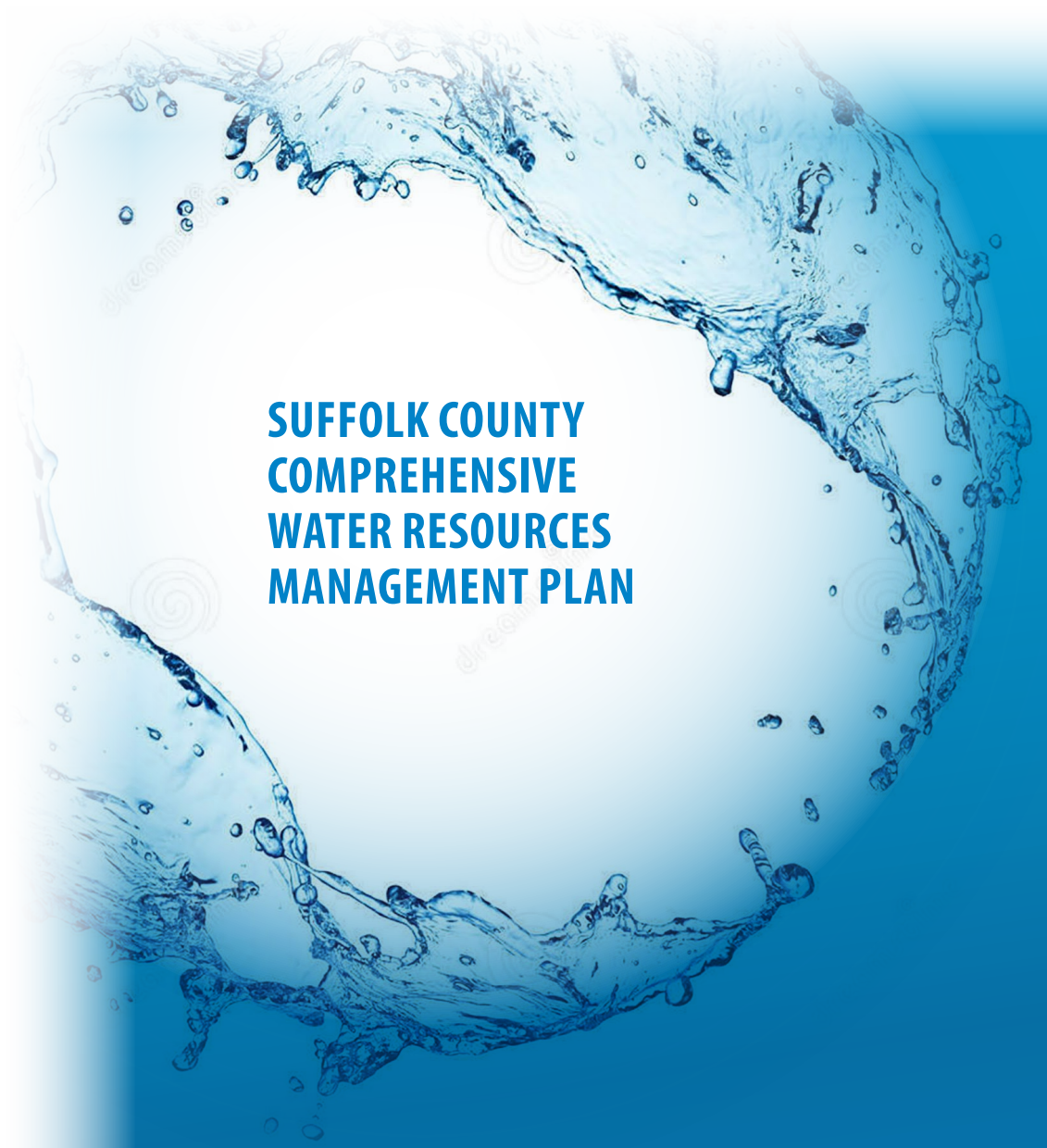


SUFFOLK COUNTY COMPREHENSIVE WATER RESOURCES MANAGEMENT PLAN

Section 3

GROUNDWATER RESOURCES

Source Water Assessments

Recognizing that activities in a water supply's source water area have a significant potential to affect water quality of the potable supply, the New York State Department of Health (NYSDOH) directed the development of Source Water Assessments for all public supply wells in Suffolk County in 2003.

As part of this Plan, updated source water assessments were completed for all community supply wells in Suffolk County. The source water assessments have three major components:

Use of three dimensional groundwater flow and contaminant transport models to delineate the area contributing recharge to each well (source water area), and to estimate the average time of travel from the water table to the well screen;

Use of GIS and extensive databases to identify the prevalence of each contaminant category within the source water area, based upon land uses and the presence of potential point sources of contamination;

Evaluation of the susceptibility of each well to potential contamination, based upon contaminant prevalence, contaminant fate and transport characteristics, and travel time from the water table to the well screen.

A sample source water assessment report for SCWA's Woodchuck Hollow Road is included at the end of this chapter.

Section 3 Groundwater Resources

3.1 Problem Identification

Protection of Suffolk County's groundwater resources has long been of concern in Suffolk County, both because groundwater provides the sole source of potable water supply to County residents, and because it provides baseflow to the County's surface waters. The 1987 Suffolk County Comprehensive Water Resources Management Plan (hereinafter referred to as the **1987 Comp Plan**) provided extensive documentation of the County's aquifer system, groundwater quantity, and groundwater quality that is not repeated here. This section describes how updated information, databases and new tools were used to build upon earlier studies, to enhance the understanding of the aquifer system, to define groundwater quality and quantity issues facing Suffolk County, and to begin to develop the information necessary to help to guide future resource management decisions.

3.1.1 Groundwater Quality

3.1.1.1 Background

Suffolk County's 1.5 million residents live directly on top of the County's water supply. It is not surprising that the impacts of human activities above ground are observed in the groundwater below. Due to the concerted efforts of water resource managers, in general, groundwater quality throughout most of Suffolk County continues to be very good. Potable water supplied by community water systems in Suffolk County meets all drinking water quality standards. However, review of water quality data reveals that concentrations of key contaminants found in groundwater have increased in some areas over the almost three decades since the **1987 Comp Plan** was completed.

Water resource managers have long recognized that land uses and activities occurring above ground can have a direct impact upon groundwater quality, as recharging precipitation can transport dissolved contaminants down through the unsaturated zone to the underlying aquifer. Currently, New York State Department of Environmental Conservation (NYSDEC) has established groundwater quality criteria for over one hundred contaminants, although improved analytical capabilities allow detection of hundreds more, at increasingly lower concentrations.

This study focused on those contaminants of potential concern that have been identified in Suffolk County groundwater. Nitrate has long been identified as

Timeline of Significant Legislation & Regulations

1948: Federal Water Pollution Control Act (Clean Water Act)

1972: Amendments to Clean Water Act
NPDES permit program

1974: Safe Drinking Water Act (SDWA)

1976: National Interim Primary Drinking Water Regulations
2,4-D, coliform bacteria, nitrate, others (total of 22)

1987: Regulation of Phase I VOCs
Benzene, carbon tetrachloride, 1,1,1-TCA, TCE, others

1991: Regulation of Phase II Contaminants
List expands to include aldicarb, atrazine, carbofuran, total nitrate -- nitrite, PCE, others (total of 61)

Lead and Copper Rule

1992: Regulation of Phase V
List expands to include dioxin, PAHs, simazine, others (84 total)

1995: New York State Action Level established for perchlorate at 18 µg/L

1996: Amendments to SDWA
Establishes SWAP

1998: Stage I Disinfection Byproducts Rule

2004: New York State Drinking Water Standard for MTBE established at 10 µg/L

2006: Groundwater Rule

2010: USEPA identifies testing of 134 chemicals as potential endocrine disruptors

the inorganic parameter causing the most widespread concern; increased levels of nitrates resulting from overlying land uses have been documented in Suffolk County for many years. Contamination by volatile organic compounds (VOCs) and pesticides has also previously been identified as a serious threat to groundwater quality (Dvirka and Bartilucci, 1987, CDM, 1998). Since 1987, additional contaminants of concern, such as perchlorate, 1,4-dioxane and pharmaceuticals and personal care products (PPCPs) have also been identified in groundwater.

A wide variety of regulatory programs have been developed and implemented over the years to address potential sources of groundwater contamination and to prevent pollutants from being introduced to the aquifers. The sanitary sewering program that was implemented in southwest Suffolk County and other densely developed parts of Suffolk County has been effective in reducing groundwater contamination from sanitary, commercial, and industrial wastewaters (**Task 1C Report, Groundwater Quality and Monitoring Programs**, Long Island Source Water Assessment Program, CDM, 2003). Sanitary sewers continue to reduce the levels of nitrates, detergents, and other contaminants associated with wastewater from reaching the groundwater in these areas. Discharges from industrial and commercial facilities are regulated, and monitoring and enforcement activities have been implemented to reduce the impacts of VOCs on groundwater supplies. Implementation of land use restrictions and the purchase of large tracts of open space for preservation and groundwater protection have also helped to protect groundwater quality in targeted areas. Regulatory bans and voluntary restrictions on products of concern such as phosphate detergents and certain pesticides have also been effective in reducing the amount of contaminants introduced to the aquifer.

Nevertheless, Suffolk County remains largely unsewered, and contamination of the County's groundwater resource remains a concern, particularly in the unsewered parts of the County. Existing data and tools were used to assess the impacts of various types of development on groundwater quality as described in the following pages. In particular, tools were developed to assess the impacts of proposed developments or changes in land use on nitrate levels, as described in more detail below.

During this study, groundwater quality data collected by Suffolk County Department of Health Services (SCDHS) and the Suffolk County Water Authority (SCWA) was used to characterize current groundwater conditions in the County. Changes in groundwater quality since completion of the **1987 Comp Plan,** as indicated by changes in the concentrations of representative water quality parameters measured at public supply wells, were documented to:

The Long Island Source Water Assessment Program (SWAP) evaluated the susceptibility of public supply wells to nitrate contamination by considering land uses and travel times within each supply well's recharge area. As discussed in the SWAP documentation and in the Task 5.5 memorandum entitled ***Refined Source Water Assessments*** (CDM, 2009), each land use type present in a well's source water area has a different potential to introduce specific contaminants to underlying groundwater. Both high density unsewered residential areas and agricultural areas were considered to have a high potential to release nitrate to the underlying groundwater.

At the time that the source water assessments were developed, SCDHS reported that approximately 75 percent of the County's population relied on on-site sanitary wastewater disposal systems for wastewater management (***Report on the Sewage Treatment Facilities of Suffolk County*, draft, SCDHS, 2006**). Because land uses and wastewater management in Suffolk County have a high potential to introduce nitrate to the groundwater system, and because of the persistence and mobility of nitrates in groundwater, sixty six percent of community supply wells have a high or very high susceptibility to nitrate contamination.

- Assess the impacts of continued development upon groundwater quality;
- Assess the effectiveness of existing groundwater resource protection programs, and
- Identify additional resource management needs.

The relationships between land use and groundwater quality assessments presented in this document are built upon the information developed during earlier studies using:

- More extensive information (the databases available to characterize water quality parameters measured at community, non-community and private supply wells and monitoring wells, land use maps and facility mappings) and
- More powerful tools (Geographic Information System capabilities and calibrated three dimensional groundwater flow and contaminant transport models).

SCDHS developed the assessments presented here to improve the understanding of the relationships between land use and groundwater quality that were presented in the **1987 Comp Plan,** and to develop the information necessary to help to guide future resource management decisions. A summary of these evaluations is presented in the following pages; more detailed information and reference materials are presented in the Task 4, Task 5 and Task 11 memoranda.

3.1.1.2 Contaminants of Concern

This study's assessment of groundwater quality focused upon both those contaminants that have historically been identified as contaminants of concern, and documented in the **1987 Comp Plan**, and contaminants of potential health concern that have been detected during the County's sampling programs. The contaminants evaluated during this study include:

- Nitrate;
- Three of the most commonly detected VOCs Suffolk County groundwater in 1987, 2005 and 2013 (tetrachloroethylene, trichloroethylene and 1,1,1-trichloroethane;
- MTBE;
- Perchlorate;

- Pesticides; and
- Emerging contaminants of concern including PPCPs, 1, 4-dioxane, chlorate and hexavalent chromium.

3.1.1.3 Nitrate

Susceptibility to Nitrate Contamination

The impacts of anthropogenic sources of nitrogen on groundwater quality are much greater than the impact of natural sources of nitrate in the environment, such as precipitation and decaying biological matter. Anthropogenic sources of nitrogen include on-site sanitary wastewater disposal in unsewered areas, sewage treatment plant discharges to groundwater, application of fertilizer to agricultural land, and use of turf care products on lawns and golf courses. Excess nitrogen in the environment can contaminate groundwater and the County's drinking water supplies. In addition, because the groundwater discharges to surface waters, high nitrogen levels can negatively impact marine and fresh water ecological resources by contributing to algal blooms that can reduce dissolved oxygen levels and result in fish kills.

Anthropogenic sources of nitrogen include on-site sanitary wastewater disposal in unsewered areas, sewage treatment plant discharges to groundwater, application of fertilizer to agricultural land, and use of turf care products on lawns and golf courses.

Pre-development nitrate (nitrate as nitrogen, referred to as "nitrate" throughout this Plan) levels in the upper glacial aquifer were less than 1 milligram per liter (mg/L), and pre-development nitrate levels in the deeper Magothy and Lloyd aquifers were less than 0.05 mg/L (**1987 Comp Plan**). In undeveloped areas of the County, nitrate concentrations generally remain less than 1 mg/L, but in densely developed unsewered areas, data shows that nitrate concentrations in groundwater can exceed the 10 mg/L Maximum Contaminant Level (MCL) drinking water standard for nitrate, and in some agricultural areas, nitrate levels in private wells can still exceed 20 mg/L.

Because groundwater discharges to surface waters, high nitrogen levels can negatively impact marine and fresh water resources by contributing to algal blooms that can reduce dissolved oxygen levels and result in fish kills.

Nitrogen contamination resulting from disposal of sanitary wastewater and fertilization (associated with both residential and agricultural land uses) has been studied extensively and documented in the past (e.g., **Long Island Comprehensive Waste Treatment Management Plan,** hereinafter identified as the **208 Plan,** the **1987 Comp Plan,** various research projects at Stony Brook University and Cornell Cooperative Extension).This study used the work presented in the **208 Plan** and the **1987 Comp Plan** as the foundation for updated evaluations, using the more comprehensive databases, Geographic Information Systems (GIS) coverages of historical and contemporary land uses, and three dimensional calibrated groundwater modeling tools that are now available.

Figure 3-1 illustrates the susceptibility ratings for nitrate at community supply wells identified by the updated 2009 source water assessment analyses. Since

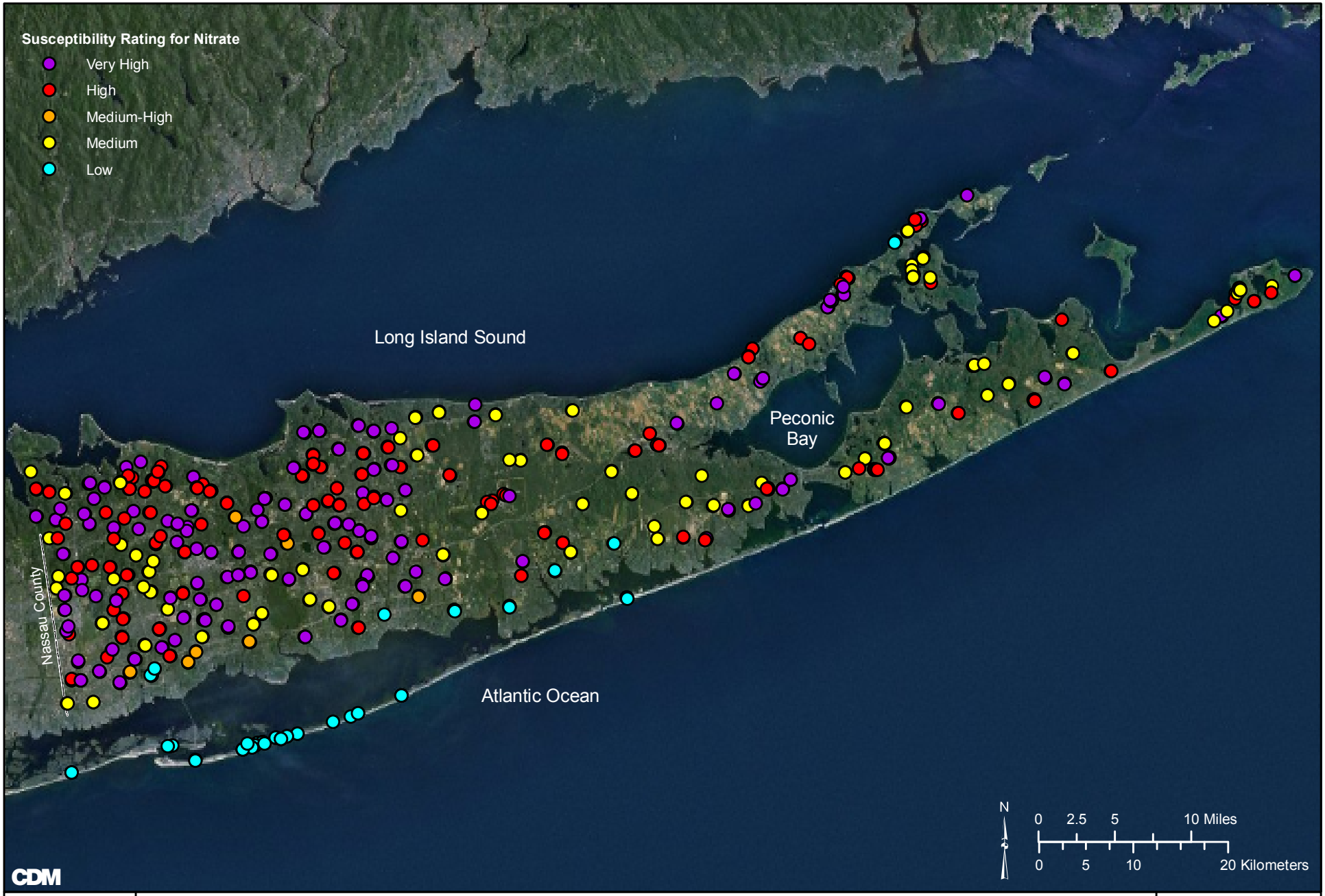
nitrate is a conservative contaminant in groundwater, these ratings are primarily a function of the land uses within the contributing areas (see the Task 5.5 memoranda).

Community supply wells with very high susceptibility to nitrate contamination are scattered throughout the County, including unsewered densely developed areas in the western part of the County, and agricultural areas of the North Fork. The high susceptibility ratings do not imply that the wells will eventually become contaminated by nitrate, as a variety of resource management and pollution prevention programs have been implemented to protect groundwater from nitrate contamination. Nonetheless, the pattern of measured nitrate levels in community supply wells was generally consistent with the susceptibility rating results, summarized on **Figure 3-2**, which shows that nitrate concentrations (as indicated by nitrate measurements from 2000 through 2005 data) are much lower in wells with a medium or low susceptibility rating for nitrate. While the average nitrate concentration for community supply wells with a very high or high susceptibility rating for nitrate was 4.75 mg/L, the average nitrate concentrations in supply wells with medium and low susceptibility ratings were 1 mg/L and 0.1 mg/L, respectively. The susceptibility ratings indicating that the majority of community supply wells are vulnerable to nitrate contamination identify a need for additional groundwater protection measures.

Current Nitrate Levels in Suffolk County Groundwater

To characterize nitrate concentrations in each of the County's three aquifers, data from SCDHS's community and non-community well databases were used, because they provide consistent long term records of water quality at the same depths and geographic locations from year to year. This data was supplemented by data that SCDHS collected from private wells from 1997 through 2013 and from monitoring wells installed during focused investigations of the impacts of land uses such as agriculture and golf courses.

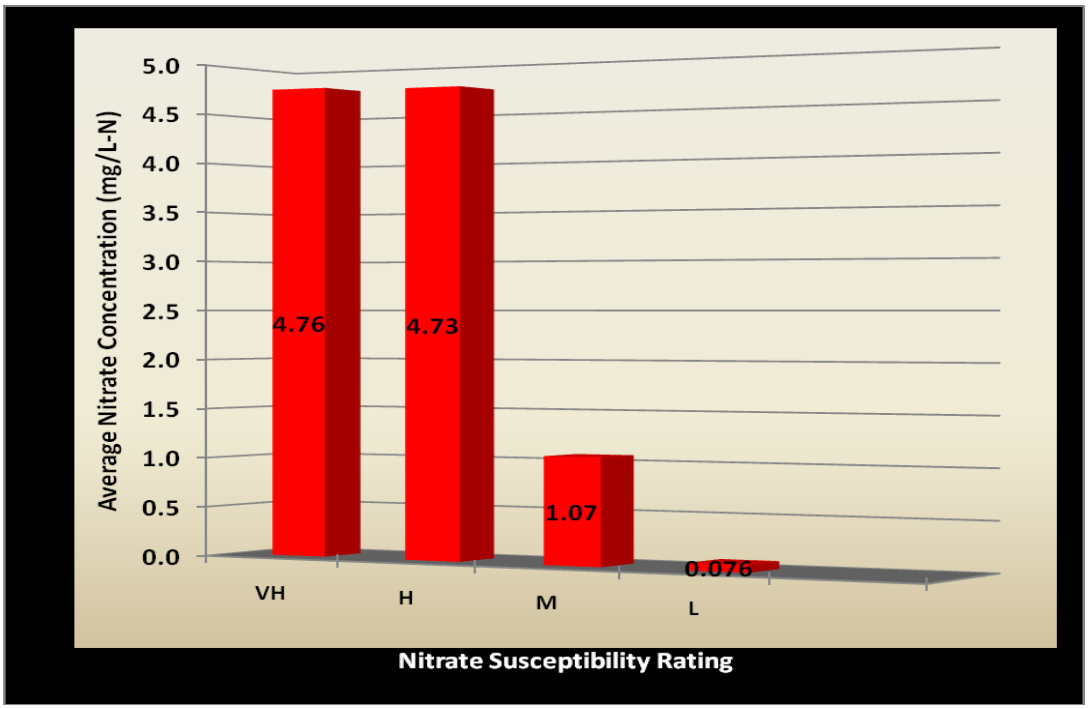
Average nitrate concentrations observed in community and non-community supply wells in 2013 are shown on **Figures 3-3a** through **3-3c** for the upper glacial, Magothy, and Lloyd aquifers respectively. Less than 1 mg/L of nitrate was reported in supply wells shown in blue, indicating very high quality groundwater. Nitrate concentrations are between 1 and 6 mg/L in wells shown in green, indicating some impact from development.



Community Supply Well Susceptibility Rating for Nitrate

Suffolk County Comprehensive Water Resources Management Plan

Figure 3-1



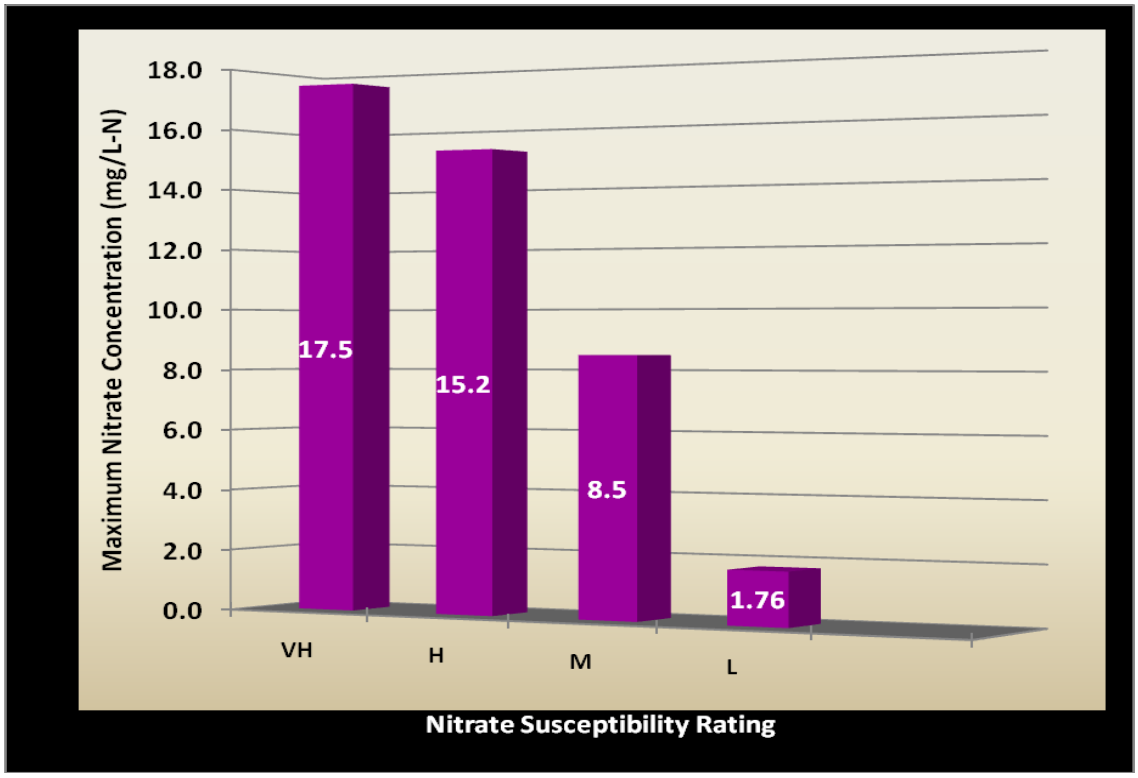


Figure 3-2 Relationship between Nitrate Susceptibility Ratings and Nitrate Concentrations in Community Supply Wells

Wells shown in yellow have reported nitrate concentrations between 6 and 10 mg/L; water from these wells is in compliance with the drinking water MCL of 10 mg/L, but has been clearly impacted by human activity. Samples collected from wells shown in red exceeded the drinking water MCL for nitrate - these wells have either been removed from service, or the water is treated to achieve drinking water standards before it is delivered to County residents.

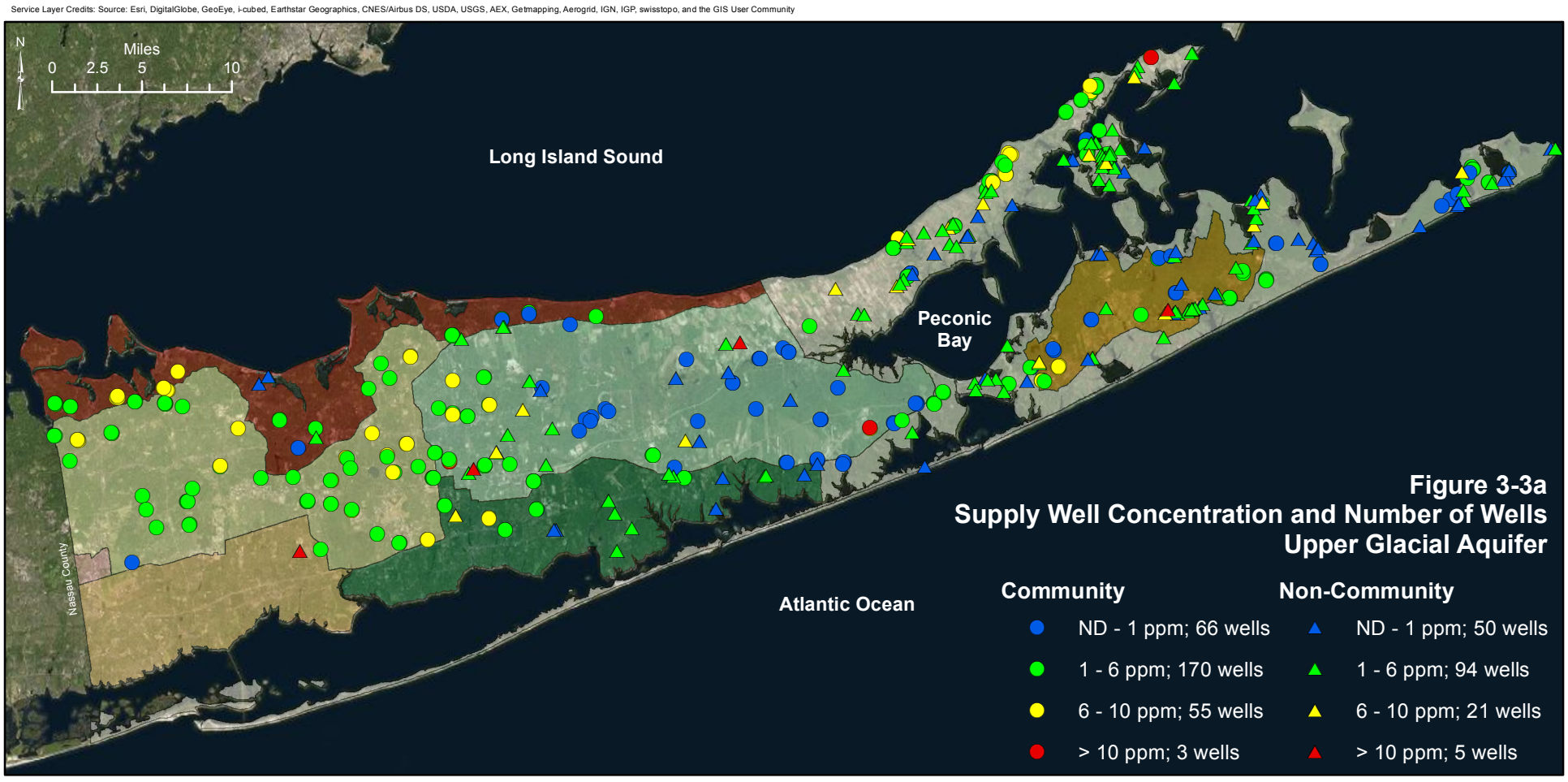
To protect human health, Article 6 of the Suffolk County Sanitary Code established Groundwater Management Zones (GMZs) which seek to limit groundwater nitrogen concentrations to 4 mg/L in GMZs III, V, and VI and to 6 mg/L elsewhere, as shown on **Figure 3-4**.

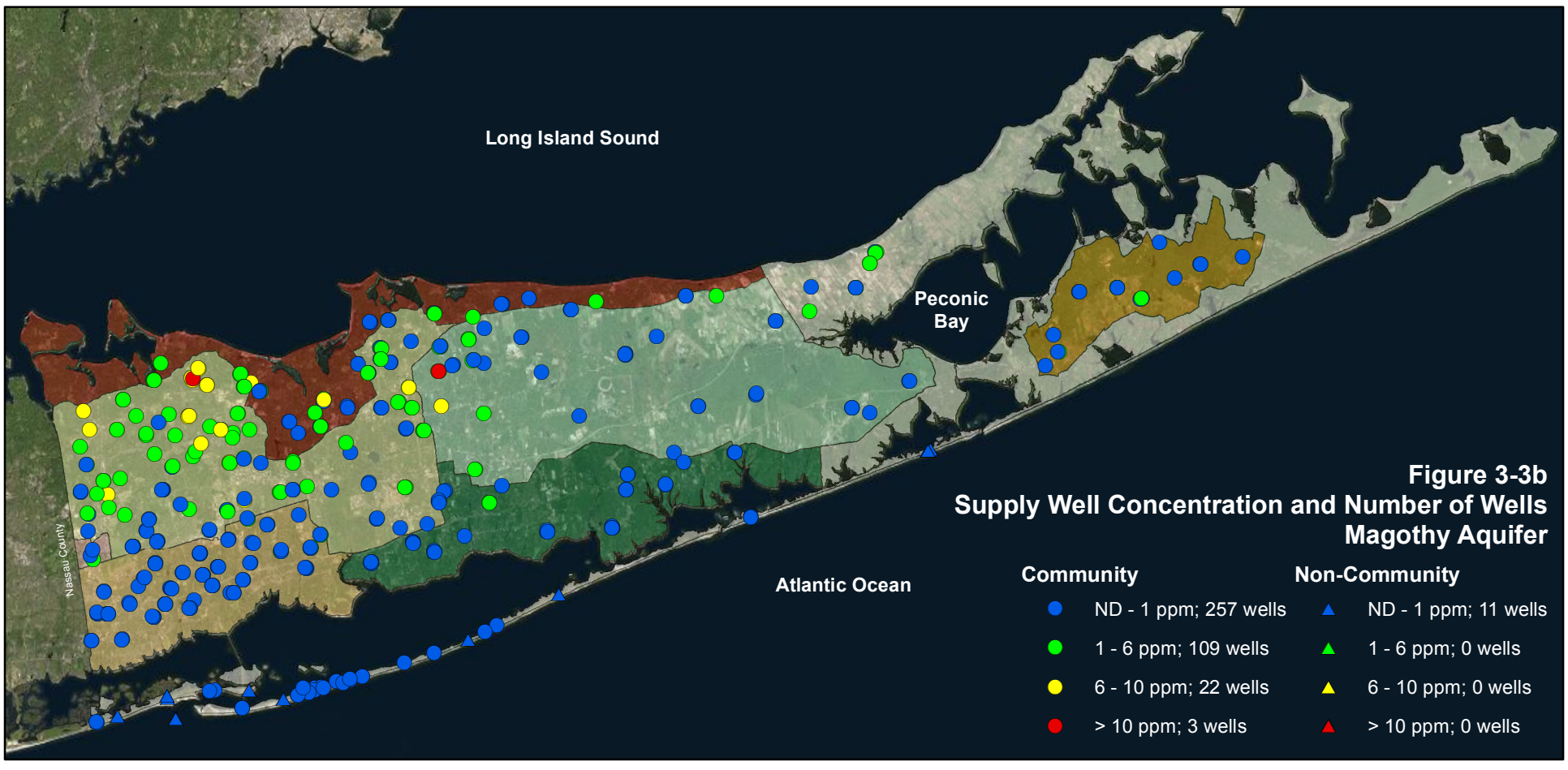
Figure 3-3a shows that while nitrate levels in over 80 percent of the upper glacial supply wells are less than or equal to 6 mg/L, wells impacted by nitrate contamination are present throughout the County. Nitrate levels exceeding 6 mg/L were found in upper glacial supply wells located on the North Fork, an unsewered agricultural area, as well as the northwest and central parts of the County. **Figures 3-3b** and 3-**3c** show that in general, nitrate concentrations in the Magothy and Lloyd aquifers remain lower than in the upper glacial aquifer; ambient levels of less than 1 mg/L continue to be observed throughout the Magothy aquifer in the southern part of the County. Nitrate has been observed in excess of 6 mg/L in wells located in the unsewered areas of Huntington, Smithtown and northern Brookhaven.

Additional nitrate data was available from the private well testing program that SCDHS has implemented for five decades. **Figures 3-5a** and **3-5b**, a summary of nitrate levels measured in private wells by SCDHS from 1997 through 2006 and 2007 through 2013 respectively, provide additional information to characterize conditions within the upper glacial aquifer, where the vast majority of private wells are screened. While this large recent data set provides extensive information on the state of the upper glacial aquifer and contaminant occurrence in the County; there are several limitations associated with its use. Geographically, the monitoring is generally skewed to the eastern portions of the County where the majority of private wells exist. The data set is not random, as private wells are sampled by request and during surveys initiated by SCDHS in response to unusual or significant contaminant detections. In addition, repeat sampling of some wells may occur.

Private well sample results showed that almost a third of the private wells approached native groundwater quality, with nitrate levels less than 1 mg/L nitrate and nitrate concentrations in approximately 75 percent of the private wells sampled were less than or equal to 6 mg/L during both sampling periods.

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

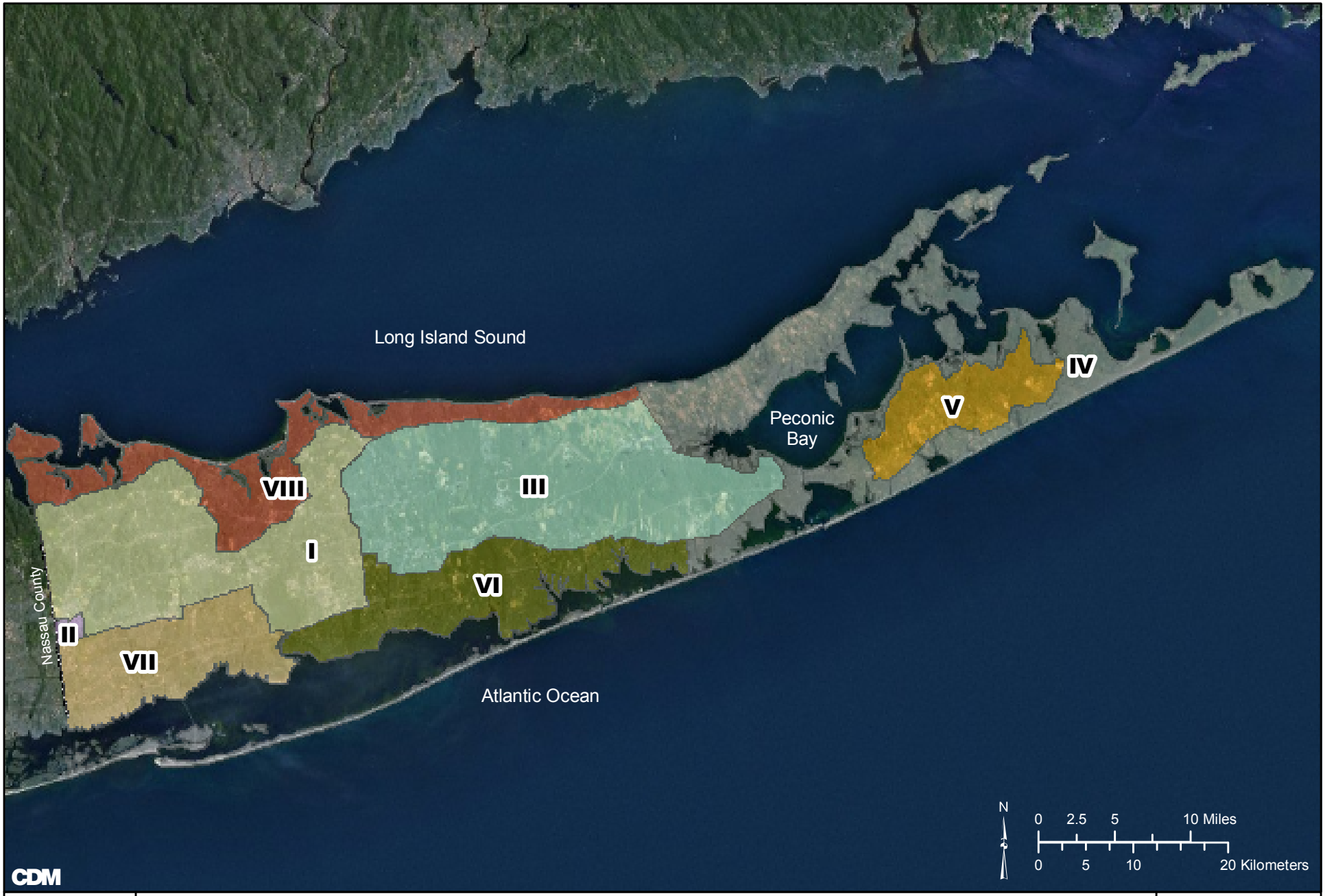




Average Nitrate Concentration in the Upper Glacial, Magothy & Lloyd Aquifers Community and Non-Community Supply Wells - 2013

Suffolk County Comprehensive Water Resources Management Plan

Figure 3-3

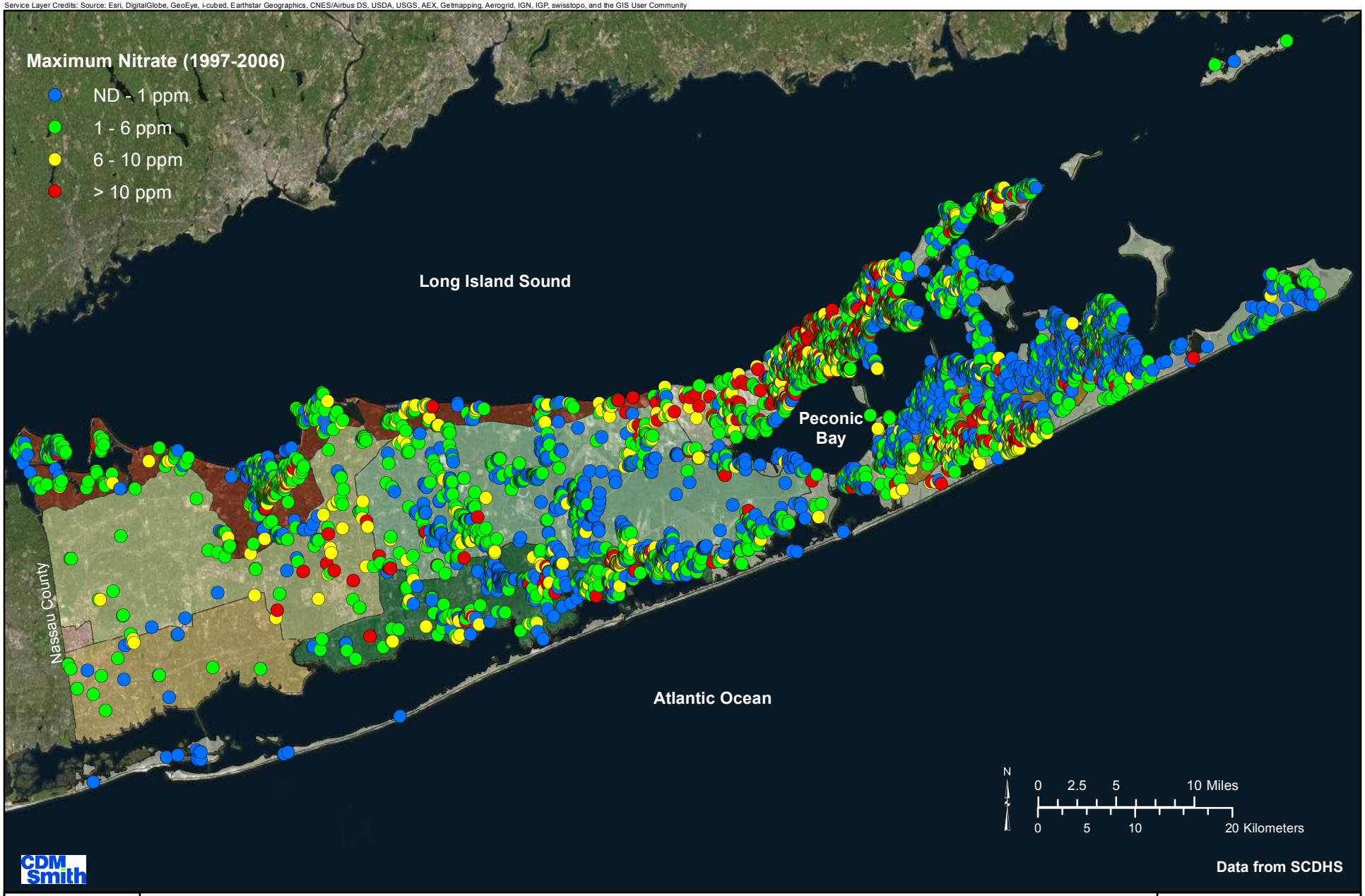


Groundwater Management Zones

Suffolk County Comprehensive Water Resources Management Plan

Figure 3-4

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

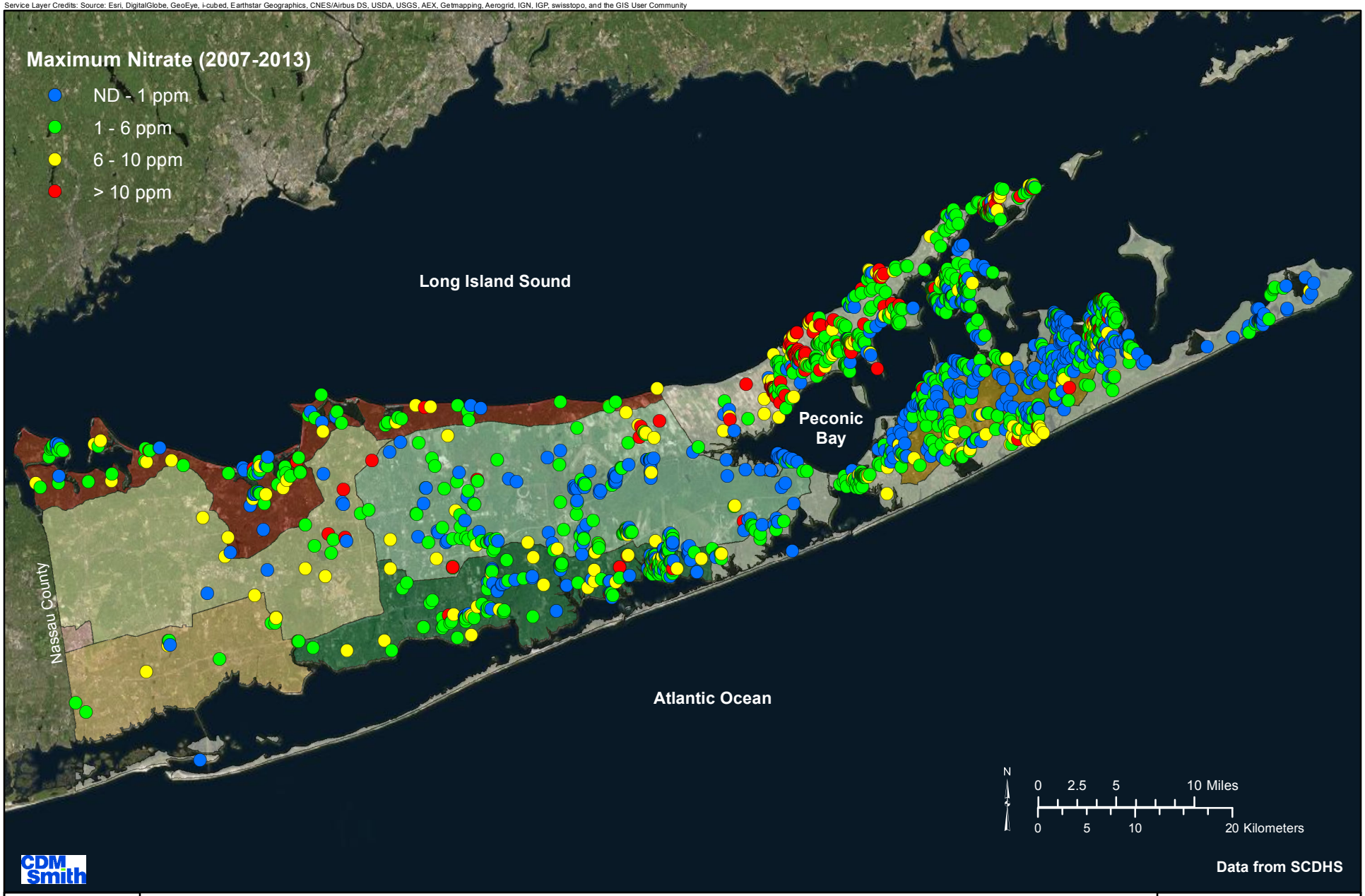


Maximum Nitrate Concentrations in Private Wells 1997 - 2006

Suffolk County Comprehensive Water Resources Management Plan

Figure 3-5a

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



Maximum Nitrate Concentrations in Private Wells 2007 - 2013

Suffolk County Comprehensive Water Resources Management Plan

Figure 3-5b

Nitrate levels in the same set of 175 public supply wells sampled in 1987 and 2013 have increased by an average of 1 mg/L, and nitrate levels in the same set of 213 Magothy public supply wells sampled in both 1987 and 2013 have increased by an average of 0.76 mg/L.

