen levels close to zero) where facultative bacteria assist in the reduction of nitrate to nitrogen gas (N_2).

$[\text{Carbon Source}] + NO_3^- \rightarrow N_2 + CO_2 + H_2O + OH^-$

However, the bacteria require a carbon food source, which is accomplished with the addition of chemicals such as methanol (**See Figure 8-44**) or by using the incoming untreated wastewater as the carbon food source (See **figure 8-45**). [29]

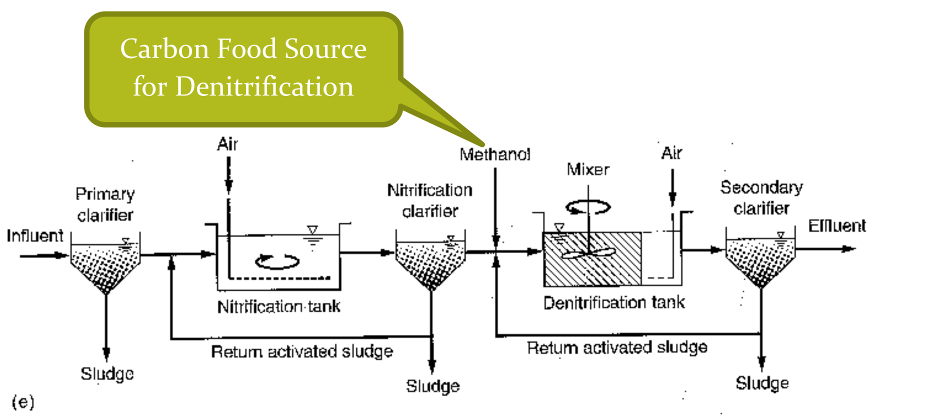


Figure 8-44 Denitrification Process with Addition of Methanol as Carbon Food Source

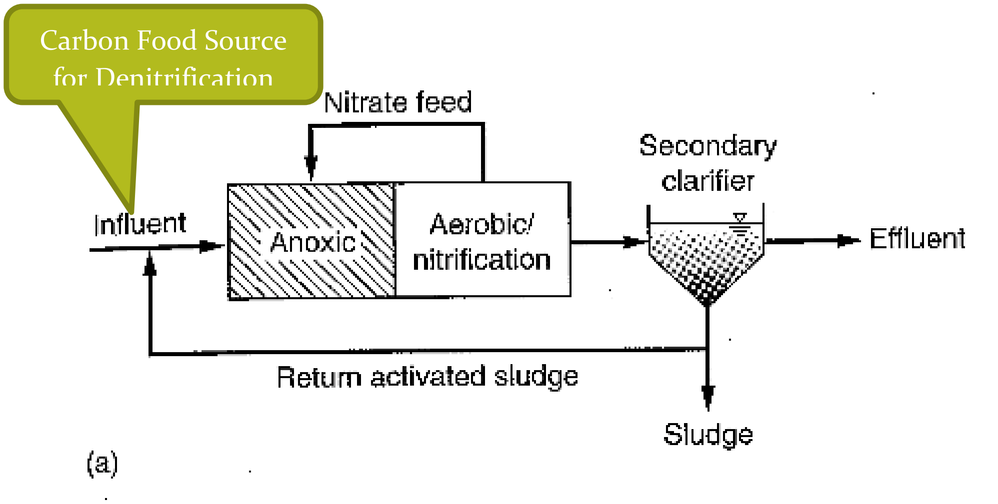


Figure 8-45 Denitrification Process with Incoming Effluent used as Carbon Food Source

The most popular types of tertiary STP plants used to remove nitrogen below 10 mg/l in Suffolk County are as follows:

(1) *Extended Aeration with Denitrification Filter*
Suffolk County has 43 plants that utilize an extended aeration process with denitrification filter to reduce effluent nitrogen to 10 mg/l or less. Historically, conventional extended aeration systems were designed as secondary sewage treatment plants as previously described (**See Figure 8-42**) but have been modified to provide nitrogen removal via a denitrification filter. An example of a denitrification filter is depicted in **Figure 8-46**. **Figure 8-46** depicts an upflow continuous-backwash filter. In order to promote denitrification a carbon source must be added to the filter.[30]

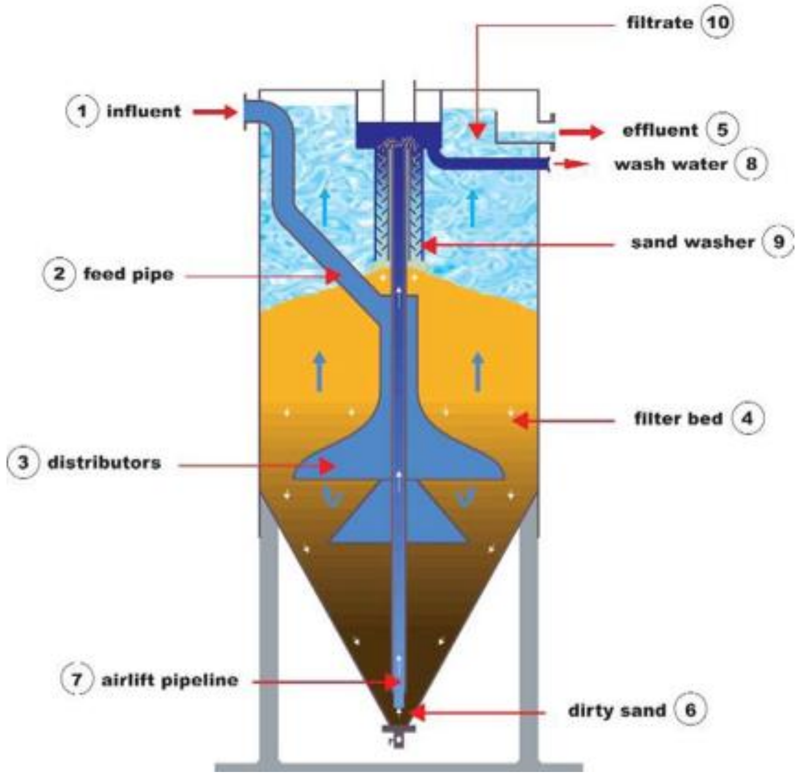


Figure 8-46 Upflow Continuous-backwash Filter

(2) *Rotating Biological Contractors with Denitrification Filters:*
There approximately twelve RBCs with denitrification filters installed in Suffolk County. An RBC consists of a series of closely spaced circular disks of polystyrene or polyvinyl chloride that are submerged in wastewater and rotate throughout it.[29] The disks are rotated approximately 1 to 1.6 revolutions per minute via a mechanical or air-driven drive unit. Aeration is provided for BOD and nitrification reduction when the disk is rotated out of the wastewater and exposed to the atmosphere. **Figure 8-47** is a typical example of an RBC. Wastewater flows through a primary clarifier or fine screen then into the RBC unit then to the secondary clarifier to remove additional solids. Similar to the extended aeration process, a denitrification filter is added to the process to reduce nitrogen.

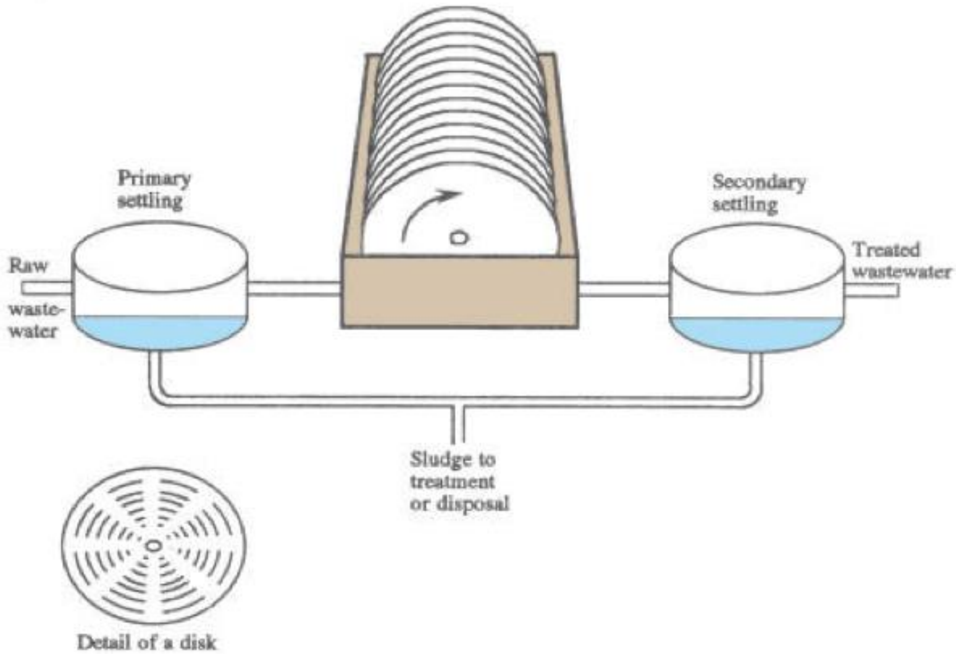


Figure 8-47 Rotating Biological Contractors

(3) *Sequencing Batch Reactor:*

There are currently approximately sixty-six sequencing batch reactors (SBRs) operating in Suffolk County. Conventional SBRs are an activated sludge process, which operates on fill draw principles. The nitrification, denitrification, settling, and decanting steps all occur sequentially in a single treatment tank on a cyclic basis. Nitrification usually occurs in the aeration phase with the use of aeration blowers and mixers are used during the anoxic phase to complete denitrification by promoting bacterial breakdown of nitrate to permit nitrogen gas to escape.[29] **Figure 8-48** depicts the Sanitaire Intermittent Cycle Extended Aeration (ICEAS) process. The Sanitaire ICEAS process differs slightly from a conventional SBR due to the addition of a pre-reaction tank, which allows continuous flow to enter the SBR tanks even during the settling and decant phase.

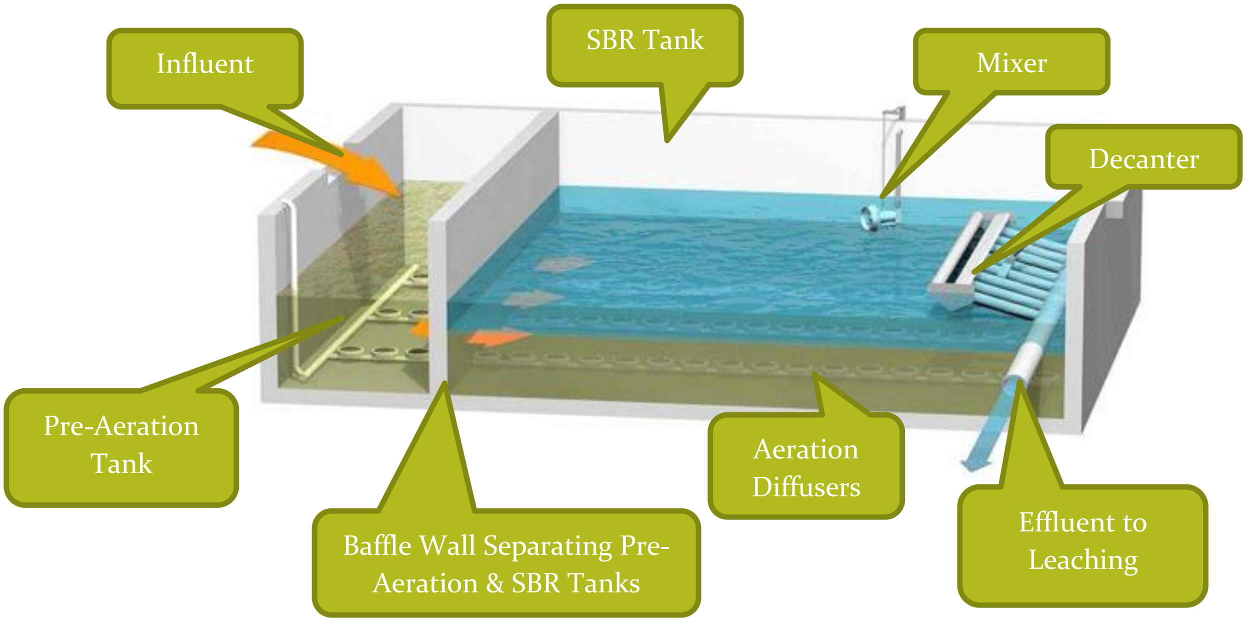


Figure 8-48 Sequencing Batch Reactor with Pre-aeration Tank[31]

(4) *CromoFlow:*

There are approximately thirty-one CromoFlow (also known as Cromoglass) systems located within Suffolk County. CromoFlow is also a SBR process approved for use in Suffolk County for design flows up to 15,000 gpd. The system uses pumps and venturi aspirators to aerate and mix. In addition, the clarifier section has a baffle wall separating the compartment to permit a continuous flow into the system. These systems are prefabricated packaged systems capable of reducing total nitrogen to 10 mg/l or less when properly operated.

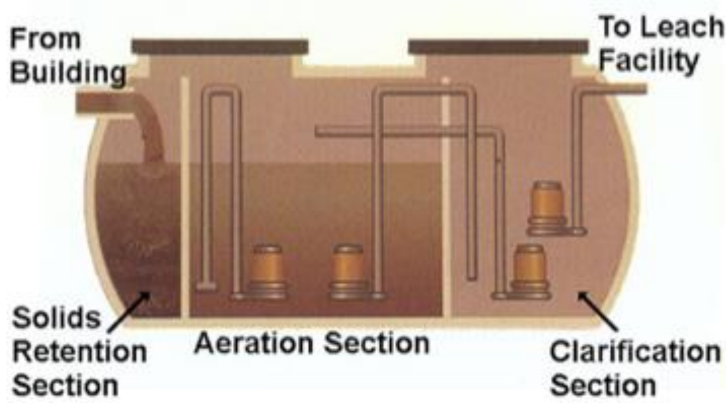


Figure 8-49 CromoFlow Process Tank

(5) *Biologically Engineered Single Sludge Treatment (BESST):*
A 15,000 gallon per day BESST system manufactured by Purestream, inc. was initially installed in Suffolk County Sewer District #12 (Birchwood STP) for piloting purposes in 2001. Some of the incoming wastewater to the sewer district plant was diverted to the BESST system to test the operation and treatability of the system. After successfully completing the pilot with effluent nitrogen below 10 mg/l, the system was permitted to be installed in Suffolk County. The main components of the BESST system are the anoxic compartment, aeration compartment, and clarifier. Since there are no valves isolating the compartments the systems essentially operates as one treatment tank. The anoxic compartment is where denitrification occurs under anaerobic conditions with the use of incoming untreated wastewater as the carbon food source for the microorganisms to assist in the reduction of nitrate to nitrogen gas. Oxygen is provided to the aeration compartment through the use of blowers to complete nitrification as well as reduce BOD. The clarifier is the final step to reduce suspended solids and discharge a portion of the flow to the recharge beds while returning activated sludge (RAS) to the anoxic zone. Therefore the process order follows these steps: (1) influent enters the anoxic zone, (2) flows to the aeration zone, (3) flows to the clarifier were some flow (4A) exits the plant to the leaching system or (4B) RAS is returned to the anoxic tank (See **Figure 8-50**). Some operational keys to reducing nitrogen are the amount of oxygen provided to the aeration zone and the return rate of the RAS. There are currently six BESST systems in operation within Suffolk County.

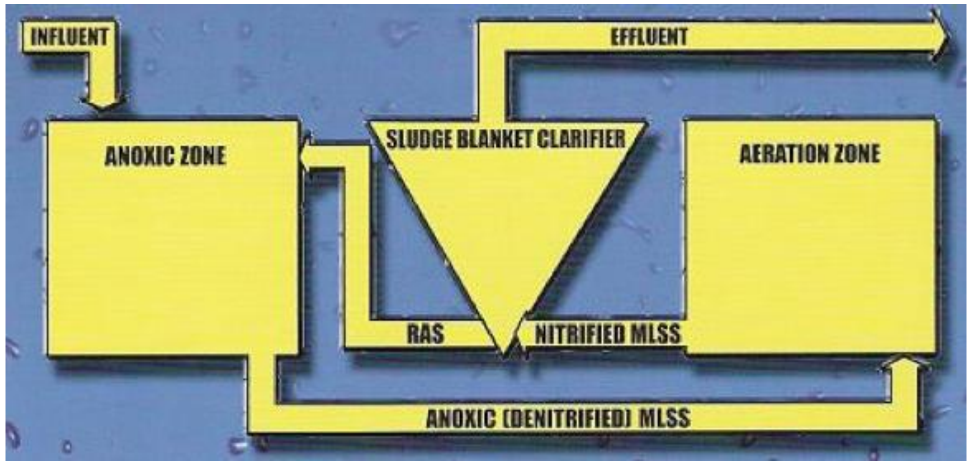


Figure 8-50 Biologically Engineered Single Sludge Treatment (BESST) Flow Diagram

(6) *Membrane Bioreactor (MBR):*

MBRs are the newest technology to be installed in Suffolk County. They have been used for treatment of sanitary wastewater as well as industrial wastewater. MBRs have been known to provide effluent comparable to a combination of secondary clarification and microfiltration. [29] This type of STP requires smaller footprints then a SBR or extended aeration processes. This is due to the membranes filtering the wastewater which eliminates a clarifier and allows the process to operate at a higher MLSS in the range of 8,000 mg/l to 12,000 mg/l as compared to other processes. The major components of these systems are: (1) preliminary treatment to remove inorganic solids such as a bar screen, screw screen, etc. (2) an anoxic zone for denitrification (3) pre-aeration zone for nitrification and BOD reduction, (4) aerated membrane zone for further nitrification, BOD reduction and discharge. **Figure 8-51** depicts a general MBR setup with the exception of the pre-aeration zone. In the figure, flow enters the anoxic zone, similar to the BESST process then overflows into the aeration/MBR zone. In the aeration/MBR zone a portion of the flow is recirculated to the anoxic zone for denitrification with the incoming untreated wastewater as the carbon food source.

(http://www.hitachi-aqt.com/products/membrane.html)

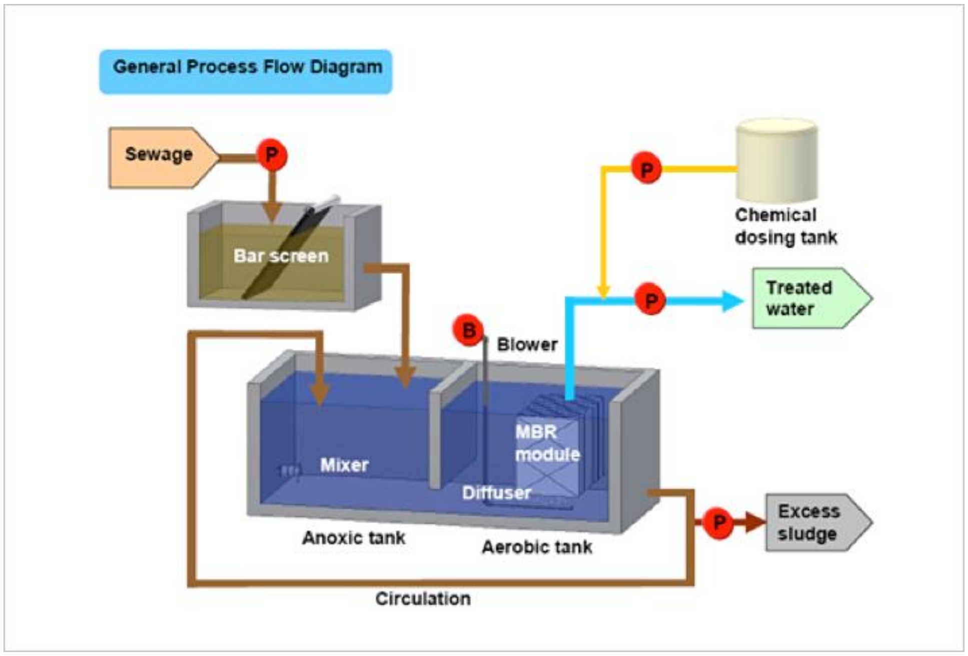


Figure 8-51 Membrane Bioreactor (MBR) Flow Diagram

There are currently two operational MBR plants within Suffolk County which were replacements of two aging STPs. As of 2014 there is one additional MBR plant under construction to replace an outdated secondary plant serving an apartment complex in Commack. Fairfield Properties Commack apartment complex was constructed in approximately 1970 with 256 rental apartment units. A secondary STP was installed on the site to treat the wastewater using an extended aeration process. The plant is over 40 years old and is coming to the end of its useful life. Due to reduced area to construct a new STP, the engineers designing the new plant decided to use MBR technology to reduce nitrogen since it requires a reduced footprint as shown by **Figure 8-52**.