However, nitrate levels in nearly another third of the wells in the private well data base exceeded their respective GMZ target levels of 4 and 6 mg/L and nitrate levels in nearly ten percent of the 7,135 private wells sampled between 1997 and 2006 exceeded the 10 mg/L MCL. Fewer private wells were sampled between 2007 and 2013, but the pattern of contamination remained the same. Nitrate levels in nearly 25 percent of the wells for which coordinates were available (1,817) exceeded their respective GMZ target levels of 4 and 6 mg/L, and nitrate levels in approximately 7 percent of the 2,338 well samples collected from 2007 through 2013 exceeded the 10 mg/L MCL. Private wells impacted by nitrate contamination are located throughout the County, but most are found in agricultural areas of the North and South Forks and in pockets of the more densely developed unsewered areas of the north and south shores.

Changes in Nitrate Levels Since 1987

To assess changes in nitrate over time, average nitrate concentrations measured in community supply wells that were sampled in both 1987, (as documented in the ***1987 Comp Plan***) and in 2013 were compared. A summary of nitrate concentrations of samples taken from the same set of 390 public supply wells sampled in both 1987 and in 2013 is provided by **Table 3-1**. The data show that nitrate levels have increased in all three aquifers, and that nitrate concentrations in the same set of 175 upper glacial public supply wells sampled in both 1987 and 2013 have increased by an average of 1 mg/L as shown by **Figure 3-6a.** Nitrate concentrations in the same set of 213 Magothy public supply wells sampled in both 1987 and 2013 have increased by an average of 0.76 mg/L, as depicted by **Figure 3-6b.** Only one Lloyd aquifer well was sampled in both 1987 and 2013; the nitrate concentration in that well increased by 0.50 mg/L. **Figures 3-6a** and 3-**6b** also indicate that using data from all community supply wells to characterize aquifer conditions, nitrate levels, on average, have increased by nearly 0.4 mg/L in both the upper glacial and Magothy aquifers. Based on the limited data available to characterize the Lloyd aquifer, the average nitrate concentration has increased significantly. However, data was available from wells located in one general area on the north shore of the County and nitrate concentrations may not be representative of the Lloyd aquifer as a whole.

Nitrate levels in untreated groundwater samples collected from over 99 percent of all community supply wells complied with the 10 mg/L MCL in 2013; nevertheless, nitrate concentrations in all three aquifers continues to increase.

Overall, average nitrate concentrations remained less than or equal to 6 mg/L in nearly 83 percent of all community supply wells in 2013, and exceeded the drinking water MCL in untreated samples obtained from less than one percent of all community supply wells in 2013. While the overall assessment shows that nitrate levels remain in compliance with applicable standards in the majority of public supply wells, comparison of data collected from the same sampling

Table 3-1 Nitrate Concentration from Community and Non-Community Supply Wells

Aquifer	1987	2009-2013	2013	Same Set Wells 1987	Same Set Wells 2013
Upper Glacial Aquifer					
n (wells	714	570	477	175	175
Minimum (mg/L)	ND	ND	ND	ND	ND
Maximum (mg/L)	23.0	26.8	15.4	22.70	14.00
Average (mg/L)	3.05	3.40	3.44	2.63	3.69
10th Percentile (mg/L)	ND	0.14	ND	ND	ND
50th Percentile (mg/L)	1.90	3.00	3.10	1.80	3.55
90th Percentile (mg/L)	7.30	6.95	7.32	5.87	7.30
No. of Wells > 6 mg/L	135 / 116	133 / 91	86 / 82	20 / 17	37 / 35
Magothy Aquifer					
n (wells)	281	418	402	213	213
Minimum (mg/L)	ND	ND	ND	ND	ND
Maximum (mg/L)	12	10.9	10.2	12.00	10.20
Average (mg/L)	1.07	1.34	1.41	0.95	1.71
10th Percentile (mg/L)	ND	ND	ND	ND	ND
50th Percentile (mg/L)	ND	0.13	ND	ND	ND
90th Percentile (mg/L)	3.85	4.53	4.80	3.59	5.80
No. of Wells > 6 mg/L	18 / 13	39 / 23	29 / 26	12 / 8	21 / 19
Lloyd Aquifer					
n (wells)	4	6	5	1	1
Minimum (mg/L)	ND	1.90	2.1	1.60	2.10
Maximum (mg/L)	1.70	8.80	4.2	1.60	2.10
Average (mg/L)	1.24	3.72	3.18	1.60	2.10
10th Percentile (mg/L)	0.56	2.21	2.3	N/A	N/A
50th Percentile (mg/L)	1.55	3.15	3.50	N/A	N/A
90th Percentile (mg/L)	1.67	5.80	3.92	N/A	N/A
No. of Wells > 6 mg/L	0 / 0	2 / 1	0 / 0	0 / 0	0 / 0

Notes:
1. Data compiled from SCDHS databases.
2. Averages and percentiles calculated from annual well averages.
3. No. of wells > 6 mg/L is based on well maximum and averages, respectively (max/avg).

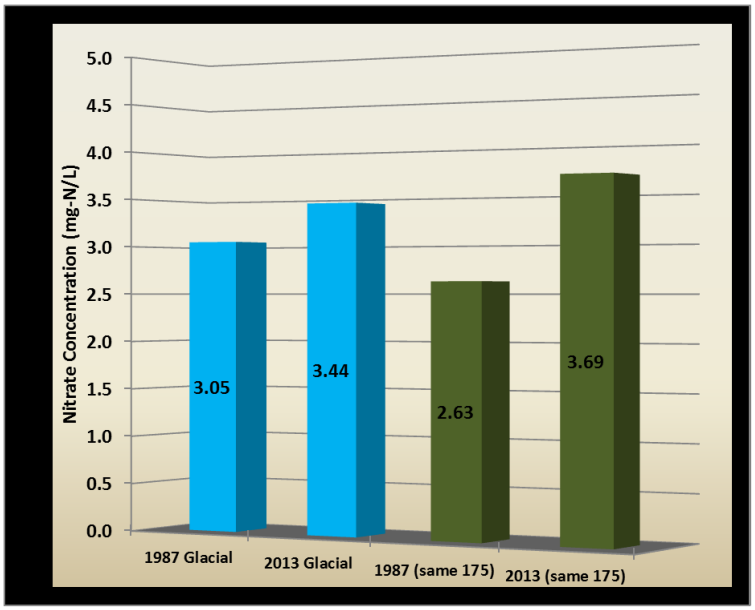


Figure 3-6a Nitrate Trends in Public Supply Wells Screened in the Upper Glacial Aquifer 1987-2013

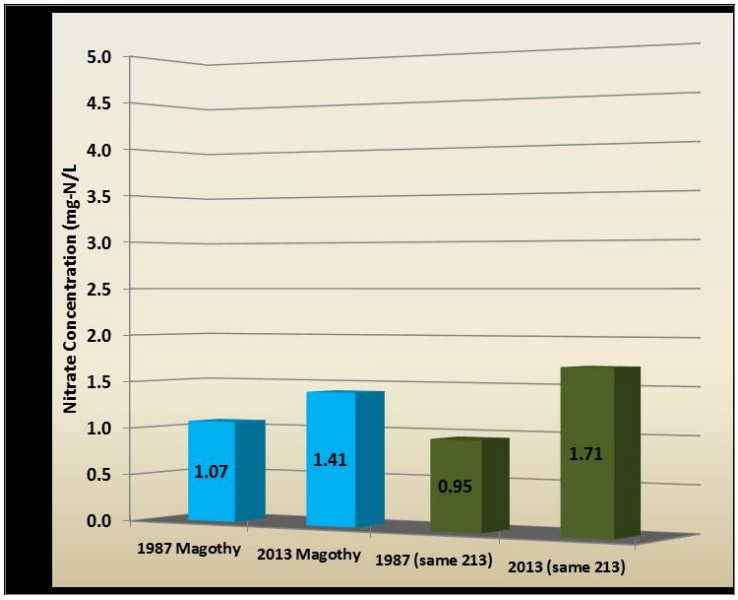


Figure 3-6b Nitrate Trends in Public Supply Wells Screened in the Magothy Aquifer 1987-2013

points in 1987 and in 2013 has revealed that nitrate concentrations have continued to increase in all aquifers, and that more deep public supply wells are being used to obtain better water quality.

Nitrate and Land Use

Several studies have investigated the impacts that various land use types have had on nitrate levels in Suffolk County groundwater, although a regional analysis has not been completed since the **1987 Comp Plan**. The **1987 Comp Plan** evaluated water quality from 25 shallow monitoring wells that were installed downgradient of specific land use types. **Table 3-2** summarizes the nitrate concentrations observed downgradient from the land uses studied. Results from the **1987 Comp Plan** study are shown graphically on **Figure 3-7** along with results from the **208 Study** (1978), based on nitrate data from wells in unsewered areas of Nassau County, and results from the WALRAS model developed by Cornell University (Dvirka and Bartilucci, 1987). This work was updated to consider more detailed assessments of land surface areas contributing recharge to public supply wells, historical land uses within the contributing or source water areas and estimated travel times from the water table to the supply well screen, as described below.

Historical Land Use and Nitrate Concentrations

The Suffolk County Department of Economic Development and Planning (formerly Suffolk County Planning Department) used historical aerial photographs to document changing land use within the contributing areas of 56 community supply wells located within 29 wellfields (please see Task 3 memoranda) over four historical time periods dating back to 1930. The Department of Economic Development and Planning (SCDEDP) used the contributing areas that were simulated during the Task 5.5 assessment of source water areas, based upon long term average conditions of precipitation and recharge and projected future water supply pumping rates, and intersected those source water areas with land use data from 1930, 1947, 1977 and 2004. The historical land uses were used to estimate the nitrate levels that could be expected in downgradient groundwater, and these estimates were compared to measured nitrate levels in the supply wells. Annual nitrate trend plots were developed for each of the 56 wells to qualitatively evaluate water quality trends resulting from changes in land use over time. The contributing area, historical land use data for each time period, and water quality data for SCWA's Woodchuck Hollow Road wellfield are included on the following page as **Figure 3-8**; the analysis of the other wellfields may be found in the Task 5.1 memorandum (**Past and Current Land Use Impacts**, CDM, 2010).

The average nitrate concentrations associated with each land use type that were documented in the **1987 Comp Plan** and the historical land use types

Table 3-2 Water Quality Summary for Nitrate (as Nitrogen), Ammonia and Total Nitrogen from the 1987 Comprehensive Water Resources Management Plan (from Dvirka and Bartilucci, 1987)

Land Use	Nitrate (as N)			Ammonia			Total Nitrogen		
	Mg/L			Mg/L			Mg/L		
	Avg.	Min	Max	Avg.	Min	Max	Avg.	Min	Max
Low Density Res.	3.35	2.97	3.70	0.36	0.06	0.68	3.88	3.02	4.75
Medium Density Res.	5.82	4.40	7.94	0.12	0.06	0.21	5.94	4.48	8.00
High Density Res.	2.60	0.34	8.03	5.32	2.94	9.55	7.92	3.59	11.50
Commercial	1.74	0.08	4.05	6.11	0.06	17.50	8.04	1.11	17.50
Industrial	4.25	1.13	6.99	2.96	0.06	5.12	7.13	1.18	10.80
Institutional	8.20	7.87	8.53	0.06	0.06	0.06	8.27	7.93	8.60
Recreation / Open Space	3.91	2.40	6.07	0.72	0.06	1.64	4.63	2.46	6.18
Agriculture	7.83	5.62	10.00	0.06	0.05	0.06	7.89	5.68	10.10
Vacant	1.15	1.00	1.30	0.05	0.05	0.06	1.21	1.05	1.35
Transportation	2.39	0.59	4.54	0.07	0.06	0.08	2.46	0.66	4.61

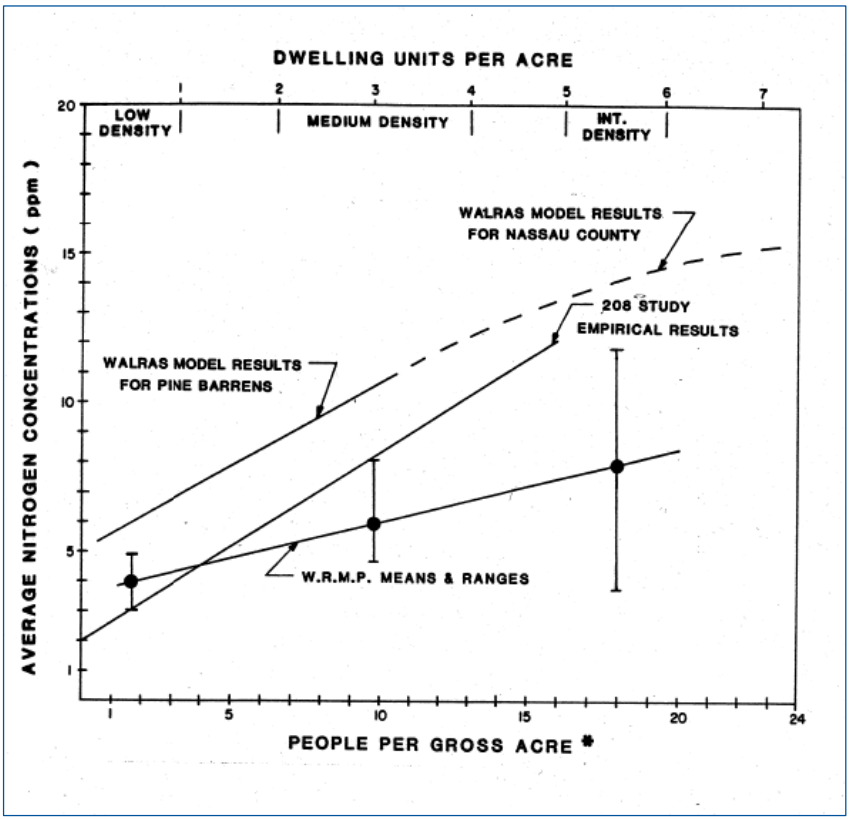
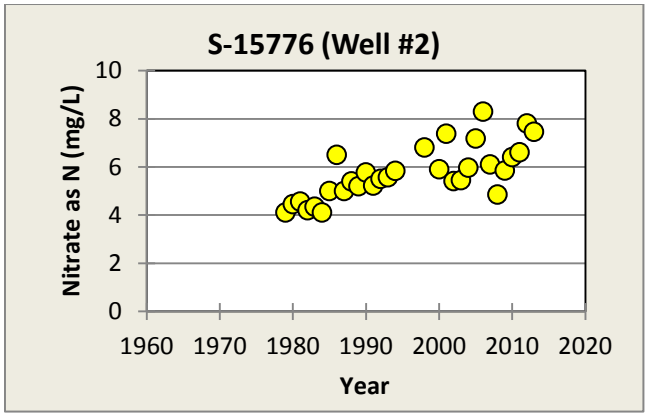
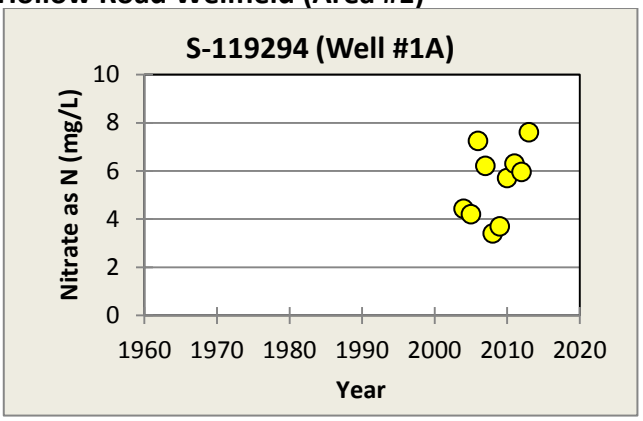
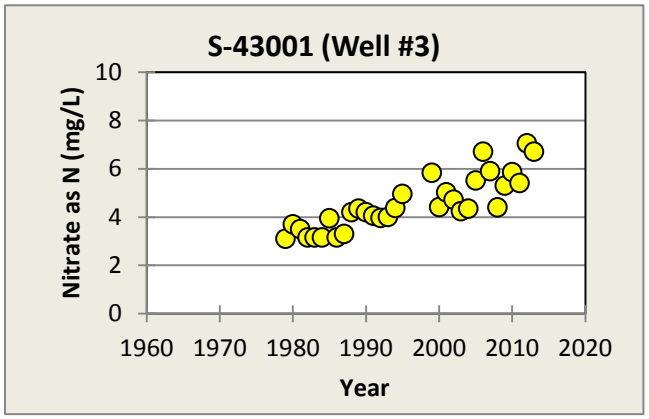


Figure 3-7 Density & Nitrogen Concentrations in Groundwater
(from 1987 Comp Plan, Dvirka and Bartilucci)

SCWA Woodchuck Hollow Road Wellfield (Area #1)







Well	Time of Travel (yrs) Minimum	Maximum	Pumping gpm	Depth (ft)
S-15776	9.8	35.6	300	507
S-43001	14.7	83	300	596
S-119294	28.3	91.3	300	604

Sewered: 1%
Unsewered: 99%

Wells are screened in the **upper glacial aquifer**

	1930		1947		1977		2004	
	Acres	% of Total	Acres	% of Total	Acres	% of Total	Acres	% of Total
Low Density Res.	15	3.55%	16	3.78%	7	1.71%	2	0.38%
Medium Density Res.	53	12.53%	120	28.37%	223	54.39%	189	35.93%
High Density Res.	0	0.00%	0	0.00%	27	6.59%	88	16.73%
Commercial	7	1.65%	6	1.42%	66	16.10%	90	17.11%
Industrial	0	0.00%	0	0.00%	19	4.63%	18	3.42%
Institutional	4	0.95%	4	0.95%	10	2.44%	8	1.52%
Recreation & Open Space	0	0.00%	0	0.00%	0	0.00%	4	0.76%
Agriculture	140	33.10%	129	30.50%	4	0.98%	0	0.00%
Vacant	204	48.23%	148	34.99%	52	12.68%	7	1.33%
Transportation		0.00%		0.00%		0.00%	118	22.43%
Utilities	0	0.00%	0	0.00%	2	0.49%	2	0.38%
Waste Handling	0	0.00%	0	0.00%	0	0.00%	0	0.00%
Total	423		423		410		526	

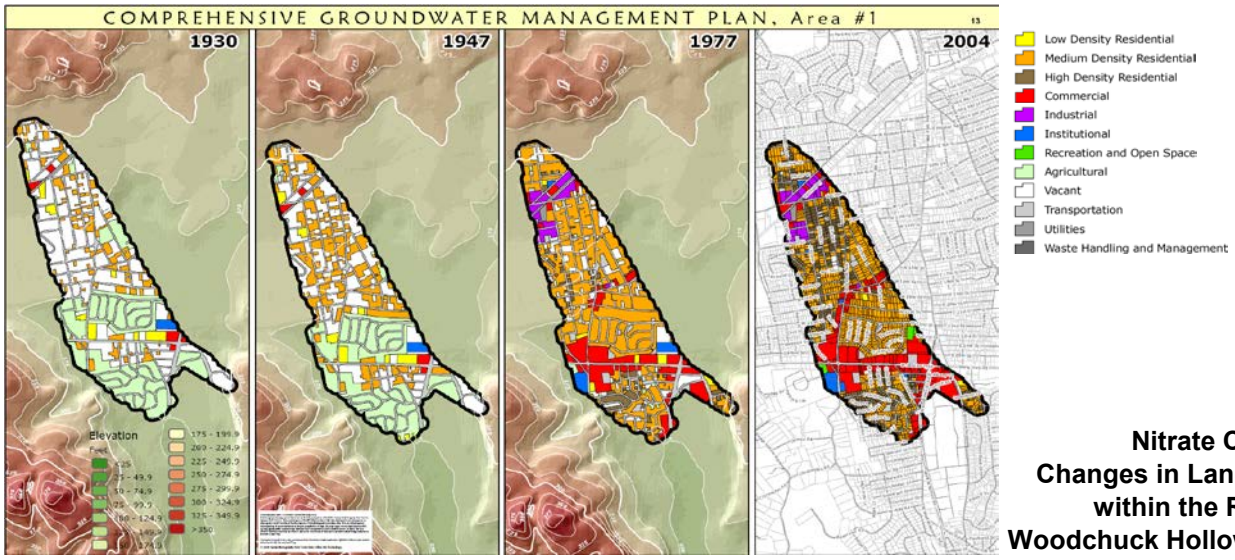


Figure 3-8
Nitrate Concentrations & Changes in Land Use Over Time within the Recharge Area to Woodchuck Hollow Road Wellfield

compiled for each well's contributing area were used to evaluate how the area-weighted concentrations predicted from the contributing area land use(s) would compare with actual nitrate data collected from the supply wells.

The evaluations considered the simulated travel time from the water table to each well screen, and the estimated nitrate loading from the variety of land use types existing through the range of travel times. Groundwater pumped from each supply well includes water originating over the entire contributing area, considering the range of travel times from the water table to the well screen. For example, if a well has contributing areas within the 0 to 2, 2 to 5, and 5 to 25 year travel time intervals, the water withdrawn from the well is a composite of water recharged from the land uses within each of these areas. Nitrate loads therefore reflect the land use types present over the entire 0 to 25 year travel time zone of contribution. Assessments of nitrogen levels in wells with even longer travel times considered the land uses documented in the aerial photos from several historical time periods, as land uses that existed decades ago can have an impact on water quality observed today. Clearly, this assessment provides only an estimate of nitrogen loading rates, as a variety of land use types exist within most contributing areas and nitrate loading rates can vary considerably over different parcels of the same land use type. However, although exceptions exist, in many instances, nitrate levels, and the change in nitrate concentration over time appears to correlate with land use patterns within the contributing area.

The results for all 29 wellfields are tabulated in **Table 3-3**. Nitrate is added to the aquifer by septic systems in unsewered areas and by lawn fertilization and agricultural practices. As expected, higher concentrations of nitrate are generally observed in wells with more densely developed and/or agricultural uses within the contributing areas. The range of land use-specific nitrate concentrations documented in the ***1987 Comp Plan*** appear to be representative of the water quality data observed in the wells included in this analysis. In general, the maximum nitrate concentrations from the ***1987 Comp Plan*** provide a closer approximation to observed data for many of the wells. The results are site-specific and matched better for some wellfields than others due to a variety of factors, some of which are identified below.

More than fifty percent of the contributing areas for five of the twenty-nine areas evaluated are served by sanitary sewers. As expected, nitrate concentrations are generally lower in sewered areas than in unsewered areas. For example, the contributing area for the Strathmore Court Drive wellfield is essentially entirely sewered and nitrate concentrations are generally low (below 4 mg/L), whereas average concentrations for wellfields with unsewered contributing areas often exceed 5 or 6 mg/L.

Table 3-3

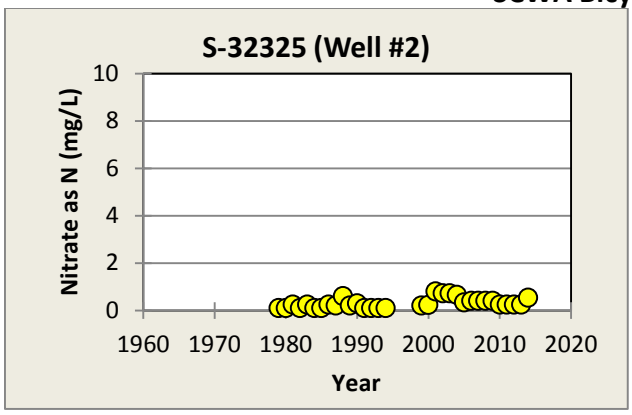
Summary of Calculated (using 1987 Comp Plan Concentrations) and Observed Nitrate Concentrations

Area	Wellfield	% Sewered	Average Nitrate as Nitrogen (mg/L) 2004-2009		Analytical Calcs			Notes
			Low	High	Average	Minimum	Maximum	
1	Woodchuck Hollow Road	1%	3.60	6.37	3.99	2.45	6.36	Average and maximum concentrations from the 1987 Comp Plan are within the range of observed nitrate concentrations.
2	Waterside Road	0%	7.39	7.39	4.81	3.38	6.82	This contributing area has a relatively high percentage of high density residential. Maximum 1987 Comp Plan concentrations are close to observed, but an increase in the repersentative concentration for high density residential may provide a closer approximation.
3	Laurel Hill Road	0%	3.39	3.81	5.43	4.04	7.06	This contributing area has a relatively high % of agriculture. Since observed concentrations are approximately 4 mg/L, it is possible that the type of agriculture is not fertilizer intensive and therefore does not contribute significant nitrogen loading to groundwater. Using minimum 1987 concentrations, the calcualted values are within the range of concentrations observed from the three wells from 2000 to present.
4	Belle Rose Avenue	0%	5.70	5.70	7.04	5.14	9.19	Concentrations have approached 9 mg/L in early 1990s. Supports Article 6 standards as medium density lots average approximately 20,000 sq. feet (see Table 4) and concentrations are near the target of 6 mg/L.
5	Larkfield Road / South Spur	0%	7.95	7.95	5.79	4.19	7.83	Using maximum concentrations provides a reasonable approximation to observed data, although the observed data appear to be increasing over time
6	Schuyler Drive	0%	4.96	9.33	4.77	3.53	6.27	Well 1 shows a good approximation, although well 2 has shown concentrations > 10 mg/L.
7	Vanderbilt Parkway	0%	1.83	1.83	3.92	3.09	4.96	Large parcel size for medium density residential. Also may have well maintained septic systems and/or low rates of fertilization. However, concentrations in early 2000s approach analytical
8	Ryder Avenue	0%	2.30	2.30	4.20	3.18	5.44	High relative percenage of low density residential. Maybe reduce impact from LDR.
9	Wheeler Road	0%	2.57	5.00	4.33	3.45	5.53	Concentrations from the 1987 Comp Plan provide a close approximation to observed nitrate concentrations.
10	Oval Drive	0%	5.04	5.65	3.62	1.83	5.57	Using maximum concentrations, the analysis provides a good approximation. Concentrations appear relatively stable for nitrate.
11	Wheat Path	0%	2.17	4.21	3.76	2.80	5.11	Concentrations from the 1987 Comp Plan provide a close approximation to observed nitrate concentrations.
12	Mt. Sinai-Coram Road	56%	8.59	8.59	3.32	2.38	4.52	Concentrations have exceeded the drinking water standard and unsewered portions of the contributing area may have poorly maintained septic systems or excessive fertilization. In addition, the high concentrations could represent the flushing of former agricultural source water (with a high nitrogen load) as concentrations seem to be decreasing since 2001.
13	Bicycle Path	60%	0.43	5.82	3.95	2.90	5.45	The range of concentrations from the 1987 Plan provide a reasonalbe approximation to well #1, but is a little low. Most of the contributing area to well #1 is also in unsewered area, while much larger portion of well #2 in a sewered area, which has much lower concentrations of nitrate.
14	Chestnut Street	58%	0.50	1.07	2.40	1.79	3.24	Minimum concentrations provides a reasonable approximation. The wells in this wellfield are almost 600 feet deep, so it is possible that more dilution is occuring in the vertical profile of the aquifer as opposed to a shallow upper glacial well. In addition, the maximum time of travel for all three wells is near 100 years and the water pumped from the well may have a significant percentage which is older than 33 years, when much of the land use was vacant.
15	Strathmore Court Drive	99%	0.13	2.98	3.38	2.37	4.83	Sewered (calcs slightly higher than observed). Wells 1 and 3 are significantly more shallow and concentrations approach 4 in these 2 wells. Concentrations in well 3 may be stablizing, or at least approaching stable concentrations.
16	Hawkins Road	0%	8.95	8.95	3.42	2.53	4.68	Calculated data are lower than observed. Although there is an apparent sharp increasing trend between 1980 and 2002, concentration data between 2002 and 2008 appear to have stabilized near 9 mg/L. Regardless, the observed concentrations are much higher than calculated, perhaps due to excessive fertilization.

Table 3-3
Summary of Calculated (using 1987 Comp Plan Concentrations) and Observed Nitrate Concentrations

Area	Wellfield	% Sewered	Average Nitrate as Nitrogen (mg/L) 2004-2009		Analytical Calcs			Notes
			Low	High	Average	Minimum	Maximum	
17	**Eastwood Boulevard**	0%	4.69	4.69	5.65	4.52	7.31	Using minimum or average concentrations from the 1987 Plan provide a good approximation of observed data.
18	**Boyle Road South**	0%	5.03	5.03	3.22	2.25	4.43	Calculated values are an underestimate of observed data and the observed data appear to be increasing over time. This may be due to excessive fertilization within the area.
19	**Dare Road**	2%	5.75	5.75	4.26	3.17	5.71	Using maximum concentrations appear to provide a good approximation of observed data. Although early data indicate an increasing trend, concentrations appear relatively stable between 1999-2009.
20	**Flint Lane**	78%	2.22	3.33	3.09	2.20	4.33	Calculated concentrations are within the range of observed data between 2004-2009, although a significant portion of the contributing area is sewered. Regarding the concentrations in the individual wells, 68% of the contributing area to well #2 is sewered while 88% of the area in well #1 is sewered and this is represented in the observed concentration data. Although differences in concentration are relatively slight, concentrations in well #2 are approximately 1 ppm higher than well #1.
21	**Meehan Lane**	17%	6.20	8.24	3.71	2.83	4.89	Calculated data are lower than observed. Recent data have been higher than 5 mg/L and a portion of the contributing area is sewered, and anticipated to yield lower concentrations of nitrate. The portion of the contributing area that is recreation / open space may be a golf course or septic systems may be somewhat poorly maintained or the area undergoes excessive fertilization.
22	**Pleasant Avenue**	0%	7.03	7.19	4.08	3.07	5.52	Observed concentrations are slightly higher than target for GWMZ I. Average parcel size slightly smaller than Article 6 standards, but may be due to a few inadequate septic systems or over-fertilization. Concentrations approaching 10 mg/L in Well 1 (ultimately blended with Well #4 (not included in analysis)).
23	**Morris Avenue**	27%	3.52	4.92	3.89	2.94	5.14	Using average and maximum concentrations is within the range of observed data. Calculated values are slightly higher using maximum concentratins, although a portion of the contributing area is sewered and expected to have a lower nitrogen load.
24	**Barton Avenue**	0%	6.61	6.85	4.95	3.79	6.62	Using maximum concentrations from the 1987 Comp Plan, the calculated concentrations are within the range of observed.
25	**North Country Road**	0%	3.58	3.58	3.44	2.45	4.71	Using average concentrations appears to be slightly lower than observed concentrations. Nitrate concentrations have been above near and above 5 mg/L in the 1990s, or close to the predicted nitrate concentration using maximum values from the 1987 Plan.
26	**Moriches Riverhead Road**	0%	0.11	0.21	2.33	1.58	3.36	Approximately 85% of the contributing area is classified as recreation / open space. Review of aerial photography indicates that the area is open space and does not contain a golf course or any other recreational parcel that may utilize fertilization. Qualifying as vacant land will give a better approximation to observed data.
27	**Old North Road (Greenport)**	0%	8.16	8.89	6.27	4.48	8.10	Using maximum concentrations, the analysis provides a good approximation. Elevated nitrate concentrations likely attributed to high percentage of agriculture in the well contributing areas.
28	**Ackerly Pond Lane**	0%	6.19	6.94	7.13	5.08	9.24	Much of this contributing area is agricultural. However, BMPs may have been implemented as the increasing trend in the late 1980s into the 1990s appears to have reversed in which average concentrations have decreased to below 7 mg/L.
29	**Bridgehampton Road**	0%	2.74	8.05	3.33	2.45	4.40	The range of concentrations from the 1987 Plan provide a reasonalbe approximation to wells 2A and 3A, but are significantly low for well #1. Well #1 has a higher percentage of agriculture than the other 2 wells which may explain the higher observed nitrate concentrations.

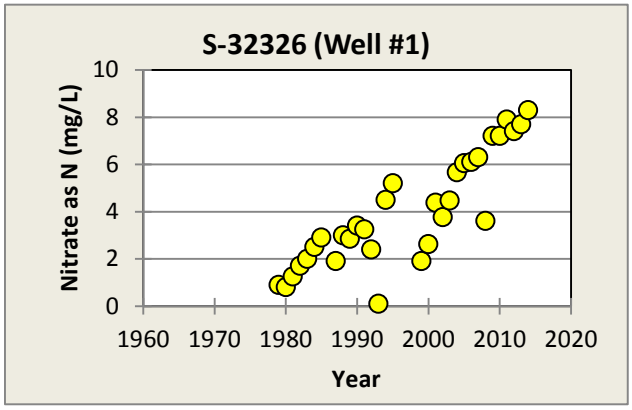
SCWA Bicycle Path Wellfield (Area #13)



Well	Time of Travel (yrs) Minimum	Maximum	Pumping gpm	Depth (ft)
S-32325	0.63	25.9	400.00	353.00
S-32526	0.71	11.5	166.00	159.00

Sewered: 60%
Unsewered: 40%

Wells are screened in the **upper glacial aquifer**



	1930		1947		1977		2004	
	Acres	% of Total	Acres	% of Total	Acres	% of Total	Acres	% of Total
Low Density Res.	0	0.00%	1	0.56%	1	0.57%	2	0.92%
Medium Density Res.	0	0.00%	2	1.13%	81	46.29%	143	65.60%
High Density Res.	0	0.00%	0	0.00%	0	0.00%	1	0.46%
Commercial	0	0.00%	0	0.00%	0	0.00%	0	0.00%
Industrial	0	0.00%	0	0.00%	0	0.00%	0	0.00%
Institutional	0	0.00%	0	0.00%	0	0.00%	0	0.00%
Recreation & Open Space	0	0.00%	0	0.00%	0	0.00%	6	2.75%
Agriculture	0	0.00%	0	0.00%	1	0.57%	0	0.00%
Vacant	178	100.00%	174	98.31%	92	52.57%	20	9.17%
Transportation		0.00%		0.00%		0.00%	43	19.72%
Utilities	0	0.00%	0	0.00%	0	0.00%	3	1.38%
Waste Handling	0	0.00%	0	0.00%	0	0.00%	0	0.00%
Total	178		177		175		218	

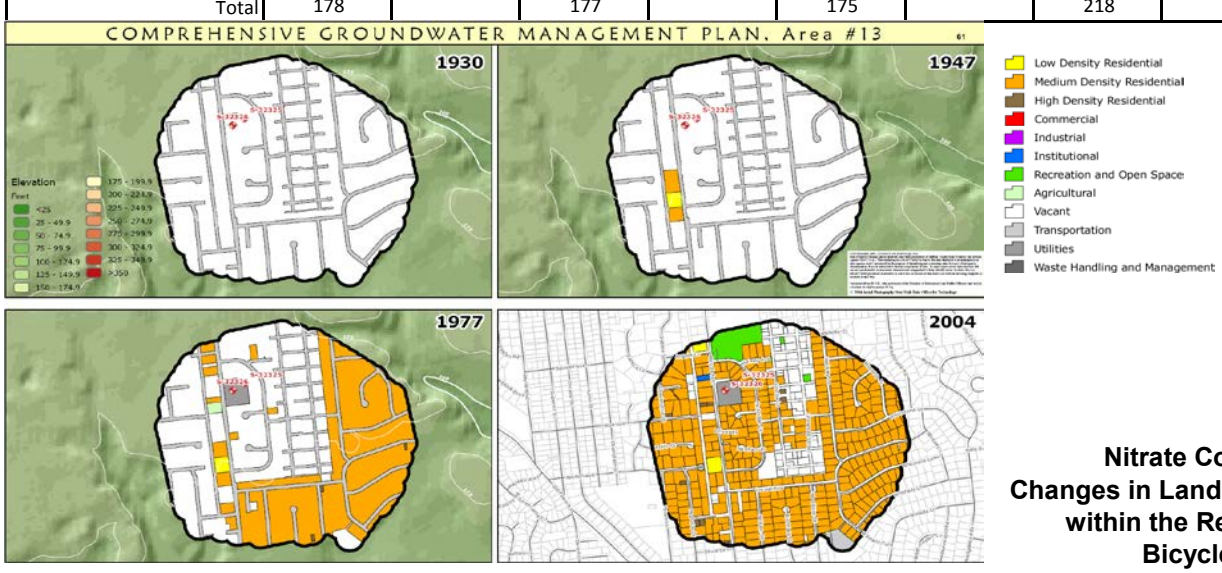


Figure 3-9
Nitrate Concentrations & Changes in Land Use Over Time within the Recharge Area to Bicycle Path Wellfield

Historical Land Use and Nitrate Concentration Assessment

The evaluation of the impacts of historical land uses and downgradient nitrate levels were based on available information; the assessment necessarily incorporated some assumptions that are worthy of note.

The Suffolk County Department of Economic Development and Planning evaluation is based on the available aerial photographs and land use documentation, which is somewhat limited – for example, the available historical documentation may not capture the significant differences in land uses that occurred during the thirty year time periods between 1947 and 1977 or 1977 and 2004 in some study areas.

The contributing areas used for this analysis were based on water supplier-projected future average annual pumping rates, which may be very different than historical pumping rates and/or supply well locations. Changes in pumping rates and well locations and/or depths will have a significant influence on a contributing area; this is a significant source of uncertainty for the wells with longer travel times.

The land use analysis is based on the combined contributing areas for all wells of interest for a particular wellfield. In some instances, the difference in land use is minimal, whereas in others, the differences in land uses in the well-specific contributing area are better indicators of individual well water quality.

Estimated nitrate concentrations do not exceed 10 mg/L using the average (or even the maximum) nitrate concentrations associated with each land use type as reported in the 1987 Comp Plan – however nitrate concentrations exceeding 10 mg/L were observed in some supply wells, indicating that the nitrate concentrations resulting from some land use types may have been may have been greater, particularly those from agriculture.

An example of the effectiveness of sewers in reducing nitrate concentrations can be seen in the two wells located at the Bicycle Path wellfield **(Figure 3-9)**. The relative percentages of land use types are similar for both wells, although the contributing area to well #1, an upper glacial aquifer well, is only 4 percent sewered while the contributing area to well #2 is 57 percent sewered. Nitrate

concentrations in well #2, a Magothy well screened 200 feet deeper than well #1 are less than 1 mg/L, while concentrations in well #1 have continued to increase and exceed 8 mg/L.