Figure 8-52 New and Existing STP's at Fairfield Commack (Top), Inside Existing Extended Aeration STP at Fairfield Commack (Bottom Left), and Inside New MBR STP at Fairfield Commack (Bottom Right)

Another use of MBR technology is treatment of wastewater for reuse. For example, the Town of Riverhead is constructing an MBR to be used as a wastewater polishing step. Municipal wastewater completes treatment via an SBR process. After the SBR process the effluent will enter the MBR unit for further treatment then pass through a UV system. This will permit the reuse of the effluent for irrigation on the neighboring Indian Island Golf Course. A process schematic is depicted in **Figure 8-53.** [32]

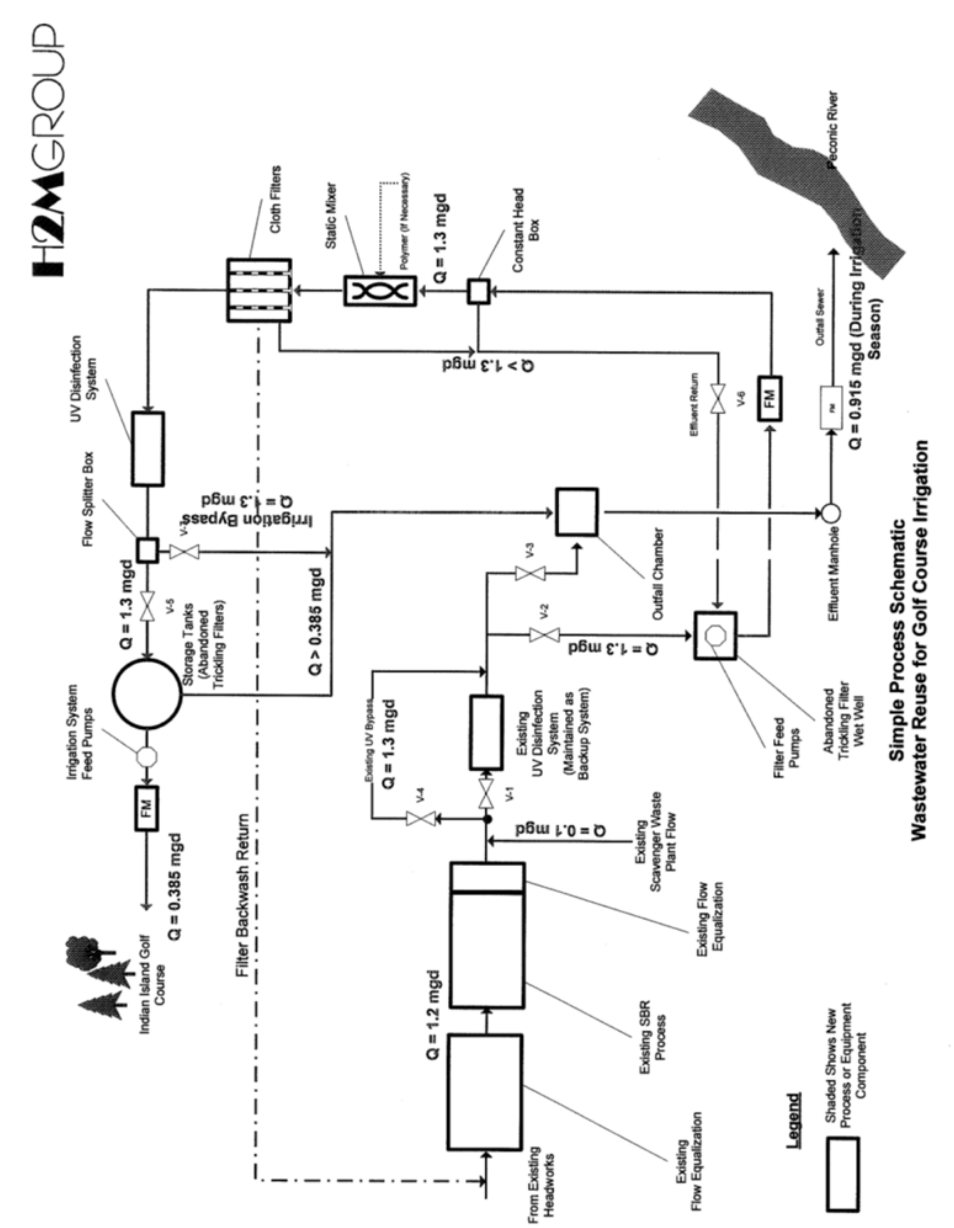


Figure 8-53 Town of Riverhead STP Water Reuse Schematic

Suffolk County Department of Public Works (SCDPW) has been repairing/upgrading and/or replacing sewage treatment plants. In the past 15 years three major sewer district STPs were replaced and/or upgraded. Suffolk County Sewer District # 1 located in Port Jefferson was upgraded from an RBC process to an SBR process. **Figure 8-54** depicts the plant in 2004 and the plant in 2010 after the upgrade. The improvement expanded capacity and reduced effluent nitrogen.

Figure 8-54 Aerials of SCDPW Port Jefferson STP in 2004 (Left) and 2010 (Right)

Suffolk County Sewer District # 6 located in Kings Park was also upgraded from an extended aeration process to an SBR process to reduce total nitrogen and increase capacity for future development. **Figure 8-55** depicts the plant in 2001 and after the plant after the upgrade in 2013.

Figure 8-55 Aerials of SCDPW Kings Park STP in 2001 (Left) and 2013 (Right)

Suffolk County Sewer District # 18 has recently been upgraded to an SBR to improve nitrogen reduction and increase capacity for additional connections to the plant. Sewer District #18 originally consisted of two plants SD# 18N and SD #18S. Both plants were demolished and merged into one plant known as SD#18. SD#18N was an extended aeration with denitrification filter process which was demolished and converted to the leaching area for SD #18. SD# 18S was an RBC with denitrification filter which was demolished and converted to an SBR process. **Figure 8-56** depicts SD#18S in 2010 before the conversion and the site in 2014 (Picture Google Earth) after the construction was completed. Figure 8-57 depicts SD#18N before the demolition in 2004 and the site in 2014 after the demolition.

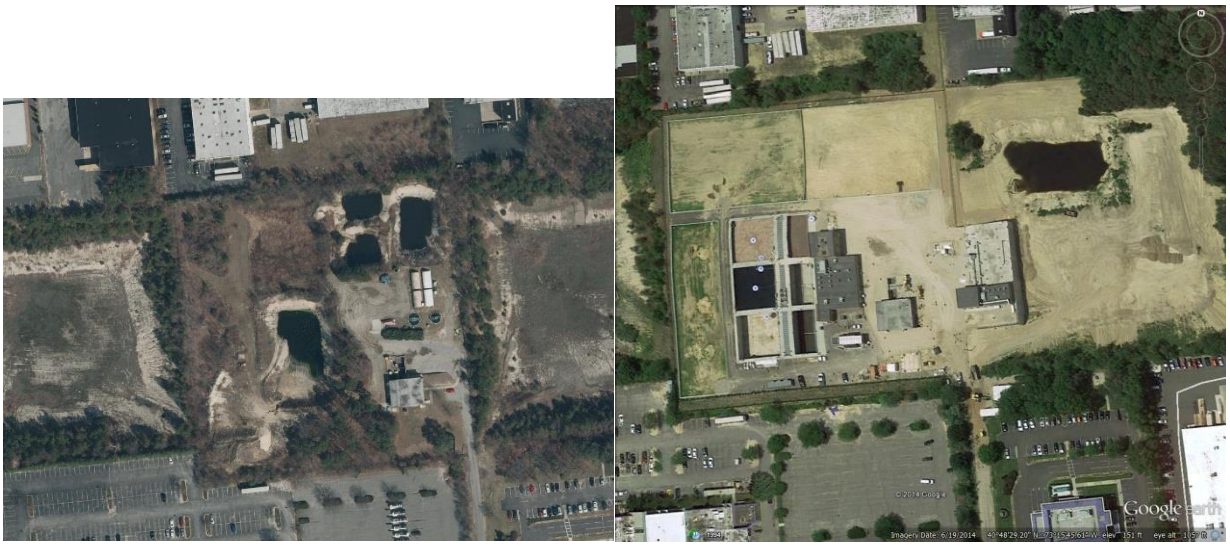


Figure 8-56 Aerials of SCDPW Hauppauge STP in 2004 (Left) and 2014 (Right)

Figure 8-57 Aerials of SCDPW Hauppauge STP Leaching in 2004 (Left) and 2014 (Right)

The SWSD, known as sewer district # 3 is currently undergoing an expansion to increase the capacity from 30 MGD to 40 MGD to permit the connection of additional facilities (commercial, industrial, and/or residential structures) to the sewer district. In addition, the Bergen Point WWTP recently received a $13.6 million loan from New York State's Storm Mitigation Loan Program for wastewater and storm resiliency improvements at the plant.33

SCDHS and SCDPW must continue to investigate new technologies for modifications to existing treatment plants to increase performance and/or permit effluent reuse (e.g. pumping equipment, aeration equipment, flow measuring equipment, nutrient monitoring equipment, screening equipment, effluent treatment equipment such as UV disinfection, etc.). SCDHS and SCDPW should investigate new treatment processes and consider piloting them at existing SCDPW STPs, such as the pilot of the BESST system, to provide more options for treatment of wastewater. In addition, with the growing concern of emerging contaminants due to increased use of PPCPs, Suffolk County should continue to monitor research progress for new wastewater solutions to help reduce these containments in effluent wastewater streams. The County should evaluate when these new treatment solutions should be implemented, for an example STPs treating effluent from medical facilities such as hospitals, rehabilitation centers, nursing homes, and assisted living facilities. Currently there are approximately 23 STPs operating in Suffolk County serving these types of facilities.

8.3.6 Section Summary

Suffolk County must achieve their wastewater goals and objectives by establishing a wastewater management plan. The plan should clearly identify nitrogen target loads that will reverse ground and surface waters trends such as reversing the increasing level of nitrates in groundwater. The target loads should be used to establish a GIS based map indicating the level of nitrogen treatment for individual parcels to improve water quality. The identified treatment level would be connecting parcels to sewers, installation of I/A OWTS, or installation of a conventional onsite sewage disposal system.

Suffolk County should establish an I/A OWTS program that includes the establishment of an RME to oversee operations, maintenance, enforcement, and financing of systems, create a pilot program that includes demonstration projects, and amend the Suffolk County Sanitary Code and SCDHS Construction standards to permit the an the establishment of an I/A OWTS program.

Suffolk County should build on its $383 million award to sewer approximately 10,000 homes located in Mastic/Shirley, Great River, Patchogue Village, and North Babylon and continue seeking funding sources for future projects to sewer additional areas to improve water resources. In addition, SCDPW should continue developing sewer feasibility studies which will help to prioritize future sewering projects within the County. Suffolk County should encourage towns and villages to develop their own sewering plan such as the Village of Patchogue sewering plans. In addition, Suffolk County should assist and encourage multiple property owners to form their own privately run decentralized sewer districts to improve water quality.

SCDHS should continue to require the remaining secondary STPs to upgrade to tertiary plants that can remove nitrogen and existing aging tertiary plants that are not meeting required nitrogen discharge limits. In addition, SCDPW should continue on the path of upgrading older STPs to newer technologies and expanding the capacities of existing STPs to permit additional sewer connections. Both SCDPW and SCDHS should continue to evaluate new treatment technologies such as treatment plant technologies or equipment technologies to improve wastewater treatment processes to further reduce nitrogen or PPCPs and permit the reuse of effluent for irrigation.

8.4 Implementation

Improvement of water quality by implementing the goals, objectives and recommendations requires Suffolk County, the Responsible Management Entity, property owners, design professionals, and contractors to play a part in the implementation process. The overall effectiveness of the wastewater management plan can be measured by the acceptance and willingness of these players to implement the plan. This will ensure our water resources are protected and on the path of improvement.

8.4.1 Responsibilities of Suffolk County

Suffolk County's main responsibility is to take the lead in creating an effective wastewater management plan and continue to evaluate and permit technologies to improve wastewater treatment. Suffolk County has already initiated the early steps of developing the plan by researching I/A OWTS programs in other jurisdictions, creating their own I/A OWTS demonstration project, developing this Water Resources Comprehensive Management Plan, performing Sewering Feasibility Studies, and obtaining $383 million from the New York State to extend sewers to the North Babylon, Great River, Village of Patchogue, and Mastic-Shirley areas. These items are the footings for the foundation of a responsible wastewater management plan. Unfortunately there is still more to be done to implement a wastewater management plan to protect and improve our water resources.

8.4.1.1 Study to Identify Priority Areas and Classify Wastewater Treatment Requirements for Each Area

SCDHS is in the process of developing a study to gather valuable information that will be used to prepare the County's wastewater management plan. The study is expected to be completed within 15-months of selection of a Consultant to assist with the process. The project's final product will be used to guide the County's decision-making process when establishing the best possible prioritized implementation plan for reduction of nitrogen. The Wastewater Management Plan shall define the means of reducing nitrogen discharge from domestic wastewater which impact ground and surface water resources in order to protect and improve drinking water quality, coastal resiliency, and marine habitats.

The Plan will evaluate nitrogen discharge from onsite sewage disposal systems based on a parcel-by-parcel basis using various modeling techniques. This will enable the preparation of a map and plan identifying parcels that will be permitted to remain on conventional onsite sewage disposal systems, parcels that are appropriate to be connected to public sewers, parcels that can be grouped together to connect to a cluster decentralized treatment system, and parcels that would be required to install an innovative/alternative on-site wastewater treatment system (I/A OWTS). The analysis criteria will include ground and surface water modeling, proximity to existing infrastructures such as sewer mains, public water well fields, depth to groundwater, and other factors determined to be essential in developing the Wastewater Management Plan.

The study will provide an evaluation of the potential impacts to surface water ecosystems affected by wastewater generated in the watersheds using available information. Results of this evaluation shall set the nitrogen load reduction targets and/or ambient water quality nitrogen concentration targets. These targets will be useful in establish required wastewater treatment options to meet nitrogen reduction targets (treatment options – connection to STP to meet wastewater effluent total nitrogen (TN) of < 10 mg/l, or I/A OWTS to meet TN <19 mg/l, or conventional system TN>19 mg/l).

The nitrogen targets and/or ambient water quality nitrogen concentration targets established and required treatment options for each parcel will help with the creation of the wastewater management plan. Based on the targets and required treatment obtained from the study, the plan will identify the required treatment and rank and prioritize areas for onsite sewage disposal upgrades by area based on benefit gains such as increased coastal resiliency to storm surges, improved drinking water supply, improved economy, etc. In addition, a required timeline for upgrades can be established to meet the nitrogen targets, the amount of funding required can be estimated to complete the upgrades within the timeline limits.

8.4.1.2 SCDHS Sanitary Code and Construction Standards

A crucial component to permitting the use of I/A OWTS and implementing the wastewater management plan are having standards and codes in effect to address I/A OWTS systems, upgrades/repairs to existing systems, and the RME. The Suffolk County Sanitary Code Article 6 clearly defines when a conventional onsite sewage disposal system can be installed for new construction and when a site must connect to sewers for new construction (new construction includes additions to residential dwellings that include an increase in bedrooms). Article 6 must be amended to include language for the installation of I/A OWTS for new construction in priority areas. As an example section§760-605, paragraph B currently reads:

"B. Individual sewerage systems may be approved by the Department as to the method of sewage disposal provided all of the following conditions are met:

1. *the realty subdivision or development is located outside of Groundwater Management Zones III, V and VI, and all parcels of the realty subdivision or development consist of an area of at least 20,000 square feet; or the realty subdivision or development has a population density equivalent equal to or less than that of a realty subdivision or development of single family residences in which all parcels consist of an area of at least 20,000 square feet;*
2. *the realty subdivision or development is located within Groundwater Management Zones III, V or VI, and all parcels in the realty subdivision or development consist of an area of at least 40,000 square feet; or the realty subdivision or development has a population density equivalent equal to or less than that of a realty subdivision or development of single family residences in which all parcels consist of an area of at least 40,000 square feet;*
3. *the realty subdivision or development, or any portion thereof, is not located within an existing sewer district and is located in an area where subsoil and groundwater conditions are conducive to the proper functioning of individual sewerage systems; and*
4. *the individual sewerage systems comply with the Department's current Standards and the minimum State requirements as set forth in 10 NYCRR, Part 75, to the extent applicable to Suffolk County; and*
5. *the requirements of §760 606 hereof are complied with."*

As an example, an additional sub-paragraph in this section could read:

"Individual sewage systems located in priority areas, identified by the Department, shall install an innovative/alternative onsite wastewater treatment system capable of reducing total nitrogen to 19 mg/l or less acceptable to the

Department for the purpose of protecting ground and surface water resources. Such innovative/alternative onsite wastewater treatment systems shall be subject to the requirements of the Department established Responsible Management Entity per Article XXX, Section XXX of this Sanitary Code"

As for existing residential properties, and if found to be feasible, a new section could be added to the Sanitary Code or Article 5, General Sanitarian, could be revised to include evaluations of systems at the time of transfer. Section §760-605, Sewage Disposal currently reads:

1. No person, either as owner, lessee or tenant of any property, dwelling, building, or place shall construct or maintain any private or individual sewage disposal system, pipe, or drain so as to expose or discharge the sewage contents or any other deleterious liquid or matter therefrom onto the surface of the ground, or expose to the atmosphere nor so to endanger any source or supply of drinking water.

2. No person shall discharge any sewage into any waters of the health district unless a permit therefore has been issued by the Commissioner or unless a permit is issued under the provisions of the New York State Environmental Conservation Law for such discharge.

3. No person shall undertake to construct, operate, or provide a system or facilities for the private or individual disposal of waterborne sewage, domestic or industrial or trade wastes to serve any building, dwelling, school, institution, or any other premises from which such wastes may be discharged, unless such construction conforms to standards approved by the Commissioner or a permit is issued for such system under the provisions of the New York State Environmental Conservation Law. The Commissioner may require the submission of plans and any other information necessary to insure that such systems conform to approved standards.

4. a. No person shall construct or permit to be constructed on any premises any private or individual sewage disposal system where an approved public sanitary sewer is available and accessible.

b. Sewage from any building or premises shall be discharged directly into a municipal sewage disposal system, if available and accessible.

c. If there is no municipal sewage disposal system or facility connecting therewith available and accessible, sewage from any building or premises shall be discharged directly into a privately-owned community sewage disposal system or a facility connecting with a privately-owned community sewage disposal system, if available and accessible.

d. If there is no municipal or privately-owned community sewage disposal system or facility connecting therewith available and accessible, an individual sewage disposal system approved by the Department as hereinafter provided may be used.

e. In the event that a municipal or communal sewage disposal system or facility connecting therewith becomes available and accessible, any building or premises shall be connected to such municipal or privately-owned community sewage disposal system, and immediately thereafter the use of any other sewage disposal system or facility shall be discontinued.

f. At the time of connection of an industrial, non-residential institutional, non-residential commercial or trade building to a municipal or communal sewage disposal system, all other points of liquid discharges except uncontaminated stormwater runoff and non-contact cooling water shall be discontinued and the discharge pipes permanently removed or sealed. All cesspools, septic tanks, dry wells and other drainage facilities for any liquid discharges other than stormwater runoff or non-contact cooling water shall be pumped dry of any liquid, cleaned of any accumulated sludge and filled in to grade with clean soil. Any industrial or domestic sludge or liquid waste resulting from such cleaning shall be removed by a properly licensed industrial or domestic waste hauler. Any pre-treatment necessary to render a liquid waste acceptable to the municipal or communal sewage disposal system shall be provided prior to discharge to the sewer. No discharges to or into the ground shall be allowed when sewer service is available except for stormwater runoff and non-contact cooling water.

As an example, an additional subparagraph could be added to the section to address property transfers as follows:

"No person shall transfer a property to a new property owner without first having their onsite sewage disposal system inspected by a licensed Professional (Engineer or Architect) and an evaluation report submitted to the Department for review and acceptance. Upon review of the evaluation report by the Department the system shall be deemed acceptable for transfer and a transfer certificate shall be issued or deemed unacceptable for transfer and the system must be upgraded to Department current standards by submitting an application to the Department per Article 6 of this Sanitary Code prior to issuance of a transfer certificate. Transfers exempt from this requirement are:

a) Transfer from a spouse.

b) Change in ownership solely to exclude a spouse.

c) Transfer subject to life lease or life estate, (until the life lease or life estate expires).

d) Transfer to effect foreclosures or forfeiture of real property.

e) Transfer into a trust where the settlor or the settlor's spouse conveys property to the trust and is also the sole beneficiary of the trust.

f) Transfer creating or ending joint ownership if at least one person is an original owner of the property or his or her spouse.

g) Transfer to establish or release a security interest, i.e. pay off mortgage.

h) Premises built within the previous twenty-four months prior to date of property transfer, i.e. newly constructed home with system approved by the Department.

i) Premises that shall be demolished and shall not be occupied after the property transfer.

j) New homes that have not been occupied.

k) Municipal Sanitary Sewer and/or municipal water service will be available within three (3) months, and system is not failing. Affidavit will be required.

l) Refinance of mortgage connected to the property.

m) A property which receives a final inspection approval by the Department for either an onsite water supply system or septic system during the previous twelve (12) months. After the 12 month period has passed and the Department has not received a notice of deed transfer, the Department will notify the owner and/or applicant that the letter of approval has expired. At that time, the owner and/or applicant will have sixty (60) days to request a follow up inspection and if the inspection demonstrates conditions have not changed, an extension of the initial letter of approval for the property will be issued by the Department. This extension will not exceed twelve (12) months from the expiration date of the initial approval letter."