A qualitative assessment of the nitrate levels over the years shows that increasing trends in nitrogen levels were observed in approximately half of the wellfields evaluated in this task. Nitrate levels in seven additional wellfields exceeded 6 mg/L, and showed the impact of human activity throughout the period of record. In fact, average annual nitrate concentrations have exceeded the 10 mg/L drinking water standard for nitrate at four wellfields during the evaluation period (Hawkins Road, Mt. Sinai Coram Road, Old North Road and Schulyer Drive wellfields; water from these wells was blended to reduce nitrogen levels prior to distribution). The increasing trend in nitrate concentrations has been attributed to the increase in residential development.

The evaluation of the impacts of historical land uses on nitrate levels yielded the following conclusions:

- Nitrate levels were lowest in wells with contributing areas comprised primarily of open space.
- In general, nitrate levels in wells with sewered contributing areas were lower than nitrate levels in unsewered areas.
- Groundwater nitrogen levels increase in unsewered areas as housing density increases.
- Wellfields with contributing areas that comply with the population density goals established by Article 6 all meet the target nitrate concentrations.
- Agriculture remains a major source of nitrogen contamination of the aquifer, particularly on the North Fork. The type of agriculture present within the contributing area affects the resulting groundwater nitrate level, since nitrogen loading can vary considerably depending on crop-specific fertilization requirements. The data shows average nitrogen concentrations in groundwater for row crops at 13.4 mg/L and average nitrogen concentrations in groundwater for vineyards at 5.1 mg/L.
- A limited set of wells screened in the Magothy aquifer with unsewered contributing areas was evaluated; the data shows an increasing trend in nitrate concentrations. In general, wells screened

in the Magothy aquifer had lower nitrate concentrations than those screened in the upper glacial aquifer.

- The land use-specific range of nitrate concentrations identified in the 1987 Comp Plan represented the observed water quality in the supply wells studied during this analysis reasonably well, although projected and observed nitrate levels matched better for some wellfields than others. In general, it appears that the maximum concentrations from the 1987 Comp Plan provide a better representation of the observed nitrate concentrations for many of the wells than do the average or minimum values.

In summary, nitrate concentrations at the wells are, in most cases, reflective of the type of land use found in the contributing area. Nitrate levels in samples collected from these 29 wellfields reflect the land uses that existed throughout the historical period defined by the maximum and minimum times of travel to the well, not just the most recent land use. Use of the contributing area assessments under the projected pumping conditions should be more useful in evaluating the impacts of land use moving forward.

Effectiveness of Existing Nitrate Management Programs

Discharge of sanitary wastewater and fertilization have been identified as the two most significant sources of anthropogenic nitrogen to groundwater.

Since the 1970s, a wide variety of regulatory programs have been developed and implemented to control the amount of nitrate that is introduced to the aquifer system. Discharge of sanitary wastewater and fertilization have been identified as the two most significant sources of anthropogenic nitrogen to groundwater. Sanitary sewering that has been implemented in southwest Suffolk County and other densely developed parts of Suffolk County has been effective in reducing groundwater contamination from sanitary, commercial, and industrial wastewaters. Implementation of land use restrictions, the purchase of large tracts of open space for preservation and groundwater protection, and limiting fertilization have also helped to protect groundwater quality in targeted areas.

Sanitary wastewater management is the most important factor affecting nitrate levels in groundwater throughout most of the County. Due to the significant contribution of groundwater baseflow to the County's surface waters, improved sanitary wastewater management practices can also have a positive impact on nitrate levels in surface waters. Sanitary wastewater management options were implemented to protect the groundwater resource, as indicated by compliance with the 10 mg/L drinking water standard for nitrogen. In 1980, Suffolk County amended Article 6 of the Suffolk County Sanitary Code to specifically address the impacts of sanitary wastewater on the County's groundwater. Since 1980, in accordance with Article 6, on-site wastewater

disposal is permitted for residential parcels greater than or equal to one acre in the deep recharge zone (Groundwater Management Zones III, V and VI), and on-site wastewater disposal is permitted for residential parcels greater than or equal to one half acre in all other GMZs. Residential development on lot sizes smaller than one acre within the deep recharge zone and one half acre outside of the deep recharge zone require a use of a community sewage system for wastewater treatment and disposal.

There are generally three sanitary wastewater management options currently utilized in Suffolk County:

- Discharge to a centralized sewage collection and treatment system, such as Southwest Sewer District No. 3;
- Discharge to an alternative treatment system, in accordance with Article 6 requirements; or
- Discharge on-site via septic systems/cesspools/leaching fields in accordance with Article 6 density requirements.

Provision of a centralized sanitary wastewater collection and treatment system is an effective way to reduce the impacts of development on ground and surface water resources.

Centralized sewage treatment and collection systems such as Southwest Sewer District No. 3 (SWSD) were established to reduce levels of wastewater contaminants in groundwater located beneath densely developed areas. Provision of a centralized sanitary wastewater collection and treatment system is an effective way to reduce the impacts of development on ground and surface water resources; conventional treatment schemes remove suspended solids, organic material, and deactivate pathogens via disinfection. More advanced treatment processes can be used to remove nutrients such as nitrogen to protect drinking water and prevent eutrophication and degradation of ecological communities. Nitrogen levels in sanitary wastewater vary considerably; typical secondary wastewater treatment processes reduce influent total nitrogen concentrations by 50 percent or less. Additional treatment processes utilized at biological nutrient removal (BNR) facilities can further reduce nitrogen levels to less than 10 mg/L, and sometimes to 4 to 6 mg/L.

Suffolk County and NYSDEC also permit the use of alternative treatment systems for flows up to 15,000 gallons per day (gpd); these systems are required to meet effluent nitrogen limits of 10 mg/L. These systems have previously been discussed in the SCDHS report entitled **Report on the Sewage Treatment Plants of Suffolk County** (Doroski and Olsen, November 2006); their effectiveness was summarized in the Task 5.2 memorandum.

BROOKHAVEN CASE STUDY
Montauk Highway Corridor

As part of this study, a modeling approach to simulate the impacts of proposed development upon nitrate groundwater levels was developed and applied to the Montauk Highway Corridor, to serve as an example of how the impacts of future proposed land use scenarios on downgradient groundwater quality can be evaluated. A subregional groundwater model was developed to evaluate the area of the Montauk Highway corridor that the Town of Brookhaven has proposed for redevelopment. A nitrogen loading spreadsheet model was developed to utilize Suffolk County Department of Economic Development and Planning (SCDEDP) land use files and assemble groundwater model input files for thousands of nitrogen point sources, which were used to represent the nitrogen loading associated with individual parcels within the study area. This nitrogen loading spreadsheet can be readily applied to other areas of the County by incorporating minor study area-specific changes.

Groundwater model simulations were conducted for both existing conditions and proposed future development scenarios based on a parcel-specific contaminant transport simulation over the region. Water quality data collected from recently installed SCDHS monitoring wells were used as targets to verify the model's ability to represent existing nitrogen transport, and loading parameters were varied until simulated and observed nitrogen concentrations were in general agreement. Using documented nitrogen loading assumptions for on-site wastewater treatment systems, simulated nitrogen concentrations at the monitoring wells successfully represented the observed concentrations.

Groundwater modeling evaluations of the Montauk Highway Corridor concluded that:

- The average simulated concentration of total nitrogen in the shallow groundwater beneath the medium-high density study area from on-site wastewater disposal was 12.5 mg/L, which is consistent with water quality data collected from nearby monitoring wells;
- The total nitrogen concentration in shallow groundwater resulting from the proposed development is projected to increase to 14.5 mg/L;
- Both existing development and the proposed development scenario result in nitrate levels that exceed 10 mg/L;
- As the Forge River already experiences severe water quality degradation (e.g., eutrophication), increased development of the Montauk Highway Corridor without sewering would be expected to exacerbate the observed problems.

The development and application of the modeling tools that have been produced during this study to enable planners and water resource managers to assess the impacts of proposed development alternatives on groundwater quality are described in the Task 5.2 memorandum. The evaluation approach, which was demonstrated for a pilot area in the Town of Brookhaven, will enable detailed, objective evaluation of the impacts of proposed changes in land use upon downgradient groundwater nitrate levels.

There are close to 200 of these small facilities operating in Suffolk County today. When successfully operated and maintained, these systems are, in many cases, capable of significantly reducing the nitrogen load to groundwater. However, they do require considerable operator attention to consistently and successfully operate, they require SCDHS oversight, and they do not necessarily remove organics and PPCPs that may be contained in the effluent. As of 2013, 197 sewage treatment plants were located in Suffolk County, sixteen of which discharged to surface waters. SCDHS records indicate that 139 of the sewage treatment plants are privately owned and inspected by SCDHS on a quarterly basis; the 33 municipal plants are inspected by NYSDEC. All of the sewage treatment plants are required to operate in compliance with a State Pollutant Discharge Elimination System (SPDES) permit and Suffolk County Article 7 requirements. As of 2013, 171 of the sewage treatment plants were designed to remove nitrogen from the wastewater to comply with SPDES permit discharge limits of 10 mg/L. Monitoring wells are sited at the plants discharging to groundwater to monitor the impacts of the treated effluent upon groundwater quality; samples are collected and analyzed on a quarterly basis from these wells.

Nitrogen removal at the sewage treatment plants is accomplished via denitrification; two of the systems currently employed in the County are sequencing batch reactors (SBRs) and Cromaglass systems. SCDHS collects and analyzes samples from the sewage treatment plants and from downgradient monitoring wells for nitrogen. The Task 5.2 memorandum documented the challenges faced by the SCDHS Office of Wastewater Management (OWM) in obtaining compliance with the 10 mg/L effluent limit – at that time, fewer than 50 percent of the plants (66 out of the 138 monitored at that time) maintained average effluent nitrogen concentrations less than or equal to the 10 mg/L limit.

The impact of both operations and the alternative technologies on performance was also considered. The small treatment systems are complicated to operate and treatment efficiency can be affected by diurnal flow variation and temperature. While operators of these community wastewater treatment systems are required to be certified New York State operators, effluent quality varies widely. Nonetheless, all fifteen of the Suffolk County Sewer District plants discharging to groundwater that were operated by the Suffolk County Department of Public Works (SCDPW) successfully maintained average effluent nitrogen concentrations of less than 10 mg/L; the average effluent nitrogen level from these facilities was 5.2 mg/L. Differences in technology performance were also evident. Out of sixty operating SBR facilities, fifty five percent had average effluent nitrogen levels less than or equal to the 10 mg/L limit, but the average effluent nitrogen level was 13 mg/L.

Only 25 percent of the sixteen Cromaglass facilities operating at the time that the document was prepared had average effluent nitrogen levels below the 10 mg/L limit. The average level of nitrogen in Cromaglass effluent was 22.3 mg/L. Considering all other types of treatment systems, less than fifty percent (28 out of 58) had average effluent nitrogen levels of less than or equal to 10 mg/L; the average effluent nitrogen concentration was 13.3 mg/L.

In 2007, SCDHS OWM initiated several actions to improve the effectiveness of the Cromaglass systems, which are currently approved for community sewage treatment in Suffolk County. SCDHS identified both mechanical and electrical problems and the Cromaglass maintenance challenges that caused the non-compliance. Working with Cromaglass owners and operators to improve system performance, more recent SCDHS data shows that average effluent nitrogen levels from facilities that have implemented the required improvements have been significantly reduced. Five year service contracts with Cromaglass are now required to improve operational reliability, and immediate fines are levied for violations.

By 2008, the following year, Cromaglass system operations had been improved such that two thirds of the operating systems complied with the 10 mg/L effluent limit and the average effluent nitrogen concentration of all Cromaglass systems had been reduced by more than 50 percent to 10.6 mg/L. At that time, SCDHS had initiated legal action against additional systems that were not in compliance, and treatment effectiveness has continued to improve.

In 2008, SCDHS OWM continued to work with treatment plant owners and operators to improve facility operations, and implemented a new policy requiring legal action and mandatory fines for violations. The policy also required issuance of Consent Orders for facilities requiring substantial upgrade, to require completion without unnecessary delays. Effluent quality data available from 2008 showed that within that first year, treatment had improved such that nearly 70 percent of the plants had achieved the 10 mg/L discharge limit for nitrogen. SCDHS OWM is also revising Suffolk County Sanitary Code Article 7 Sewage or Industrial Waste Treatment Facilities Operation and Maintenance Standards. These revised standards, which will clearly define the increased responsibilities of plant operators, engineers of record and owners, will also help to continue to improve effluent quality.

SCDHS OWM's **Report on the Sewage Treatment Plants of Suffolk County 2013 Performance Evaluation** reported that the average effluent total nitrogen concentration of the 128 plants that were not under consent order or were not operating in a steady state condition was 5.9 mg/L, while the overall effluent nitrogen concentration for all operational plants was 8.7 mg/L.

SCDHS's OWM's efforts have clearly been successful in improving wastewater treatment facility effectiveness.

The last sanitary wastewater management alternative, currently utilized by approximately 74 percent of County residents, is on-site wastewater disposal systems, typically consisting of a cesspool or a septic tank and leaching pools. Septic systems are widely used throughout the world; they are passive systems that successfully reduce organic loading to the environment. However, reported nitrogen removal rates within household systems vary widely and are not always easy to assess. Reported nitrogen removal rates vary from ten to fifty percent.

When properly sited, designed and maintained, all three of these approaches are capable of enabling the groundwater resource to achieve the 10 mg/L groundwater standard for nitrate on a regional basis.

Effectiveness of Article 6

Article 6 of the Suffolk County Sanitary Code allows on-site wastewater disposal systems for new residential subdivisions with lot sizes greater than or equal to one acre in Groundwater Management Zones III, V and VI and greater than or equal to one half acre in all other zones (please refer to **Figure 3-4**); undersized lots existing prior to 1981 are exempt.

New residential development on lot sizes smaller than one acre within the deep recharge zone and one half acre outside of the deep recharge zone requires use of a community sewage system for wastewater treatment and disposal. As nitrogen levels in groundwater (as characterized by measured concentrations in public supply wells) have continued to increase, the relationship between unsewered residential development density and nitrogen levels, and the adequacy of the Article 6 density restrictions in protecting groundwater quality have been questioned and were evaluated during this study.

By the time that Article 6 was enacted in 1980, a number of existing residences with on-site wastewater disposal systems had already been constructed on parcels smaller than ½ acre and 1 acre as specified in Article 6. While sufficient information to quantify the number of residential parcels that were developed with on-site sanitary wastewater disposal prior to enactment of Article 6 was not available, the number of parcels less than or equal to one half acre and zoned for residential use was identified. Data provided by the Suffolk County Department of Economic Development and Planning showed that almost 53 percent of unsewered residential parcels in the County are less than or equal to one half acre. Because the populations of the west end towns have not increased significantly since 1970, it is evident that a large portion of the

smaller parcels do rely upon on-site septic systems for wastewater disposal, and nitrate levels in groundwater reflect these conditions. Residential parcels that are less than or equal to ½ acre are illustrated on **Figure 3-10** and summarized by Town on **Table 3-4**.

In fact, residentially zoned properties in the western towns are even smaller; the locations of residential properties less than or equal to one quarter acre are shown on **Figure 3-11** and summarized by Town on **Table 3-5**.

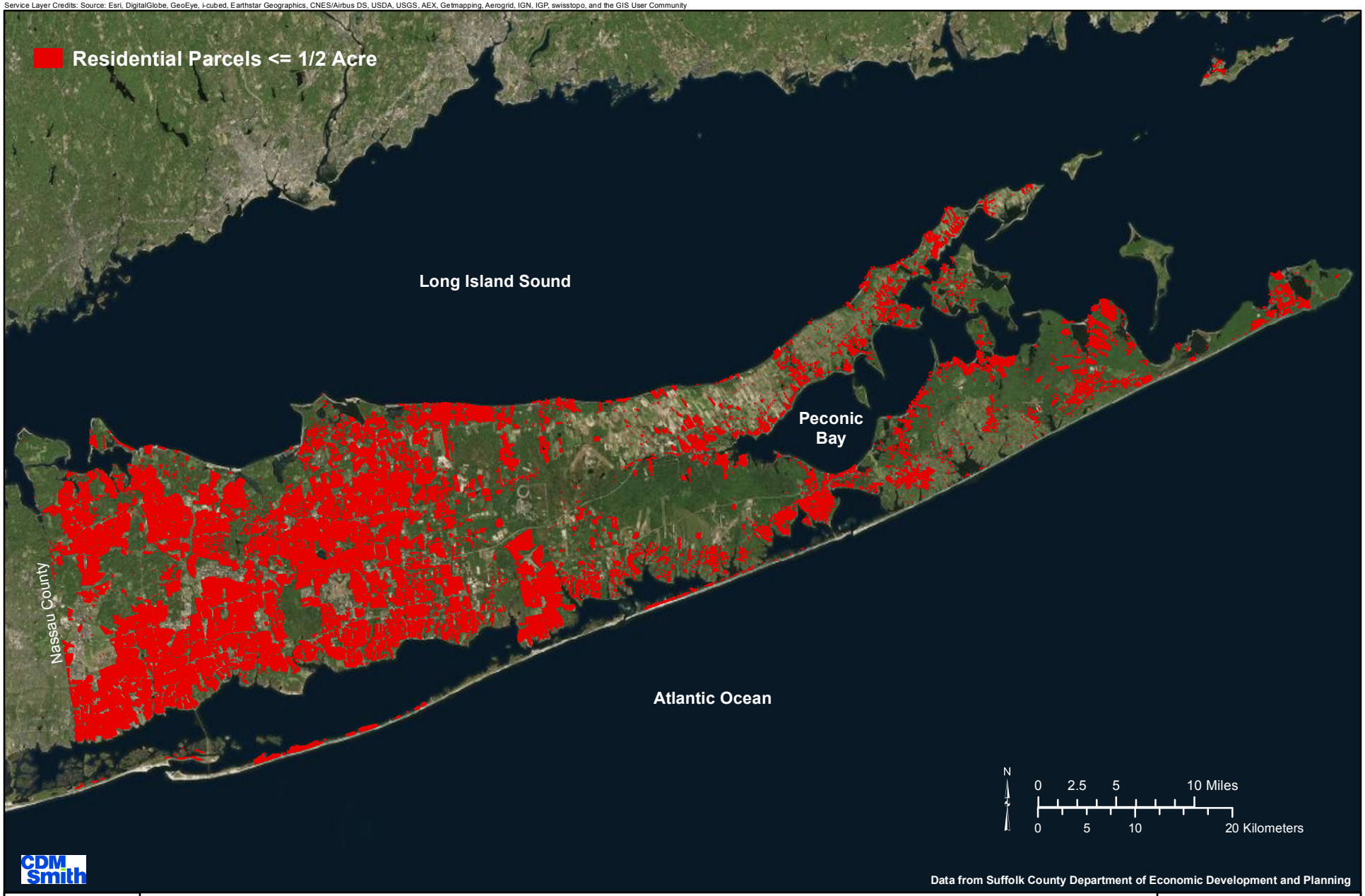
Table 3-4 Residential Parcels Smaller than or Equal to One-Half Acre

Town	Number of Residential Parcels Less than or Equal 1/2 Acre	Number of Unsewered Residential Parcels Less than or Equal to ½ Acre	Total Residential Parcels	% of Unsewered Parcels Less than or Equal to 1/2 Acre
Babylon	58,377	15,291	59,485	25.7%
Brookhaven	119,535	92,253	151,672	60.8%
East Hampton	9,452	9,157	19,342	47.3%
Huntington	44,952	39,566	64,747	61.1%
Islip	78,796	47,143	88,138	53.5%
Riverhead	6,996	5,276	11,957	44.1%
Shelter Island	491	384	2,498	15.4%
Smithtown	28,181	24,985	37,643	66.4%
Southampton	17,776	17,114	37,365	45.8%
Southold	7,462	6,457	14,235	45.4%
Totals	**372,018**	**257,626**	**487,082**	**52.9%**

Source: Suffolk County Department of Economic Development and Planning

Over one third of the unsewered residential properties in Brookhaven and Huntington are less than or equal to one quarter acre. Approximately one quarter of the unsewered residential properties in Riverhead and Smithtown are less than or equal to one quarter acre, and over fifteen percent of unsewered residential properties in the east end towns of East Hampton and Southampton are also less than or equal to one quarter acre. Over eighty percent of the total residential properties in Babylon are less than or equal to one quarter acre; groundwater contamination resulting from the on-site septic systems prompted the implementation of the Southwest Sewer District in the 1970s.

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

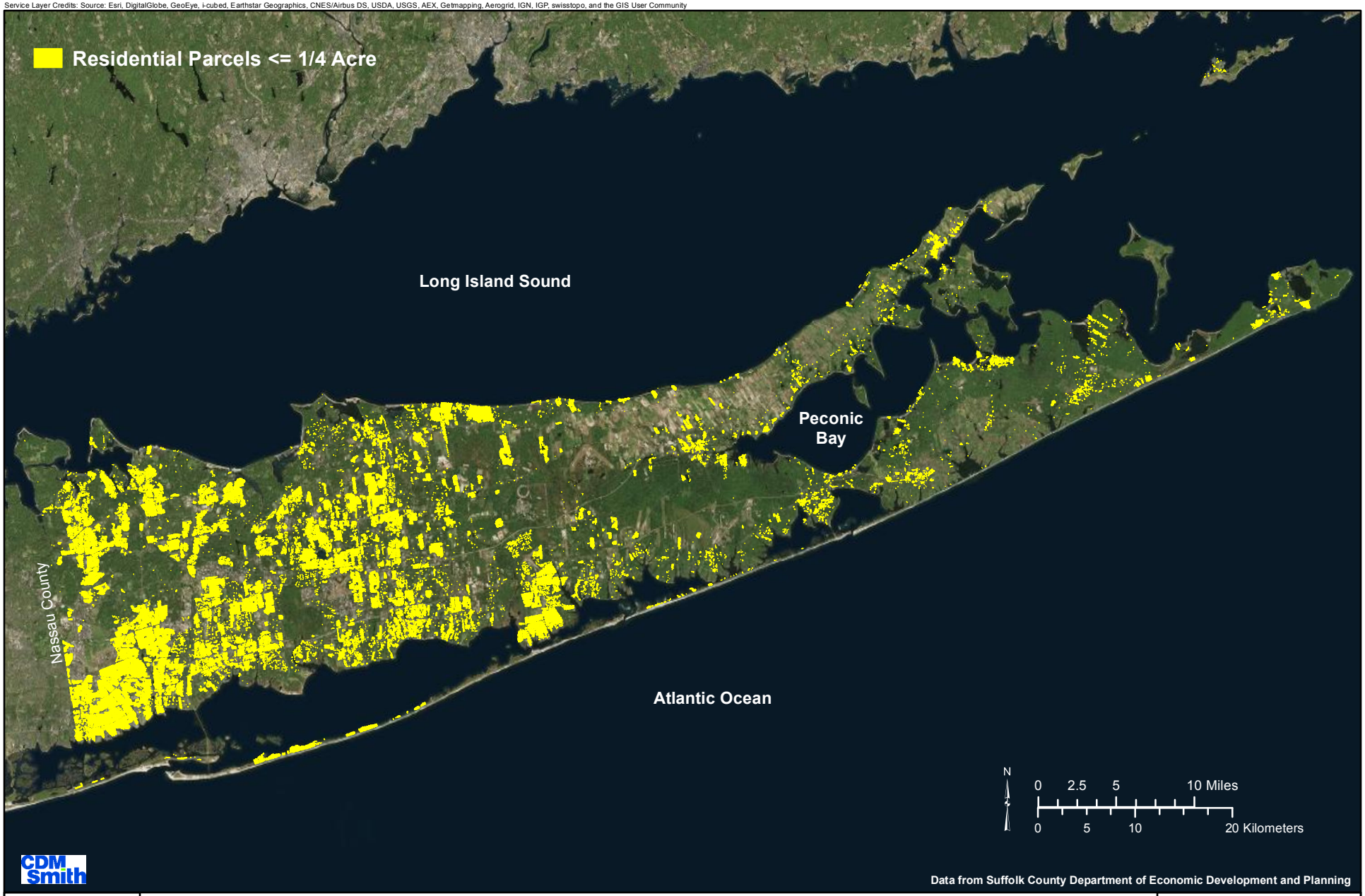


Residential Parcels Less Than or Equal to 1/2 Acre

Suffolk County Comprehensive Water Resources Management Plan

Figure 3-10

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



Residential Parcels Less Than or Equal to 1/4 Acre

Suffolk County Comprehensive Water Resources Management Plan

Figure 3-11

Table 3-5 Residential Parcels Smaller than or Equal to One-Quarter Acre

Town	Number of Residential Parcels Less than or Equal ¼ Acre	Number of Unsewered Residential Parcels Less than or Equal to ¼ Acre	Total Residential Parcels	% of Unsewered Parcels Less than or Equal to ¼ Acre
Babylon	50,094	12,381	59,485	20.8%
Brookhaven	67,423	50,334	151,672	33.2%
East Hampton	3,479	3,186	19,342	16.5%
Huntington	27,373	22,608	64,747	34.9%
Islip	38,994	19,577	88,138	22.2%
Riverhead	4,064	2,926	11,957	24.5%
Shelter Island	128	53	2,498	2.12%
Smithtown	13,766	10,823	37,643	28.8%
Southampton	6,791	6,132	37,365	16.4%
Southold	2,791	1,927	14,235	13.5%
Totals	**214,903**	**129,947**	**487,082**	**26.7%**

Source: Suffolk County Department of Economic Development and Planning

While the exact number of on-site sanitary wastewater disposal systems that had been constructed prior to Article 6 could not be verified, it is evident that a significant number of smaller parcels do rely upon on-site septic systems for wastewater disposal, and nitrate levels in groundwater reflect these conditions. This is further corroborated by census data provided by SCDHS documenting the presence of over 340,000 on-site septic systems in Suffolk County in 1990, and SCDEDP estimates indicating that wastewater disposal for approximately 74 percent of County properties is provided by individual on-site sanitary systems consisting either of septic tanks or septic tanks and/or leaching pools.

A summary table showing the average parcel size for each residential land use category in each of the 29 wellfields that was evaluated for this study is summarized on **Table 3-6**, along with the percentage of residential parcels served by sanitary sewers, the GMZ in which the contributing area is located, the associated nitrate target concentration, and the average recent supply well nitrate concentrations. The target GMZ-specific nitrogen concentration is exceeded in groundwater from 16 of the 29 wellfields.

Table 6

Summary of Residential Parcel Size for All Parcels Intersecting the Water Table Contributing Areas for the 29 Identified Wellfields

Area	Wellfield	% Residential (2004)	Count of Parcels			Average Size of Parcels (sq ft)			Average Nitrate as Nitrogen (mg/L) 2004-2009			
			Low Density	Medium Density	High Density	Low Density	Medium Density	High Density	Low	High	GWMZ	Target (mg/L)
1	Woodchuck Hollow Road	53.04%	3	777	566	44,555	11,602	7,197	3.60	6.37	1	6
2	Waterside Road	74.52%	3	464	337	65,812	15,532	7,207	7.39	7.39	1	6
3	Laurel Hill Road	47.21%	43	119	53	57,907	23,883	5,779	3.39	3.81	1	6
4	Belle Rose Avenue	82.35%	1	81	0	49,157	20,743	0	5.70	5.70	1	6
5	Larkfield Road / South Spur	71.25%	3	158	7	48,023	20,142	6,191	7.95	7.95	1	6
6	Schuyler Drive	30.55%	8	612	18	43,318	11,871	5,985	4.96	9.33	1	6
7	Vanderbilt Parkway	89.61%	39	45	0	55,271	42,482	0	1.83	1.83	1	6
8	Ryder Avenue	70.32%	57	114	1	47,617	26,368	366	2.30	2.30	1	6
9	Wheeler Road	16.67%	1	44	1	71,632	21,560	201,516	2.57	5.00	1	6
10	Oval Drive	25.00%	6	59	2	48,462	27,059	52,922	5.04	5.65	1	6
11	Wheat Path	73.63%	59	487	22	56,883	20,682	5,094	2.17	4.21	3	4
12	Mt. Sinai-Coram Road	62.16%							8.59	8.59	8	6
	sewered		0	82	17	0	22,157	24,961				
	unsewered		7	68	5	47,717	25,659	2,384				
	% sewered (residential; area)		0	51%	97%							
13	Bicycle Path	66.97%							0.43	5.82	3	4
	sewered		0	217	3	0	16,478	6,388				
	unsewered		2	193	9	47,564	17,622	4,409				
	% sewered (residential; area)		0	51%	33%							
14	Chestnut Street	57.14%							0.50	1.07	3	4
	sewered		1	353	2	60,496	16,616	1,468,315				
	unsewered		10	376	17	52,501	18,047	4,644				
	% sewered (residential; area)		10%	46%	97%							
15	Strathmore Court Drive	61.78%							0.13	2.98	3	4
	sewered		0	455	205	0	16,801	26,226				
	unsewered		0	6	13	0	16,385	2,520				
	% sewered (residential; area)		0%	99%	99%							
16	Hawkins Road	54.30%							8.95	8.95	1	6
	sewered		0	2	0	0	17,269	0				
	unsewered		0	536	13	0	10,292	7,429				
	% sewered (residential; area)		0%	1%	0%							
17	Eastwood Boulevard	54.29%	0	93	0	0	10,913	0	4.69	4.69	1	6
18	Boyle Road South	52.94%	11	314	26	61,663	14,088	7,188	5.03	5.03	3	4
19	Dare Road	70.73%							5.75	5.75	3	4
	sewered		1	2	0	43,898	32,838	0				
	unsewered		8	171	12	49,299	23,006	6,595				
	% sewered (residential; area)		10%	2%	0%							
20	Flint Lane	43.18%							2.22	3.33	3	4
	sewered		0	206	97	0	16,485	16,869				
	unsewered		2	131	125	57,196	16,304	2,372				
	% sewered (residential; area)		0%	61%	85%							
21	Meehan Lane	64.22%							6.20	8.24	3	4
	sewered		10	3	1	87,284	24,932	6,579				
	unsewered		6	367	1	49,207	16,249	401,417				
	% sewered (residential; area)		75%	1%	1%							
22	Pleasant Avenue	76.19%	3	124	1	74,863	18,959	3,697	7.03	7.19	1	6
23	Morris Avenue	52.98%							3.52	4.92	1	6
	sewered		6	303	1	91,484	16,852	8,474				
	unsewered		7	452	7	75,195	18,698	5,168				
	% sewered (residential; area)		51%	38%	19%							
24	Barton Avenue	61.39%	15	229	10	57,815	19,043	5,003	6.61	6.85	3, 6	4
25	North Country Road	51.69%	2	103	1	112,681	22,700	7,987	3.58	3.58	3, 8	4, 6
26	Moriches Riverhead Road	0.00%	0	0	0	0	0	0	0.11	0.21	3	4
27	Old North Road (Greenport)	12.07%	4	3	0	104,996	23,577	0	8.16	8.89	4	6
28	Ackerly Pond Lane	4.67%	2	4	0	83,166	29,637	0	6.19	6.94	4	6
29	Bridgehampton Road	33.53%	10	117	2	55,252	29,381	8,154	2.74	8.05	5	4

Recognizing the impacts of fertilizer on our water resources, in 2007 Suffolk County passed Local Law 41-2007 to reduce the impacts of improper lawn fertilization on nitrogen loading to ground and surface waters.

The law prohibits fertilization from November 1st to April 1st, and allows imposition of fines of up to $1,000 for violations.

In addition, all new applicants or renewals for Suffolk County Home Improvement Contractors Licenses who apply fertilizer must take a Suffolk County-approved turf management class. As of 2014, 28 classes providing information on the proper use, application and timing of fertilization, native planting alternatives to fertilized landscapes, and the environmental consequences of nitrogen runoff were offered and 1,470 certificates have been issued.

Signs and brochures publicizing the prohibition of fertilization between November 1st and April 1st, describing appropriate fertilization techniques and explaining the impacts of nitrogen on water resources were updated, translated into Spanish and redistributed to all retail locations in Suffolk County where fertilizer is sold.

The contributing areas of eleven of the wellfields that currently exceed the GMZ nitrate target concentrations for nitrate include medium or high density residential parcels that are smaller than the 20,000 or 40,000 ft^2 designation established by Article 6. These sites are in towns that were developed long before the adoption of Article 6. The elevated nitrate concentrations in three of the other five wellfields appear to result from agricultural use within the contributing area; nitrate levels in a fourth wellfield also appear to result from historical agricultural use in the contributing area.

The data shows that a significant number of on-site sanitary wastewater disposal systems do serve properties that are less than the minimum lot sizes designated in Article 6; observed nitrogen levels in Suffolk County groundwater result from a combination of the Article 6-compliant and the older non-compliant parcels. In general, GMZ target nitrogen levels are achieved in areas where unsewered residential density is compliant with Article 6 density requirements; GMZ target nitrogen levels are exceeded in unsewered areas developed at higher densities prior to enactment of Article 6. Regulation of residential density in areas relying upon on-site wastewater disposal is widely implemented across the country to manage impacts on groundwater quality. In order to provide further perspective on the adequacy of the residential density limits included in the Suffolk County Sanitary Code, housing density limits in similar unsewered areas relying upon groundwater for potable supply elsewhere throughout the country were reviewed. Information available to characterize residential density restrictions based upon nitrogen loadings across the country identified a minimum lot size of one half acre for unsewered areas, although minimum lot size requirements in some areas of the country were larger. The half-acre minimum lot size is consistent with Article 6 requirements.

While not exhaustive, information on permissible residential densities in unsewered areas was collected from other sources throughout the country, with the following results:

- No communities were identified that allow a development density greater than 2 dwelling units per acre in areas that are both unsewered and rely upon groundwater for water supply.

- Unsewered areas that historically allowed greater than 2 dwelling units per acre report groundwater and/or surface water contamination that led to either code changes or subsequent construction of sanitary sewers.

Nitrate levels remained less than or equal to 6 mg/L in nearly 88 percent of all public supply wells tested in 2013; the 10 mg/L MCL was exceeded in untreated water from less than one percent of public supply wells.

Nitrate levels have continued to increase in all three aquifers over the study period from 1987 to 2013. Nitrates were detected in more wells, and generally at higher concentrations in 2013 than in the past. Significant increases in nitrogen levels have been observed in groundwater in parts of Huntington, Smithtown and northern Brookhaven.

The average nitrate concentration, and the number of public supply wells with nitrate concentrations in excess of 6 mg/L have increased, based on a comparison of nitrate levels measured in the same set of public supply wells in 1987 and again in 2013.

Article 6 of the Sanitary Code has been successful in achieving target nitrate levels in areas that have been developed subsequent to enactment in 1980 – however observed nitrate levels in groundwater result from a combination of Article 6-compliant and older non-compliant parcels.

Existing regulatory programs have been successful in limiting the impacts of the County's 1.5 million residents on nitrate levels; however, additional efforts to reduce nitrogen loading to the aquifer will be required to maintain the integrity of the groundwater supply for future generations and reduce the loading and subsequent impacts to Suffolk's water resources.

- Additional details can be found in the Task 5.2 memorandum (**Future Land Use Impacts**, CDM, 2008).

The observed nitrogen levels in groundwater, which have increased in some areas since the ***1987 Comp Plan***, result from a combination of the Article 6-compliant and the older non-compliant parcels. Building upon the work documented in the ***1987 Comp Plan***, several evaluations of parcel size and downgradient groundwater nitrogen concentration have been conducted which demonstrate that nitrate levels increase with increasing density. However, existing water quality data and land use information are not always straightforward to interpret, given the variation in land use, density, household size and nitrogen loading in any given area of interest. Therefore, an assessment of the impacts of hypothetical unsewered areas of various densities on nitrogen levels in groundwater was performed for an area in southern Brookhaven, using the detailed modeling framework previously established during the task 5.5 modeling effort. The modeling assessment was a hypothetical exercise, in that it assumed that the study area was comprised completely of developments of uniform lot sizes of ¼ acre, ½ acre, 1 acre and 2 acres.

The groundwater flow model was run using the model inputs, stresses, and boundary conditions that have been documented in the Task 5.5 Memorandum, **Refined Source Water Assessments** (CDM, 2009) and nitrogen loading rates documented in the Task 5.2 Memorandum. From within the modeled region, a pilot area covering approximately 8,000 acres was selected to examine the effects of nitrogen loading resulting from various uniform residential densities on groundwater quality. This pilot area was chosen to be within the relatively undeveloped Pine Barrens Region and beyond the influence of streams. The pilot area contains five public supply wells screened in the upper glacial aquifer. A series of model simulations was performed to assess the groundwater nitrogen levels associated with hypothetical unsewered residential developments of uniform densities of 2 acres, 1 acre, ½ acre and ¼ acre, respectively. The household nitrogen loading rate was assumed to be based upon a 3.1 person household, with each person discharging 10 pounds of nitrogen each year to the septic system; furthermore thirty-five percent of the discharged nitrogen load was assumed to be removed within the septic system. In addition, for the purposes of this exercise, all of the simulated nitrogen was assumed to be nitrate as

nitrogen.

Fertilizer use is a second significant source of nitrate to the aquifer system. Suffolk County has implemented a plan to reduce the impacts of fertilizer on ground and surface water features. Recognizing the impacts of fertilizer on our water resources, in 2007 Suffolk County passed Local Law 41-2007 to reduce the impacts of improper lawn fertilization on nitrogen loading to ground and surface waters. The law, which went into effect in 2009, includes a variety of components, including prohibition of fertilization from November 1st to April 1st, a requirement that licensed landscapers (approximately 1,200 in Suffolk County in 2010) complete a turf management course, and allows imposition of fines of up to $1,000 for violations.

Signs and brochures publicizing the prohibition of fertilization between November 1st and April 1st, describing appropriate fertilization techniques and explaining the impacts of nitrogen on water resources were updated, translated into Spanish and redistributed to all retail locations in Suffolk County where fertilizer is sold.

Fertilizer sales in Suffolk County have declined by over 11 percent since the law took effect in 2009, however they still significantly higher than fertilizer sales in other counties within New York State.

A second set of model simulations was used to assess the effects of nitrate released from fertilizer on nitrate levels in unsewered areas of various densities; in all cases, this assessment assumed that 2.5 pounds of nitrogen is applied each year for each 1,000 ft^2, that 23 percent of each parcel is fertilized, and that 20 percent of the applied nitrate reaches the water table.

The simulated nodal concentrations representing nitrate concentrations averaged over the top 40 feet of saturated aquifer thickness throughout the pilot area are shown for 4, 10, and 20 year intervals for each of the development densities considered on **Figures 3-12** through **3-15**. Consistent with observed data throughout the County, **Figure 3-12** shows that nitrate concentrations resulting from discharge of sanitary wastewater via on-site septic systems in areas with ¼ acre zoning exceed the drinking water standard of 10 mg/L in the shallow aquifer. **Figure 3-13** shows that ½ acre lots are successful in maintaining groundwater nitrate levels at less than 10 mg/L. Nitrate levels resulting from on-site wastewater disposal on 1 acre and 2 acre properties remain less than 4 mg/L in downgradient groundwater as shown by **Figures 3-14** and **3-15**.

Time histories of simulated nitrate concentrations pumped out of three centrally located public supply wells within the pilot area were also evaluated.

The simulated pumped nitrate concentrations for each of the eight scenarios simulated are shown in **Figure 3-16**. The results, which assumed an initial background nitrate concentration of zero, illustrate that it can take years for the impacts of a development to be manifested at a downgradient wellfield. Shallow supply wells with contributing areas within the developed zone will show increased nitrate levels more quickly, while it may take many years for deeper supply wells located miles downgradient of their contributing areas to reach equilibrium nitrate concentrations.

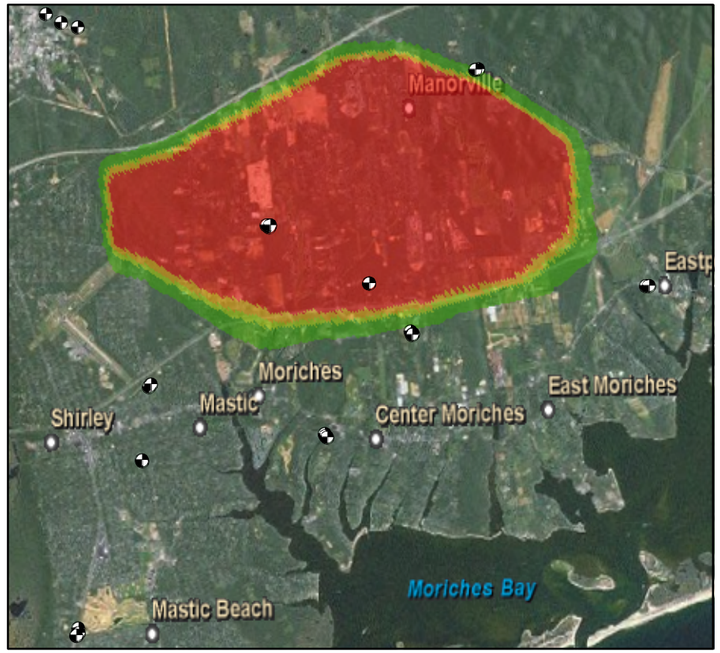
This hypothetical evaluation did not include allowance for streets; incorporation of roadway areas within a development would tend to reduce the simulated concentrations that are shown here. However, the evaluation was also based upon a background nitrate concentration of zero. In actuality, depending upon the previous land use, background nitrate levels could range from 0.5 mg/L (undeveloped) to over 10 mg/L (historical agricultural use); which would increase the final nitrate levels shown.

It is recommended that an evaluation of modifying Article 6 to require a minimum lot size of one acre for new development utilizing on-site sewage disposal systems be considered for other areas, such as Zone IV, to reduce nitrogen loading to surface waters from groundwater baseflow.

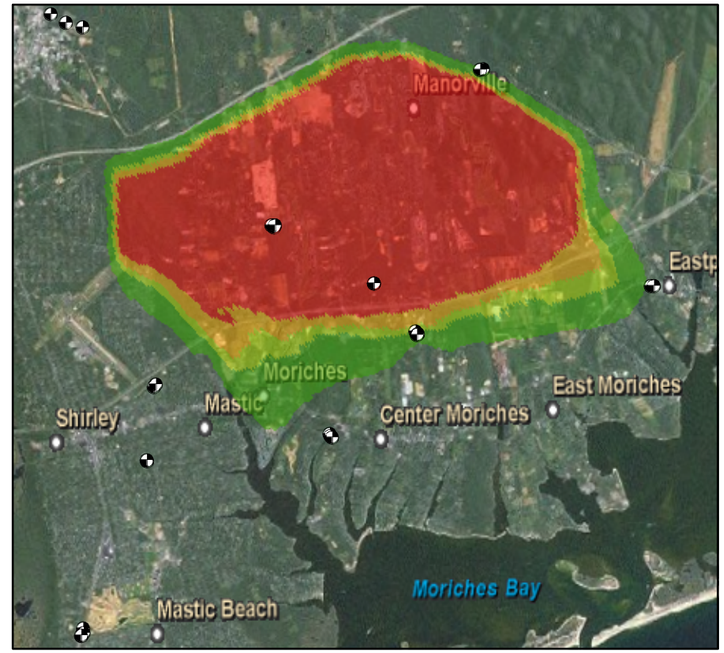
Building upon the body of SCDHS work over the past decades, the evaluations relating land use to observed nitrate levels completed as part of this study (e.g., documented in task memoranda 5.1, 5.2, and 18), review of density/nitrate relationships established elsewhere in the country, and these most recent model results, it is recommended that the Suffolk County Board of Health consider modifying Article 6 to require a minimum lot size of one acre for the use of individual on-site sewage disposal systems in realty subdivisions and developments in additional areas of the County. While nitrate concentrations resulting from an area of uniform ½ acre density are simulated to be close to 6 mg/L, new development occurs within the framework of properties that have already been developed; many pre-1980 developments include parcels that are less than ½ acre or even ¼ acre in size.

The North Shore Embayment Watershed Management Plan (SCDHS, 2007) reported that groundwater was the greatest contributor of nitrogen to the embayments within the study area; this appears to be the case along the entire north shore. The recommended minimum of one acre zoning in unsewered areas of Hydrogeologic Zone IV will also reduce nitrogen loading to surface waters from groundwater baseflow. While this recommendation focuses upon nitrogen criteria, it was also developed in recognition of the fact that many other contaminants of potential concern can also be introduced to the subsurface from on-site wastewater disposal.

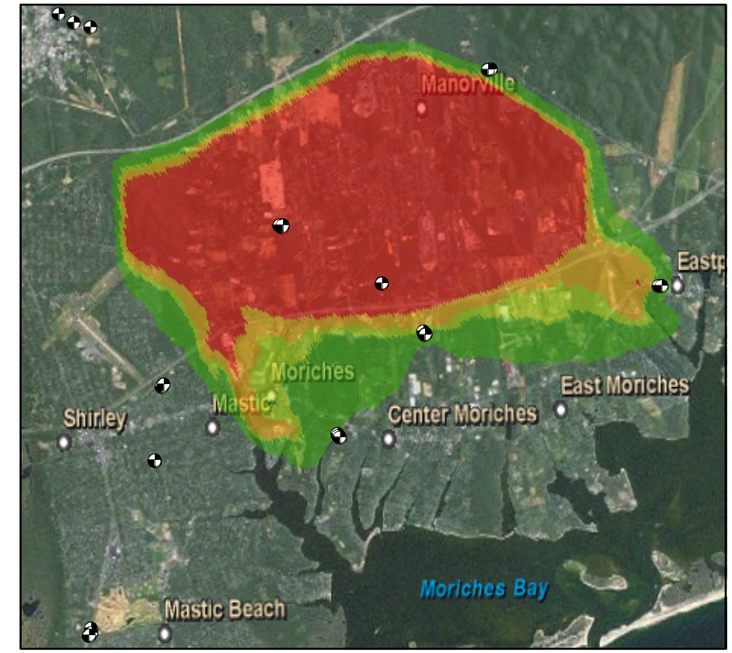
Quarter Acre Density 4 yr No Fertilizer



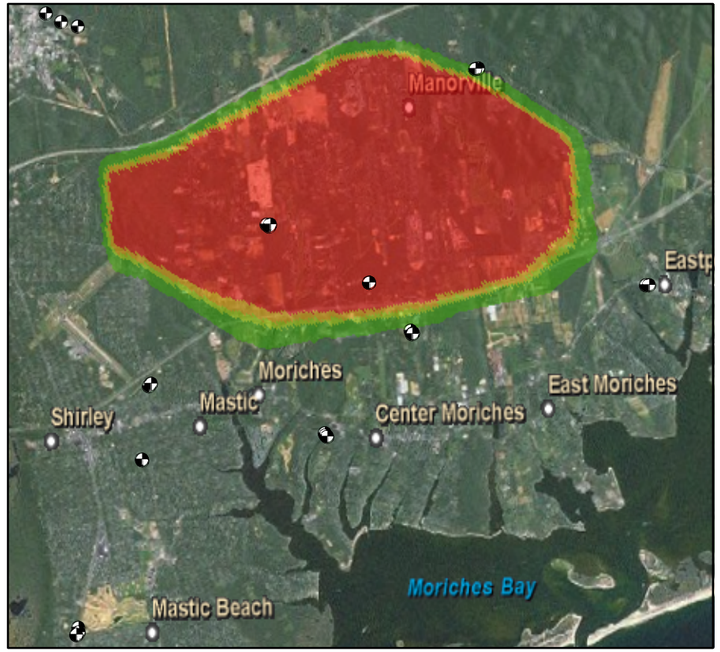
Quarter Acre Density 10 yr No Fertilizer



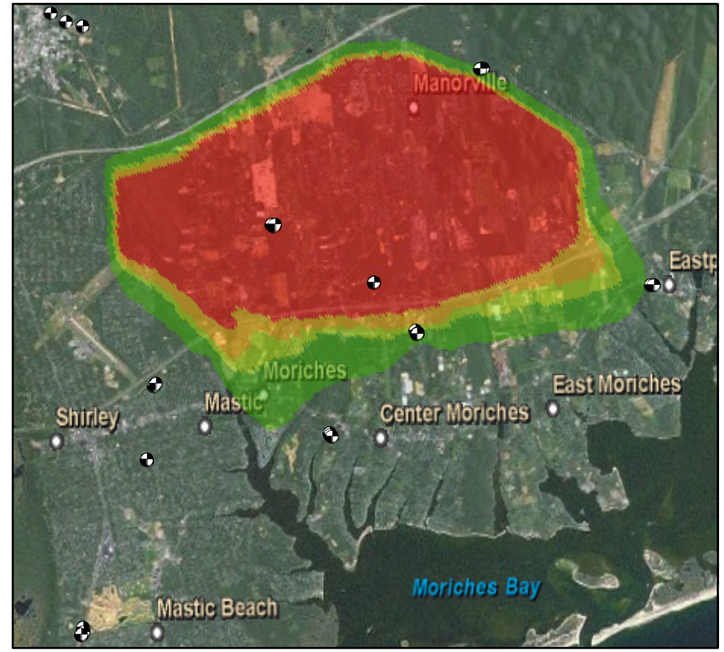
Quarter Acre Density 20 yr No Fertilizer



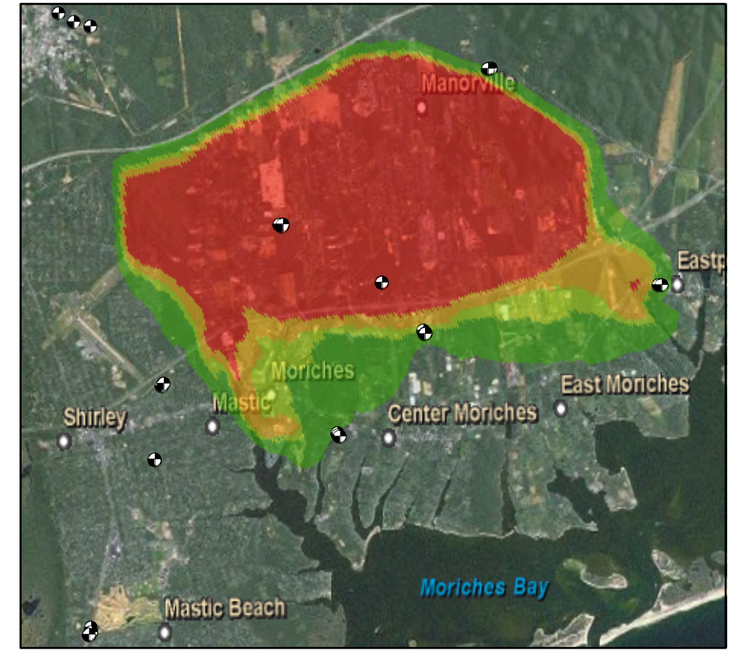
Quarter Acre Density 4 yr Fertilizer



Quarter Acre Density 10 yr Fertilizer



Quarter Acre Density 20 yr Fertilizer



CDM

Nitrogen (mg/l)
- 0.5 - 4
- 4 - 6
- 6 - 10
- > 10

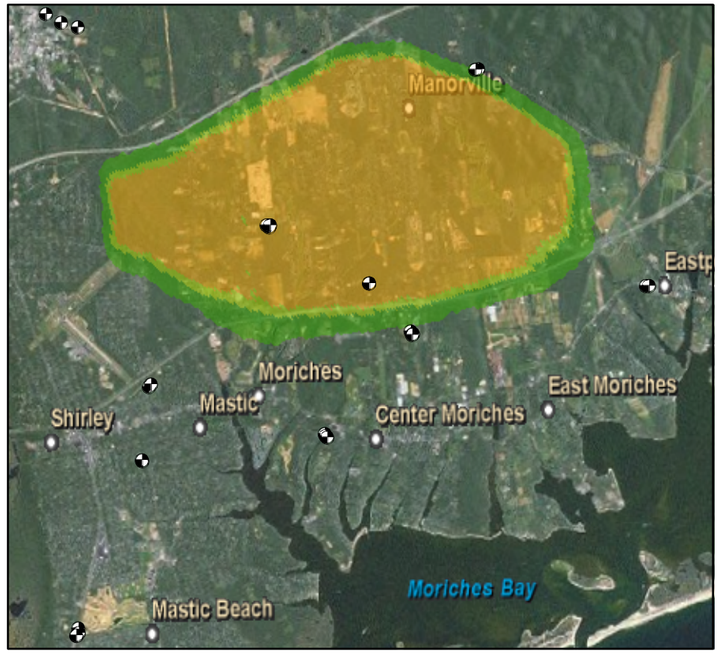
Supply Well

Nitrogen Loading Simulation - 1/4 Acre Density

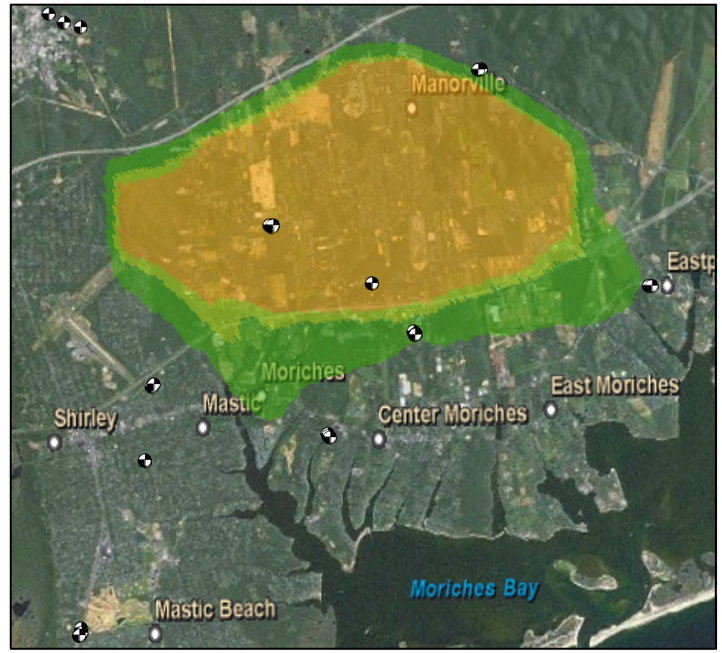
Suffolk County Comprehensive Water Resources Management Plan

Figure 3-12

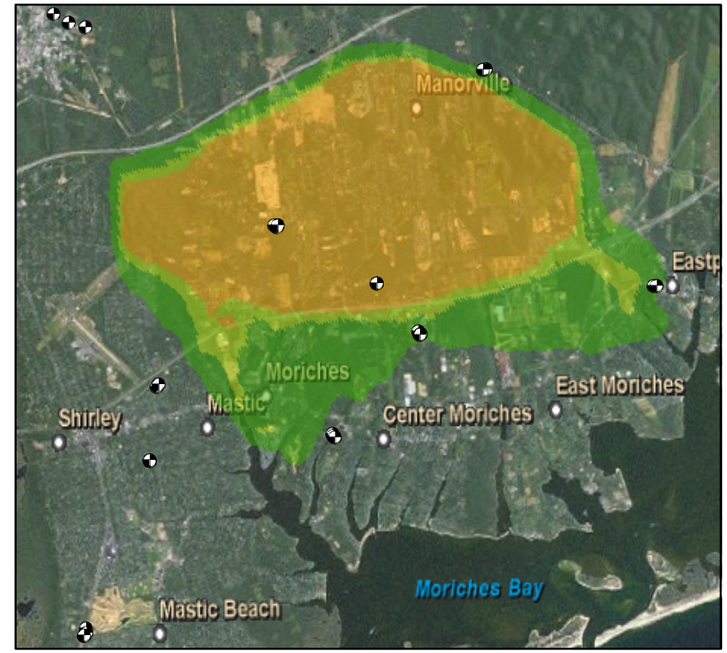
Half Acre Density 4 yr No Fertilizer



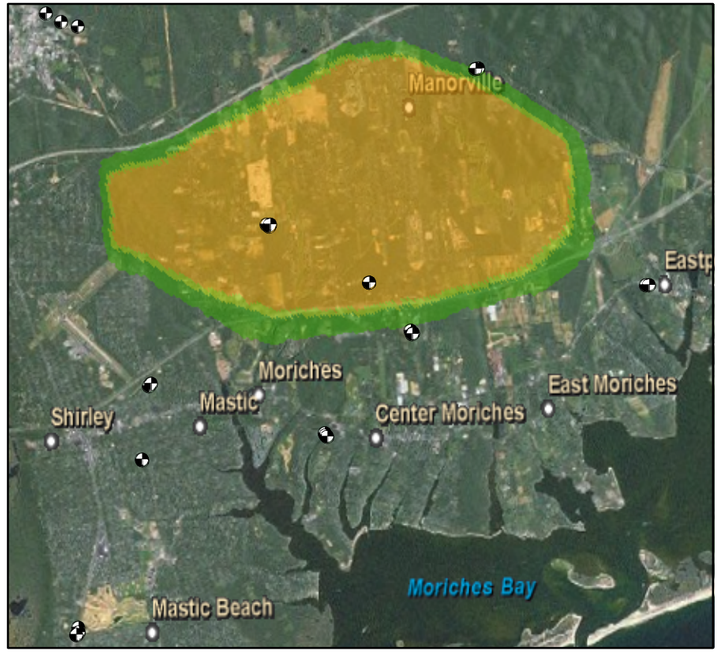
Half Acre Density 10 yr No Fertilizer



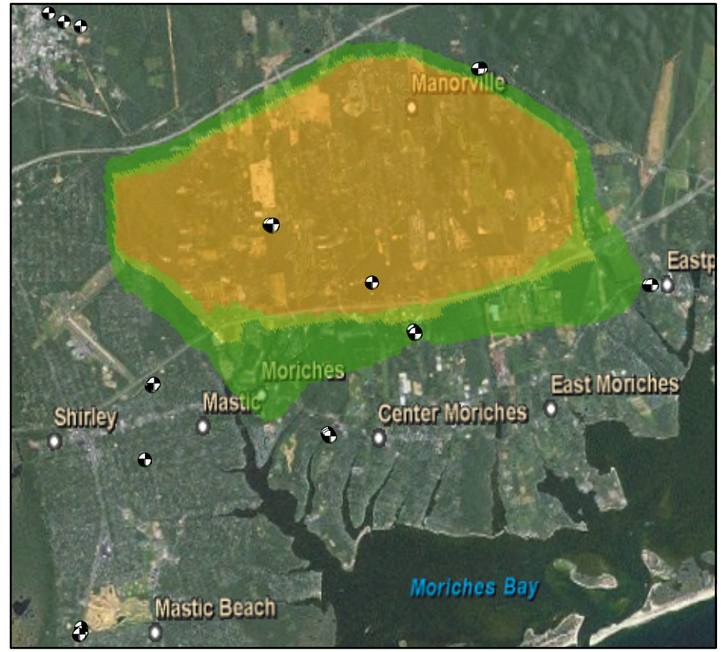
Half Acre Density 20 yr No Fertilizer



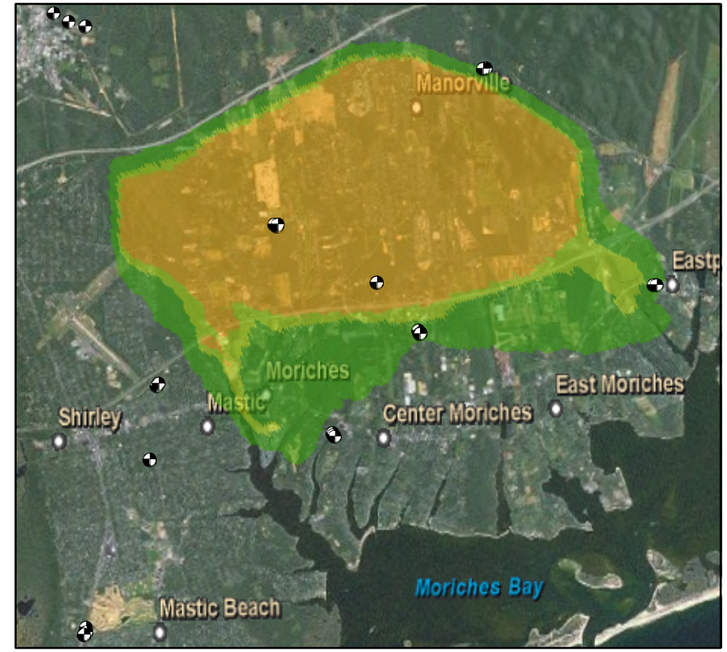
Half Acre Density 4 yr Fertilizer



Half Acre Density 10 yr Fertilizer



Half Acre Density 20 yr Fertilizer



CDM

Nitrogen (mg/l)
- 0.5 - 4
- 4 - 6
- 6 - 10
- > 10

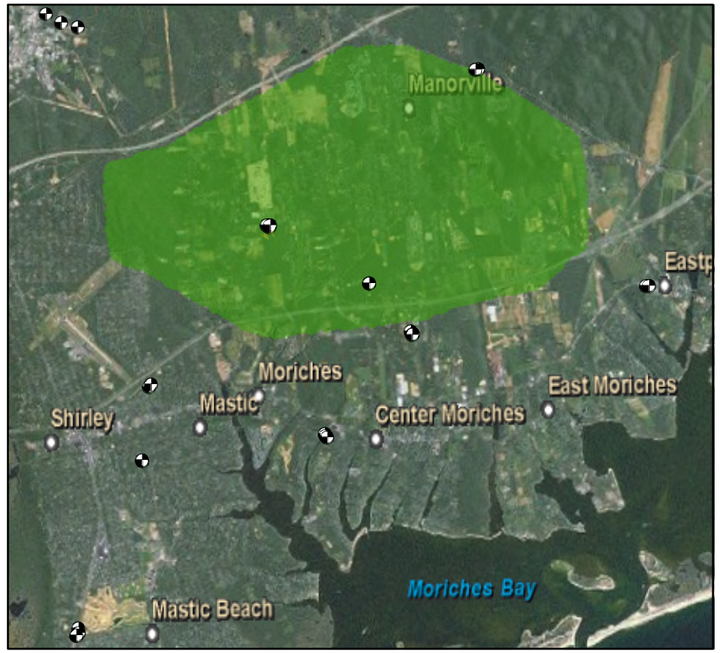
Supply Well

Nitrogen Loading Simulation - 1/2 Acre Density

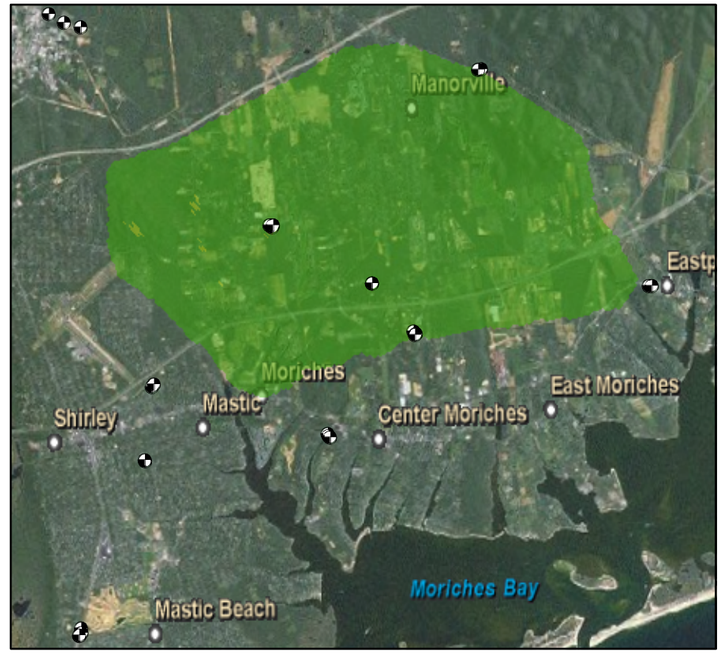
Suffolk County Comprehensive Water Resources Management Plan

Figure 3-13

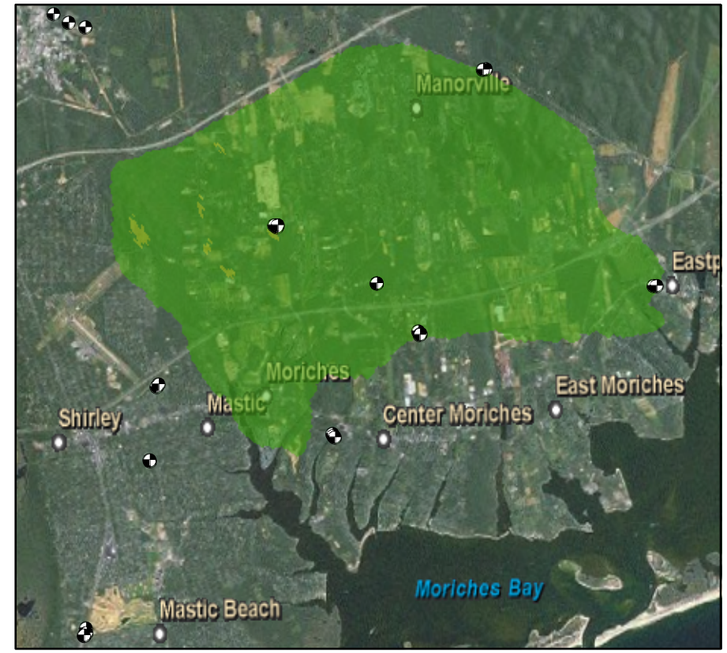
1 Acre Density 4 yr No Fertilizer



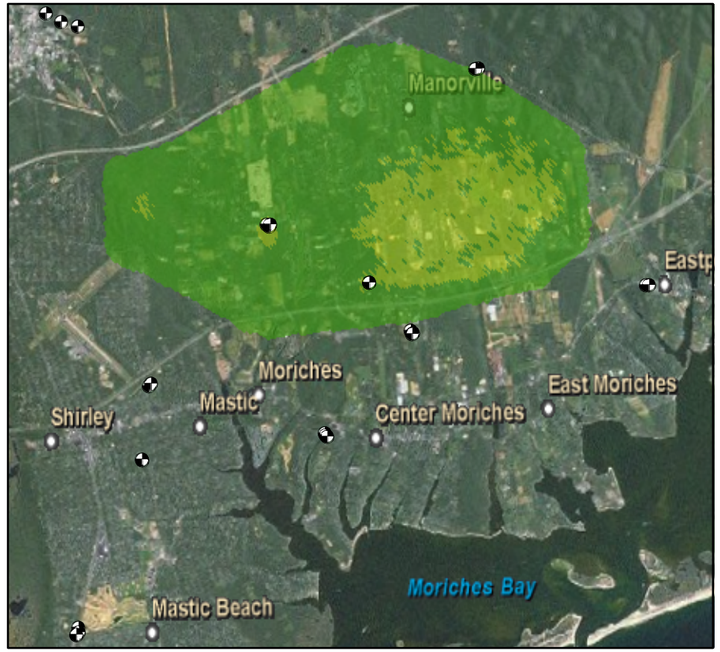
1 Acre Density 10 yr No Fertilizer



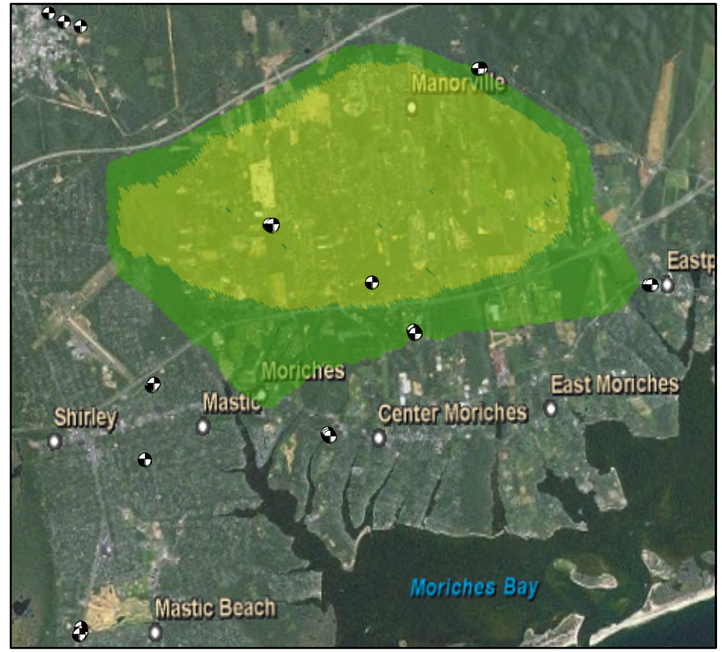
1 Acre Density 20 yr No Fertilizer



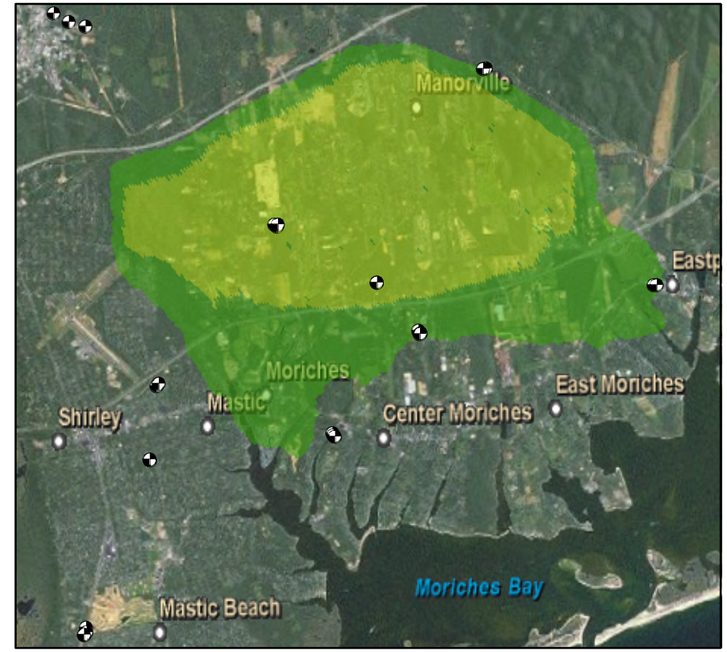
1 Acre Density 4 yr Fertilizer



1 Acre Density 10 yr Fertilizer



1 Acre Density 20 yr Fertilizer



CDM

Nitrogen (mg/l)
- 0.5 - 4
- 4 - 6
- 6 - 10
- > 10

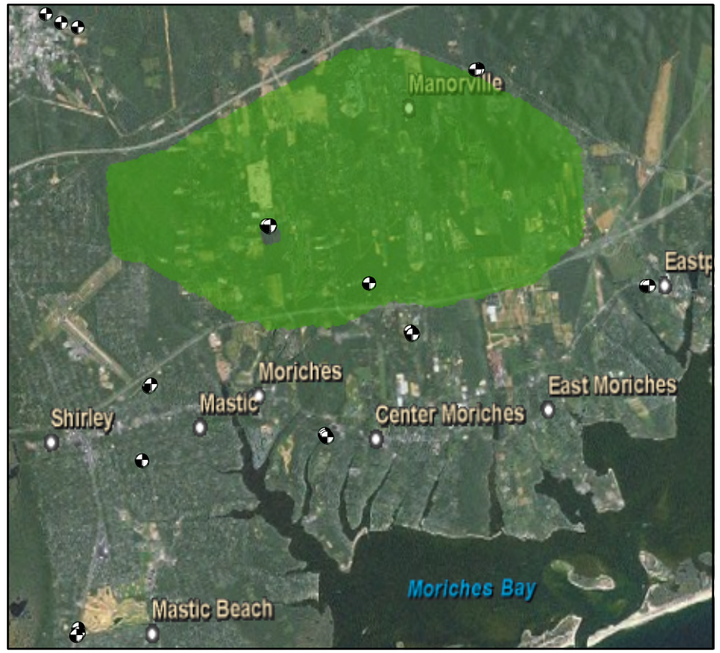
Supply Well

Nitrogen Loading Simulation - 1 Acre Density

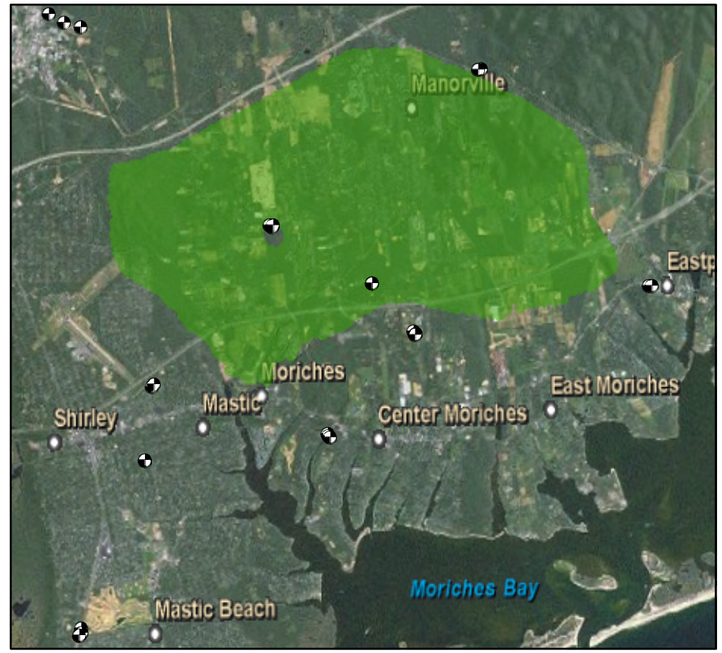
Suffolk County Comprehensive Water Resources Management Plan

Figure 3-14

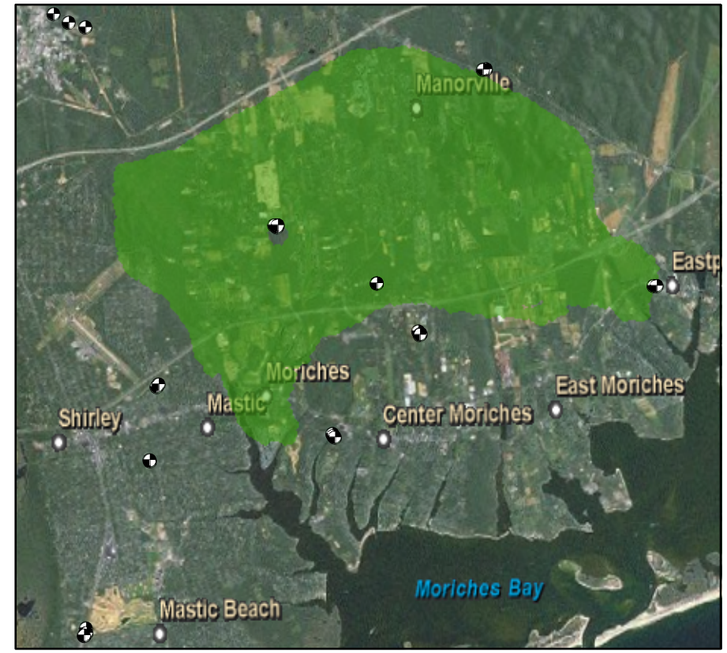
2 Acre Density 4 yr No Fertilizer



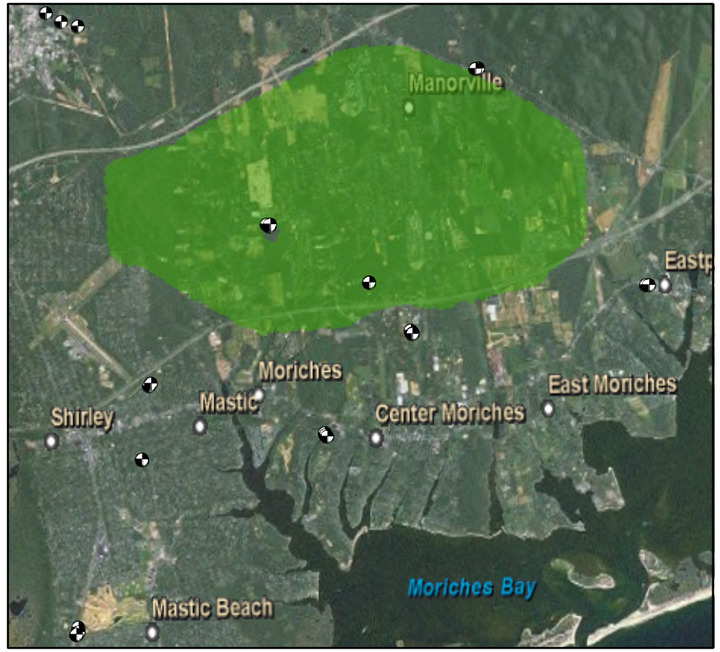
2 Acre Density 10 yr No Fertilizer



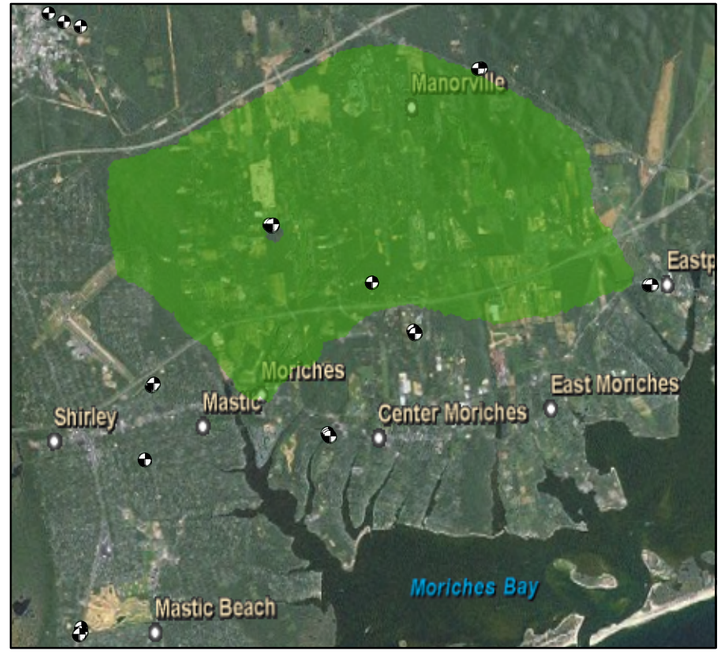
2 Acre Density 20 yr No Fertilizer



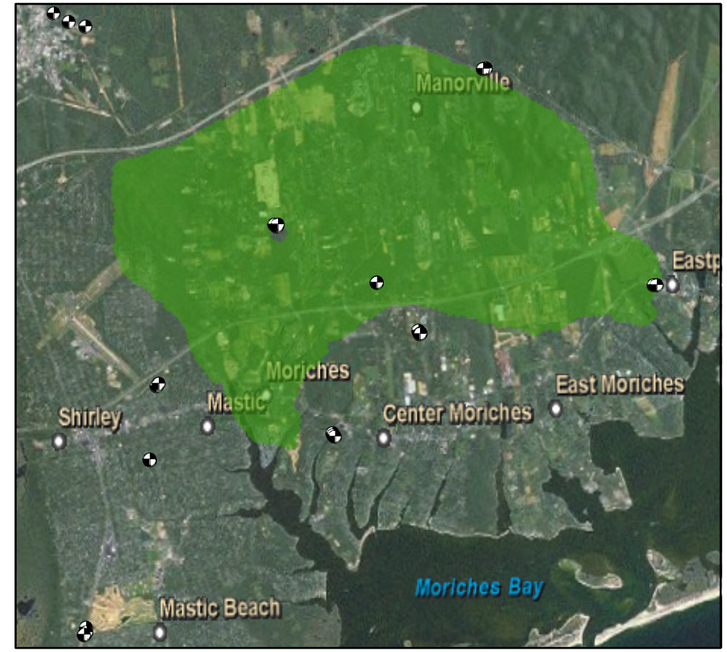
2 Acre Density 4 yr Fertilizer



2 Acre Density 10 yr Fertilizer



2 Acre Density 20 yr Fertilizer



CDM

Nitrogen (mg/l)
- 0.5 - 4
- 4 - 6
- 6 - 10
- > 10

Supply Well

Nitrogen Loading Simulation - 2 Acre Density

Suffolk County Comprehensive Water Resources Management Plan

Figure 3-15

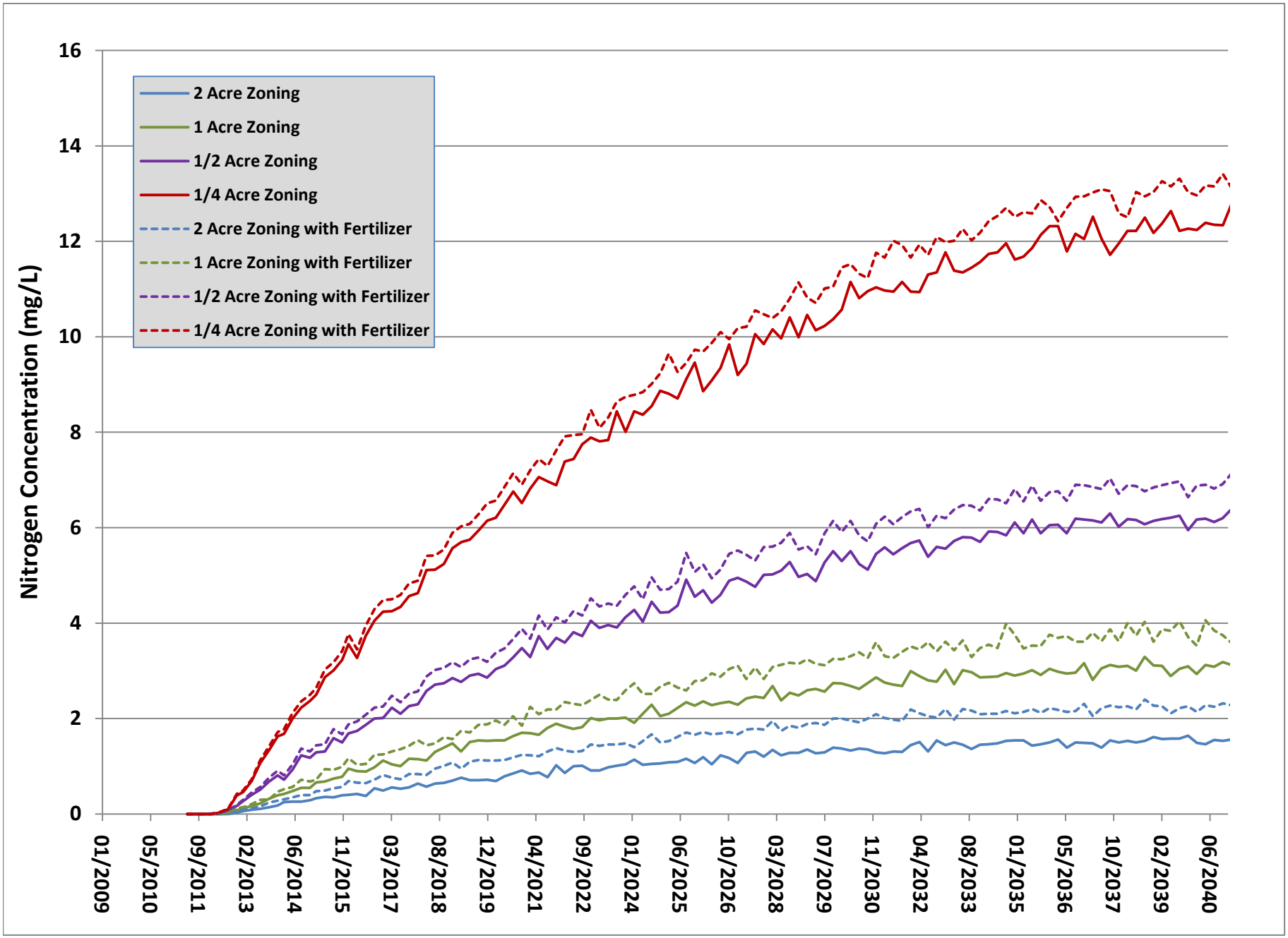


Figure 3-16
Simulated Hypothetical Nitrogen Concentrations at SCWA Country Club Drive Wellfield

The source water assessments considered each community supply well's susceptibility to contamination by VOCs.

The potential for VOCs to be used, stored or disposed of in areas used for commercial, industrial, or transportation purposes was presumed to be greater than for areas with residential uses. The presence of a variety of potential point sources within a contributing area to introduce VOC contamination to the aquifer was also assessed, using databases available from Suffolk County and NYSDEC.

VOCs are widely detected in community and non-community supply wells throughout the County and there are more than 125 VOC removal plants in the form of granular activated carbon (GAC) or air strippers. Although raw water detections are generally below the current MCL of 5 µg/L, water suppliers construct the VOC removal plants as a proactive approach to remove even low level contaminants to provide the best water quality possible.

Although the VOC removal plants exist throughout the County, they are costly to construct and to operate.