Currently, the USEPA is undertaking a Health Impact Assessment to provide an unbiased assessment of the impacts of updating the existing codes and standards to require onsite sewage disposal upgrades during property transfers, failures, or by a defined schedule based on priority areas. These upgrades could be the replacement of existing cesspools with conventional sewage disposal systems or replacement of existing cesspools and conventional on-site sewage disposal systems with I/A OWTS. The Health Impact Assessment was initiated by USEPA at the end of 2014 and is expected to be completed during 2015.

NYS Title 10. Department of Health Chapter II Part 75 Appendix 75-A are the wastewater treatment standards for residential onsite systems which were revised in 2010 to include information about enhanced treatment units and responsible management entities (RME). The definition of RME in appendix 75A includes a similar definition to the EPA definition as stated in section 8.3 but also includes a requirement of financing long-term O&M of systems as stated below:

"Responsible Management Entity (RME) - a legal entity with the requisite managerial, financial and technical capacity to ensure long-term management of residential wastewater treatment systems. RMEs may include: sewer districts, utilities, municipal authorities or other entities with the authority to enforce and the capacity to finance the long-term operation and maintenance requirements necessary to ensure residential wastewater treatment systems are functioning properly."

Other amendments to the code would have to address formation of the RME and enforcement powers. In addition the construction standards would have to be updated to address I/A OWTS such as a permitting process to allow a system to be installed in Suffolk County and minimum construction standards. This could be accomplished by amending the current standards or by issuing a new construction standard solely for I/A OWTS.

Appendix 75A and the updated companion to the appendix the "Residential Onsite Wastewater Treatment Handbook" issued 2012 provides standards on the installation of I/A OWTS and management of these systems. The Enhanced Treatment units identified in the Appendix and Handbook are generally systems capable of reducing BOD and suspended solids in wastewater, but these types of systems are similar in design to systems capable of reducing nitrogen. For example, the Orenco Advantex systems have three operating modes with the only variation difference in recirculation configurations. By modifying the recirculation they can increase nitrogen reduction.

The Suffolk County Sanitary Code defines the requirements for sewage and water supplies within Suffolk County. The Residential and Commercial construction standards state the sewage disposal systems permitted to be used in Suffolk County. As stated in section 8.3.3.1, both the Sanitary Code and Construction Standards would need to be amended to permit the use and evaluation I/A OWTS technologies, define the functions and powers of the RME and SCDHS, define when systems are required to be certified and upgraded or repaired. These Codes and Standards can be revised using Appendix 75A along with the "Residential Onsite Wastewater Treatment Handbook" and as stated in 8.3.3.1 Macomb County, Michigan "Regulations

Governing On-Site Sewage Disposal and On-site Water Supply System Evaluation and Maintenance" and Massachusetts Tile 5 Septic System Regulations among other jurisdictions regulations, codes, and standards.

With the concern for emerging contaminants and rising sea levels the construction standards should provide provisions for use of new technologies for treatment of emerging contaminants if determined to be required. In addition, the standards should address rising sea/groundwater level by providing increased separation between the bottom of leaching structures and groundwater and permitting the use of and outlining the requirements of alternate leaching systems such as pressure dosing shallow narrow drain fields.

SCDHS is currently working on updating the residential construction standards to permit the use of an I/A OWTS and in the future the Sanitary Code and commercial construction standards will be revised. These standards will permit the use of I/A OWTS, expedite the installations by requiring I/A OWTS for new construction, modifications to existing structures (e.g. addition of bedrooms), and system evaluations at the time of property transfer, ensure the systems are properly operated and maintained to meet total nitrogen requirements, address contaminants of emerging concern, and rising sea/groundwater levels which are all required to implement the wastewater management plan.

8.4.1.3 Creation and Functions of a Responsible Management Entity to Oversee Funding, Operation, and Maintenance of an I/A OWTS Program

After an I/A OWTS or a decentralized STP is installed, the County must be assured that the system is functioning properly to meet total nitrogen discharge limits to meet nitrogen load targets. These systems require operations and maintenance (O&M) contracts to ensure they are functioning properly and meeting discharge limits. Most of these types of systems have mechanical components that are susceptible to failure, which could eliminate the ability of a system to meet discharge limits or could cause an overflow condition creating a public health hazard. Larger systems (other than single-family dwellings) such as decentralized STPs require daily routine O&M due to the high volume of wastewater being treated. I/A OWTS, on the other hand, require minimum O&M.

A means must be in place to ensure O&M is being completed in order for systems to meet discharge limits. The oversight of these systems is usually accomplished by a Responsible Management Entity. As discussed in the recommendations sections the preferred RME would follow the EPA's Management Model 4 where the RME is responsible for operation and maintenance. Permitting and construction oversight would still fall within the SCDHS jurisdiction if the RME was an entity independent of the SCDHS.

In addition the RME's responsibilities in Suffolk County would be to provide educational outreach to homeowners, contractors, and design professionals and provide financing options for property owners to permit them to install or repair an I/A OWTS or decentralized STPs in an affordable manner, oversee the operation and maintenance of I/A OWTS and privately owned decentralized STPs.

As soon as the SCDHS updates/amends the Suffolk County Sanitary Code and Construction Standards to permit the use of I/A OWTS, without the need for a variance, and before the creation of the wastewater management plan the SCDHS Office of Wastewater Management should assume the role of temporary RME. After financing options are established for property owners for upgrades and repairs of I/A OWTS, which would be issued by the RME and the wastewater management plan is completed then a public entity or new branch of SCDHS should be established to operate as the RME as determined by the County. One idea outlined in the Suffolk County IBM Smarter Cities report entailed the County consolidating water and wastewater management processes through the integration with the Suffolk County Water Authority, but the legality of instituting the combined water and wastewater through the SCWA would have to be determined. In addition, funding of the RME would have to be provided.

One advantage of establishing the RME as part of the SCDHS is the RME can utilize the existing staff and enforcement powers to regulate I/A OWTS such as issuing violations to property owners who are not maintaining O&M contracts or failing to repair an I/A OWTS. In addition, all of the components of a I/A OWTS program would be under one roof including permitting, evaluation of new technologies, funding of systems, tracking and enforcement, rather than as splitting the duties between the SCDHS and a public entity RME. If the RME was to be part of the SCDHS then funding would be assumed through the County's General Fund or by other means, but if the RME was a public entity then a type of usage fee would likely have to be created under the guidance of the County. One example of a fee issued by Maryland that could be used as a financing means of a SCDHS RME or public entity RME, Maryland created the Bay Restoration Fund (BRF) fee where 60% of the BRF goes to onsite sanitary system and wastewater treatment plant upgrades. The BRF fee assigned to the property tax the fee is $60 per household. Eight percent of the 60% BRF funds used for onsite sanitary system upgrades funds the Maryland Department of the Environment overhead cost to implement the I/A OWTS program such as:

- Review and approval of the design and construction of upgrades,
- Issue loans as the provider,
- Implement an education, outreach, and upgrade program to advise owners of onsite sewage disposal systems on the proper O&M of the system
- Provide technical support to owners of upgraded onsite sewage disposal systems to operate and maintain the upgraded system.

If Suffolk County was to institute a similar fee such as a wastewater discharge fee at $60 per household with private sewage disposal per year (or $5.00 per month) then $21.6 million ($60 per household x 360,000 households) would be collected and 8 percent or $1.73 million would be used to fund the SCDHS RME operation while the remaining $19.87 million could be used for onsite sewage disposal system upgrades in the form of grants.

As part of the RME establishment the County must implement a computer based tracking system such as Barnstable County, MA Carmody system.[15] This would allow the RME to track when I/A OWTS contracts have expired, when the system was pumped out, and when repairs were performed. In addition, sampling data for each system could be entered on the system for performance tracking purposes and could be used as part of a possible data sharing agreement with other jurisdictions utilizing I/A OWTS.

The creation of an RME is estimated to be complete in the third quarter of 2015, which is one of the components to allow the installation of I/A OWTS. In addition, the RME would help to implement the wastewater management plan to ensure water quality goals are being met through proper installation and operation of I/A OWTS and decentralized STPs.

8.4.1.4 Permitting and Evaluation of Innovative/Alternative Onsite Wastewater Treatment Systems for Use in Suffolk County

The main requirement of I/A OWTS is to reduce total nitrogen discharge to the environment. There are many proprietary and non-proprietary systems on the market that claim to reduce nitrogen. Suffolk County is in the process of establishing a means of evaluating I/A OWTS to gain confidence that the systems permitted for use in Suffolk County will provide adequate nitrogen reduction to improve water resources. Suffolk County has developed a tentative process for obtaining approval to install an I/A OWTS, which mirrors the Massachusetts Title V standards. The process for obtaining approval would be similar to the following steps:

1) A manufacturer would submit design specifications and sampling data to SCDHS for review. SCDHS will review the information and if found acceptable will permit the I/A OWTS to be installed as a pilot system.
2) Pilot System – A minimum of five pilot systems would be required to be installed and sampled bi-monthly for a period of 18-months (maximum 15 systems permitted to be installed during the pilot phase). The sampling and operational performance of the pilot systems will be evaluated by SCDHS. Piloting is considered successful if a minimum of 75% meet total nitrogen removal targets for 12 months. If determined acceptable then the system would be granted provisional approval.
3) Provisional Approval – Under provisional approval, 50 I/A OWTS must be installed and sampled for a minimum of 36-months. Again, SCDHS will review the sample results and operation performance. Provisional Use is considered successful if at least 90% of the systems perform properly. If determined acceptable then the system would be granted general use approval.
4) General Use Approval – Systems certified for General Use should maintain the approval as long as there are no significant environmental or public health concerns (e.g., recurring overflows/failures or odor nuisances that can't be abated with proper operation and maintenance).

Table 8-24 Example Standard I/A OWTS Approval Process

Standard Innovative Alternative Onsite Wastewater Treatment Systems Approval Process			
	Pilot Systems	**Provisional Approval**	**General Use Approval**
Number of Systems Required	5 to 15	50	50+
Months of Sampling	0 to 18	36	n/a

Suffolk County has initiated a demonstration project to be used to evaluate I/A OWTS where manufactures pay for the cost of installation of their system. A total of four manufacturers have committed to installing 19 total systems for evaluation and educational purposes. By participating in the demonstration project these manufacturers will be able to fast-track the approval process in Suffolk County as depicted in **Table 8-25** in section 8.3 and **Figure 8-29**. It is anticipated that future demonstration projects will be held to permit the same fast-track privileges to other manufacturers.