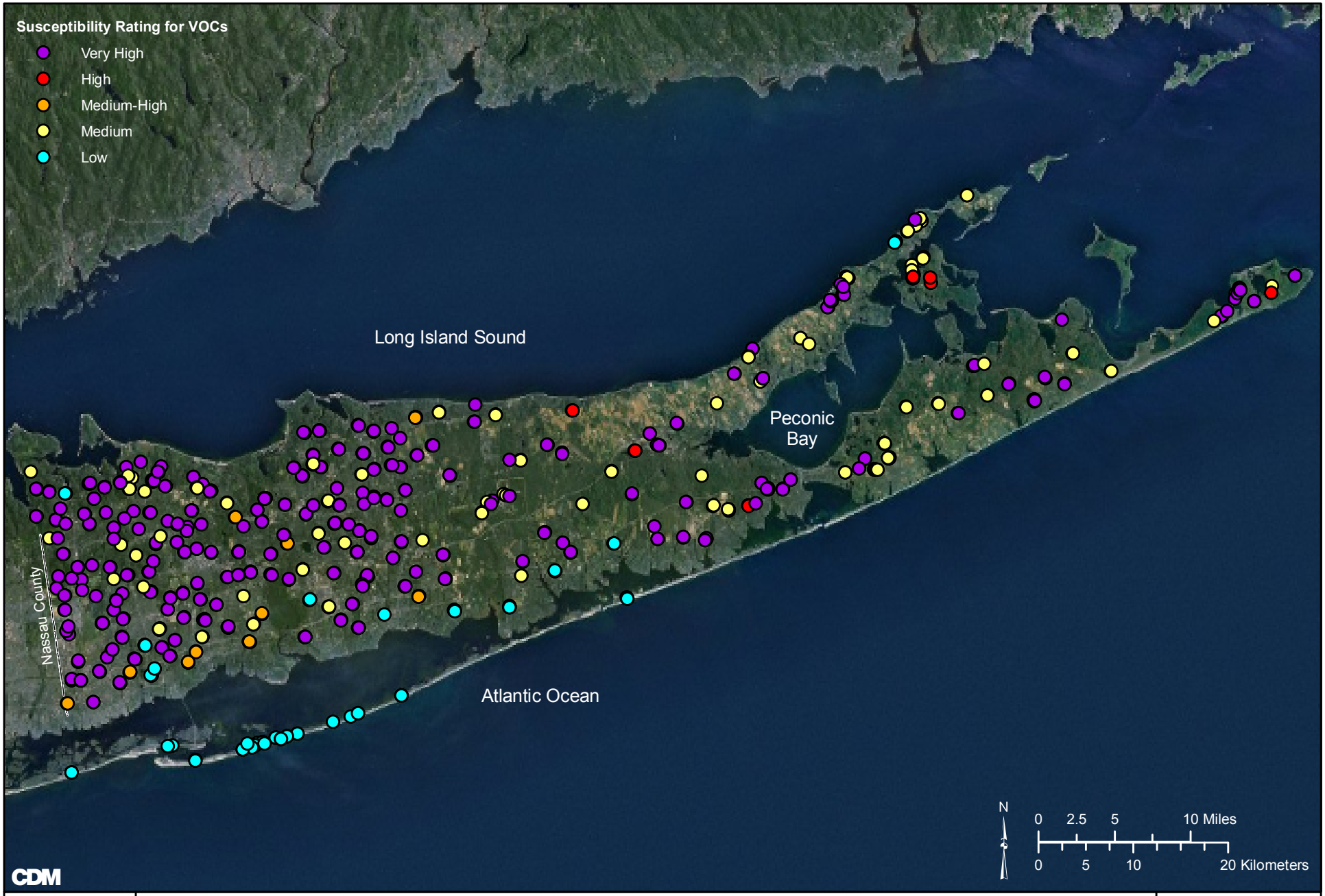
Although residential development can have an adverse impact on groundwater quality, particularly with regard to nitrate, land use impacts to groundwater are certainly not limited to residential development. Agricultural practices in the eastern part of the County also adversely impact groundwater by introducing nitrate to underlying groundwater supplies.

3.1.1.4 Volatile Organic Compounds

The ***1987 Comp Plan*** identified contamination by synthetic organic chemicals as the greatest threat to Suffolk County groundwater quality; volatile organics (solvents and degreasers such as tetrachloroethylene, trichloroethylene and trichloroethane) and hydrocarbons associated with fuel (benzene, toluene and xylene) were identified as the most commonly detected VOCs. Use of VOCs as solvents and degreasers became widespread beginning in the mid-1940s. VOCs are also present in products such as paint, cleaning agents, deodorants, adhesives, and polishing products that were commonly used by industries, commercial establishments, and homeowners without disposal restrictions until the mid-1970s, when VOCs began to be detected in groundwater. VOCs can be both mobile and persistent in the natural environment and many are known carcinogens.

As described in the Task 5.5 memorandum, the susceptibility of nearly seventy percent of community supply wells in the County was rated as high or very high for contamination by VOCs. Although the very high susceptibility rating does not mean that these wells will be impacted by VOCs, it indicates that a potential source of VOC contamination is present in the area contributing recharge to the supply well. Susceptibility ratings for VOCs at community supply wells located throughout the County are shown on **Figure 3-17**.

Although SCDHS, the SCWA and all other community suppliers routinely analyze groundwater for a large number of VOCs, most are not detected in Suffolk County groundwater. This study focused on three of the VOCs that have been most frequently detected in Suffolk County groundwater through the years - tetrachloroethene (PCE), trichloroethene (TCE) and 1,1,1-trichloroethane (TCA), along with MTBE, a gasoline additive that was widely detected in groundwater samples in recent years. The evaluations are based primarily upon samples collected by SCDHS and SCWA from public supply wells, supplemented by SCDHS private well sampling data.



Community Supply Well Susceptibility Rating for VOCs

Suffolk County Comprehensive Water Resources Management Plan

Figure 3-17

PCE has been detected most frequently in the western part of the County, with increased levels observed in unsewered areas of Huntington and Smithtown.

South Huntington Water Plant

PCE was not detected in 92% of the public supply wells sampled from 2009 through 2013.

Average PCE concentrations in the same set of 160 upper glacial aquifer supply wells sampled in both 1987 and 2013 increased from 0.30 µg/L to 0.58 µg/L; the average PCE concentrations in the same set of 210 Magothy supply wells increased from 0.31 µg/L to 0.71 µg/L.

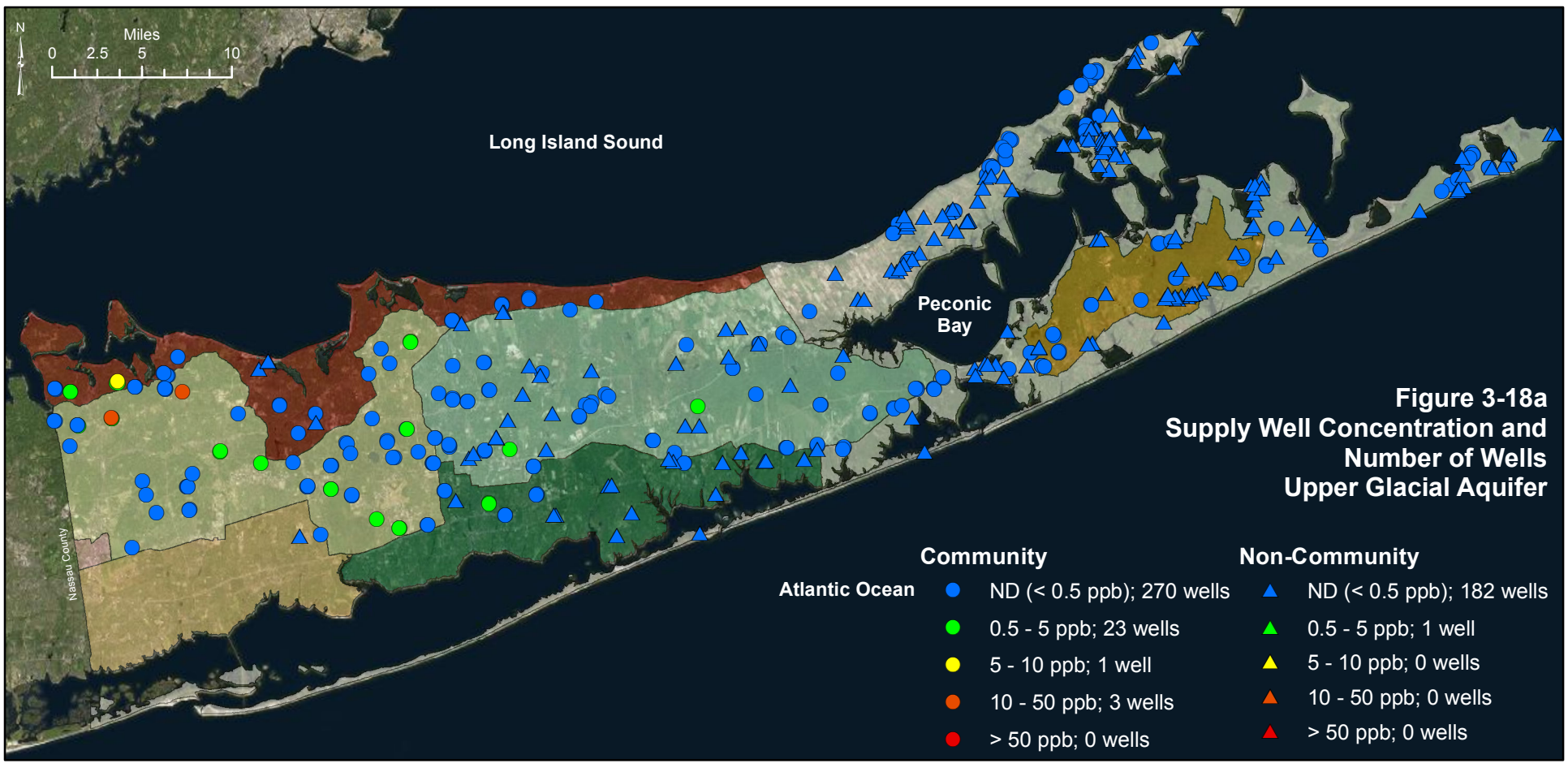
Tetrachloroethene (PCE)

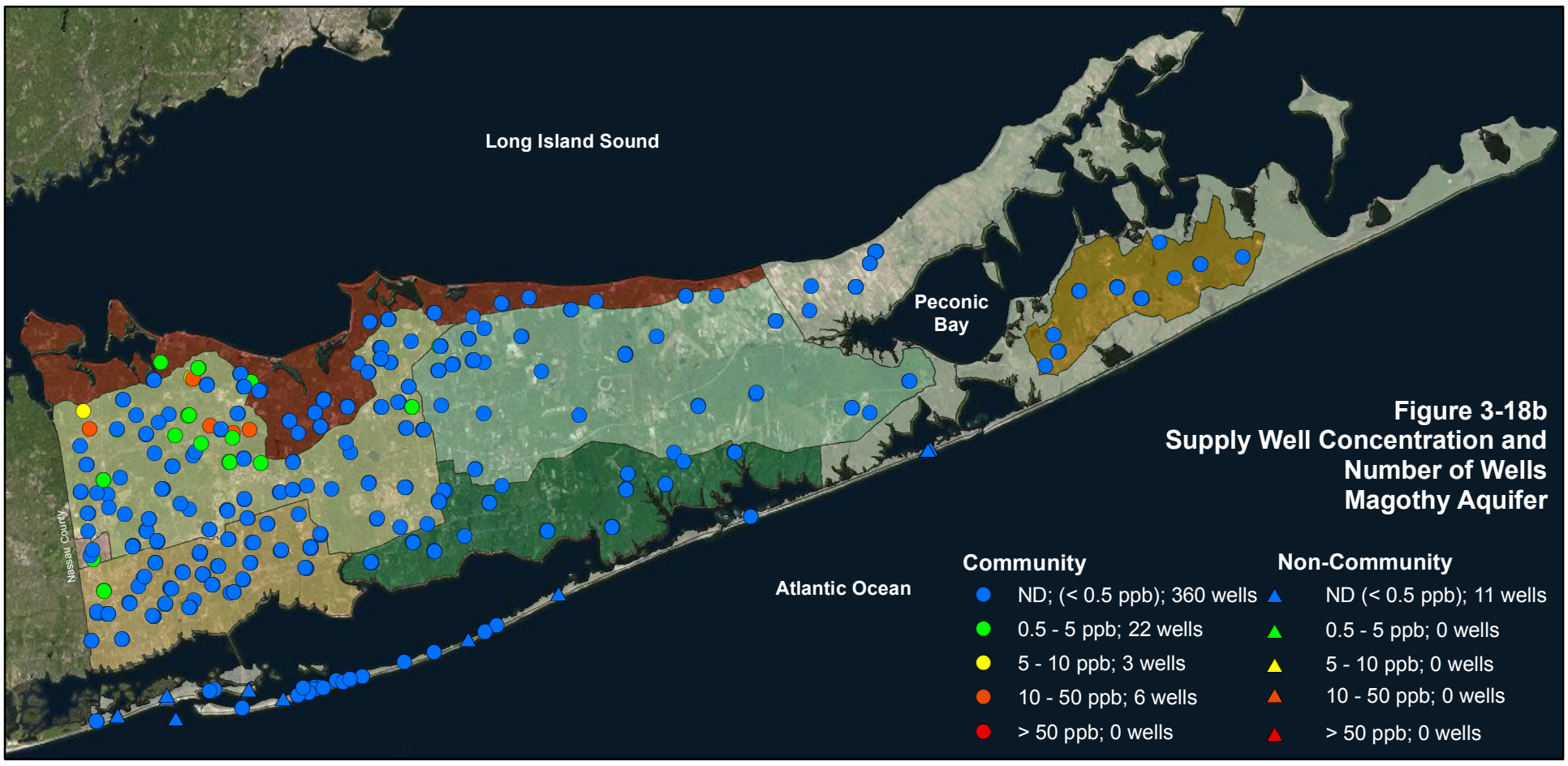
Tetrachloroethene is primarily used as a solvent and is widely used in the dry cleaning industry because it dissolves many organic materials. It is also used as a metal degreaser and in the manufacture of various other chemicals. The USEPA has established PCE as a carcinogen, and has developed an MCL of 5 µg/L. The average concentrations of PCE in raw water sampled from community and non-community supply wells in 2013 are shown on **Figures 3-18a, 3-18b** and **3-18c** for the upper glacial, Magothy, and Lloyd aquifers, respectively. Most PCE detections have been observed in wells in the western part of the County, with only a few detections at very low levels in eastern towns.

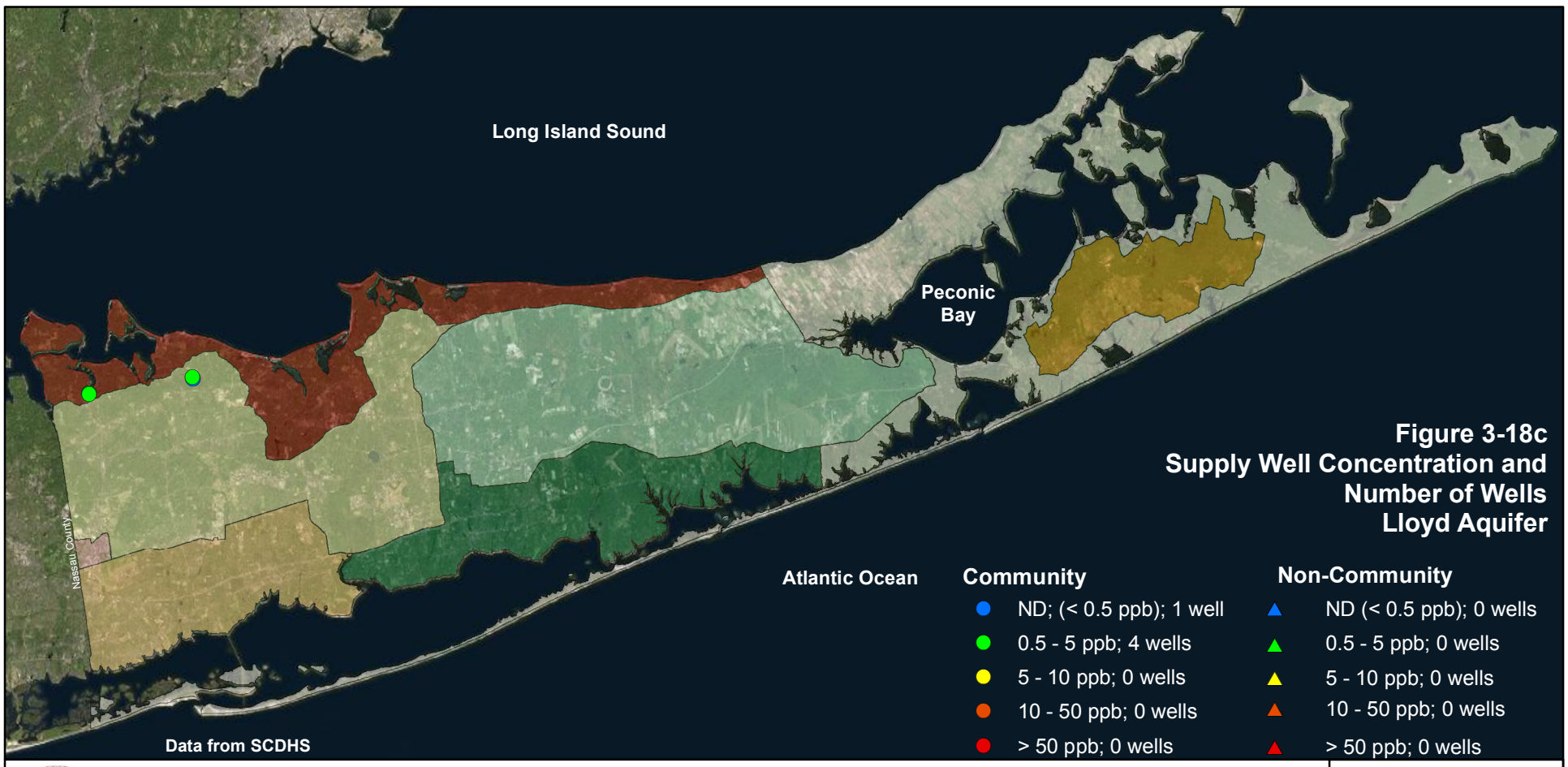
Table 3-7 summarizes average annual PCE concentrations for supply wells that were sampled in both 1987 and in 2013. The percentiles shown in **Table 3-7** are based on well averages, while reported maximum and minimum values are based on the entire sample sets. The data shows that PCE has not been detected in 92 percent of the supply wells sampled from 2009 through 2013, and PCE levels in raw water samples collected from over 98 percent of the supply wells tested remain below the drinking water standard of 5 µg/L. However, a comparison of PCE levels in wells that were sampled in both years indicates that PCE was detected in over three times as many wells in 2013 as in 1987 and that increased PCE levels have been observed in unsewered areas of the towns of Huntington and Smithtown.

Although PCE was detected in more wells in 2013 than in 1987, this is at least partially attributable to the fact that advances in analytical technology allow analysts to detect increasingly lower levels of contaminants, including PCE, in the environment. For most wells tested in Suffolk County, the reported limit of detection in 1987 was 1 µg/L, while the reported detection limit in 2013 was 0.5 µg/L. In 2013, PCE concentrations in 15 of the 63 wells with PCE detections were below 1 µg/L. However, average PCE concentrations almost doubled from 0.30 to 0.58 µg/L in the 160 upper glacial public supply wells in the same- set analysis, indicating that degraded water quality is also partially responsible for the increased detections. (For the purposes of this comparison, non-detects in 1987 were assumed to be equal to 0.25 µg/L, or ½ the detection limit in 2013. Therefore, comparisons and calculations including concentrations of "ND" were similar.) A similar trend is seen in the same-set Magothy wells where average PCE concentrations increased from 0.31 µg/L to 0.71 µg/L. Only one of the wells sampled in both 1987 and 2013 exceeded the 5 µg/L MCL in 1987, while five wells in the dataset exceeded the standard in 2013. While no PCE was detected in the Lloyd aquifer in 1987, it was detected in four Lloyd wells in 2013, at an average concentration of 3.52 µg/L. However, as shown on **Figure 3-**

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







CDM Smith

Average Tetrachloroethene Concentration in the Upper Glacial, Magothy & Lloyd Aquifers Community and Non-Community Supply Wells - 2013

Suffolk County Comprehensive Water Resources Management Plan

Figure 3-18

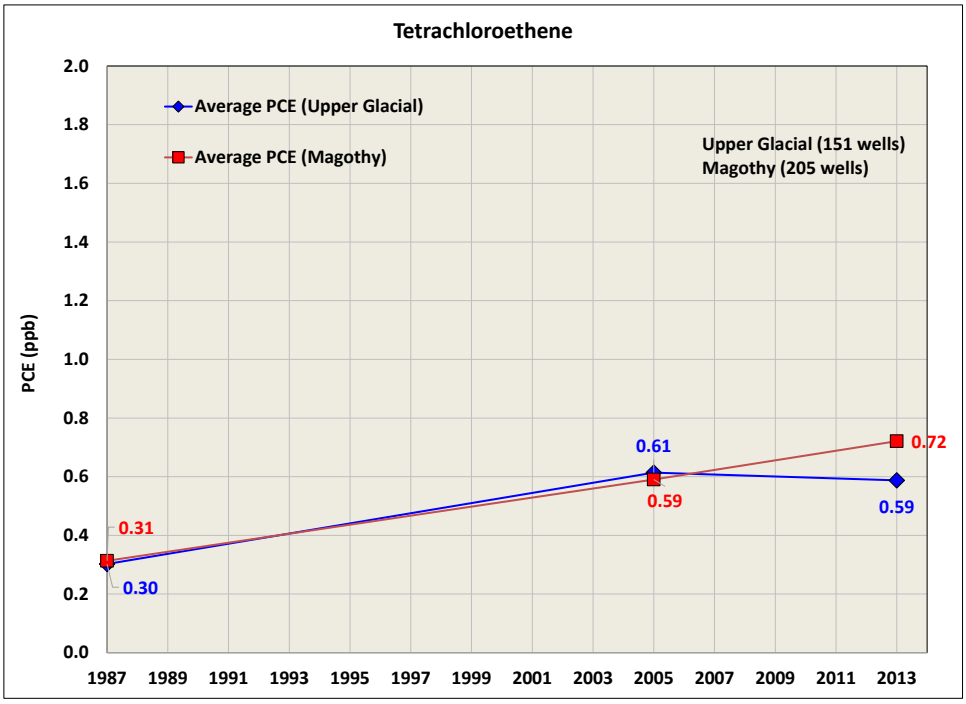
Table 3-7 Tetrachloroethene (PCE) Concentrations from Community and Non-Community Supply Wells

Aquifer	1987	2009-2013	2013	Same Set Wells 1987	Same Set Wells 2013
Upper Glacial Aquifer					
n (wells)	588	570	489	160	160
Minimum (µg/L)	ND	ND	ND	ND	ND
Maximum (µg/L)	160	93	50	11	14
Average (µg/L)	0.60	0.43	0.48	0.30	0.58
10th Percentile (µg/L)	ND	ND	ND	ND	ND
50th Percentile (µg/L)	ND	ND	ND	ND	ND
90th Percentile (µg/L)	ND	ND	ND	ND	0.7
No. of wells with detects	20	44	28	5	18
No. of wells with Detect > 5 µg/L	3 / 2	7 / 5	4 / 4	1 / 0	3 / 3
Magothy Aquifer					
n (wells)	279	418	402	210	210
Minimum (µg/L)	ND	ND	ND	ND	ND
Maximum (µg/L)	8	49	39	8.00	25.00
Average (µg/L)	0.31	0.64	0.71	0.31	0.71
10th Percentile (µg/L)	ND	ND	ND	ND	ND
50th Percentile (µg/L)	ND	ND	ND	ND	ND
90th Percentile (µg/L)	ND	ND	ND	ND	0.61
No. of wells with detects	9	38	31	7	22
No. of wells with Detect > 5 µg/L	2 / 1	11 / 10	9 / 9	1 / 1	5 / 5
Lloyd Aquifer					
n (wells)	4	5	5	1	1
Minimum (µg/L)	ND	ND	ND	ND	ND
Maximum (µg/L)	ND	3.80	3.80	ND	ND
Average (µg/L)	ND	1.48	3.52	ND	ND
10th Percentile (µg/L)	ND	0.49	0.55	ND	ND
50th Percentile (µg/L)	ND	1.44	2.10	ND	ND
90th Percentile (µg/L)	ND	2.48	3.52	ND	ND
No. of wells with detects	0	4	4	0	0
No. of wells with Detect > 5 µg/L	0/0	0 / 0	0 / 0	0 / 0	0 / 0

Notes:
1. Data compiled from SCDHS databases.
2. Averages and percentiles calculated from annual well averages.
3. No. of wells > 5 µg/L is based on well maximum and averages, respectively (max/avg).

18c, these wells are all located in northwest Suffolk County, where the Lloyd aquifer is much closer to the surface than much of the County. Detections of VOCs are not anticipated within the Lloyd aquifer throughout most of Suffolk County.

Considering a slightly different data set (e.g. the same set of 151 supply wells screened in the upper glacial aquifer that were sampled in 1987, 2005 and 2013), the trend lines shown below shows that the average concentration of PCE in the upper glacial aquifer has remained relatively stable between 2005 and 2013, while the concentration in the same set of 205 wells screened in the Magothy aquifer has continued to increase. As shown, average concentrations remain below the MCL of 5 µg/L.



Photograph of a typical GAC unit

Although untreated groundwater from the vast majority of supply wells remains in compliance with MCLs, the data shows an increasing trend.

TCE was detected in more wells and at higher average concentrations in 2013 than in 1987. Most TCE detections were observed in unsewered areas of the western part of the County.

Trichloroethene (TCE)

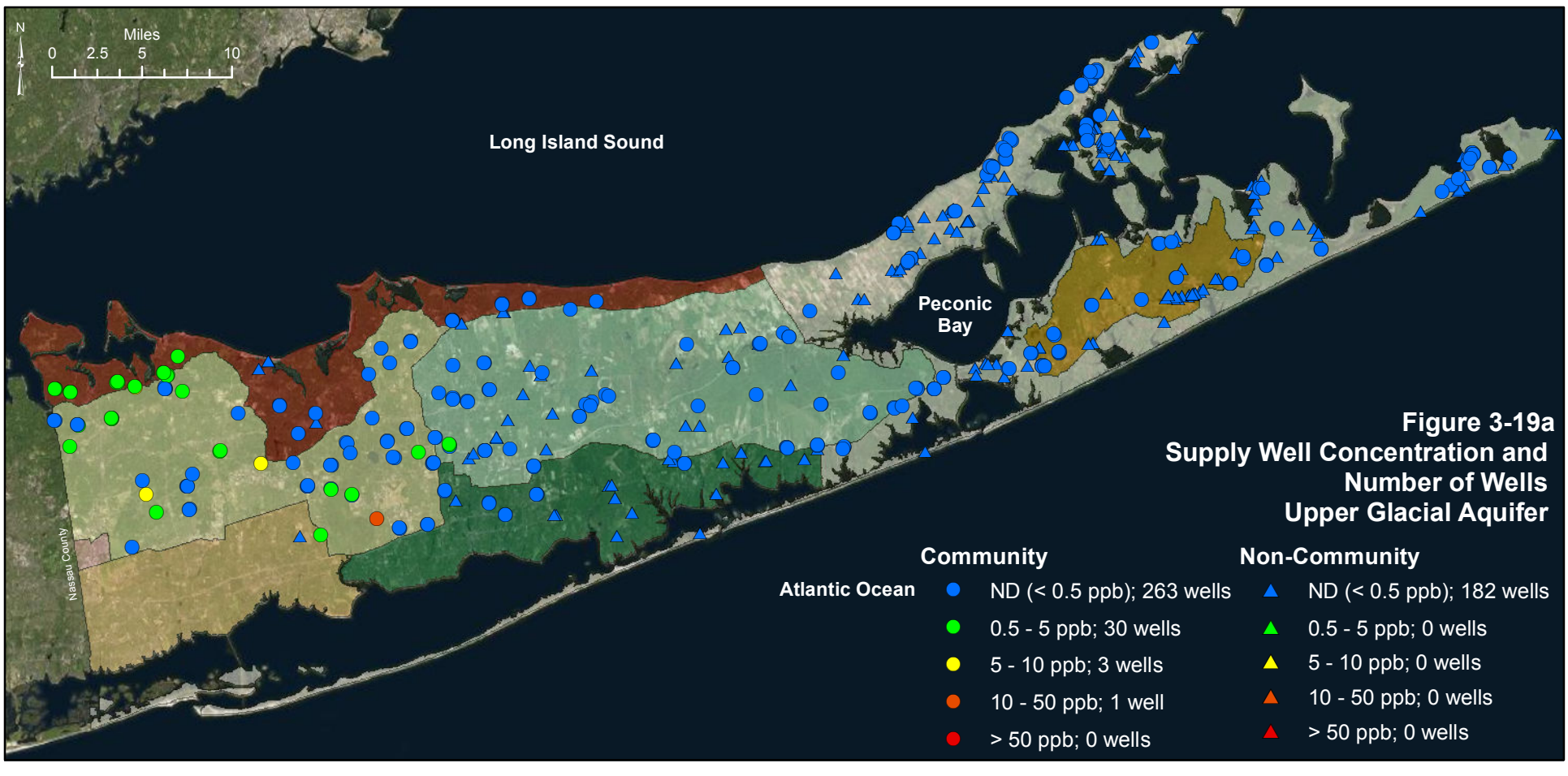
Trichloroethene has been widely used since the 1930s as a degreasing agent for cleaning fabricated metal (HSIA, 2001). It is also used in the dry cleaning industry and is a degradation product of PCE. The average concentrations of TCE in raw water sampled from community and non-community supply wells in 2013 are shown on **Figures 3-19a, 3-19b** and **3-19c** for the upper glacial, Magothy, and Lloyd aquifers, respectively. Detections were observed in the western part of the County in the towns of Islip, Huntington and Smithtown, TCE was not detected in active East End supply wells at the time.

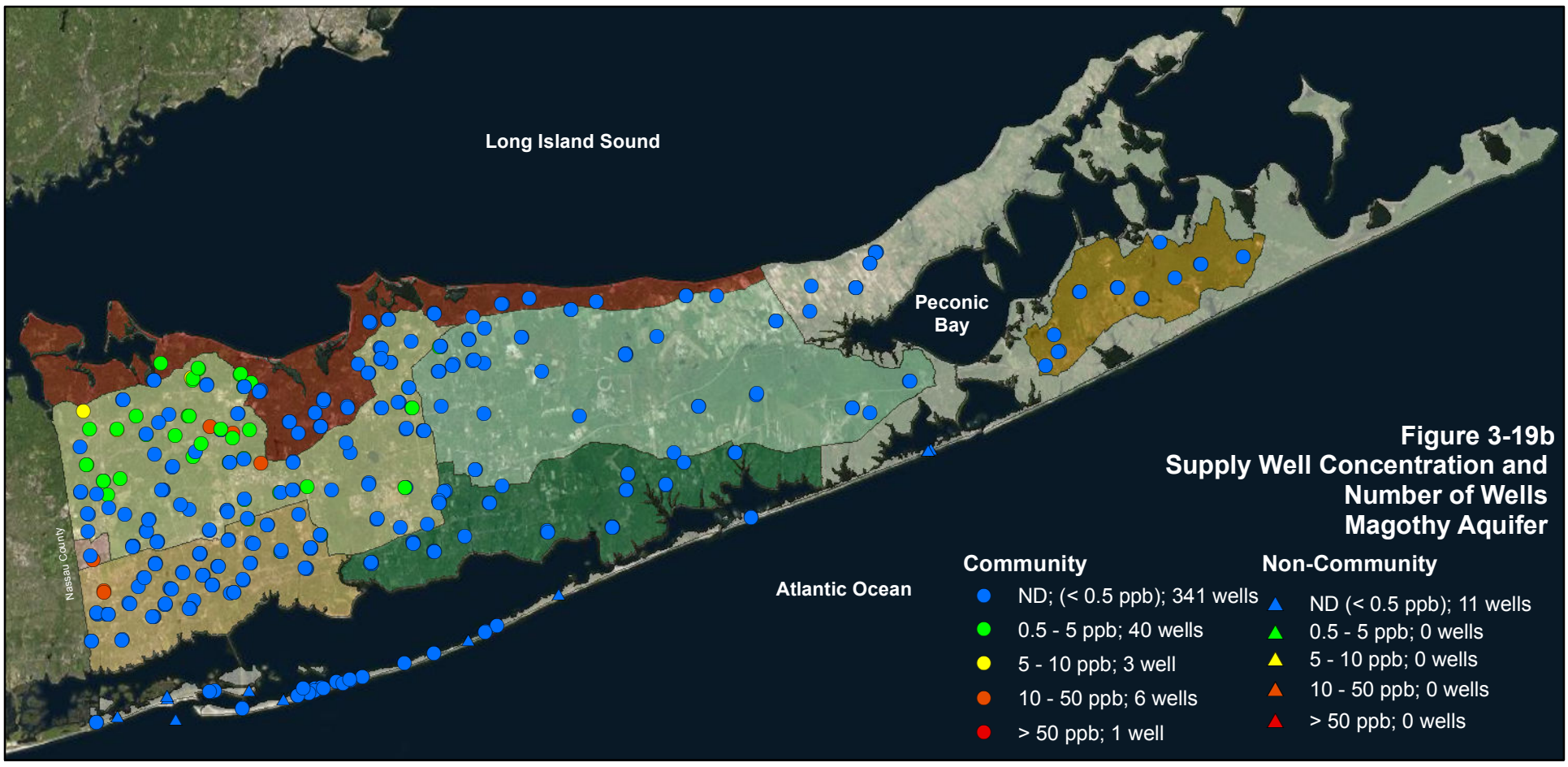
Table 3-8 summarizes average annual TCE concentrations for supply wells that were sampled in both 1987 and in 2013. Although TCE was detected in more wells in the sample set in 2013 than in 1987, it was not detected in 84 percent of the wells, and concentrations in over 98 percent of supply wells remained below the drinking water standard of 5 µg/L. TCE was not detected in the single Lloyd well sampled in either year. Increased TCE concentrations were identified in several Magothy supply wells in the western towns. As shown in **Table 3-8**, TCE was detected in more wells – and at higher average concentrations – in 2013 than in 1987. Twenty six upper glacial and 36 Magothy wells that were sampled in both 1987 and 2013 had detectable TCE concentrations in 2013. As discussed above, the increased number of detections may, in part, be attributable to the reduction in the TCE detection limit from 1 to 0.5 µg/L between 1987 and 2013, as TCE was detected in 19 of the 62 wells at concentrations less than 1 µg/L during 2013.

Average TCE concentrations in the same set of 160 upper glacial aquifer supply wells sampled in both 1987 and 2013 increased from 0.31 µg/L to 0.80 µg/L; the average TCE concentrations in the same set of 210 Magothy supply wells increased from 0.33 µg/L to 0.93 µg/L.

Average TCE concentrations nearly tripled from 0.31 µg/L to 0.80 µg/L in the 160 upper glacial public supply wells that were sampled in both 1987 and 2013. (As with PCE, for the purposes of the comparison, non-detects in 1987 were assumed to be equal to 0.25 µg/L, or ½ the detection limit in 2013. Therefore, comparisons and calculations including concentrations of "ND" were similar.) A similar trend is seen in the Magothy wells sampled in both 1987 and 2013 where average TCE concentrations increased from 0.33 µg/L to 0.93 µg/L, indicating contaminant flow to the deeper portions of the aquifer. Only one of the wells sampled during both years exceeded the 5 µg/L MCL in 1987, while eight wells exceeded the standard in 2013, indicating deteriorating water quality. Considering a slightly different data set (e.g. the same set of 151 supply wells screened in the upper glacial aquifer that were sampled in 1987, 2005 and 2013), the trend lines shown below illustrate that the upwards trends in TCE concentrations in both the upper glacial and Magothy aquifer have remained consistent throughout the period. Average concentrations remained less than 5 µg/L throughout the period.

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





CDM Smith

Average Trichloroethene Concentration in the Upper Glacial, Magothy & Lloyd Aquifers Community and Non-Community Supply Wells - 2013

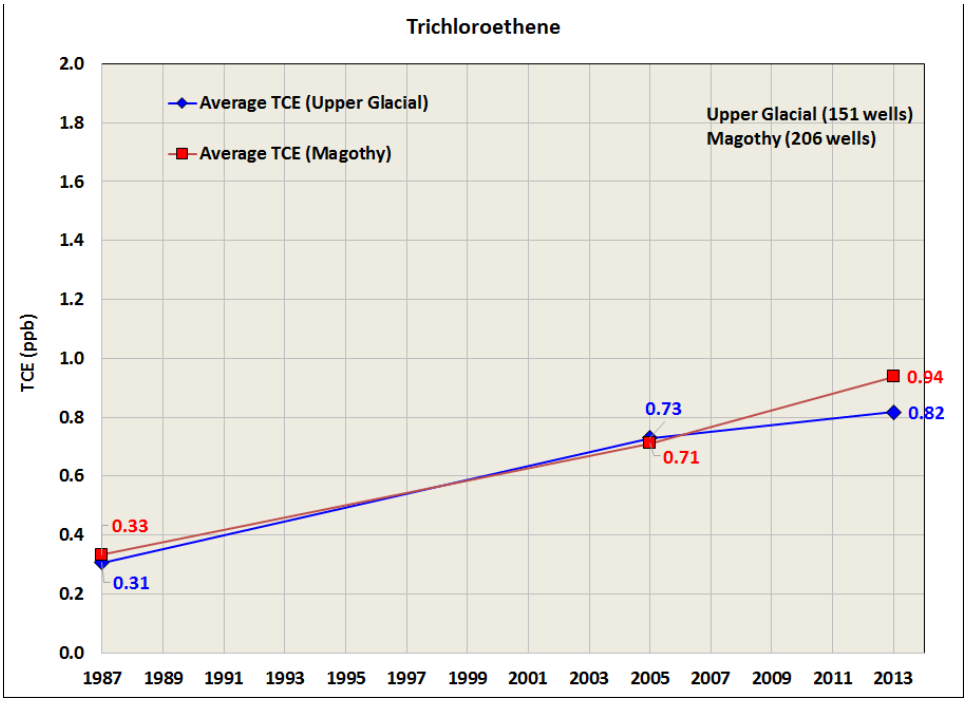
Suffolk County Comprehensive Water Resources Management Plan

Figure 3-19

Table 3-8 Trichloroethene (TCE) Concentrations from Community and Non-Community Supply Wells

Aquifer	1987	2009-2013	2013	Same Set Wells 1987	Same Set Wells 2013
Upper Glacial Aquifer					
n (wells)	590	570	489	160	160
Minimum (µg/L)	ND	ND	ND	ND	ND
Maximum (µg/L)	63.0	44	43	3	43
Average (µg/L)	0.44	0.41	0.45	0.31	0.8
10th Percentile (µg/L)	ND	ND	ND	ND	ND
50th Percentile (µg/L)	ND	ND	ND	ND	ND
90th Percentile (µg/L)	ND	ND	ND	ND	1.01
No. of wells with detects	28	42	34	7	26
No. of wells with Detect > 5 µg/L	4 / 4	6 / 3	4 / 4	3 / 3	0 / 0
Magothy Aquifer					
n (wells)	279	418	402	211	211
Minimum (µg/L)	ND	ND	ND	ND	ND
Maximum (µg/L)	15	58	58	15	27
Average (µg/L)	0.32	0.7	0.83	0.33	0.93
10th Percentile (µg/L)	ND	ND	ND	ND	ND
50th Percentile (µg/L)	ND	ND	ND	ND	ND
90th Percentile (µg/L)	ND	0.62	0.8	ND	1.2
No. of wells with detects	6	67	50	5	36
No. of wells with Detect > 5 µg/L	1 / 1	11 / 10	10 / 10	1 / 1	8 / 8
Lloyd Aquifer					
n (wells)	3	5	5	1	1
Minimum (µg/L)	ND	ND	ND	ND	ND
Maximum (µg/L)	ND	2.60	2.60	ND	ND
Average (µg/L)	ND	0.47	0.77	ND	ND
10th Percentile (µg/L)	ND	ND	ND	ND	ND
50th Percentile (µg/L)	ND	ND	ND	ND	ND
90th Percentile (µg/L)	ND	0.88	1.76	ND	ND
No. of wells with detects	0	2	2	0	0
No. of wells with Detect > 5 µg/L	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0

Notes:
1. Data compiled from SCDHS databases.
2. Averages and percentiles calculated from annual well averages.
3. No. of wells > 5 ppb is based on well maximum and averages, respectively (max/avg).



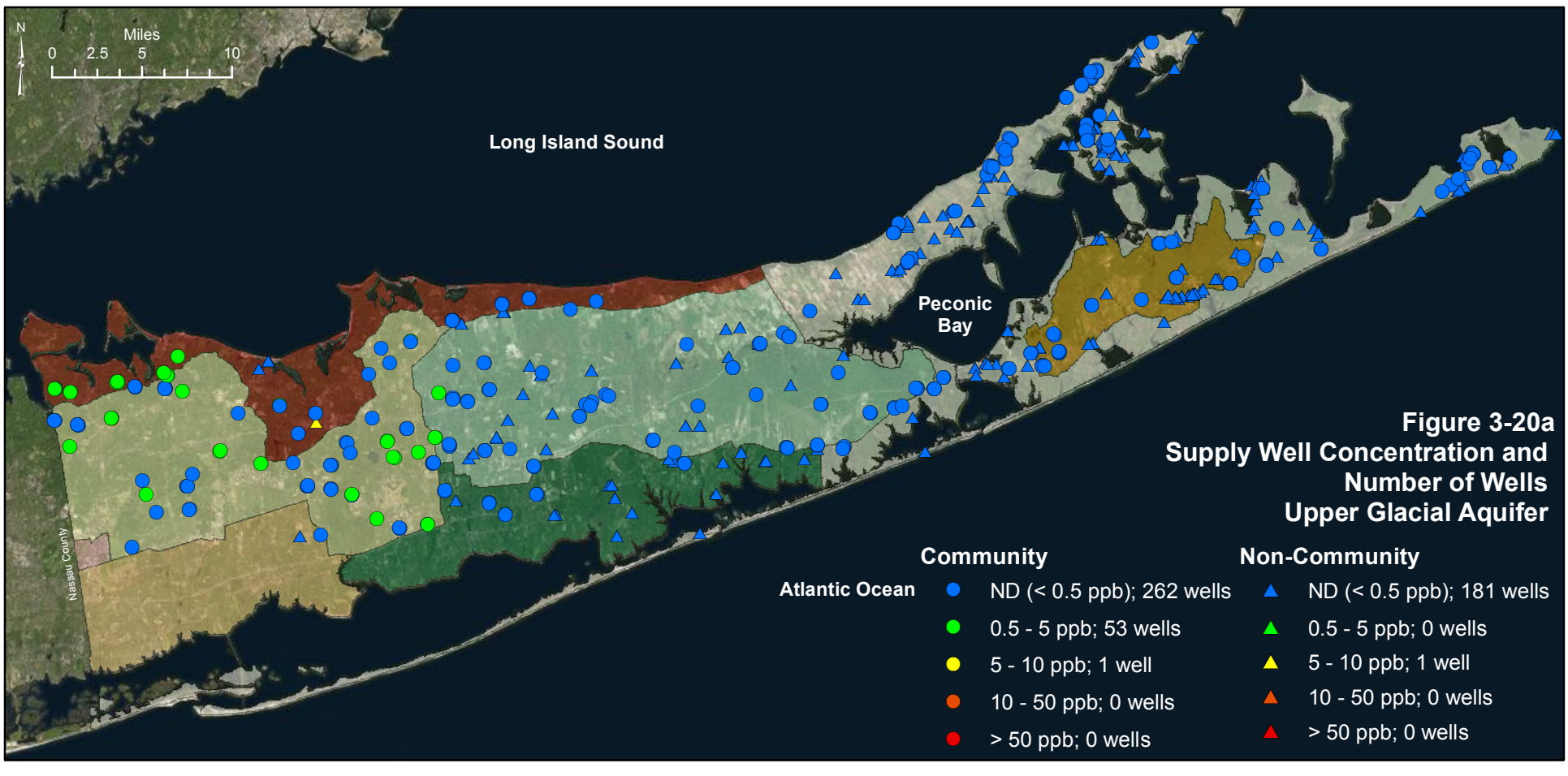
1,1,1 Trichloroethane (TCA)

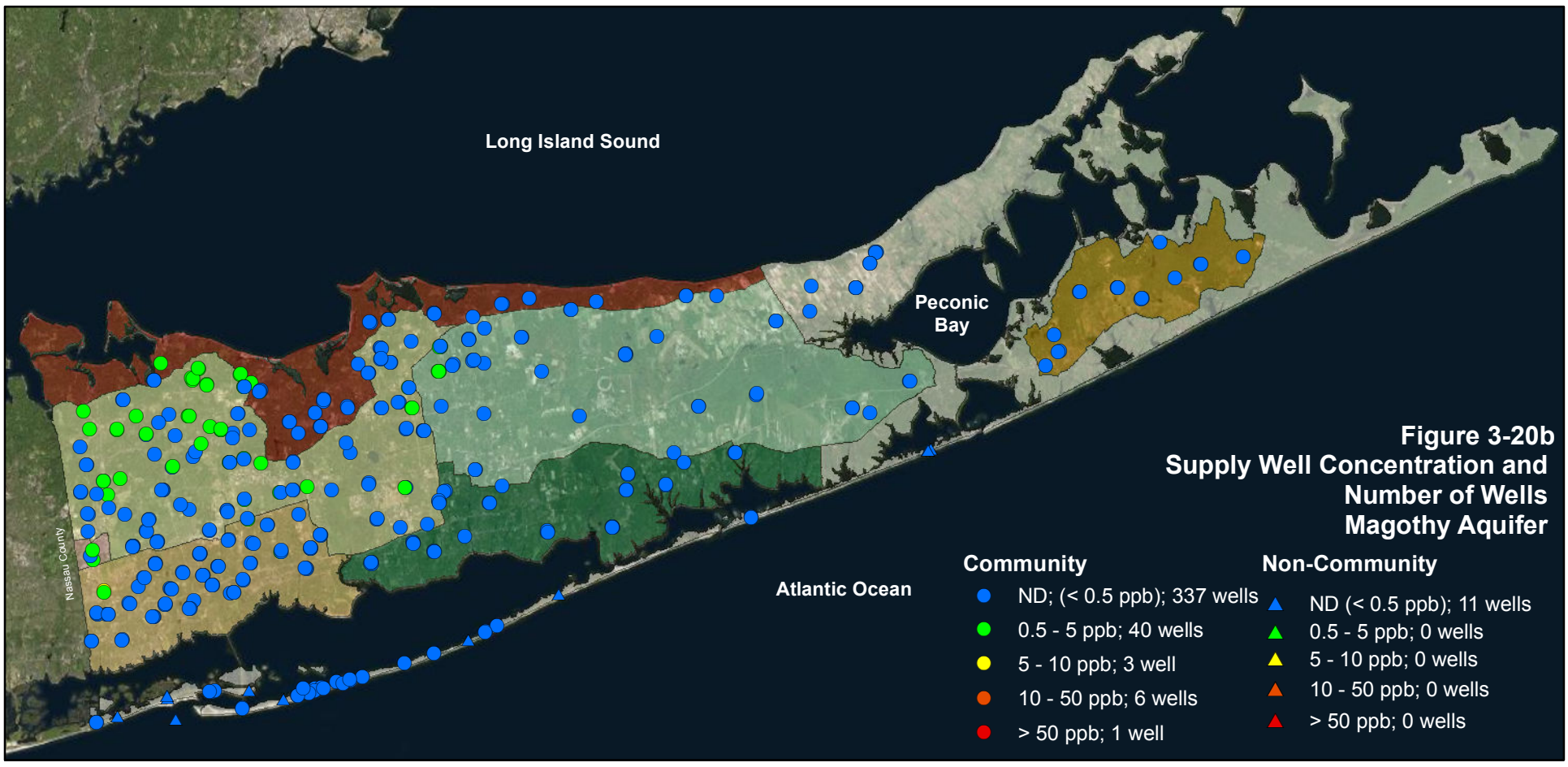
The ban of TCA appears to be effective in reducing contamination observed in the aquifer. TCA has been detected in fewer wells and at lower average concentrations since the draft Plan was completed in 2010.

1,1,1-Trichloroethane (TCA) has been manufactured since the mid-1950s as an "all-purpose" solvent, primarily used in degreasing and cleaning fabricated metal and in aerosols (HSIA, 1994). It is also used in various other industrial/commercial processes including textiles, production of coatings, inks and for dry cleaning leather and suede. TCA was also a major component of cesspool cleaners sold to homeowners in gallon quantities until 1980, when cleaners containing TCA and other solvents were banned by Suffolk County (Local Law 12-1980).

The average concentrations of TCA in untreated water samples collected from community and non-community supply wells in 2013 are shown on **Figures 3-20a, 3-20b** and **3-20c** for the upper glacial, Magothy, and Lloyd aquifers, respectively. Very low levels of TCA were reported in all aquifers; TCA levels and the number of impacted wells have declined since the last assessment was performed in 2005. **Table 3-9** summarizes changes in average TCA concentrations in the upper glacial, Magothy and Lloyd aquifers for supply wells that were sampled in both 1987 and in 2013. TCA levels in supply wells met the 5 µg/L drinking water standard in over 99 percent of all supply wells tested in 2013.

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





CDM Smith

Average 1,1,1-Trichloroethene Concentration in the Upper Glacial, Magothy & Lloyd Aquifers Community and Non-Community Supply Wells - 2013

Suffolk County Comprehensive Water Resources Management Plan

Figure 3-20

Table 3-9 1,1,1 Trichloroethane (TCA) Concentrations from Community and Non-Community Supply Wells

Aquifer	1987	2009-2013	2013	Same Set Wells 1987	Same Set Wells 2013
Upper Glacial Aquifer					
n (wells)	584	570	489	159	159
Minimum (µg/L)	ND	ND	ND	ND	ND
Maximum (µg/L)	760	10	6.2	760	5.4
Average (µg/L)	1.55	0.35	0.35	3.16	0.47
10th Percentile (µg/L)	ND	ND	ND	ND	ND
50th Percentile (µg/L)	ND	ND	ND	ND	ND
90th Percentile (µg/L)	1.75	ND	ND	1.12	0.88
No. of wells with detects	103	51	37	26	25
No. of wells with Detect > 5 µg/L	23 / 18	3 / 1	2 / 2	11 / 7	1 / 1
Magothy Aquifer					
n (wells)	284	418	402	211	211
Minimum (µg/L)	ND	ND	ND	ND	ND
Maximum (µg/L)	16.00	6.10	5.50	16.00	5.50
Average (µg/L)	0.54	0.41	0.43	0.57	0.47
10th Percentile (µg/L)	ND	ND	ND	ND	ND
50th Percentile (µg/L)	ND	ND	ND	ND	ND
90th Percentile (µg/L)	1.09	0.65	0.79	1.00	0.94
No. of wells with detects	39	65	54	30	37
No. of wells with Detect > 5 µg/L	5 / 4	2 / 0	1 / 1	5 / 4	1 / 1
Lloyd Aquifer					
n (wells)	3	5	5	1	1
Minimum (µg/L)	ND	ND	ND	ND	ND
Maximum (µg/L)	ND	2.60	2.60	ND	ND
Average (µg/L)	ND	0.47	0.77	ND	ND
10th Percentile (µg/L)	ND	ND	ND	ND	ND
50th Percentile (µg/L)	ND	ND	ND	ND	ND
90th Percentile (µg/L)	ND	0.88	1.76	ND	ND
No. of wells with detects	0	2	2	0	0
No. of wells with Detect > 5 µg/L	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0

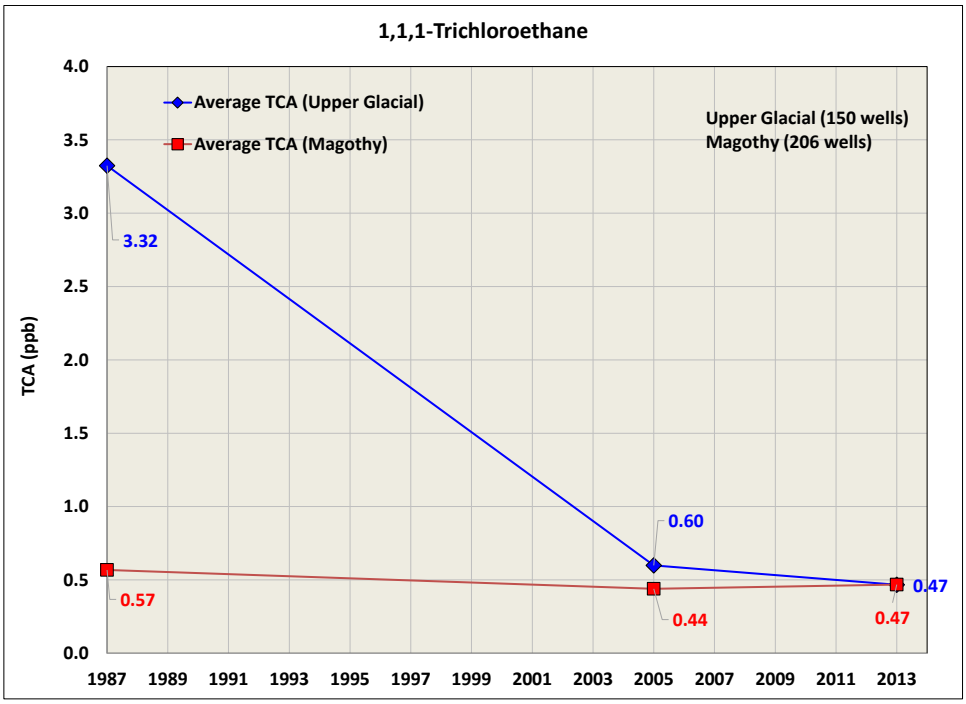
Notes:

1. Data compiled from SCDHS databases.
2. Averages and percentiles calculated from annual well averages.
3. No. of wells > 5 µg/L is based on well maximum and averages, respectively (max/avg).

Average TCA concentrations in the same set of 159 upper glacial aquifer supply wells sampled in both 1987 and 2013 decreased from 3.16 µg/L to 0.47 µg/L; the average PCE concentrations in the same set of 210 Magothy supply wells increased from 0.57 µg/L to 0.47 µg/L.

Average TCA concentrations decreased from 3.16 µg/L to 0.47 µg/L in the 159 public supply wells screened in the upper glacial aquifer that were tested in both 1987 and 2013, most likely reflecting a positive response to Suffolk's cesspool cleaner ban enacted some 25 years earlier. (As with PCE and TCE, for the purposes of the comparison, non-detects in 1987 were assumed to be equal to 0.25 µg/L, or ½ the detection limit in 2005. Therefore, comparisons and calculations including concentrations of "ND" were similar.) Average TCA concentrations in the Magothy supply wells tested from both years also decreased, although not as dramatically, from 0.57 µg/L to 0.47 µg/L. The number of detections in Magothy wells that were sampled in both 1987 and 2005 exceeding the 5 µg/L MCL also declined in the same set wells, from 5 in 1987 to only one in 2013. No detections of TCA were reported in the same set of Lloyd wells sampled in both years.

Review of a slightly smaller data set (e.g. the same set of 150 supply wells screened in the upper glacial aquifer that were sampled in 1987, 2005 and 2013), the trend lines shown below confirm the decline in average TCA concentrations in the upper glacial aquifer, and that concentrations in the Magothy aquifer have remained consistent since 2005. Average concentrations remained less than 5 µg/L throughout the period.



Methyl Tert-Butyl Ether (MTBE)

MTBE, which was used as an octane-enhancing replacement for lead from 1979 until 2004 has been detected in Suffolk County groundwater since the SCDHS began monitoring for the substance in 1991. The USEPA Clean Air Act of 1990 Reformulated Gasoline and Oxygenated Fuel requirements greatly increased MTBE use at higher concentrations to fulfill the gasoline oxygenate requirements of the program (NYSDEC website http://www.dec.ny.gov/chemical/8692.html). MTBE is highly water soluble, and persists in groundwater, biodegrading much more slowly than other gasoline-related compounds. It is often detected in the absence of other gasoline constituents, and in fact, has been more widely detected throughout Suffolk County than benzene, toluene or xylene. Spills or discharges of MTBE can move quickly through the soil, dissolve in the groundwater and migrate great distances with the same velocity as groundwater. In addition to fuel storage leaks, small amounts of gasoline from recreational and household activities associated with the use of small engines can also introduce MTBE to groundwater.

Although the USEPA did not require MTBE monitoring until the 2001-2003 monitoring cycle, SCDHS has conducted routine monitoring for MTBE since 1991, and has required community water suppliers to incorporate MTBE into their VOC monitoring of supply wells since 1994. In response to the widespread detections of MTBE, on May 24, 2000, New York State enacted legislation (Chapter 35, Laws of 2000) that prohibited gasoline containing MTBE as an additive from being imported, sold or dispensed in New York State as of January 1, 2004.

The ban on use of MTBE as a gasoline additive in New York State has been successful in reducing the detection of the contaminant in untreated groundwater samples from public supply wells.

As shown in **Table 3-10**, MTBE was detected in 129 public supply wells (community and non-community) in Suffolk County from 2009 through 2013, and in 2013, it was detected in 37 upper glacial supply wells and 12 Magothy supply wells (community and non-community wells located throughout the County). The average concentrations of MTBE in raw water sampled from community and non-community supply wells in 2013 are shown on **Figures 3-21a, 3-21b** and **3-21c** for the upper glacial, Magothy, and Lloyd aquifers, respectively. **Table 3-10** shows that MTBE was not detected above the current New York State drinking water standard for MTBE of 10 µg/L in raw water samples from public supply wells in 2013 and that most detections have been observed in the shallower upper glacial wells.

In 2005, MTBE was detected in the raw water from 16 percent of the supply wells tested. The presence of MTBE was detected in almost 10 percent of the private wells SCDHS tested from 1997 through 2007, and 1.4 percent exceeded the drinking water standard of 10 µg/L as shown on **Figure 3-22**.

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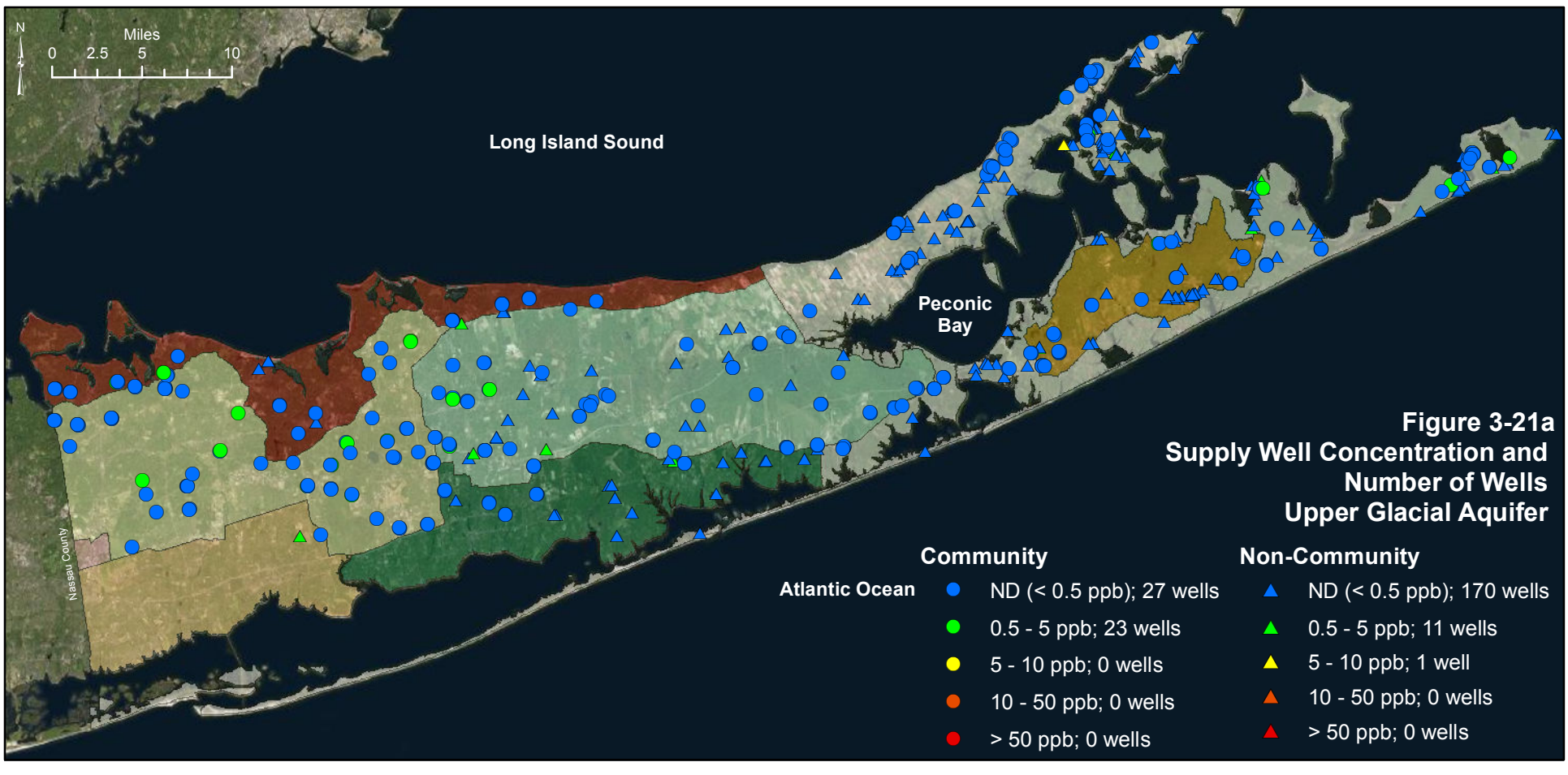

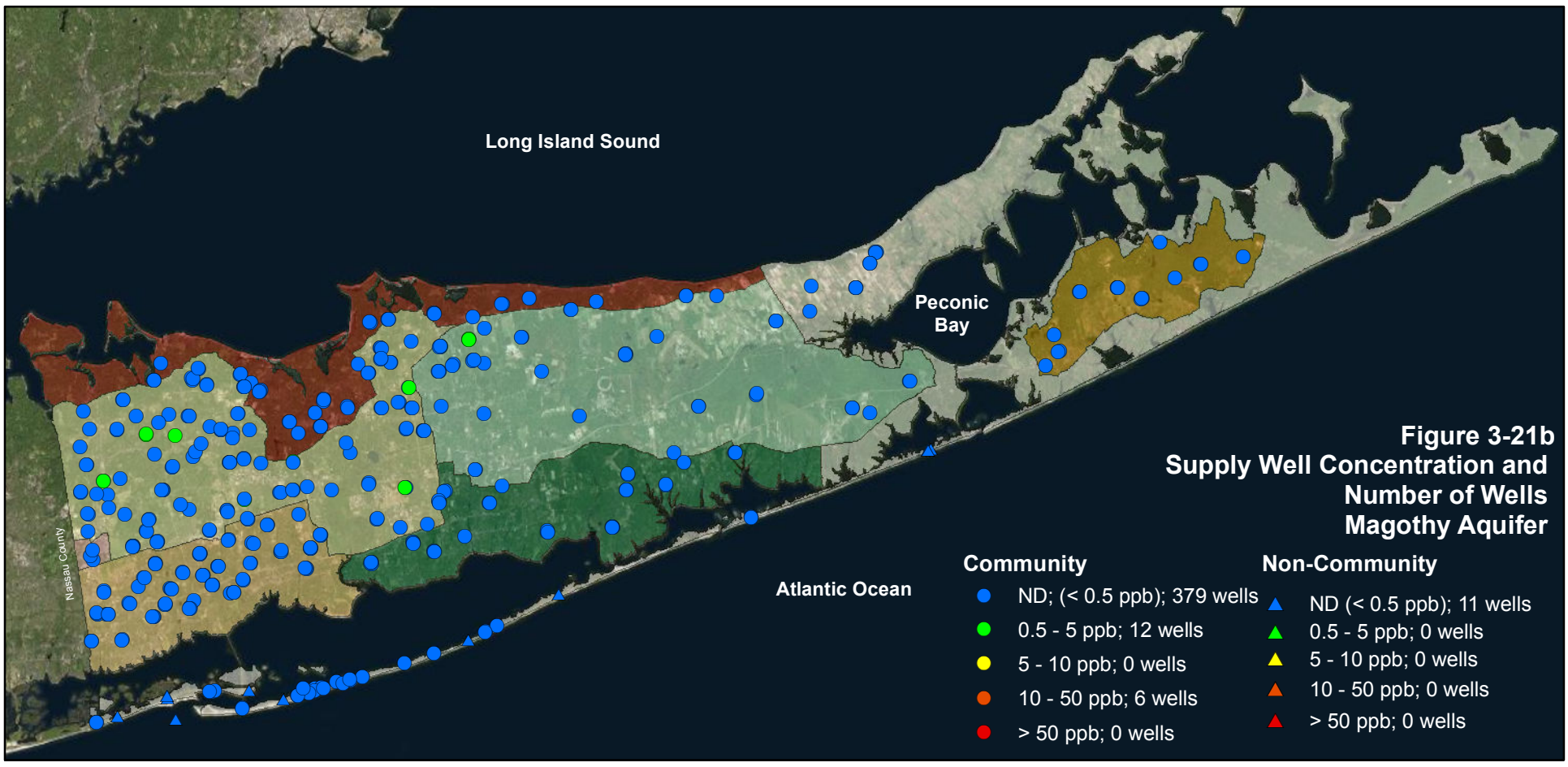

CDM Smith

Average MTBE Concentration in the Upper Glacial, Magothy & Lloyd Aquifers Community and Non-Community Supply Wells - 2013

Suffolk County Comprehensive Water Resources Management Plan

Figure 3-21

Table 3-10 Methyl Tert-Butyl Ether (MTBE) Concentrations from Community and Non-Community Supply Wells

Aquifer	1987	2009-2013	2013
Upper Glacial Aquifer			
n (wells)	N/A	570	489
Minimum (µg/L)	N/A	ND	ND
Maximum (µg/L)	N/A	13	7.7
Average (µg/L)	N/A	0.37	0.3
10th Percentile (µg/L)	N/A	ND	ND
50th Percentile (µg/L)	N/A	ND	ND
90th Percentile (µg/L)	N/A	0.45	ND
No. of wells with detects	N/A	101	37
No. of wells with Detect > 5 µg/L	N/A	6 / 1	1 / 0
Magothy Aquifer			
n (wells)	N/A	418	402
Minimum (µg/L)	N/A	ND	ND
Maximum (µg/L)	N/A	12	4.7
Average (µg/L)	N/A	0.3	0.28
10th Percentile (µg/L)	N/A	ND	ND
50th Percentile (µg/L)	N/A	ND	ND
90th Percentile (µg/L)	N/A	ND	ND
No. of wells with detects	N/A	28	12
No. of wells with Detect > 5 µg/L	N/A	2 / 1	0 / 0
Lloyd Aquifer			
n (wells)	N/A	5	5
Minimum (µg/L)	N/A	ND	ND
Maximum (µg/L)	N/A	ND	ND
Average (µg/L)	N/A	ND	ND
10th Percentile (µg/L)	N/A	ND	ND
50th Percentile (µg/L)	N/A	ND	ND
90th Percentile (µg/L)	N/A	ND	ND
No. of wells with detects	N/A	0	0
No. of wells with Detect > 5 µg/L	0 / 0	0 / 0	0 / 0

1. Data compiled from SCDHS databases; SCDHS did not analyze for MTBE in 1987.
2. Averages and percentiles calculated from annual well averages.
3. No. of wells > 5 µg/L is based on well maximum and averages, respectively (max/avg).

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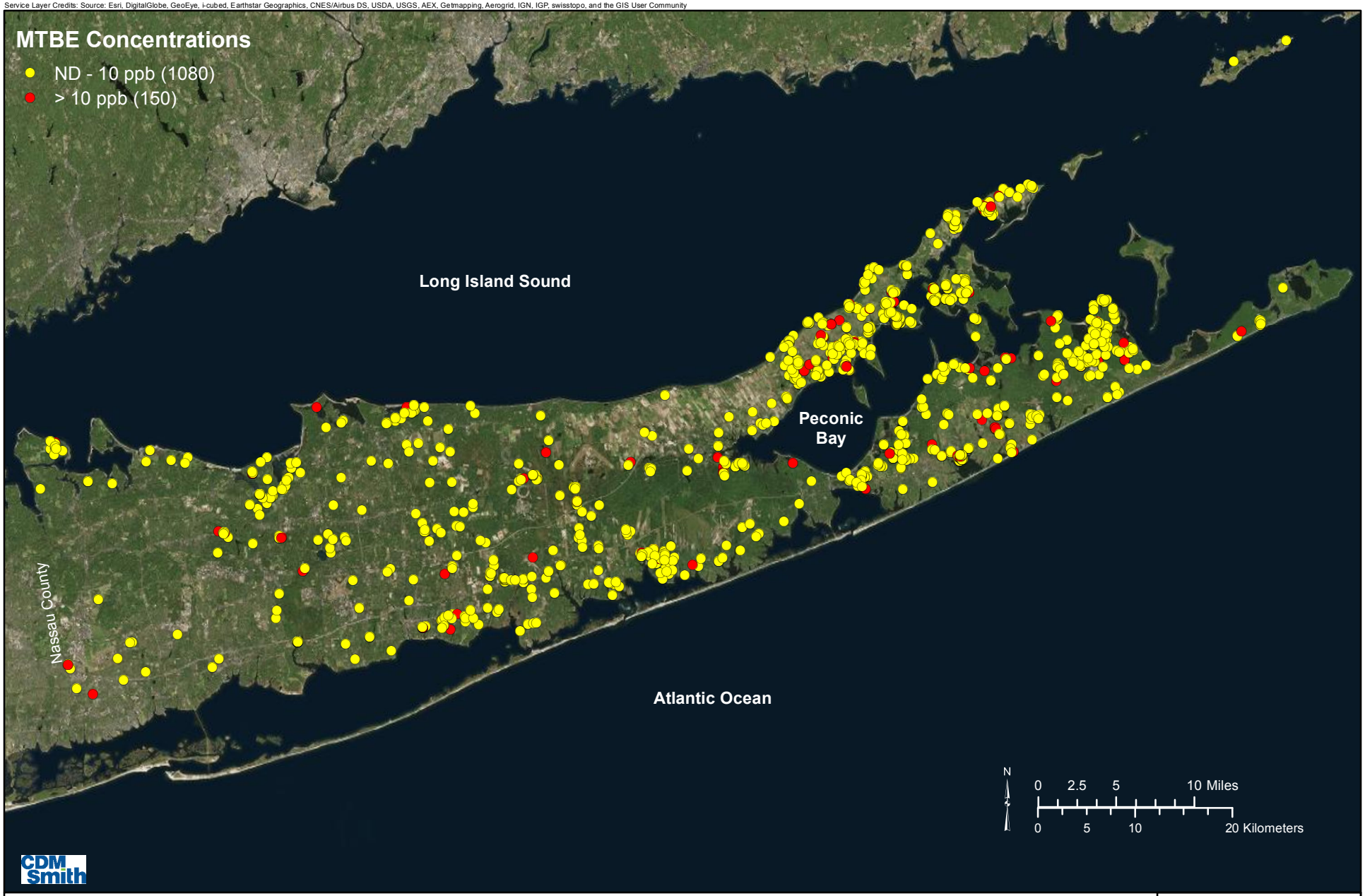


Suffolk County Department of Health Services
MTBE Detections
Private Well Database
1997 - 2013
Suffolk County Comprehensive Water Resources Management Plan

Figure 3-22

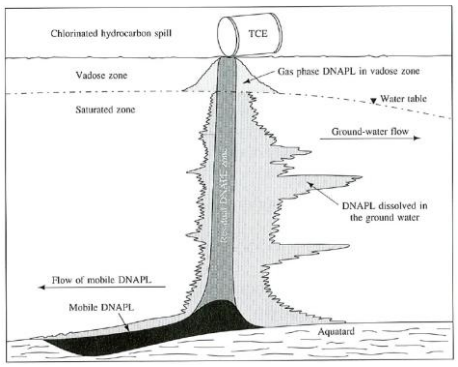
In 2013, MTBE was detected in less than five percent of raw groundwater samples collected from all supply wells, marking a significant improvement, as shown on **Figure 3-22a**.

Other VOCs

SCDHS continues to monitor the County's groundwater resources for a variety of other potential contaminants of concern. A review of SCDHS's private well data for the period from 1997 through 2007 indicated that low level VOC contamination is widespread, with VOC detections in more than one-half of the private wells tested. Approximately seven percent of the wells exceeded the 5 µg/L threshold. The data revealed that 21 percent of the private wells tested contained detectable levels of chloroform and that chloroform levels in nearly two percent of the private wells exceeded 5 µg/L. It is hypothesized that chloroform detections may result from the use of household laundry bleach interacting with organic sewage wastes and/or the discharge of chlorinated swimming pool waters. More recent private well data collected by SCDHS reveals that VOC detections in excess of the 5 µg/L threshold have been reported in 19% of the private wells sampled from 1997 through 2013, as shown on **Figure 3-23.**

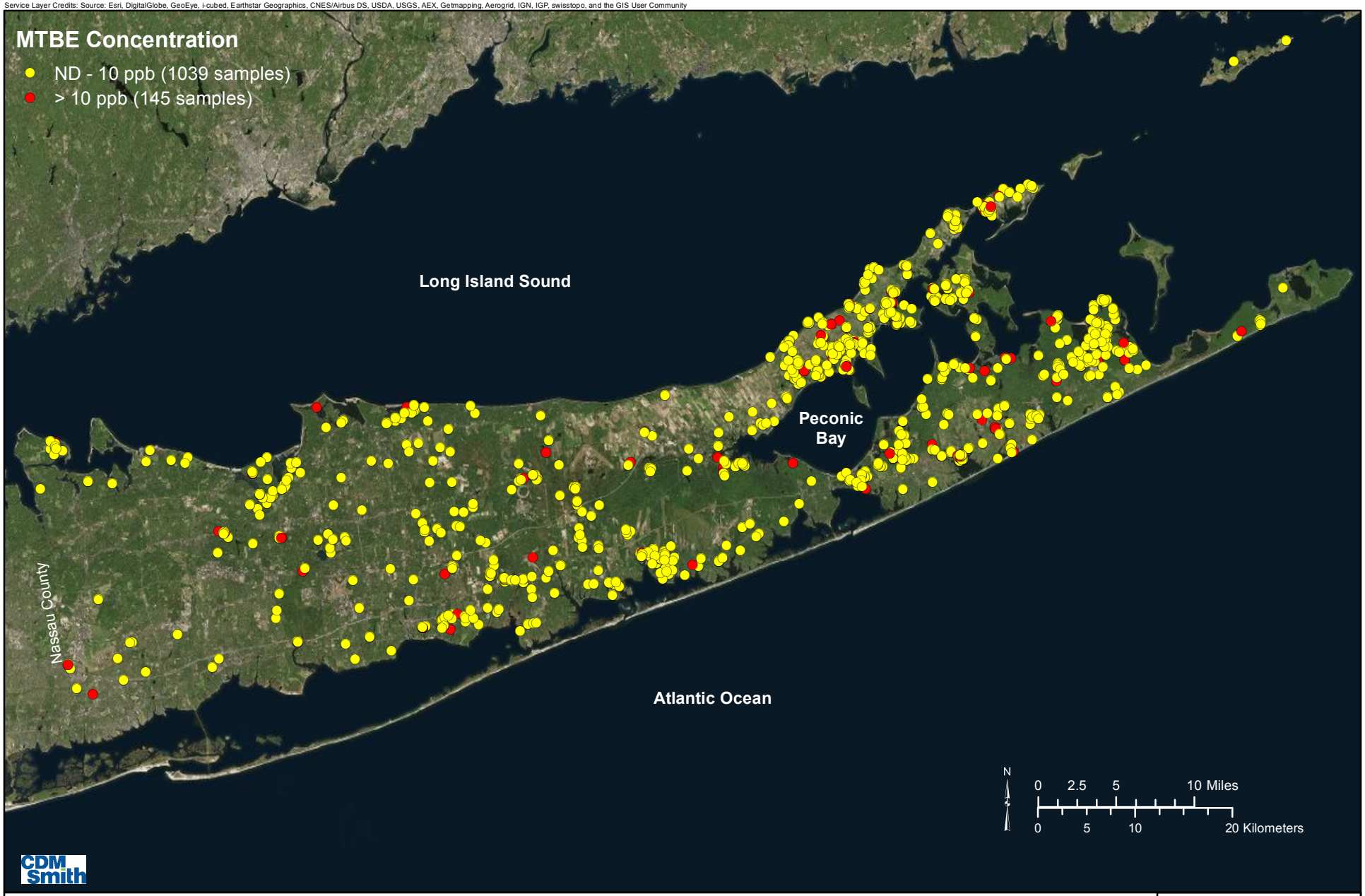
VOCs and Land Use

While non-point sources represent a significant source of nitrogen loading to groundwater, sources of VOC contamination can include both point sources, such as leaking underground storage tanks, illegal discharges and spills, and non-point sources such as septic system discharges. The impacts of land use on four of the most commonly detected VOCs in Suffolk County groundwater (PCE, TCE, TCA and MTBE) were evaluated based on the Suffolk County Department of Economic Development and Planning's analysis of historical land uses within the contributing areas of 56 community supply wells located within 29 wellfields as described below. Although the nitrate analysis indicated that land use-specific nitrate concentrations could be used to estimate nitrate levels in a supply well, predicting land use-specific concentrations for VOCs is more challenging. For example, while primary users of the targeted VOCs include dry cleaners and gasoline stations, both of which are classified as commercial land uses, most commercial establishments are neither dry cleaners nor gasoline stations and in fact use very little VOCs other than over the counter cleaning products. VOCs may also be found in a wide variety of products that are used in residential areas, including automatic transmission fluid, degreasers, hydraulic fluids, motor oils, gasoline, diesel fuel, kerosene, heating oil, car waxes and polishes, asphalt and roofing tar, paints, varnishes, stains, dyes, paint and lacquer thinners, paint and varnish removers, paintbrush cleaners, floor and furniture strippers, metal polishes, laundry soil and stain removers, spot removers and dry-cleaning fluids, refrigerants, bug



Example of DNAPL flow (from Fetter, 1999).

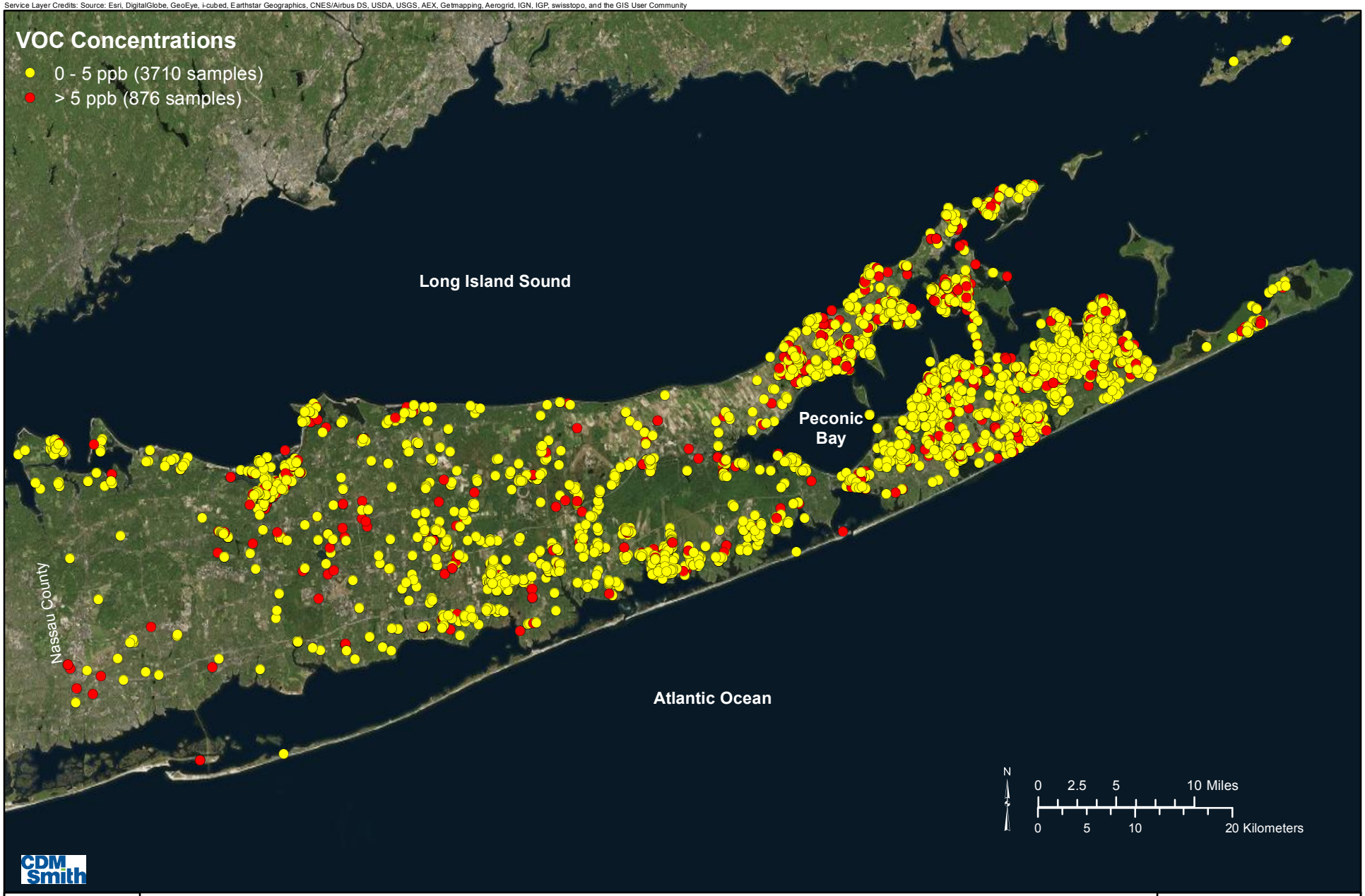
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community



Suffolk County Department of Health Services
MTBE Detections
Private Well Database
1997 - 2013
Suffolk County Comprehensive Water Resources Management Plan

Figure 3-22

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



Suffolk County Department of Health Services
VOC Detections
Private Well Database
1997 - 2013
Suffolk County Comprehensive Water Resources Management Plan

Figure 3-23

and tar removers, household cleaners, oven cleaners, toilet cleaners, some cesspool cleaners and printing inks.

In fact, household wastes were estimated to be a significant source of observed VOC contamination in groundwater in Nassau County (CDM, 1994, Nassau County Department of Health, 1979). Because much of Suffolk County is not sewered, low levels of VOCs may be introduced to groundwater via septic systems. Many of the small sewage treatment plants that serve commercial and industrial areas discharge treated effluent to groundwater; it is also possible that this could be another pathway by which VOCs are introduced to the aquifer system. Unlike nitrates, organic compounds can adsorb onto sediments that will retard their movement through the aquifer; therefore, evaluation of VOC migration from the water table to a well screen is not straightforward. The adsorption or retardation of a particular contaminant is related to the amount of organic carbon in the sediments, which can vary in different zones of the aquifer. It may take VOCs much longer to reach a well screen than it would take a non-retarded contaminant such as nitrates. Although the time it takes water to travel from the water table to a well screen may be defined as 10 years, land uses from previous decades can continue to influence VOC levels. In addition, VOCs such as PCE and TCE that are denser than water (dense, non-aqueous phase liquids, or DNAPLs) can sink vertically into the aquifer until an aquitard, such as a clay layer, is reached. DNAPLs can present a much more extensive source area as the dissolved phase of the contaminants can spread vertically throughout the aquifer.

During this study, the types of land uses that are located within the contributing areas of 29 wellfields were evaluated. Historical water quality data indicate that low level VOC contamination is widespread throughout the County; in fact, VOCs have been detected in all but the following two of the 29 wellfields that were evaluated:

- North Country Road – the unsewered contributing area is now primarily medium density residential; and
- Old North Road (Greenport) – more than 67 percent of the contributing area is agricultural and includes very limited commercial land.

VOCs above the drinking water standard (5 µg/L for PCE, TCE, and 1,1,1-TCA and 10 µg/L for MTBE) were identified in untreated water samples from 11 wellfields; the contributing areas for each well included commercial, industrial, institutional or transportation uses. As an aside, it should be noted that VOC removal facilities are in operation at all of the impacted wellfields, to provide potable supply that is in compliance with applicable MCLs. The

targeted VOCs were also detected at low levels (below drinking water standards) in five wellfields that do not have any commercial, industrial or transportation land use within the contributing areas, indicating that unsewered residential areas can also introduce low level VOC contamination to the aquifer.

Widespread detections of VOCs, particularly PCE and TCE, have been observed in the wellfields included in this analysis. Relating the presence of VOCs in groundwater to overlying land use is not straightforward, given the widespread detections of low levels of VOCs in shallow groundwater, and the myriad of potential pathways by which low levels of the contaminants can be introduced to the aquifer system. However, commercial, industrial and/or transportation or institutional land uses have existed within the contributing areas of most of the wells that have shown significant (e.g., exceeding applicable drinking water standards) VOCs. If significant levels of VOCs are identified in a well, and no commercial, industrial or institutional uses are present within the well's contributing area, the possibility that an upgradient DNAPL exists should be considered.

SCDHS Office of Pollution Control (OPC) regulates facilities that store and use toxic and hazardous materials; there are currently over 20,000 industrial and commercial facilities in the OPC database. OPC has prioritized these facilities based on the contaminants used, the potential for release to the environment, and historical enforcement actions. Those facilities with a medium or low ranking are inspected less frequently than high priority sites. However, recent staffing levels have precluded the SCDHS from inspecting the regulated facilities at the frequency they have targeted for groundwater protection. For example, underground gasoline storage facilities are only inspected on a three-year interval. Because the use of a commercial property may change over time, the priority assigned to a particular property may remain out of date for years, until the facility is inspected again.

Currently, only high priority facilities, those with permitted storage (approximately 3,200 facilities) are inspected. No routine inspections of dry cleaners currently occur. OPC has estimated that between five and ten percent of the lower priority facilities are improperly storing and/or disposing of hazardous materials. As fewer facilities are inspected, the number of environmental clean-ups has also declined, from approximately 300 per year to 148 per year (from January through November 2014).

A recent initiative known as the VOC Action Plan resulted in the hiring of 5 new staff members in the Division of Environmental Quality (DEQ) to increase inspections at commercial/industrial facilities. Implementation of the VOC

Action Plan will result in annual inspections at gasoline stations and dry cleaners as long as these resources are maintained in DEQ. This plan also allows for additional sampling at these facilities and initiation of enforcement actions where violations are found. This plan does not include staff for inspections at the thousands of other non-permitted industrial and commercial facilities which have the potential to use and discharge large quantities of VOCs. In order to complete these inspections on a routine basis, several additional staff members would be required. The most effective way to address this deficiency will be studied in the next phase of the VOC Action Plan via implementation of the Reducing Toxics Study.