Table 8-25 Example Demonstration Project I/A OWTS Approval Process

Approval Process for Innovative Alternative Onsite Wastewater Treatment Systems Installed As Part Of The Demonstration Project W/ NSF 245 Certification or ETV Certification			
	Pilot Systems	**Provisional Approval**	**General Use Approval**
Number of Systems Required	1 to 5	50	50+
Months of Sampling	0 to 6	24	n/a

In order to increase the number of types of I/A OWTS permitted for approval in Suffolk County, the County should consider participating in an I/A OWTS data-sharing program between jurisdictions. One such data-sharing program under development is the Chesapeake Bay states data-sharing program for I/A OWTS. This program will allow jurisdictions to use data from other states to prove the effectiveness of a system. If Suffolk County joined this data-sharing program with the Chesapeake Bay states or created our other jurisdictions then instead of a manufacturer installing five pilot systems the County could review the systems installed in the Chesapeake Bay States and evaluate the data of the systems. If the data is found to be acceptable then the system could move directly to the provisional approval stage without a manufacturer installing a system within Suffolk County.

A program to evaluate and permit the use of I/A OWTS in Suffolk County would be outline in the Suffolk County Sanitary Code and be implemented by SCDHS or the RME. Evaluating and permitting I/A OWTS for use in Suffolk County is necessary for the creation of the wastewater management plan since the use of these systems will enable communities to meet nitrogen targets outlined in the plan when community sewerage treatment is not available.

8.4.1.5 Funding of Innovative/Alternative Onsite Wastewater Treatment Systems (I/A OWTS)

In 2012 Suffolk County prepared a report titled "Suffolk County Decentralized Wastewater Needs Survey". The report outlined the cost to install or replace conventional sanitary system under three scenarios. The first scenario was a standard site with good soils and no ground water conditions installing a 1,500 gallon septic tank with 8' diameter by 16' deep leaching pool. From **Table 8-26**, the average cost for a standard installation of a new conventional system plus abandonment of the existing sanitary system was $6,880. Additional scenarios were also reviewed such as a site with poor soils, which would yield an average sanitary system replacement cost of $19,346 and the worst-case site scenario with poor soils and high ground yielded an average sanitary system replacement cost of $53,230.[1]

Table 8-26 Average Cost of Installation of a Conventional Sewage Disposal System Consisting of 1,500 gallon septic tank with 8' diameter by 16' deep leaching pool

Contractor	Cost of System	Cost of Abandonment	Total
Al Aparo	$5,739	$900	$6,639
Hampton Drainage	$4,500	$2,000	$4,500
Latham	$5,000	$2,500	$7,500
		Average	$6,880

During the septic tour representatives from Suffolk County obtained estimates for the installation of I/A OWTS treatment systems only. **Table 8-27** depicts the average cost of purchase, installation and O&M for systems approved for use in Maryland. The average cost of these systems is $11,596.[15]

Table 8-27 Average cost of Purchase, Installation and O&M for Systems Approved for Use in Maryland

BAT Approved technologies	Cost of Purchase, Installation and 5 Year O&M	O&M per Year After 5 year Contract
Orenco Advantex AX20	$12,300	$200
Orenco Advantex AX20RT	$12,300	$200
Hoot BNR	$11,954	$150
Norweco Singulair TNT	$11,079	$90.88
Norweco Singulair Green	$11,079	$90.88
Septitech M400 denite	$13,056	$399
Bio-Microbics RetroFAST	$9,405	$300

In New Jersey the average cost of an I/A OWTS with installation and O&M was $18,401 based on the data in **Table 8-28**.[15] Some of the I/A OWTS require a septic tank preceding the treatment unit, which would mean that the total average cost for a standard site to replace their system with an I/A OWTS would be between $18,276 and $25,081. In some cases where septic tanks are not required, such as with the installation of a BUSSE system, the total cost may be reduced.

Table 8-28 Average Cost of Purchase, Installation and O&M for Systems Approved for Use in New Jersey Pinelands

System	Average Treatment System Cost & 5 Year Service Cost	Average Total Cost
Amiphidrome	$19,196	$31,492
Bioclere	$17,654	$31,866
Cromaglass	$22,345	$35,262
FAST	$17,819	$29,633
Bio Barrier	$15,000	N/A
Busse GT	$24,000	N/A
SeptiTech	$16,700	N/A
Hoot ANR	$14,500	N/A

The high costs of I/A OWTS plus the annual O&M cost which can range from as little as $90 year to as high as $1,000 per year places a financial burden on property owners. In order to ease the burden of the installation costs affordable funding options must be established and provided to property owners.[15]

Table 8-29 Average I/A OWTS O&M Costs in Jurisdictions Outside of New York

Septic Tour Jurisdiction Visited	Reported I/A OWTS O&M Contract Yearly Cost
Maryland DEP	$90 to $399
NJ Pinelands Commission	$600 to $1,000
Rhode Island	Not Provided
Barnstable County, MA	Not Provided

Three funding options implemented in other jurisdictions are low interest loans, grants for I/A OWTS treatment unit, and tax incentives. Most jurisdictions obtaining funding to issue loans obtain a loan from the State Revolving fund then use the money to issue low interest loans to property owners. Rhode Island is an example of a state using revolving funds to issue low interest loans for onsite sewage disposal system upgrades or repairs. The Rhode Island Clean Water Finance Agency issues loans to the local communities (Counties, Towns, and Villages) at 0 % interest. The local communities then issue loans to property owners at 2% for 10 years ($25,000 max) to repair or upgrade existing onsite sewage disposal systems.

The New York State Environmental Facilities Corporation (NYSEFC) works with the NYSDEC to issue low-cost financing through the States Clean Water

State Revolving Fund (CWSRF). Interest rates can be as low as zero percent. Suffolk County can apply for financing from the CWSRF as a nonpoint source pollution project which permits funding for decentralized wastewater treatment systems to replace deficient or failing on site systems, including costs for new or replacement septic systems. Environmentally innovative projects that demonstrate new and/or innovative approaches to delivering services or managing water resources. The wastewater management plan is a project that would prioritize areas for upgrades of existing onsite sanitary system to I/A OWTS to reduce nonpoint source nitrogen pollution to surface waters and drinking water supplies. CWSRF loan money can then be used by the RME to provide affordable financing to property owners to upgrade their onsite sewage disposal systems to an I/A OWTS to improve water resources.[34]

Example payment of a I/A OWTS if Suffolk County issues a low interest loan to cover the entire cost of the system installation at a 2% and 1% annual interest rate for 10, 20 and 30 year terms (Interest rates based on RI and MA loan program rates) are summarized on **Table 8-30**.[15]

Table 8-30 Example Monthly Financed Payments for the Installation of an I/A OWTS

I/A OWTS Payment for 1% and 2% annual interest rate for 10, 20 and 30 year terms (Cost Includes Septic Tank, Advanced Treatment Unit, and Leaching product, installation & O&M Cost)				
Interest Rate	**Average Amount Financed (Min and Max Standard System Cost)**	**10 years (Monthly payment)**	**20 years (Monthly payment)**	**30 years (Monthly payment)**
1%	$18,276	$160.09	$84.04	$58.78
	$25,081	$219.71	$115.34	$80.67
2%	$18,276	$168.76	$92.46	$67.55
	$25,081	$230.78	$126.88	$92.70

The second funding option is for the Suffolk County to provide grant opportunities to homeowners to fund upgrade of their onsite sewage disposal system. As previously stated in section 8.4.1.2 Suffolk County could create a fund similar to Maryland's BRF where the fees collected for the fund would be used to finance the RME and provide grants to homeowners for the cost of the I/A OWTS treatment unit and installation. If Suffolk County created a wastewater discharge fee at $60 per household with private sewage disposal per year (or $5.00 per month) then $21.6 million ($60 per household x 360,000 households) would be collected and 8% or $1.73 million would be used to fund the SCDHS RME operation while the remaining $19.87 million could be used for onsite sewage disposal system upgrades in the form of grants. This grant would pay for approximately 1700 to 1100 I/A OWTS treatment units per year based on the average treatment unit costs from Maryland and the New Jersey Pinelands Commission. This would amount to a total nitrogen reduction in Suffolk County of 52 to 81 lbs./day for every 1100 to 1700 systems upgrade by the grants (assumes 300 gpd per system based on SCDHS standards and effluent total nitrogen of 19 mg/l).

A third funding option would be to provide tax incentives to property owners in priority areas who upgrade their onsite sewage disposal system to an I/A OWTS system. The State of Massachusetts offers a tax credit for 40% for repair or replacement of failed cesspools or septic systems up to $6000, spread over 4 years at $1500 per year. Suffolk County would have to investigate the feasibility of implementing a tax credit.

In addition to the above, Suffolk County can offer combinations of the three funding options such as low interest loans combined with grants. The grant could pay for the treatment unit and the loan would be used to finance the septic tank and leaching components, which would reduce a 10-year payment to $101.58 to $161.19 at an interest rate of 1% and $106.70 to $169.31 at 2% interest rate.

If Suffolk County can identify funding sources for the installation of I/A OWTS implementation of the wastewater management plan will occur at a faster rate than if no financing options were provided. In addition, the residents of Suffolk County will see an expedited improvement in water resources as well as a reduced financial burden when installing an I/A OWTS.

8.4.1.6 Decentralized Sewage Treatment Plant Systems

Suffolk County has a number of operating decentralized sewage treatment plants systems serving one or more tax parcels. Most of the decentralized sewage treatment plant systems (non-municipal) were created during the initial phases of development of a subdivision, apartment building, condominium or townhouse development, and industrial/commercial building to permit the project to exceed the Article 6 of the Suffolk County Sanitary Code density requirements. Decentralized sewage treatment plants are required to produce maximum effluent nitrogen of 10 mg/l. The creation of decentralized sewage treatment systems is easy to establish before a site is developed since a developer incorporates the cost of sewering into the selling price of a dwelling, condominium, or townhouse and the rent of an apartment, industrial building, or commercial building.

These types of systems will continue to be implemented by developers for new projects and reviewed and approved by the SCDHS and SCDPW. Monitoring and enforcement operation and maintenance of these systems will continue to be controlled by the SCDHS unless transferred to a RME.

The use of decentralized sewage treatment plant systems is another means of sewering existing developed areas. For these cases, property owners would have to join together to sewer multiple lots. In some cases the cost to construct and installation of a cluster decentralized treatment system has been estimated to be less than a centralized treatment system. One example is depicted in the engineering report prepared by Applied Water Management, dated December 2013, prepared for Peconic Green Growth for a proposed decentralized system to serve West Mattituck.[35] The proposed nitrogen load per day would be reduced from 58.35 pounds/day (lb./day) to 10.4 lb./day. The proposed collection system was recommended to be a combination of gravity and low-pressure sewers. The estimated project cost was stated to be approximately $10.6 million.

The proposal is to sewer 365 single-family dwellings, 36 future single-family dwellings, and a couple of commercial structures with a total design flow of 124,100 gpd. These types of systems would still require approval of the Suffolk County Sewer Agency and a Sewer Agency Contract must be put in place with provisions for the County to take over the plant under certain circumstances. The major roadblocks are organizing homeowners to participate in forming the decentralized system and the cost. If Suffolk County or a local municipality were to organize a small community plus provide funding to construct and install the system then the homeowners could possibly form a type of owners association, which would own and operate the plant possibly reducing costs. Further evaluation of this concept would have to be completed to determine if it would be feasible, economically viable, and could be legally accomplished. If found to be an acceptable and affordable means of sewering then it would help the implementation of the wastewater management plan and oversight of the new decentralized sewer district owned by the association would fall under the oversight of the SCDHS or RME.

8.4.1.7 Public Sewer District Expansions and/or Creation in Identified Priority Areas (Centralized/Municipal)

SCDPW has begun the initial phases of expanding sewers and STP capacity. Suffolk County has recently evaluated the feasibility of sewering various areas throughout Suffolk County through the implementation of the Suffolk County Sewer District/Wastewater Treatment Task Force established by the Suffolk County Legislature to examine Suffolk's existing wastewater treatment facilities, educate the public as to the environmental and economic benefits of wastewater treatment facilities, and seek out public and private resources of funds to expand Suffolk County's wastewater treatment facilities to suitable areas in the County.

The areas studied or in the process of being studied are Bellport-North Bellport, Deer Park-North Babylon-Wyandanch, Flanders Riverside Corridor, Lake Ronkonkoma Hub, Mastic-Shirley, NY 25 Corridor, Sayville, Southampton Village, and Yaphank. The expansion of sewers into the areas studied has the ability to reduce the nitrogen load to area water resources and improve the local economy in each area. The feasibility studies established costs and anticipated implementation schedules. Due to the high property owner costs associated with the extension of sewers in these areas it was determined that grant funding would be required to extend sewers and remove the financial burden from residential property owners.

One grant was recently received by Suffolk County in the amount of $383 million to extend sewers to portions of the Babylon-Wyandanch study area, Mastic-Shirley Study Area, Great River, and the Village of Patchogue. This will reduce nitrogen loads by eliminating existing onsite sewage disposal systems, which will reduce the nitrogen load to the Great South Bay to improve coast resiliency. In addition, abandonment of onsite sewage disposal systems and connection to sewers in shoreline areas will eliminate the impacts of sea and groundwater level rise to onsite sewage disposal systems. Suffolk County must continue to conduct sewer feasibility studies in identified priority areas and seek additional funding sources to implement the results of the sewer feasibility studies to reduce wastewater nitrogen to improve water resources and local economies. Based on the feasibility studies and study to identify treatment based on a parcel-by-parcel basis (as identified in section 8.4.1.1) Suffolk County can prioritize areas to be sewered. The information is useful in the preparation of a wastewater management plan.

8.4.1.7.1 Improved Sewage Treatment Plant Technologies

SCDPW and SCDHS have both been exploring and permitting the use of improved sewage treatment technologies such as the MBR process. SCDPW and SCDHS will continue to explore new technologies to improve wastewater treatment plant to further reduce nitrogen and emerging contaminates. Pilot programs at existing SCDPW plants are essential to determine if technologies meet claims and would be eligible for implementation in Suffolk County. Technologies can range from full-scale treatment processes to minor process improvement equipment such as pumps, aeration blowers, effluent filters, UV systems, odor control systems, monitoring equipment, etc.

SCDPW and SCDHS should implement water reuse programs such as the Town of Riverhead program where highly polished effluent produced through the use of MBR and UV technology will be used to irrigate a neighboring golf course. Similar opportunities exist at the SCDPW Bergen Point STP with modifications to use effluent to irrigate the Bergen Point Golf Course and the SCDPW Wind Watch STP with modifications to irrigate the Hamlet Wind Watch Golf & Country Club.

In addition SCDPW has been actively upgrading existing STPs to replace existing aging STPs, improve processes, and increase treatment plant capacity. Some of these treatment plants were discussed in section 8.3.5. These improvements are essential to providing the capacity to extend sewers to unsewered lots and reducing wastewater nitrogen. SCDHS has also been actively requiring owners of private decentralized STPs to upgrade their secondary treatment plant process or aging tertiary treatment process to improved tertiary treatment process to provide improved nitrogen reduction resulting in an 2013 overall wastewater effluent nitrogen average in Suffolk County of 8.7 mg/l which is less than the requirement of 10 mg/l.

Improved sewage treatment plant technologies help Suffolk County meet our water quality goals as part of the wastewater management plan. As an example MBR technology, was proposed as part of some of the sewer feasibility studies where STPs were required due their ability to meet effluent total nitrogen between 3 to 5 mg/l when properly operated.

8.4.1.7.2 Evaluation of Existing Capacity of Scavenger Plants to Process Waste from On-site Sanitary Systems Based on a Defined Pump-out Schedule

Suffolk County has three scavenger plants in operation 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. As for onsite sewage disposal systems, property owners usually have them pumped only when they start to backup 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. If this occurs in an I/A OWTS it would mean the 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 a pump-out schedule be created by the SCDHS to insure I/A OWTS are functioning properly. 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". Most I/A OWTS systems have septic tanks preceding the system, which should be pumped out routinely to ensure system performance. Therefore the existing capacity of the scavenger plants would have to be evaluated by Suffolk County compared to the required pumping needs of the existing and proposed wastewater treatment plants and future pumping needs of I/A OWTS. Currently the existing overall treatment capacity of the three scavenger plants is 1.46 MGD (See **Table 8-31**). The evaluation of scavenger plant capacity is crucial to the wastewater management plan to ensure I/A OWTS can be properly pumped to maintained effluent nitrogen requirements and that the sludge removed from the system can be properly treated in Suffolk County.

Table 8-31 Suffolk County Scavenger Plant Capacities

Scavenger Plant	Capacity (MGD)
SCDPW Bergen Point	0.5
Town of Huntington	0.86
Town of Riverhead	0.1

8.4.1.8 Follow-Up Studies and Programs to Monitor Wastewater Management Plan Progress

When implementing the wastewater management plan Suffolk County should establish programs to measure the performance of the wastewater management plan to improve water resources.

One program would be to measure coastal eel grass which is considered a true seagrass. Eelgrass is important for coastal resiliency because it slows currents and reduces wave forces, and rhizome/root mats stabilize the sea floor by trapping sediments, preventing sediments from shifting or becoming resuspended, helping to reduce the erosion on our shorelines. The NYS Seagrass Task Force estimated that statewide, New York had 21,803 acres of seagrass in 2002 of which 92% were in the South Shore Estuary (which comprises the Great South Bay). **Figures 8-58**, **8-59**, and **8-60** compare South Shore coastal vegetation from 2030 to 2012. It is estimated that in 1930 there were approximately 200,000 acres of seagrass. According to the NYS Seagrass Task Force, "research has shown that elevated nitrogen concentrations not only affect seagrass through light reduction, but also may be toxic to eelgrass."[36]

One of the goals to improve water resources is to improve coast resiliency during storm surges and by reducing nitrogen loads eel grass coverage is expected to increase. Therefore, Suffolk County should measure Suffolk County's seagrass to evaluate the effectiveness of the wastewater management plan (exampled of a measurement schedule could be every 3 years, 5 years, etc.).

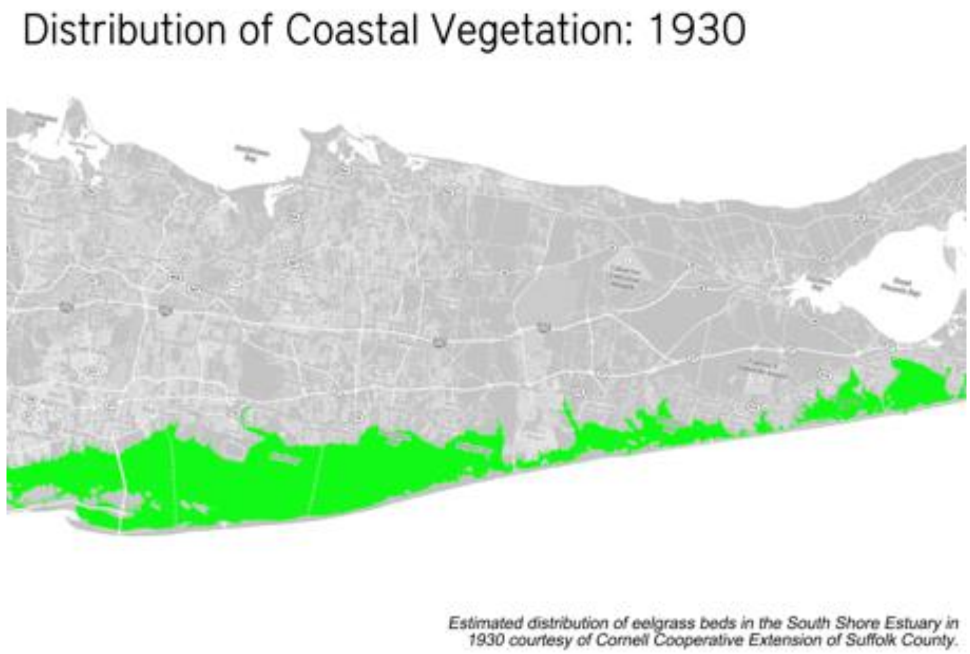


Figure 8-58 Distribution of South Shore Coastal Vegetation 1930

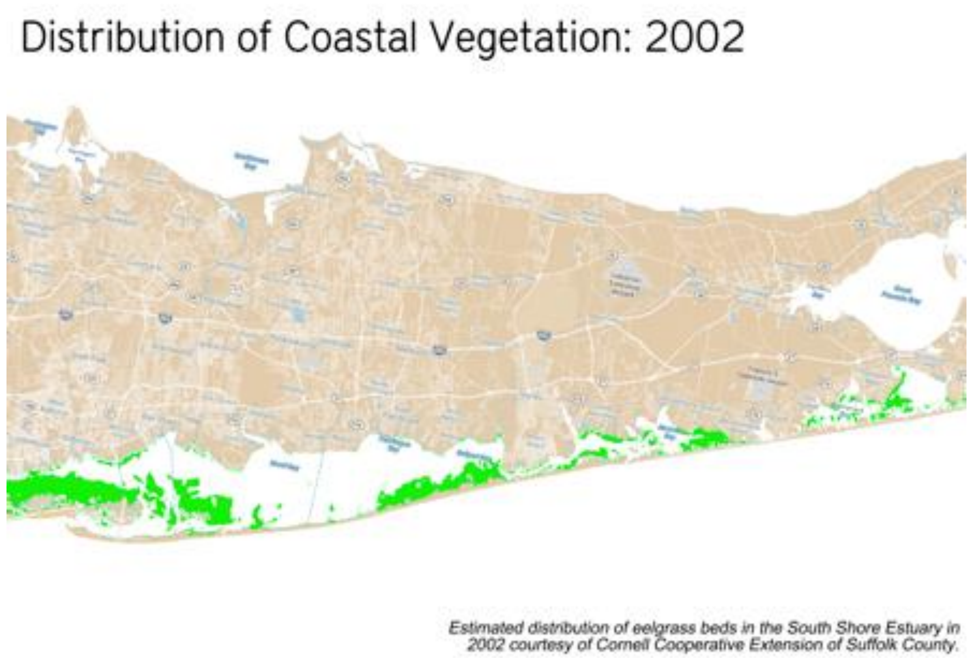


Figure 8-59 Distribution of South Shore Coastal Vegetation 2002

Figure 8-60 Distribution of South Shore Coastal Vegetation 2012

Another means of evaluating the effectiveness of the wastewater management plan to reduce effluent nitrogen contributing to the degradation of our water resources is to establish a monitoring well network where nitrates are measure to determine if they are being reduced as a result of sanitary wastewater treatment.