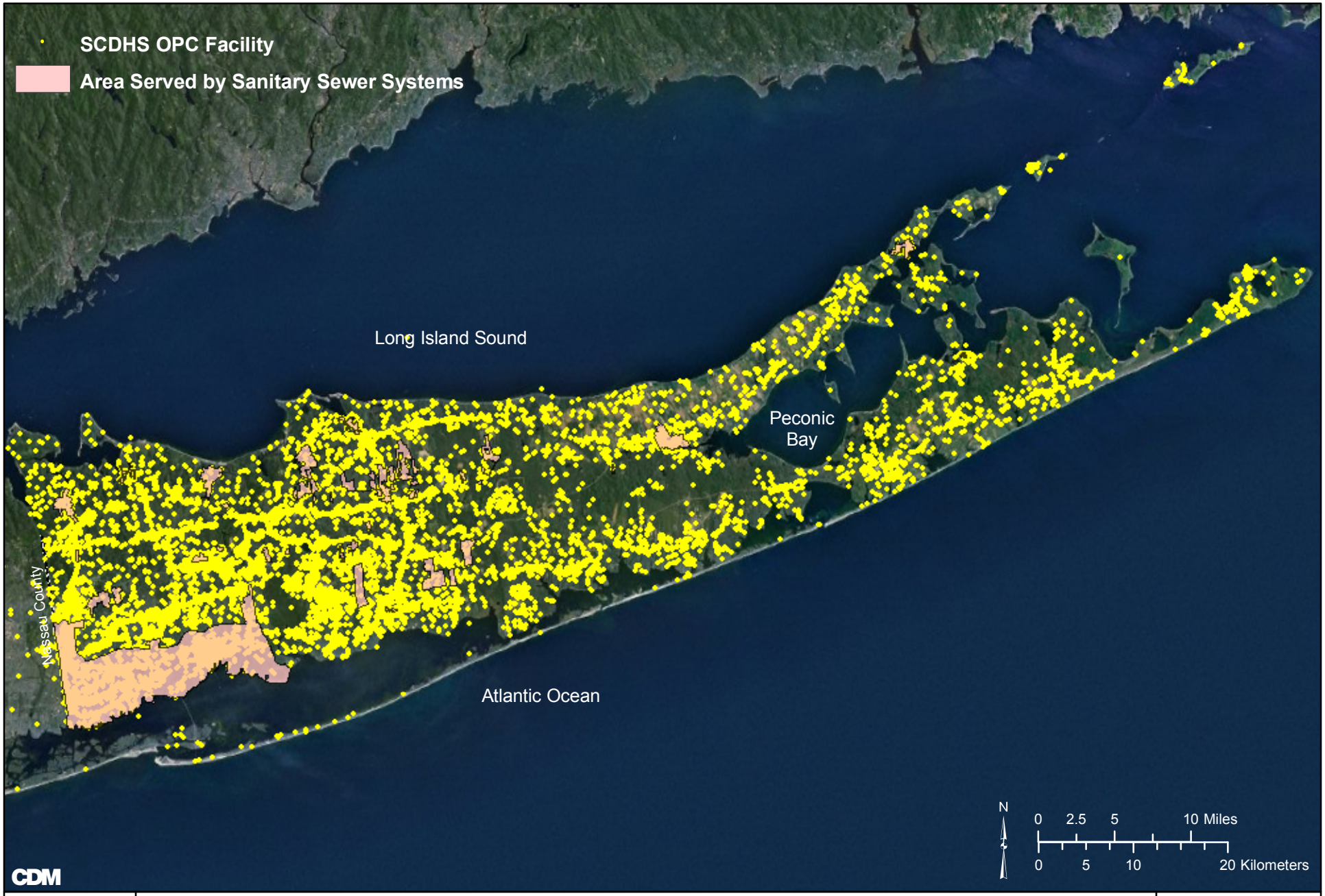
SCDHS OPC records indicate that almost 80 percent of the facilities in their database discharge to on-site septic systems; the locations of facilities in SCDHS's database is depicted along with sewer district locations on **Figure 3-24**. While many of these facilities do not use or store significant quantities of hazardous materials on-site, some facilities do have a higher potential to introduce contamination to groundwater.

While the highest levels of VOCs have been found in supply wells with industrial, commercial, transportation or industrial uses within their source water areas, low levels of VOCs were widely detected throughout the County, suggesting a widespread low-level source, such as residential septic systems.

Industrial, commercial, transportation, institutional and residential land uses all have the potential to introduce VOC contamination to the aquifer system; current VOC loads to groundwater have not been well established in the County.

Summary

Review of water quality data has shown that the highest levels of VOCs are found in wells with industrial, commercial, transportation or institutional uses within their source water areas. Nevertheless, low levels of VOCs were widely detected in groundwater throughout the County, indicating a more widespread low-level source of the observed contaminants, such as residential septic systems. Before targeted recommendations to reduce the release of VOCs to the County's groundwaters can be developed, a better understanding of the potential sources of the observed contamination is required. SCDHS OPC has developed a scope of work for a capital project to evaluate existing industrial/commercial establishments in the County using or storing hazardous materials, including the volume of materials stored, location of storage, potential for release, and assessment of contaminant fate and transport. The contaminant inventory and characterization should form the basis for a revised facility ranking system, and identification of potential new regulations, storage requirements, operator training requirements or inspection/enforcement procedures to improve the effectiveness of OPC programs, and to reduce the further release of toxic contaminants, including VOCs to the environment.



Areas Served by Sanitary Sewer Systems

Suffolk County Comprehensive Water Resources Management Plan

Figure 3-24

Public supply wells that have a history of VOC detections, particularly those in which the MCL is exceeded, should be evaluated, considering the land uses within the well's contributing area, the well operating history and sampling results, to identify the source of the observed contamination. SCDHS should work with NYSDEC/USEPA to ensure necessary actions are taken to eliminate or reduce the threat to the aquifer.

http://www.foodsafetynews.com/2010/04/appeals-court-rules-on-pesticide-application/#.VOSravnF_Nw

SCDHS investigations have identified the presence of more than 100 pesticide-related compounds in Suffolk County groundwater in recent years.

3.1.1.5 Pesticides

Overview

Pesticides, including insecticides, herbicides and fungicides, are a group of synthetic or natural compounds used to kill or control insect pests and nuisance vegetation that affect crops, turf, residential lawns and gardens, homes (e.g., termiticides), pets, and people. They are also designed to disrupt biological functions.

Under the USEPA's Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), New York State regulates the federal registration of pesticides and is required to operate a program and track pesticide use. The authority to perform these activities is provided to the NYSDC under 6 NYCRR Parts 320-329, as well as other articles of the Environmental Conservation Law.

Most pesticides and degradation products do not have specific Federal or New York State drinking water standards, or MCLs. As a result, many of these compounds are typically regulated as Unspecified Organic Contaminants (UOCs) by the New York State Department of Health (NYSDOH) and have an assigned drinking water standard of 50 parts per billion or µg/L. In addition, there is also a total organic compound MCL of 100 µg/L in drinking water set by the NYSDOH.

Pesticide Compounds Detected in Suffolk County Groundwater (1986)
aldicarb (Temik)
carbaryl (Sevin)*
carbofuran (Furadan)
chlorothalonil
dacthal
dibrom*
1,2-dibromoethane (EDB)
1,2-dichloropropane (Telone, D-D, Vorlex)
dinoseb
methomyl (Lannate)*
oxamyl (Vydate)
paraquat*
picloram*
* detection not confirmed by repeat samples or second lab

from 1987 Comp Plan

The ***1987 Comp Plan*** reported the confirmed presence of eight pesticide compounds and unconfirmed detections of five additional compounds in Suffolk County groundwater. In recent years, more extensive investigations conducted by SCDHS, including sampling of private wells and monitoring wells, have identified the presence of more than 100 pesticide-related compounds in Suffolk's groundwater (NYSDEC, 2014).

SCDHS has been on the forefront of pesticide monitoring and has implemented several intensive pesticides monitoring programs since 1979, when aldicarb (Temik) was detected in several private wells in eastern Suffolk County. SCDHS collected and analyzed samples from more than 8,000 private wells during the initial monitoring events, focusing on additional carbamate pesticides (e.g., carbofuran, oxamyl, methomyl), soil fumigants (1,2 dichloropropane, EDB) and an herbicide (dacthal) known to be widely applied

to agricultural crops in the County. The PEHL has published methods for the determination of carbamate pesticides (e.g. aldicarb and its breakdown products), and the breakdown products of dacthal (e.g. TCPA).

Historic sampling results showed that more than 27 percent of the wells sampled contained more than 1 µg/L of aldicarb. As a follow-up, NYSDEC authorized SCDHS (in cooperation with NYSDEC, Nassau County Department of Public Works and Nassau County Health Department) to conduct a more comprehensive evaluation of pesticides contamination that included sampling and analysis of nearly 6,000 samples from approximately 600 community supply wells, and sampling and analysis of private wells and monitoring wells in areas of known or suspected high pesticide use, including agricultural areas, vineyards, lawn care businesses, and golf courses. The United States Geological Survey (USGS) has also conducted an independent pesticide investigation targeting shallow wells in the County.

SCDHS used Cornell Cooperative Extension of Suffolk County's ***Pesticide Usage Report for Agricultural Crops in Suffolk County 1975-2000*** to guide monitoring program development and implementation. The report listed 286 pesticides applied on agricultural crops over the time period and identified 54 agricultural pesticides in common or major usage. SCDHS evaluated the ability of these compounds or their breakdown products (degradates or metabolites) to leach through soils to groundwater to identify those pesticides with the greatest potential to contaminate groundwater and drinking water supplies.

Pesticide breakdown products have been detected more frequently and in higher concentrations than parent compounds

Between 1997 and 2012, SCDHS has collected over 37,000 potable well samples (public and private) that were analyzed for pesticides. Although the concentrations have generally been low, the frequency of detections is a concern. SCDHS results indicate the following:

- Public Community Supply Wells - At least one pesticide compound was detected in about 22% of the wells sampled during this period (196 of 865 wells).
- Public Non-Community Supply Wells - At least one pesticide compound was detected in about 25% of the wells sampled during this period (150 of the 589 wells).
- Private Wells - At least one pesticide compound was detected in about 23% of the private wells sampled during this period (2300 of the 9900 wells sampled).

Between 1997 and 2012, pesticide related contaminants were detected above the MCL in 17 community supply wells, 19 non-community supply wells; and

SCDHS samples for about 150 pesticide related compounds, including both active ingredients and breakdown products.

Between 1997 and 2012, at least one pesticide-related compound was detected in approximately 22 percent of the community supply wells tested by SCDHS.

Over the past several years, we have observed in increase in the frequency of other pesticides, such as metalaxyl, and imidacloprid, at concentrations generally below the respective drinking water standards.

213 private wells. The majority of these compounds include alachlor, TCPA (a dacthal breakdown product), EDB, dichloropropane, and breakdown products of atrazine.

As of 2014, SCDHS samples for about 150 pesticide related analytes, including both active ingredients and breakdown products (**Table 3-11**; italicized compounds on the table are not routinely analyzed by the PEHL due to staff reduction, so that specific analytical methods such as EPA 555, 526 and 527 are no longer supported.) The PEHL has included additional compounds that not currently regulated to their existing laboratory methods to assist in monitoring potential public health impacts from pesticides of current interest (e.g. etofenprox, and resmetherin). Of the 155 pesticide analytes listed in **Table 3-11**, 86 have been detected in groundwater by SCDHS. The detected contaminants are summarized in **Table 3-11a**. In addition to those parameters listed in **Table 3-11** and **Table 3-11a**, additional compounds that have other uses involving arsenic, cadmium, fluoride have also been detected (NYSDEC, 2014). A summary of recent pesticide sampling and detections is shown on **Table 3-11b**. Note that the higher percentage of detections and exceedances from the monitoring wells cannot be directly compared to supply wells as many of the monitoring wells were installed to target land uses that typically utilize pesticides (e.g. agricultural).

Community supply well susceptibility ratings for pesticides are summarized on **Figure 3-25**. Susceptibility to pesticides is rated as low to medium throughout most of the County, except on the North Fork, where community supply wells are highly or very highly susceptible to pesticide contamination due to the agricultural land uses present.

Community supply wells with detections of pesticide-related chemicals are illustrated on **Figure 3-26**. Pesticide-related chemicals were detected above the MCL in raw or untreated water in only 4 community supply wells from 2011 through 2013; the pesticides detected above their MCLs were Aldicarb-Sulfone, Aldicarb-Sulfoxide, DCP and TCPA. The distribution of these MCL exceedances is shown on **Figure 3-26**. Metalaxyl has been detected in more than 300 private wells throughout the County between 1997 and 2010, particularly on the north fork (**Figure 3-26a**).

The use of many of the pesticides detected in groundwater has been banned in Suffolk County for years; nevertheless, they persist in the environment due to their chemical properties. The most frequently detected pesticide chemicals were aldicarb sulfoxide and sulfone, metolachlor, the dacthal degradate, tetrachloroterephthalic acid (TCPA), 1,2-dichloropropane (DCP), 1,2,3-

Table 3-11 Pesticide Analytes Tested by SCDHS PEHL, 2014

(Italicized Analytes Currently Not Routinely Conducted)

1,2-dibromo-3-chloropropane (DBMC)	*Cyanazine*	Methomyl
1,2-Dibromomethane (EDB)	Cyfluthrin (beta-Cyfluthrin)	Methoprene
1-Naphthol	Cypermethrin	Methoxychlor
2,4,5-T	Dacthal	Methyl parathion
2,4,5-TP (SILVEX)	Deisopropylatrazine (G-28279)	Metolachlor
3,5-Dichlorobenzoic Acid	Deltamethrin	Metolachlor ESA (CGA-354743)
4-Nitrophenol	Desethylatrazine (G-30033)	Metolachlor metabolite (CGA-37735)
Acifluoren	*Diazinon*	Metolachlor metabolite (CGA-40172)
Alpha-BHC	*Dicamba*	Metolachlor metabolite (CGA-41638)
Anthracene	Dichlobenil	Metolachlor metabolite (CGA-67125)
Delta-BHC	*Dichloroprop*	Metolachlor OA (CGA-51202)
2,6-Dichlorobenzamide	Dichlorvos	Metribuzin
1,2,3-Trichloropropane	Didealkylatrazine (G-28273)	Monomethyltetrachloroterephthalate
1,2-Dichloropropane	Dieldrin	Naled (Dibrom)
1,3-Dichloropropane	*Dimethoate*	Napropamide
2,2 Dichloropropane	Dimethyldisulfide	*Nitrofen*
2,4,6-Trichlorophenol	Dinoseb	*Norflurazon*
2,4-D	Disulfoton	Oxamyl
2,4-DB	Disulfoton sulfone	*Oxychlordane*
2,4-Dichlorophenol	Diuron	Pendimethalin
2-HydroxyAtrazine (G-34048)	Endosulfan I	Pentachlorobenzene
3-Hydroxycarbofuran	Endosulfan II	Pentachloronitrobenzene
4,4-DDD	Endosulfan Sulfate	*Pentachlorophenol*
4,4-DDE	Endrin	Permethrin
4,4-DDT	Endrin aldehyde	Picaridin
Acetochlor	EPTC	*Picloram*
Alachlor	*Esbiol*	Piperonyl butoxide
Alachlor ESA (Sulfonic Acid)	*Esfenvalerate*	Prallethrin
Alachlor OA (Oxanilic Acid)	Ethofumesate	Prometon
Aldicarb	Ethyl Parathion	Prometryn
Aldicarb sulfone	Etofenprox	Prometryne
Aldicarb sulfoxide	Etofenprox alpha-CO	Propachlor
Aldrin	*Fenvalerate*	Propamocarb hydrochloride
Allethrin	*Fonofos*	Propiconazole (Tilt)
Atrazine	gamma-BHC (Lindane)	Propoxur (Baygon)
Azoxystrobin	Germanium	Resmethrin
Benfluralin	Heptachlor	Ronstar
Bentazon	Heptachlor epoxide	Siduron
beta-BHC	Hexazinone	Simazine
Bifenthrin	Imidacloprid	Sumithrin
Bloc	Imidacloprid Urea	Tebuthiuron
Bromacil	Iodofenphos	Terbacil
Bromomethane	Iprodione	*Terbufos*
Butachlor	Isofenphos	*Terbufos sulfone*
Carbaryl	Kelthane	Tetrachloroterephthalic acid
Carbofuran	Malaoxon	*Thiobencarb*
Chloramben	Malathion	Triadimefon
Chlordane	*MCPA*	*Triadimenol*
Chlorofenvinphos	*Mecoprop(MCPP)*	Trichlorfon
Chlorothalonil	Metalaxyl	Trifluralin
Chloroxylenol	Methiocarb	Vinclozolin
Chlorpyriphos	Methiocarb sulfone	

Table 3-11a Pesticides Detected by SCDHS, 1997-2014

Pesticide Analyte	Source[1]	Pesticide Analyte	Source[1]
1,2 Dichloropropane	Blacksmith/MW	Fenarimol (Bloc)	NYSDEC(2014)
1,2,3 Trichloropropane	Blacksmith/MW	gamma-BHC (Lindane)	Blacksmith
1,2-dibromo-3-chloropropane	Blacksmith	Germanium	MW
1,3 Dichloropropane	Blacksmith	Heptachlor epoxide	Blacksmith/MW
2,4-D	NYSDEC(2014)	Hexazinone	NYSDEC(2014)
2-Hydroxyatrazine (a.k.a. hydroxyatrazine)	NYSDEC(2014)	Imidacloprid	NYSDEC(2014)/MW
2,6-Dichlorobenzamide	MW	Imidacloprid Urea	NYSDEC(2014)/MW
3-Hydroxycarbofuran	NYSDEC(2014)	Iprodione	NYSDEC(2014)
4-Nitrophenol	NYSDEC(2014)	Kelthane	NYSDEC(2014)
Acetochlor	NYSDEC(2014)	Malaoxon	NYSDEC(2014)
Alachlor	Blacksmith/MW	Mecoprop (MCPP)	NYSDEC(2014)
Alachlor ESA	NYSDEC(2014)/MW	Metalaxyl	NYSDEC(2014)/MW
Alachlor OA	NYSDEC(2014)/MW	Methiocarb	NYSDEC(2014)
Aldicarb	Blacksmith/MW	Methomyl	NYSDEC(2014)/MW
Aldicarb-Sulfone	Blacksmith/MW	Methoxychlor	Blacksmith
Aldicarb-Sulfoxide	Blacksmith/MW	Metolachlor	Blacksmith/MW
Atrazine	Blacksmith/MW	Metolachlor ESA	NYSDEC(2014)/MW
Azoxystrobin	NYSDEC(2014)	Metolachlor metabolite	NYSDEC(2014)/MW
Bentazon	NYSDEC(2014)	Metolachlor OA	NYSDEC(2014)/MW
Bromacil	NYSDEC(2014)	Metribuzin	Blacksmith
Carbaryl	NYSDEC(2014)	Monomethyltetrachloroterephthalate	Blacksmith
Carbofuran	NYSDEC(2014)	Napropamide	NYSDEC(2014)
Chlordane	Blacksmith/MW	Norflurazon	NYSDEC(2014)
Chlorofenvinphos	NYSDEC(2014)	Oxamyl	NYSDEC(2014)
Chloroxylenol	NYSDEC(2014)/MW	Pentachlorobenzene	NYSDEC(2014)
Cyanazine	NYSDEC(2014)	Pentachloronitrobenzene	NYSDEC(2014)
Dacthal	Blacksmith	Pentachlorophenol	NYSDEC(2014)
Deisopropylatrazine	NYSDEC(2014)	Piperonyl butoxide	NYSDEC(2014)
Dibromomethane	Blacksmith	Prometon	NYSDEC(2014)
Dicamba	NYSDEC(2014)	Propachlor	NYSDEC(2014)
Dichlobenil	NYSDEC(2014)	Propamocarb hydrochloride	NYSDEC(2014)
Dichlorvos	NYSDEC(2014)	Propiconazole	NYSDEC(2014)/MW
Didealkylatrazine	NYSDEC(2014)	Propoxur (Baygon)	NYSDEC(2014)
Dieldrin	Blacksmith/MW	Ronstar	NYSDEC(2014)/MW
Dimethyldisulfide	Blacksmith	Siduron	NYSDEC(2014)/MW
Dinoseb	NYSDEC(2014)	Simazine	Blacksmith/MW
Disulfoton sulfone	NYSDEC(2014)	TCPA	Blacksmith
Diuron	NYSDEC(2014)	Tebuthiuron	NYSDEC(2014)/MW
Endosulfan I	Blacksmith/MW	Triadimefon	NYSDEC(2014)/MW
Endosulfan II	Blacksmith	Triaimenol	NYSDEC(2014)

Pesticide Analyte	Source[1]	Pesticide Analyte	Source[1]
Endosulfan Sulfate	NYSDEC(2014)/MW	Trichlorfon	NYSDEC(2014)/MW
Ethofumesate	NYSDEC(2014)/MW	Triedimenol	NYSDEC(2014)
Ethyl dipropylthiocarbamate (EPTC)	NYSDEC(2014)	Vinclozolin	NYSDEC(2014)
1. Blacksmith = Supply Wells (SCDHS database); MW = SCDHS monitoring well database			

Table 3-11b Wells Sampled for Pesticides by SCDHS, 2011 through 2013

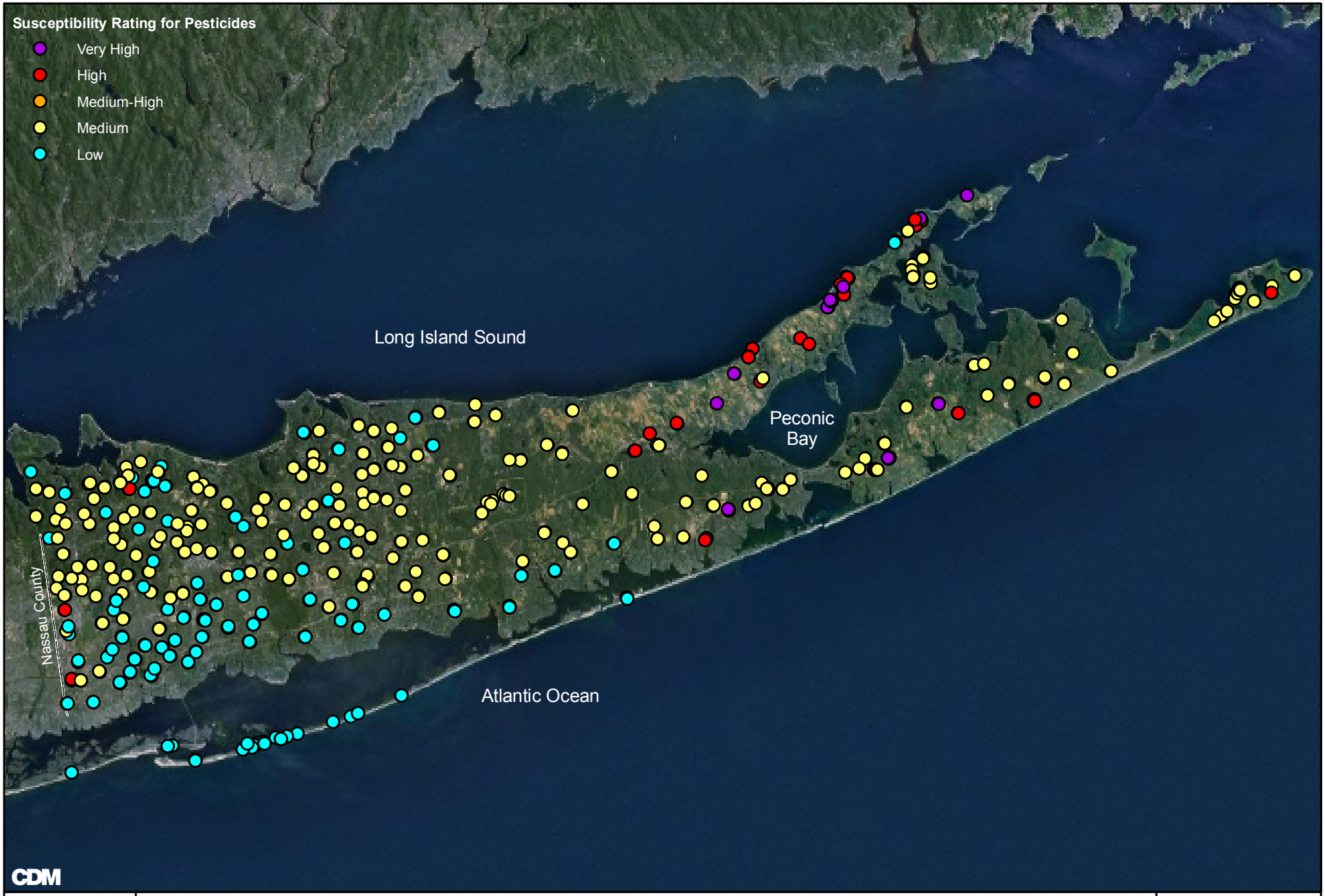
Type	# Sites Sampled	with Detects	Exceeded MCL
Community*	319	49 (15%)	4 (1%)
Non-Community*	230	22 (10%)	1 (< 1%)
Private*	966	90 (9%)	20 (2%)
Monitoring	524	192 (37%)	49 (9%)

*Based on SCDHS Blacksmith database. Some pesticides (e.g., metalaxyl, and Imidacloprid, for example) are not included in this database.

trichloropropane (TCP), alachlor, dinoseb, metalaxyl, imidacloprid, simizine and atrazine. Of the ten most frequently detected pesticide chemicals in the private wells, only simazine, metalaxyl, imidacloprid and atrazine remain registered for use on Long Island and metalaxyl has been detected in hundreds of wells (**Figure 3-26a**), albeit below the MCL of 50 µg/L.

The public and private well data compiled for selected pesticides from 1980 through 2014 demonstrates that several common agricultural pesticide chemicals can persist in groundwater for decades and that pesticide degradates are detected more frequently and in higher concentrations than some parent compounds. Levels of these older, banned pesticides have been decreasing in groundwater samples collected by SCDHS, as shown on **Figures 3-27** and **3-28**. Note that aldicarb has only been detected in three private wells since 1997 and concentrations shown on **Figures 3-27 and 3-28** are therefore almost entirely its metabolites after 1997. As shown on these figures, although these banned pesticides remain in the groundwater system, concentrations are declining and parent compounds are rarely detected supporting the effectiveness of the ban.

Crop type has a significant impact on the type and volume of pesticides that are observed in downgradient groundwater. A SCDHS report entitled **Water Quality Monitoring for Pesticides in Nassau & Suffolk County, Vineyard Monitoring Draft Report 2003-2006** describes water quality monitoring of 26 monitoring wells at seven Suffolk County vineyards. In general, low levels of pesticides or pesticide-breakdown products were widely observed, with

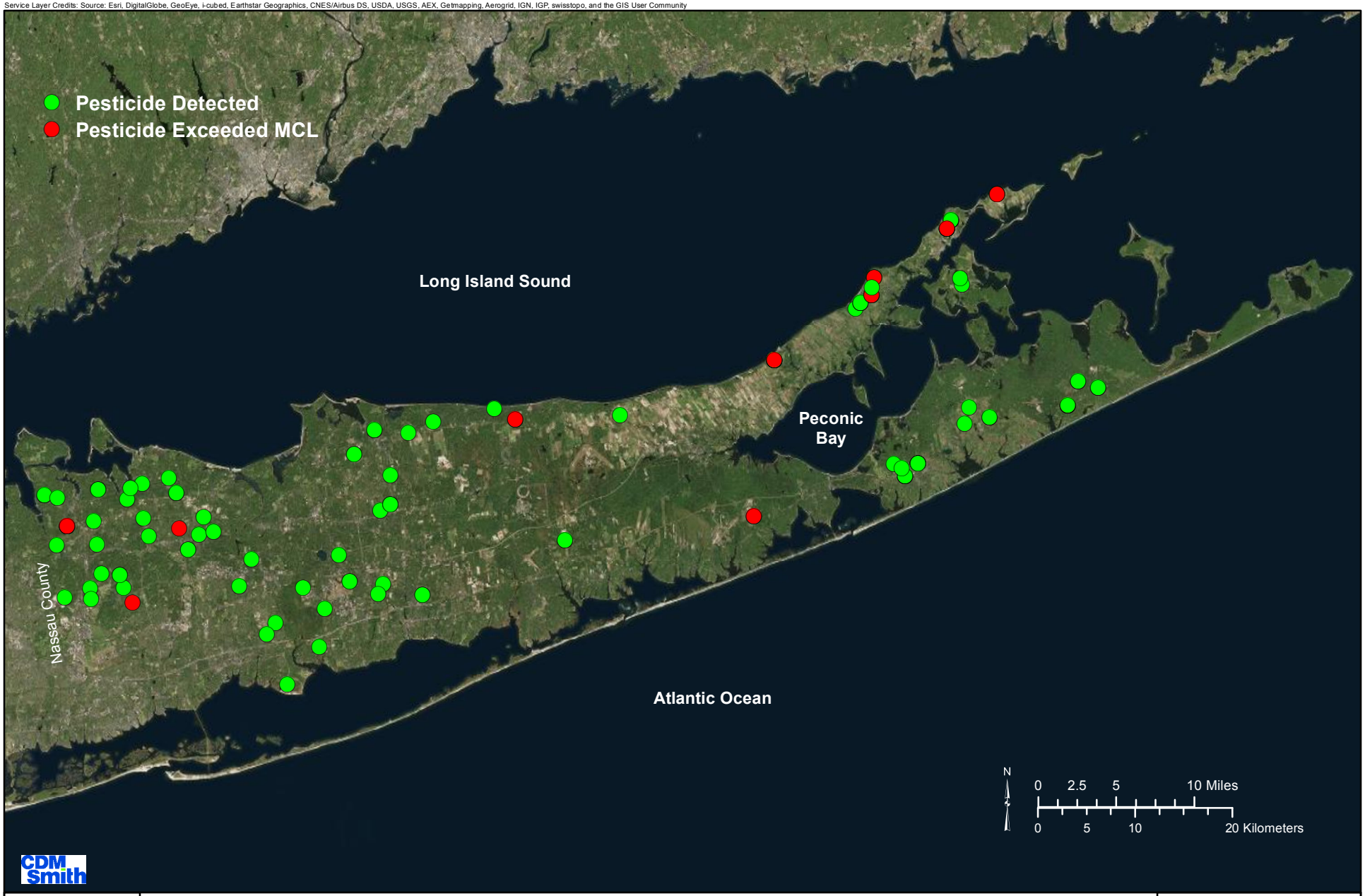


Community Supply Well Susceptibility Rating for Pesticides

Suffolk County Comprehensive Water Resources Management Plan

Figure 3-25

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



Pesticide Detections & MCL Exceedances 1997-2014
Community Public Water Supply Wells
SCDHS Blacksmith Water Quality Database

Suffolk County Comprehensive Water Resources Management Plan

Figure 3-26

The pesticide-related chemicals found most often by the SCDHS were:

Aldicarb (Temik) breakdown products aldicarb sulfoxide and aldicarb sulfone – Despite the fact that aldicarb, a water soluble pesticide used on potatoes and other agricultural crops from 1975 through 1979 was banned from sale and use on Long Island in 1980, low levels of its two breakdown products have persisted in the aquifer in agricultural areas.

Tetrachloroterephthalic acid (TCPA) – A breakdown product of the herbicide dacthal, which was used in agricultural settings and on golf courses before being removed from use on Long Island in 1988.

1,2-dichloropropane (DCP) and 1,2,3-trichloropropane (TCP) - DCP was used extensively in the 1950s through 1970s to rid potato fields of the golden nematode and the Colorado potato beetle. Although use of DCP was banned in 1987, both DCP and TCP continue to be detected; because TCP has been reported in wells in non-agricultural areas and without DCP, it suggests that a few of these detections may have resulted from its use as an industrial solvent.

Metolachlor and its metabolites --- Although the herbicide metolachlor, used since the 1980s, has been banned from sale and use on Long Island since 2002, metolachlor and its metabolites continue to be identified in the aquifer, particularly in agricultural areas.

Simazine – A herbicide that is still registered for use in areas such as utility rights-of-way and electric company substations, simazine and its degradates have been detected in public and private supply wells.

Alachlor and its two breakdown products alachlor ESA and alachlor OA – Alachlor, a widely used agricultural herbicide until it was banned in 1999, and its two breakdown products are still detected in wells located in agricultural areas.

Atrazine – Atrazine is an herbicide that is applied to turf and crops and has been detected in wells primarily on the east end.

Metalaxyl – Low concentrations of metalaxyl, a fungicide in use since the 1980s and commonly used by vineyards and golf courses, have been reported in supply wells in the eastern part of the County. As of 2014, metalaxyl remains a registered on Long Island.

Dinoseb – Dinoseb was banned in 1986 after being widely used in agricultural areas in the 1970s and 1980s; low levels of the herbicide are still reported today.

Imidacloprid – An insecticide used to control grubs and the Asian Longhorned Beetle, imidacloprid is beginning to be detected in community supply wells.

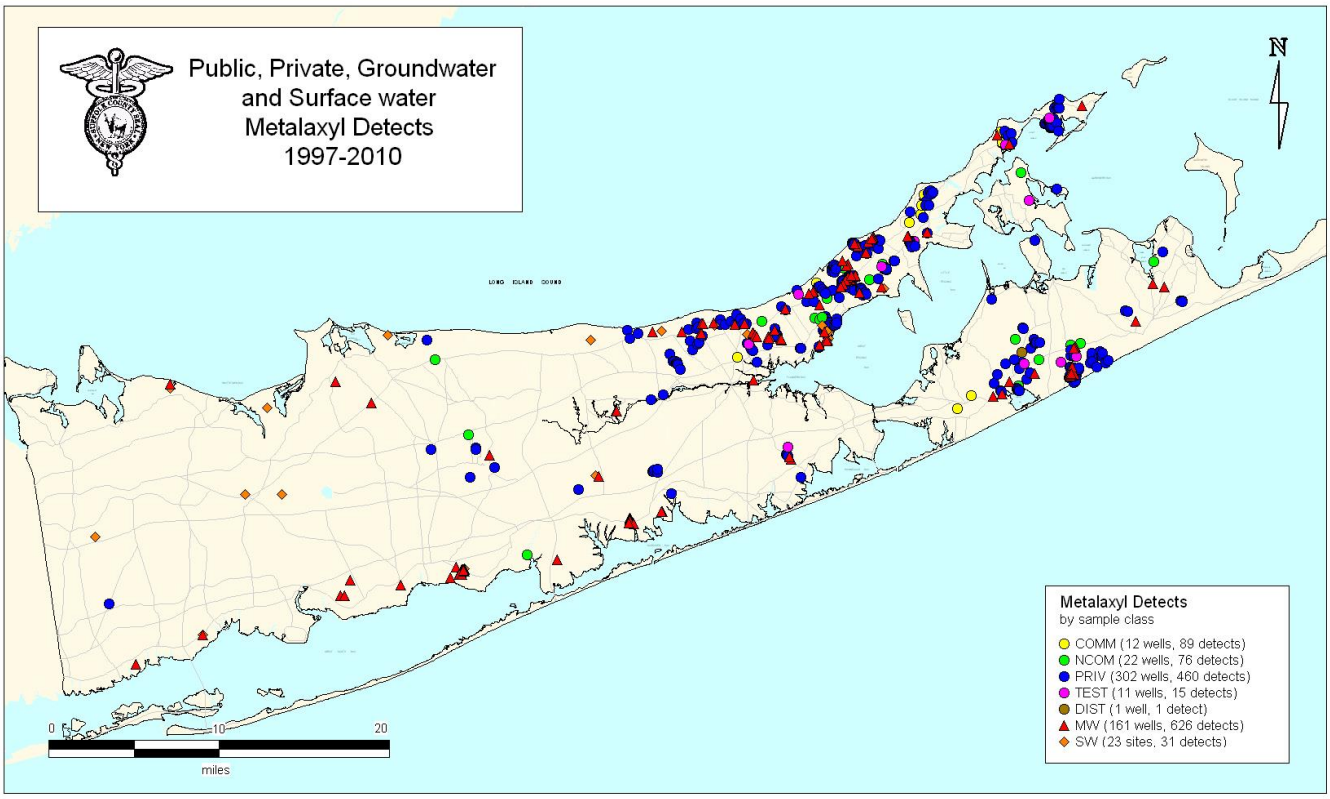


Figure 3-26a Detections of Metalaxyl between 1997 and 2010 (from SCDHS, 2011)

detections reported in 80 percent of the wells tested (21 of 26 wells) at five of the six vineyards. The fungicide metalaxyl, which is currently registered for use on grapes, was the most frequently detected compound, occurring at low levels in 15 of the wells sampled. In addition to the low levels of registered pesticides that were detected, low levels of historically applied pesticides and breakdown products not associated with vineyard applications were also widely reported, including metolachlor, alachlor and aldicarb. These compounds are likely artifacts from pesticide applications to agricultural crops that were previously grown in areas now planted in grapes. The detected pesticides were reported at concentrations an order of magnitude lower than applicable drinking water standards, except for simazine. Simazine was detected in four monitoring wells at concentrations ranging from 0.17 µg/L to 1 µg/L, all below the MCL of 4 µg/L.

Table 3-12 summarizes metalaxyl and atrazine detections in Suffolk County groundwater in 1997, 2005 and 2013 and imidacloprid detections in 2000, 2005 and 2013. The most recent data shows low levels off metalaxy detections in community, non-community and private wells. The data shows that atrazine

SCDHS records show there have been fewer detections of the oldest long withdrawn pesticides; however, these compounds are persistent and in some cases, still exceed drinking water standards. Examples include aldicarb and TCPA.

Figure 3-27 Trends in Maximum Aldicarb, Metolachlor and TCPA Concentrations Detected by SCDHS

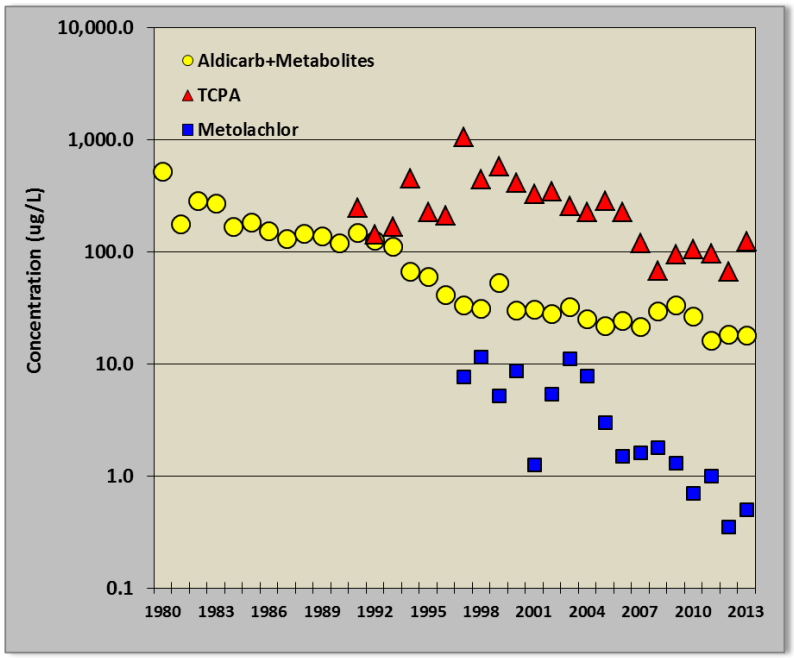


Figure 3-28 Trends in Median Aldicarb, Metolachlor and TCPA Concentrations Detected by SCDHS

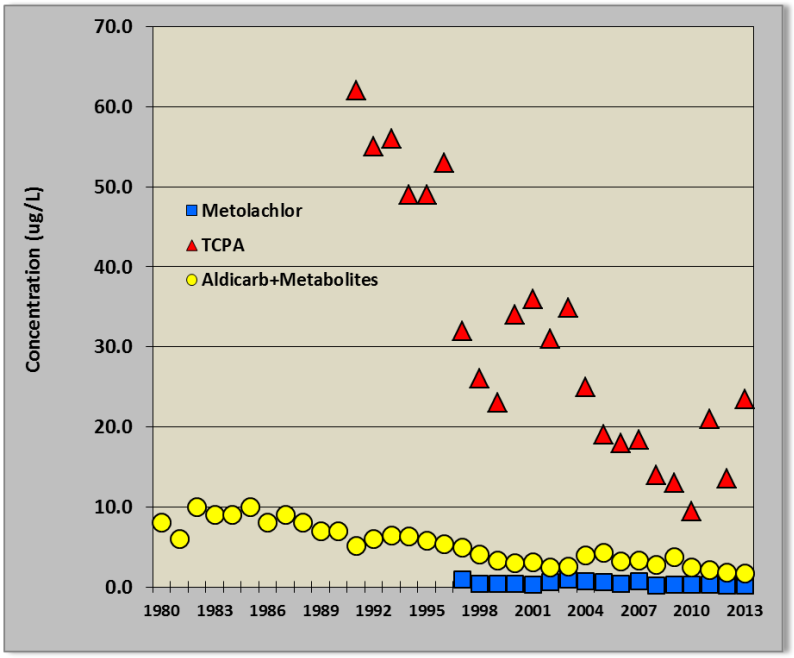


Table 3-12 Metalaxyl, Atrazine and Imidicloprid Data Trends in Community, Non-community and Private Wells

SCDHS Metalaxyl Data	1997			2005			2013		
	Com.	NC	Private	Com.	NC	Private	Com.	NC	Private
No. Wells Sampled	-	13	156	218	311	456	973	370	672
No. Wells with Detections	-	1	5	5	1	72	14	6	21
% Wells with Detections	-	8%	3%	2%	0%	16%	1%	2%	3%
Minimum Detection (µg/L)	-	0.10	0.10	0.20	0.20	0.20	0.20	0.20	0.20
Maximum Detection (µg/L)	-	1.20	0.38	3.40	0.50	4.30	2.20	1.60	2.80
Median (µg/L)	-	0.10	0.10	0.20	0.20	0.20	0.20	0.20	0.20
90% Percentile (µg/L)	-	0.10	0.10	0.20	0.20	0.20	0.20	0.20	0.20
Detection Limit (µg/L)	-	0.10	0.10	0.20	0.20	0.20	0.20	0.20	0.20
SCDHS Atrazine Data	**1997**			**2005**			**2013**		
	Com.	NC	Private	Com.	NC	Private	Com.	NC	Private
No. Wells Sampled	1	19	306	137	264	420	178	75	311
No. Wells with Detections	0	8	158	0	0	2	1	1	1
% Wells with Detections	0	42%	52%	0%	0%	0.5%	1%	1%	0%
Minimum Detection (µg/L)	0.20	0.10	0.10	0.20	0.20	0.20	0.10	0.10	0.10
Maximum Detection (µg/L)	0.20	0.20	0.65	0.20	0.20	0.80	1.00	0.20	0.20
Median (µg/L)	0.20	0.10	0.20	0.20	0.20	0.20	0.10	0.10	0.10
90% Percentile (µg/L)	0.20	0.20	0.20	0.20	0.20	0.20	0.10	0.10	0.10
Detection Limit (µg/L)	-	0.10	0.10	0.20	0.20	0.20	0.10	0.10	0.10
SCDHS Imidacloprid Data	**2000**			**2005**			**2013**		
	Com.	NC	Private	Com.	NC	Private	Com.	NC	Private
No. Wells Sampled	179	66	708	296	204	449	314	203	321
No. Wells with Detections	0	0	1	2	1	13	3	4	12
% Wells with Detections	0%	0%	0%	1%	0%	3%	1%	2%	4%
Minimum Detection (µg/L)	0.20	0.20	0.20	0.20	0.20	0.11*	0.20	0.20	0.20
Maximum Detection (µg/L)	0.20	0.20	0.42	0.27	0.40	8.44	0.30	0.70	2.80
Median (µg/L)	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
90% Percentile (µg/L)	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Detection Limit (µg/L)	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20

Notes:

1. Data compiled from SCDHS Blacksmith database.
2. Com. Is community wells, NC is non community wells.
3. Detection limits are not consistent from year to year; * sample appears to be a spurious value.