In addition there may be other programs such as measuring dissolved oxygen in fresh water supplies or nitrogen levels. These programs along with statistics of number of systems upgraded to I/A OWTS, number of systems connected to community systems, O&M tracking (includes sampling and O&M), STP sample results, etc. would be used to evaluate the effectiveness of the program and determine any required revisions to the program. This evaluation should be performed based on an established schedule determined by Suffolk County.

8.4.2 Responsible Management Entity

As previously described, the RME to oversee the O&M, educational outreach, and funding of I/A OWTS and O&M of decentralized treatment systems can be a public utility or preferably an arm of the SCDHS. A crucial component of the RME required to oversee I/A OWTS would be a database tracking system, which must be implemented at the time of establishment of the RME. This system would enable the RME to track installed systems, sampling of installed systems, maintenance such as O&M scheduled maintenance, repairs, and pump-outs, and O&M contracts.

The RME would need enforcement powers through amendments to the Suffolk County Sanitary Code to allow the RME to fine property owners for not maintaining O&M contracts, failing to make repairs, or failing to operate the system to meet effluent nitrogen requirements. Essentially SCDHS currently performs this function with STPs. The SCDHS Office of Wastewater Management (WWM) monitors all STPs within Suffolk County ensuring O&M contracts are maintained, inspecting the STPs to ensure they are functioning properly and being properly maintained, and monitoring effluent sampling to ensure permitted effluent parameters are met. If O&M contracts are not maintained, STPs are underperforming, or maintenance is not being completed WWM will issue violations with monetary fines and require a corrective action plan. The creation of a SCDHS RME with an updated tracking system would expand on the STP program to include I/A OWTS and the ability to provide funding for I/A OWTS installations for upgrades or repairs.

Education and outreach would be another function of the RME, which would include educational programs for property owners, design professionals, and contractors. Property owner educational programs would consist of pamphlets, website information, and seminars outlining why improved wastewater treatment such as I/A OWTS are required to improve water resources, funding sources and requirements to obtain funding sources for property owners to upgrade or repair I/A OWTS or conventional septic systems, system O&M, O&M contract requirements, basic do's and don'ts for I/A OWTS or conventional septic systems, etc.

Contractors and design professionals would be offered classes teaching SCDHS application requirements for installation of I/A OWTS, required information to be included on site plans for approval of installation of an I/A OWTS, installation requirements, inspection requirements, and O&M requirements. SCDHS already provides occasional classes to design professionals, contractors, and developers regarding application requirements. These classes would have to be expanded to include the new topics identified above.

Through the Office of Consumer Affairs, the RME should provide special license requirements for contractors who install and maintain I/A OWTS. As with most licensed professionals, contractors should be required to take certification credits to maintain their special license to install and maintain I/A OWTS. Classes could be similar to the classes provided by the New England Onsite Wastewater Training Program located at the University of Rhode Island, but should be provided locally by the SCDHS or SUNY Stony Brook.

8.4.3 Property Owners

Property owners play a crucial role in the implementation of a wastewater management plan. Existing property owners connected to sewers and property owners who have the privilege of abandoning their onsite sewage disposal system and can connect to gravity sewers will be the least impacted due to the least amount of O&M required. Property owners connecting to a low-pressure system are required to operate and maintain their low pressure pump station. The property owners who will be most impacted will be homeowners who install I/A OWTS. Even though property owners many not visually see their system they must take precaution to ensure proper operation of the system.

Each manufacturer of an I/A OWTS outline do's and don'ts in the homeowner's manuals. Orenco is one of the manufacturers participating in the Suffolk County Demonstration project. Orenco has a homeowner's manuals posted on their website. The manual describes the things a homeowner must do to help ensure a long life and minimal maintenance. The general rule for Orenco is:[21]

"Nothing should be disposed into any wastewater system that hasn't first been ingested, other than toilet tissue, mild detergents, and wash water."

Their manual outlines chemicals/products that should not be flushed down drains such as chemicals (e.g., pharmaceuticals, cleaners, cesspool additives, etc.) that could impact the treatment process or materials that may damage or clog equipment in the system.

Homeowners must be educated to understand how wastewater impacts ground and surface waters, the importance of these water resources to the community, and how wastewater technologies can protect these resources.

The major responsibilities of homeowners with a low pressure pump station or I/A OWTS are to obey the rules outlined in their homeowner's manual to preserve the life of the system. Other responsibilities of property owners with I/A OWTS are maintaining O&M contracts, pumping their system when required, and making required repairs to ensure proper treatment of wastewater to protect and improve water quality. Failure to maintain the system can lead to replacement of system parts or the entire system.

Property owners should take advantage of any funding resources provided by the RME or Suffolk County, if available, for upgrading or repairing onsite sewage disposal systems to ease the financial burden of installing an I/A OWTS.

Participation of property owners is crucial to the wastewater management plan because failure to maintain and follow the homeowner's manual may lead to premature failure of the system or failure of the system to properly treat wastewater to meet the wastewater management plan nitrogen targets established to protect and improve water resources.

8.4.4 Contractors and Design Professionals

Contractors and design professionals (Engineers and Architects) in Suffolk County will be required to obtain the proper knowledge to design, operate, maintain and install I/A OWTS. Unfortunately since I/A OWTS will be a new program there will be a learning curve for contractors and design professionals. They must take full advantage of educational resources provided by SCDHS and the RME.

Licensed design professionals are required to obtain continuing education credits to maintain their licenses. SCDHS and/or the RME should gain certification from the State of New York Office of Professions allowing license credits to be issued for classes held on I/A OWTS. In addition, Suffolk County Consumer Affairs should establish a new license for contractors who install and maintain I/A OWTS to protect property owners from contractors who falsely advertise their I/A OWTS installation and O&M experience. Since I/A OWTS technology changes periodically, contractors of I/A OWTS should also be required to obtain continuing education credits.

Design professionals will be required to prepare plans for the installation of an I/A OWTS, certification of construction, and certifications of existing systems during property transfers. Contractors will be responsible for the installation, repairs, pumping, and O&M of I/A OWTS.

Contractors and design professionals are important part of the wastewater management plan because they will provide design of the system, install the system, and maintain the I/A OWTS to ensure effluent wastewater will meet total nitrogen limits to improve water resources.

8.4.5 Summary

In Suffolk County, wastewater is one of the major contributors of nitrogen to the environment, which assists in the degradation of water quality. It is estimated that 69% of the nitrogen comes from onsite sewage disposal systems. This is mainly due to only 26% of Suffolk County being connected to a community sewage disposal system of which most are capable of reducing nitrogen or discharging directly to the Atlantic Ocean. The remaining 74% of the County utilize onsite sewage disposal systems to meet their sewage disposal needs. On average nitrate concentrations of community supply wells that existed in 1987 and community supply wells that have existed in 2013 have increased by approximately 1 mg/l in both the upper glacial and Magothy aquifers.

Suffolk County contains the highest density of onsite septic systems within the tri-state area with approximately 360,000 homes currently utilizing onsite sewage disposal systems. Of particular concern are the onsite septic systems located in the groundwater contributing areas of drinking water wells and estuarine surface waters. The Suffolk County Department of Economic Development and Planning has identified that approximately 209,000 of these homes with onsite sewage disposal systems are located in areas considered to be high priority areas.

Suffolk County must maintain a balance between protecting water resources and maintaining the ability to dispose of wastewater to protect public health and stimulate development in order to promote economic growth and stability. This will be accomplished by the implementation of a responsible wastewater management plan to limit the impacts of nitrogen from wastewater and emerging wastewater constituents of concern on the County's water resources to preserve and protect these resources for future generations.

The implementation and creation of a wastewater management plan requires setting nitrogen load reduction targets and/or ambient water quality nitrogen concentration targets to meet water quality goals. In addition, the plan shall identifying the means of sewage disposal on a parcel-by parcel basis to meet the nitrogen reduction targets (treatment options – connection to STP to meet wastewater effluent total nitrogen (TN) of < 10mg/l, or installation of an I/A OWTS to meet TN <19 mg/l, or installation of a conventional system to meet TN>19 mg/l). To meet the nitrogen reduction requirements and permit I/A OWTS to be installed in areas where sewers are not available, the current Suffolk County Sanitary Code and SCDHS Onsite Sewage Disposal System Construction Standards must be revised. These codes and standards will be revised to include the formation of an RME to oversee I/A OWTS and decentralized privately owned STP's, permit the installation of I/A OWTS, provide standard construction requirements for I/A OWTS, require property owners to certify their system at the time of transfer if feasible, etc. The RME, established per the revised Sanitary Code, shall provide funding sources for the upgrading and/or repairs of I/A OWTS, education and outreach, performance tracking, and Operation and Maintenance tracking. Education and outreach performed by the RME will target contractors, design professionals, and property owners. The wastewater management plan shall define when sewers should be extended in lieu of installation of onsite sewage disposal systems. Suffolk County shall continue to perform studies to extend sewers within Suffolk County and obtain funding to extend sewers. These items plus the additional topics discussed in this report shall be the basis for establishing a responsible wastewater management plan to improve and protect Suffolk County's valuable water resources for the future population.

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