Over 100 pesticides and pesticide-related chemicals have been detected in groundwater; concentrations are typically less than 5 µg/L.

Multiple pesticide and pesticide degradate compounds often co-occur in wells downgradient of agricultural areas; pesticide degradates are often detected in higher concentrations than the parent pesticide.

The highest pesticide concentrations are found in areas downgradient of agricultural areas.

Groundwater from over 98 percent of the supply wells sampled complied with the drinking water quality criteria for these contaminants.

Many of the pesticides and pesticide-breakdown products detected have been banned from use in Suffolk County for decades, but are still present in the aquifer system due both to their solubility and persistence in the environment. The continued presence of pesticide-related chemicals in both monitoring and supply wells demonstrates that pesticides continue to be of concern.

levels have declined through the years, and imidacloprid levels have increased. Imidacloprid is used throughout the County, in fact it is an ingredient in pet flea-control products.

The USGS has independently conducted pesticide investigations in Suffolk County and their findings are consistent with those of the SCDHS. As part of the National Water Quality Assessment Program, the USGS published ***Water Quality in the Long Island-New Jersey Coastal Drainages, New York and New Jersey, 1996-1998*** in 2000, and also documented their work investigating pesticides and their metabolites in shallow wells in Suffolk County. The five pesticides that were most frequently detected by the USGS were atrazine and metolachlor (agricultural herbicides), deethylatrazine (a metabolite), and prometon and simazine (herbicides available for purchase and use by homeowners). Reported concentrations of each in groundwater were well below the MCL or drinking water health advisory, except for deethylatrazine, for which no standard or guideline has been established to date.

The USGS study found that the most commonly used pesticides were not the same compounds that were most frequently detected in shallow groundwater in the study area. Pesticides that are characterized as having low persistence and/or low mobility were detected in less than five percent of the groundwater samples, even when high quantities of use had been reported. Pesticides that were reportedly applied in much lower quantities were detected more frequently when they were characterized with higher persistence and/or mobility. Due to their persistence and widespread application, organochlorine insecticides that have been banned were detected in groundwater in the study area. In addition, the USGS reports that the metabolites, or break down products of these pesticides were also widely detected throughout the study area. In fifty wells sampled on Long Island, 36 percent of the pesticide compounds detected were in fact metabolites; and the highest pesticide concentrations were associated with pesticide metabolites (Phillips et al, 1999).

Assessment of the significance of the pesticide detections is complicated by the fact that contaminant-specific MCLs have only been established for a small number of pesticides and only seven of the most frequently detected compounds in the County (alachlor, aldicarb (and metabolites), dinoseb, atrazine, simazine, DCP, TCP). The UOC MCL of 50 ppb is applied to all other pesticides. When multiple pesticide residues co-occur in wells located in agricultural areas, the total Principal Organic Contaminant (POC) and UOC MCL of 100 ppb was applied.

NYSDOH MCL	µg/L
1,2 Dichloropropane	5
1,2,3-Trichloropropane	5
1,3-Dichloropropane	5
2,2-Dichloropropane	5
2,3,7,8-TCDD (dioxin)	0.00003
2,4,5-TP (Silvex)	10
2,4-D	50
Alachlor	2
Aldicarb	3
Aldicarb sulfone	2
Aldicarb sulfoxide	4
Atrazine	3
Bromomethane	5
Carbofuran	40
Chlordane	2
Dibromochloropropane(DBCP)	0.2
Dinoseb	7
Diquat	20
Endrin	2
Ethylene dibromide(EDB)	0.05
Heptachlor	0.4
Heptachlor epoxide	0.2
Hexachlorobenzene	1
Lindane	0.2
Methoxychlor	40
Pentachlorophenol	1
Simazine	4
Toxaphene	3

The pesticide-related chemicals without contaminant-specific MCLs that were found most often by the SCDHS were:

- The herbicide Metolachlor (trade name Dual) and its two primary degradation products, metolachlor ethane sulfonic acid (ESA) and metolachlor oxanilic acid (OA);
- Tetrachloroterephthalic acid (TCPA) a dacthal herbicide metabolite;
- Metalaxyl, a fungicide; and
- Imidacloprid, an insecticide.
- Germanium
- Endosulfan sulfate

Pesticides and Land Use

The results of the initial SCDHS investigations led to expanded pesticides monitoring in Suffolk County and throughout the nation, to the ban of some pesticides found to leach to groundwater, and eventually prompted changes in the federal and state pesticide registration processes to prevent future similar contamination from occurring. Pesticide contamination in Suffolk County is primarily associated with agricultural land use, although additional sources are associated with residential, commercial or institutional lawn care. Pesticides were detected in 9 of the 29 wellfields whose historical land uses were evaluated in detail during this study; they are listed in **Table 3-13**.

Pesticide contamination in Suffolk County is primarily associated with agricultural land use, although additional sources are associated with residential, commercial and institutional lawn care.

Based on detailed evaluation of pesticide detections in a limited set of community supply wells, historical land uses, and aquifer travel times, the primary source of the pesticides detected in community supply wells appears to be agricultural activities. Agricultural land was present within the contributing area at some point in time. The USGS study also concluded that land use in the source water area is the primary factor differentiating water quality variability across the Long Island – New Jersey study area. Groundwater samples obtained from agricultural areas were most likely to show pesticide contamination.

However, it is also important to note that pesticides were not detected in water quality samples collected from fifteen of the wellfields evaluated as part of this study that included agricultural land within the contributing area. While the presence of historical agricultural use in the contributing area was related to the observation of low levels of pesticide contamination in downgradient supply wells, it seems that agriculture does not always introduce

pesticide contamination to groundwater. It is also important to understand that SCDHS tests for only a small percentage of pesticides that are registered, and it is possible that these pesticides and/or their degradates may be present.

Table 3-13 Pesticide Detections in Community Supply Wells (2011 through 2013)*

Wellfield	Agricultural Land	Pesticide Detected
Ackerly Pond Lane	Current and historical	Aldicarb metabolites
Bridgehampton Road	Current and historical	Aldicarb metabolites
Dare Road	Historical	1,2,3-Trichloropropane
Mt. Sinai-Coram Road	Historical	DCP
Old North Road (Greenport)	Current and historical	Metabolites of aldicarb, metolachlor
Ryder Avenue	Historical	DCP
Schuyler Drive	Current and historical	Simazine
Vanderbilt Parkway	Historical	DCP, TCP
Woodchuck Hollow Road	Historical	DCP, TCP, Aldicarb metabolites

*based on SCDHS Blacksmith database; Not all pesticides included.

SCDHS also investigated pesticides associated with golf course maintenance from 1999 through 2014. During the study, SCDHS collected 531 samples from 43 shallow monitoring wells installed at 27 golf courses. Over that time frame, low levels of pesticide-related chemicals were detected at nearly 93 percent (25 of 27) of the golf courses monitored.

The twenty-eight pesticides detected at the golf course wells are summarized on **Table 3-14**. Approximately 1/3 of the pesticides detected are no longer registered for application on Long Island, but persist from historical applications. The detected pesticides included herbicides, insecticides, and fungicides. The most frequently detected pesticides were metalaxyl, a fungicide, and DEET, which was detected at eight golf courses, and probably resulted from personal use rather than direct golf course application. In general, the pesticides were detected at low levels, an order of magnitude or more below applicable drinking water standards. Imidacloprid, an insecticide, and TCPA, a break-down product of dacthal, were also frequently detected. The SCDHS and USGS pesticide monitoring programs, as well as data that has been reviewed during this study, have identified agricultural use of pesticides as a major source of groundwater contaminants.

Summary

Pesticides continue to be detected in the groundwater within Suffolk County, particularly due to agricultural land use activities on the east end. Pesticides that have been banned or voluntarily restricted, have shown a decreasing trend

in concentrations indicating that the ban is effective. Although pesticides are frequently detected, currently registered pesticides have not been detected at concentrations exceeding MCLs in recent years (SCDHS, 2014).

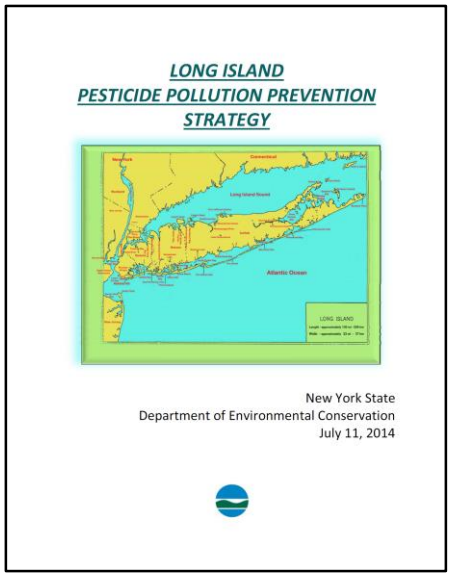
Table 3-14 Pesticide Detections in Golf Course Monitoring Wells since 1999 (SCDHS, 2014)

Compound Detected	L.I. Registration	Min (µg/L)	Max (µg/L)	No. of Wells	No. of Golf Courses	% of Courses Tested	MCL (µg/L)
Alachlor	Withdrawn	0.13	0.13	1	1	4%	2
Alachlor ESA	Withdrawn	0.1	0.4	1	1	4%	50
Alachlor OA	Withdrawn	0.16	0.81	2	2	7%	50
Aldicarb sulfone	Withdrawn	0.7	0.7	1	1	4%	2
Bentazon	Active	4.1	4.1	1	1	4%	50
Bromacil	Active	0.11	0.5	3	3	11%	50
Chloroxylenol	Active	0.16	0.34	1	1	4%	50
DEET	Active	0.1	1.4	12	8	30%	50
3,5-Dichloroaniline	Active	0.07	0.6	4	4	15%	50
2,6-Dichlorobenzamide	Active	0.1	0.1	1	1	4%	50
Dieldrin	Withdrawn	0.11	0.5	2	2	7%	5
Endosulfan Sulfate	Active	0.2	0.8	2	2	7%	50
Ethofumesate	Active	0.2	2.6	2	2	7%	50
Imidacloprid	Restricted	0.07	9.9	14	12	44%	50
Iprodione	Active	0.11	0.6	3	3	11%	50
Metalaxyl	Active	0.1	2.74	15	15	56%	50
Methomyl	Active	0.5	0.5	1	1	4%	50
Metolachlor	Withdrawn	0.1	0.4	3	3	11%	50
Metolachlor ESA	Withdrawn	0.06	2.58	10	8	30%	50
Metolachlor OA	Withdrawn	0.08	1.95	5	5	19%	50
Pentachlorobenzene	Withdrawn	0.14	0.41	4	4	15%	50
Pentachloronitrobenzene	Active	0.2	1.3	2	2	7%	50
Propiconazole	Active	0.2	3.4	2	2	7%	50
Siduron	Active	0.6	7.1	2	2	7%	50
TCPA (ppb)	Withdrawn	0	272	15	12	44%	50
Triadimefon	Active	0.15	3	2	2	7%	50
Triaimenol	Active	0.23	21	4	4	15%	50
Trichlorfon	Active	0.6	0.9	1	1	4%	50

Although concentrations are generally low for most pesticides, well below the drinking water MCL, the frequency of detection, particularly on the east end, is concerning. As long as pesticides are registered on Long Island, they will continue to be used until a proven alternative is introduced. SCDHS is committed to monitoring pesticides and their impact on the aquifer. SCDHS has pledged to:

- Continue our sampling and monitoring activities as part of our NYSDEC Pesticide Monitoring Program.

- Continue to monitor for pesticides at regulated public water systems as part of our programmatic activities, and continue to sample and test for pesticides at individual water supplies.
- Continue to explore the expansion of existing analytical capabilities at our PEHL to increase the number of pesticide compounds and degradation products that can be included in an analysis.
- Continue to work with stakeholders and the agricultural communities to implement the use of Best Management Practices (BMP) at various agricultural settings, particularly at farms where row crops are grown.


LONG ISLAND
PESTICIDE POLLUTION PREVENTION
STRATEGY

New York State
Department of Environmental Conservation
July 11, 2014

NYSDEC has released the ***Long Island Pesticide Pollution Prevention Strategy*** in July 2014. The goal of this strategy is to enhance water quality regarding pesticides through a "pollution prevention blueprint" which will focus on management methods, water quality monitoring and extensive research and outreach. As mentioned above, registered pesticides will continue to be utilized until a practical alternative is introduced. This new NYSDEC strategy coupled with extensive stakeholder input and cooperation will potentially identify alternatives and framework for implementation.

3.1.1.6 Other Contaminants of Potential Concern

Perchlorate

Perchlorate was first identified as a potential threat to groundwater and surface water supplies in 1997 when the California Department of Health Services (CADHS) developed a sensitive analytical method that was able to detect contaminant levels as low as 4 µg/L. Perchlorate (ClO_4-) originates as a contaminant in ground and surface waters from the dissolution of perchloric acid and salts of perchlorate, including ammonium, potassium, magnesium or sodium. With the exception of potassium perchlorate, these compounds have a solubility similar to table salt. The perchlorate anion is non-volatile, highly mobile in groundwater and can persist in the aquifer for very long periods of time.

Perchlorate is both naturally occurring and manufactured. Natural sources of perchlorate include atmospheric creation, evaporate deposits, and Chilean caliche deposits that have been mined and used extensively to produce fertilizer and gunpowder saltpeter since the 1830s. SCDHS has identified reports dating back to 1896 noting the presence of perchlorate in Chilean fertilizer, varying from trace concentrations to 2.7 percent (SCDHS, 2001) and has been advised that Chilean fertilizer was at one time the product of choice for many farms throughout Suffolk County, until replaced by less costly

ammonia-derived products in the late 1960s. A recent survey of existing fertilizers by EPA concluded that perchlorate should not be present in most fertilizers used today, except for products derived from Chilean caliche.

Perchlorate has been manufactured in the United States since 1910 and has been widely used; since World War II, ammonium perchlorate has been used as the oxidizer and primary ingredient in solid propellant for rocket motors, including the space shuttle rocket boosters. Other uses of perchlorate salts include flares, and fireworks (potassium salt); explosives, chemical processes and fireworks (ammonium salt); and military batteries (magnesium; Rogers, 1998), as a component of air bag inflators and in nuclear reactors (perchlorate acid), electronic tubes, lubricating oil additives, tanning and finishing leathers, color fixers in fabric and dyes, electroplating, aluminum refining, rubber manufacturing, and in the production of paints and enamels.

Routine monitoring of perchlorate by SCDHS and the SCWA began in 1998. Perchlorate is currently not regulated by the EPA. In December 1998, in response to finding perchlorate in Suffolk County groundwater, NYSDOH adopted a two-tiered Action Level requiring Public Notification at 18 µg/L and a planning-step trigger at 5 µg/L based upon the EPA reference dose.

The average concentrations of perchlorate in raw water sampled from community and non-community supply wells in 2005 are shown on **Figures 3-29a, 29b** and **29c** for the upper glacial, Magothy, and Lloyd aquifers, respectively. Low levels of perchlorate were detected throughout the County in both the upper glacial and Magothy aquifers, although no detections were reported in supply wells located in Babylon. Perchlorate detections in the upper glacial aquifer were observed in both the western part of the County in formerly agricultural areas, as well as in east end agricultural areas. Perchlorate was detected in fewer Magothy wells, and in general, at lower concentrations.

In 2011, perchlorate was detected in 365 wells, close to 60 percent of all supply wells sampled. Fourteen wells had raw water concentrations exceeding 4 µg/L, and the New York State action level of 18 µg/L was exceeded in a single well (see **Table 3-15**). During past monitoring however, perchlorate was found in excess of 18 µg/L in two community wells that were voluntarily removed from service by the SCWA, in one non-community well, and in private wells.

Perchlorate and Land Use

Perchlorate could be introduced to groundwater from overlying agricultural, commercial or industrial land uses, or from locations where fireworks disposal occurred. Based on the SCDEDP analysis of contributing area land uses and

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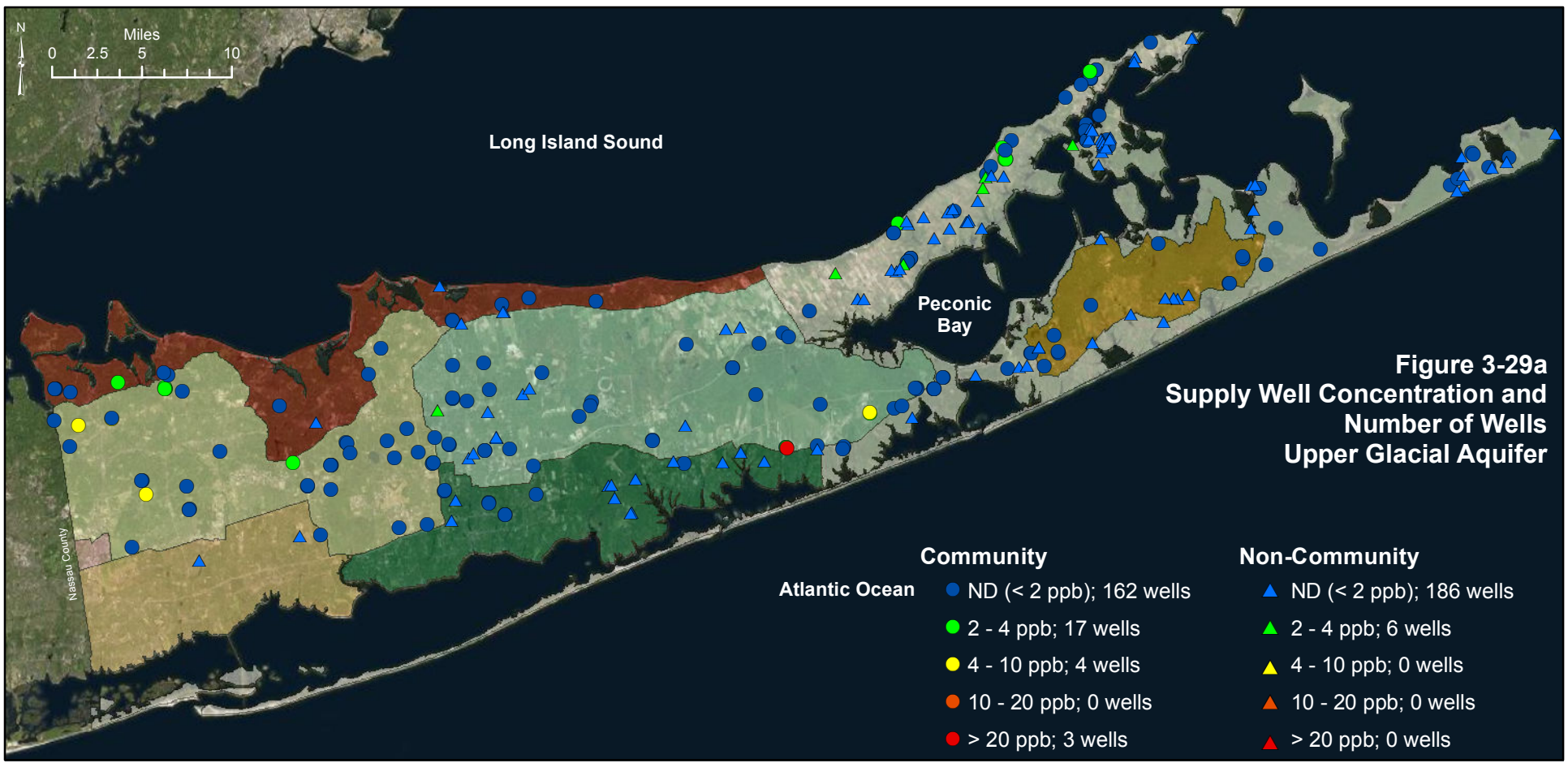
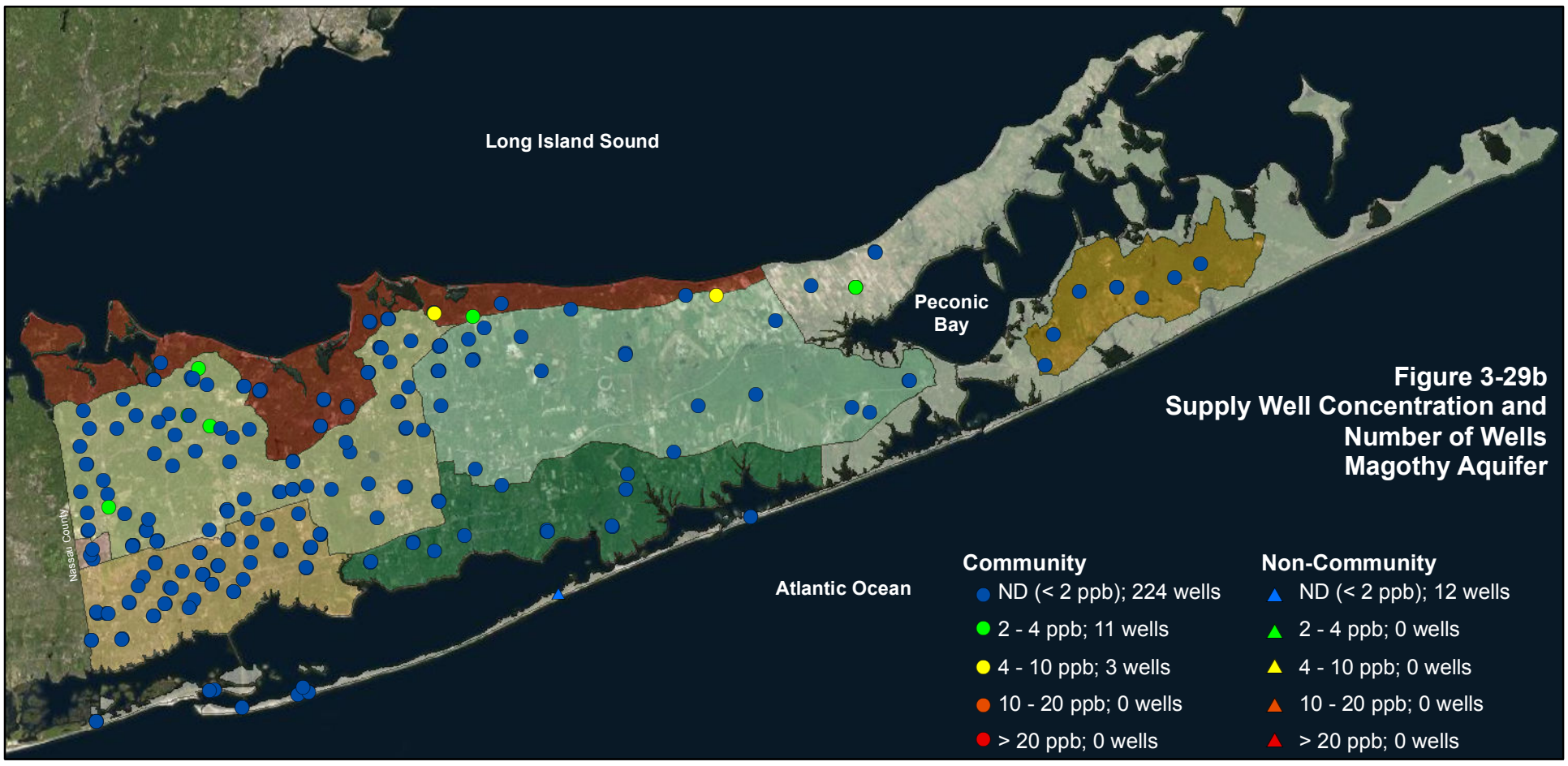




CDM Smith

Average Perchlorate Concentration in the Upper Glacial, Magothy & Lloyd Aquifers Community and Non-community Supply Wells - 2011

Suffolk County Comprehensive Water Resources Management Plan

Figure 3-29

Table 3-15 Perchlorate Concentrations from Community and Non-Community Supply Wells

Aquifer	1987	2007-2011	2011
Upper Glacial Aquifer			
n (wells)	N/A	598	380
Minimum µg/L	N/A	ND	ND
Maximum µg/L	N/A	44.7	38.7
Average µg/L	N/A	0.39	0.73
10th Percentile µg/L	N/A	ND	ND
50th Percentile µg/L	N/A	0.12	0.33
90th Percentile µg/L	N/A	0.79	0.70
No. of wells with detects	N/A	303	263
No. of wells with Detect > 4 µg/L	N/A	21 / 4	8 / 5
No. of wells with Detect > 18 µg/L	N/A	1 / 0	1 / 1
Magothy Aquifer			
n (wells)	N/A	412	250
Minimum µg/L	N/A	ND	ND
Maximum µg/L	N/A	11.8	9.9
Average µg/L	N/A	0.27	0.49
10th Percentile µg/L	N/A	ND	ND
50th Percentile µg/L	N/A	ND	ND
90th Percentile µg/L	N/A	0.40	1.20
No. of wells with detects	N/A	105	99
No. of wells with Detect > 4 µg/L	N/A	10 / 2	6 / 3
No. of wells with Detect > 18 µg/L	N/A	0 / 0	0 / 0
Lloyd Aquifer			
n (wells)	N/A	5	3
Minimum µg/L	N/A	ND	0.8
Maximum µg/L	N/A	1.50	1.5
Average µg/L	N/A	0.44	1.2
10th Percentile µg/L	N/A	0.19	0.9
50th Percentile µg/L	N/A	0.40	1.3
90th Percentile µg/L	N/A	0.71	1.46
No. of wells with detects	N/A	4	3
No. of wells with Detect > 4 µg/L	N/A	0 / 0	0 / 0
No. of wells with Detect > 18 µg/L	N/A	0 / 0	0 / 0

Notes:

1. Data compiled from SCDHS databases.

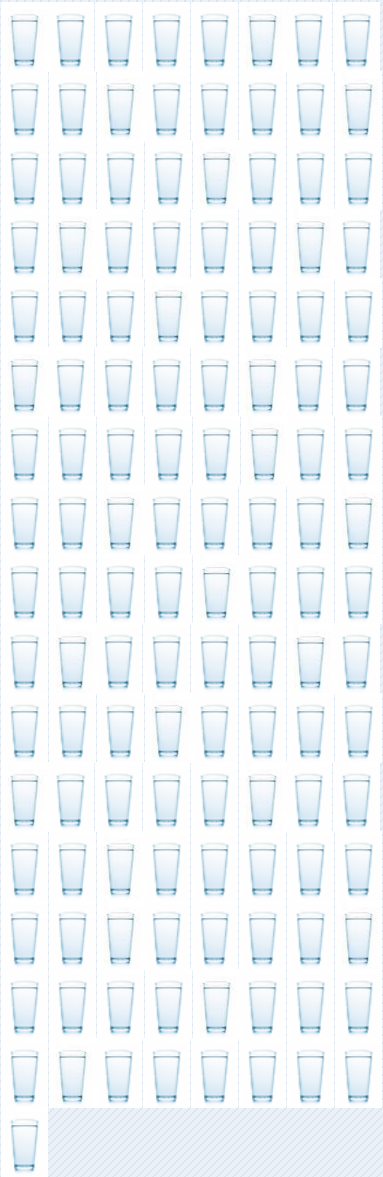
2. Averages and percentiles calculated from annual well averages.

3. No. of wells > 4 and 18 µg/L is based on well maximum and averages, respectively (max/avg).

4. 2011 data was used as it represents the most robust set of data (data in 2012 and 2013 is sparse) SCDHS did not analyze samples for perchlorate in 1987.

A person would have to drink almost 1,300 8 ounce glasses of water each day to exceed the lowest therapeutic dose (lowest dose that produces a desired clinical effect) of gemfibrozil, based on the highest concentration detected by SCDHS in groundwater to date.

Note: Each glass shown represents 10 glasses of water.



well water quality for a set of 56 community supply wells, agricultural land was either present or existed historically within the contributing areas for all 11 of the wellfields where perchlorate has been detected. Commercial and/or industrial land uses are also present in several of the contributing areas; facilities located within these areas could also have caused the perchlorate detections. Further site-specific evaluation would be required to determine if the sites are either currently or previously have been associated with perchlorate use.

Pharmaceutical and Personal Care Products (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. Aspirin was one of the first PPCPs to be identified in the environment; ibuprofen has also been detected in Suffolk County groundwater.

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 the field surveys that have been completed, 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. 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. Very little information on the fate of PPCPs in the environment is available.

Most PPCPs are not currently monitored – and in fact, cannot be monitored at this time. There are potentially hundreds, if not thousands of PPCPs and their

PPCPs include a broad range of products such as prescription and over the counter medications, fragrances, sun-screen products, cosmetics, some detergents, food and drink additives, trace plasticizer contaminants in consumer products, and all of their respective metabolites and transformation products.

PPCPs are continuously released to the environment by sewage treatment plants and on-site wastewater disposal systems.

Hundreds of PPCPs and their metabolites and breakdown products may potentially be released to the environment. Not all can be monitored, because analytical methods to detect the part per billion or part per trillion levels of PPCPs and their metabolites that may exist in the environment are not yet available.

metabolites and breakdown products that may be released to the environment. Although not all are PPCPs, Chemical Abstracts Services reports that 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).

It should not be necessary to monitor for all of these parameters, however the subset of compounds with potential human-health impacts that ultimately should be monitored has not yet been identified. In addition, analytical methods to detect the extremely low levels of some PPCPs and their metabolites that may exist in the environment are not yet available. While analytical protocols to detect some PPCPs have been developed, cost effective methods to rapidly detect the presence of many of the other compounds that may be present have not. More information on potential monitoring approaches is described in Section 3.3.5 below.

Impacts on human health resulting from exposure to PPCPs are, for the most part, hypothesized and studies that both support and refute these hypotheses exist. Many of the compounds of concern are biologically active at low concentrations. Studies of the impacts of low levels of PPCPs in the environment are complicated by the fact that drugs designed with a specific purpose can also have other non-targeted effects or unknown mechanisms of action, and specific compounds can co-occur with multiple other contaminants. Assessments of human health impacts are further complicated due to unanticipated actions of the parent compound's metabolites. Consequently, most PPCPs currently do not have contaminant-specific drinking water standards or health advisories; instead they are regulated in New York State by the unspecified organic contaminant standard of 50 µg/L established by the NYSDOH in 1989.

This level is much higher than the concentrations that have been observed to occur in the environment, since the low concentrations detected in wastewater effluents are reduced even further by dilution in the receiving ground or surface water. It is currently believed that because the extremely low levels of pharmaceuticals that have been detected in drinking water are far below the daily prescribed dosage they do not pose an appreciable health risk (NYCDEP, 2011), although research continues. Lifetime consumption of pharmaceuticals from drinking water has been compared to a maximum consumption of only 5 percent of one daily therapeutic dose (GWRC, 2004).

A subset of PPCPs, endocrine disrupting compounds (EDCs), is of particular concern. USEPA has established an Endocrine Disruptor Screening Program (EDSP) to develop an approach to identify chemicals as EDCs. The EDSP uses

Endocrine Disrupting Compounds (EDCs) are of particular concern. USEPA has developed a screening program to develop an approach to identify EDCs. USEPA will evaluate the need to regulate a potential EDC after they conduct an exposure assessment, and a risk assessment integrating the potential exposure and the hazard.

a tiered approach to assess whether a contaminant may have an effect in humans that is similar to an effect caused by estrogen, androgen or thyroid hormones. The EDSP includes establishment of priorities for chemicals to be screened and tested, Tier 1 (Screening), Tier 2 (Testing) and hazard assessment. The chemicals selected for Tier 1 screening were active ingredients and inerts in pesticides, selected based primarily on human exposure factors rather than factors related to exposure. Tier 1 screening includes assays to identify substances with the potential to interact with estrogen, androgen, or thyroid hormone systems.

Tier 2 assays are performed to determine whether a substance may cause endocrine-mediated effects involving estrogen, androgen, or thyroid hormone systems, determining consequences to the organism, and establishing the relationship between doses and observed responses. Tier 1 Screening and Tier 2 Testing data identify and characterize the hazard associated with each potential EDC. EPA will then conduct an exposure assessment based on the amount of chemical to which wildlife or humans are likely to be exposed, followed by a risk assessment, integrating the potential exposure and the hazard. Based upon the risk assessment results, the need for regulation can be determined.

The SCDHS's response to the potential impact of PPCPs on Suffolk County's water resources dates back to 2001, and includes:

- Implementation of a monitoring program incorporating analytical methodology development by the Suffolk County Public and Environmental Health Laboratory
- A continuing literature review; and
- Discussions with other environmental and public health agencies.

The presence of PPCPs in the environment is of potential significance to Suffolk County's groundwater supplies, and is being followed with great interest at federal, state and County levels. Sources of PPCPs in Suffolk County include treated and untreated sanitary wastewater, where disposal of uncompleted courses of medications such as antibiotics has occurred. PPCPs are continuously introduced into the environment by sewage treatment plants and by on-site wastewater disposal systems in unsewered areas. Recent SCDHS data indicates that PPCPs are also discharged to the groundwater by laundromats and health care facilities.

In response to the potential impacts of PPCPs on the County's groundwater, the SCDHS initiated a monitoring program incorporating analytical methodology development by the PEHL. The SCDHS PEHL utilizes EPA methodologies designed for analysis of regulated semi-volatile organic chemicals and a liquid chromatograph/mass spectrometer (LC/MS) Solid Phase Extraction method developed by the SCDHS PEHL to detect very low levels of a variety of PPCPs. SCDHS currently analyzes for 30 PPCPs. Since 1997, SCDHS has analyzed over 21,000 samples from community, non-community and private wells for the presence of PPCPs as summarized below:

SCDHS has detected PPCPs in between 5.5 to 10 percent of private wells in any given year.

- **Community water supply wells** – Low levels of PPCPs were detected in an average of approximately 2.5 percent of community supply wells in each year;
- **Non-community water supply wells** – PPCPs were detected in samples collected from between 6 and 8 percent of non-community supply wells in any given year;
- **Private wells** – PPCPs were detected in between 5.5 to ten percent of private wells in each year.

Trace levels of the following PPCPs have been detected by SCDHS in the sub- to low part per billion range:

- Ibuprofen – an anti-inflammatory and analgesic medicine available without prescription with trade names such as Advil, Motrin and Nuprin;
- Gemfibrozil – a prescription medication used to lower the levels of triglyceride in the blood with a trade name Lopid;
- Carbamazepine - an anticonvulsant drug used in the treatment of certain forms of epilepsy;
- Carisprodol – used as a muscle relaxant:
- Caffeine - a stimulant commonly found in coffee, tea, soft drinks;
- BHT and BHA - food preservatives;
- Benzophenone - a fragrance;
- DEET - one of the most common insect repellants;
- Several phthalates (chemical compounds added to plastics to increase their flexibility) that are believed to be present in shampoos and other consumer products, including diethylhexyl phthalate (DEHP);
- Bisphenol-A (BPA) – a plastic strengthener, and a suspected endocrine system disrupter; and
- Dilantin - used as an anticonvulsant to treat epilepsy and
- Triclosan – An anti-bacterial chemical used in soaps.

SCDHS has also installed shallow monitoring wells to investigate the impacts of laundromats on groundwater in unsewered areas, and detected PPCPs associated with detergent use (diethyl phthalate, benzophenone) or clothing contamination (DEET). Several detections of diethyl phthalate and DEET near laundromats have exceeded the New York State UOC MCL of 50 ppb.

Diethylhexyl phthalate (DEHP) exceeded the drinking water standard of 6 µg/L in five public wells and 10 private wells sampled between 1997 and 2013. The affected public supply wells were either removed from service or provided with treatment.

A recent SCDHS study revealed low concentrations of the insecticide DEET in 10 of 37 monitoring wells installed at 27 golf courses throughout Suffolk County. The low concentrations, ranging between 0.10 and 0.62 µg/L, are believed to reflect use by golfers and staff.

While most PPCP detections (with the noteworthy exception of wells downgradient of laundromats) have been at concentrations of less than 1 µg/L, maximum concentrations found in Suffolk County groundwater are cause for concern as summarized on **Table 3-16**. Sampling conducted by the SCDHS between 1997 and 2013 indicates that detections of PPCPs at public water systems were below the drinking water standards established by the NYSDOH, with the exception of DEHP.

As part of a Science to Achieve Results (STAR) grant from the USEPA, SUNY at Stony Brook researched the "Occurrence and Fate of Pharmaceuticals and Personal Care Products in Groundwater Environments", to characterize the occurrence and fate of PPCPs in groundwater. The study includes sampling and analysis of effluent from on-site wastewater treatment plants and adjacent monitoring wells at 18 sites (including hospitals, nursing facilities and retirement communities) to estimate loadings of selected PPCPs to groundwater, as well as fate and transport characteristics. Groundwater samples were collected and analyzed by both the USGS and SUNY Stony Brook. The USGS sampled 52 deep wells within Suffolk County and Stony Brook analyzed samples from 20 shallow wells and the effluent from five sewage treatment plants (STPs), primarily within western and central Suffolk County. Preliminary project results presented at an USEPA Workshop (Benotti and Brownawell, 2005) are summarized on **Table 3-17**.

A site-specific study sampling effluent and groundwater at a nursing home was also completed, to begin to assess contaminant mobility in the environment. Preliminary conclusions from the study indicate the following (Benotti and Brownawell, 2005):

Table 3-16 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 µg/L
Butylated Hydroxytoluene (BHT)	antioxidant; food additive	X
Caffeine	stimulant	X

Table 3-17 Preliminary Sample Results for PhAcs from Groundwater Collected in Suffolk County (from Benotti and Brownawell, 2005)

Compound	*USGS Nat'l Recon. median concentration for SW (ng/L)*	Shallow-well median concentration (ng/L)	Frequency of detect (n=20)	Deep-well median concentration (ng/L)	Frequency of detect (n=52)
Acetaminophen	*110*	14.2	65	18.5	11.5
Caffeine	*100*	18.8	85	5.5	32.7
Carbamazepine		57.9	50	3.8	55.8
Cimetidine	*74*	36.7	5	6.5	1.9
Codeine	*12*	7.0	35	9.4	7.7
Cotinine	*240*	5.2	50	3.5	19.2
Diltiazem	*21*	0.5	25	2.0	7.7
Erythromycin		47.4	10	6.3	1.9
Fluoxetine	*12*	33.1	25	174	5.8
Metformin	*110*	14.5	50	4.5	1.9
Paraxanthine	*110*	21.8	70	40.1	5.8
Ranitidine		3.9	25	nd	0
Salbutamol		7.3	10	0.7	3.8
Sulfamethoxazole	*66*	35.0	50	4.9	51.9
Trimethoprim	*103*	1.3	20	2.9	9.6

- PhACs are present in Long Island groundwater, although at concentrations that are typically lower than those found in impacted streams and rivers in the United States;
- Concentrations of PhACs are higher in shallow wells, particularly those near point source discharges;
- Transport and mobility of PhACs are limited by sorption and biological degradation.

The USGS has analyzed for, and detected additional PPCPs in groundwater in Suffolk County, including:

- Alprazolam (used to treat anxiety disorders)
- Cis-Andosterone (hormone)
- Carbazole (thryoid medication)

Suffolk County has passed two resolutions to strengthen public awareness of and encourage proper disposal of pharmaceuticals. Resolution No. 762-2008 established Operation Medicine Cabinet allowing residents to deposit unused medications in secure receptacles located in Suffolk County Police Precincts 24 hours/day, seven days/week. Resolution No. 181-2011 requires medical facilities to file a written plan for the disposal of unused or expired medications in an environmentally safe manner annually with the SCDHS.

- Cotinine (metabolite of nicotine)
- Cis-Diltiazem (used to treat hypertension/angina)
- 1,7-Demethylxanthine (stimulant)
- Diphenylhydramine (used to treat cold, cough, allergy)
- Fluconazole (antifungal)
- Galaxolide (HHCB, musk fragrance)
- Lidocane (topical analgesic)
- Loperimide (antidiarrheal)
- Methyl Salicylate (personal care)
- 4-Nonylphenol (surfactant/estrogen disruptor)
- 4-tert-octyl-phenol (detergent metabolite/EDC)
- Piperonylbutoxide (pharmaceutical/pesticide synergist)
- Thiabendazole (pharmaceutical)
- Tonalide (AHTN, musk fragrance)
- Tramadol (analgesic)
- Tributyl phosphate (TBP, plasticizer and solvent)
- Triethyl citrate (ethyl citrate, personal care)
- Triphenyl phosphate (TPP, plasticizer)
- Tris-(2-butoxy-ethyl) phosphate (TBEB, plasticizer)
- Tris-(2-chloro-ethyl) phosphate (TCEB, flame retardant and plasticizer)
- Tris-(2-dichloriso-propyl) phosphate (TDCP, plasticizer, suspected EDC)

PPCPs and Land Use - In Suffolk County, PPCPs in groundwater are of most concern in densely developed unsewered areas where sanitary wastewater is discharged directly to the ground via on-site septic systems or cesspools.

Recognizing the importance of preventing pharmaceuticals from entering ground and surface waters, in recent years, Suffolk County has passed two resolutions that both strengthen public awareness and encourage proper disposal of pharmaceuticals. Resolution No. 762-2008 established a program called Operation Medicine Cabinet, which allows residents to deposit unused medications in secure receptacles in Suffolk County Police Precincts 24 hours/day and 7 days each week. A companion program to support unused medication turn-in for the five East End Towns has been funded by the Suffolk County Water Quality Protection and Restoration Program (1/4% Sales Tax Program). Resolution No. 181-2011 requires hospitals, nursing homes, hospice facilities and long-term care facilities to file a written plan with the SCDHS annually for the disposal of unused or expired medications in an environmentally safe manner.

Concentrations of 1,4-dioxane in untreated water at SCWA supply wells in 2013 and 2014 ranged from non-detect at 0.07 µg/L to 15.2 µg/L.

1, 4 Dioxane

1,4-Dioxane ($C_4H_8O_2$) is an organic solvent with numerous industrial and synthetic uses. 1,4-dioxane is an ether that is classified by the USEPA as a probable human carcinogen. Its primary industrial use was as a stabilizer for the solvent TCA to protect the TCA from reactions with aluminum containers. Although TCA was banned worldwide starting in 1996 to protect the ozone layer, 1,4-dioxane is still directly used as a solvent in inks and adhesives, and is a manufacturing contaminant found in personal care products such as deodorants, shampoos, toothpastes, mouthwashes, bubble bath formulas, and moisturizers. It is also found as a contaminant in cleansing agents containing sodium lauryl sulfate (SLS), a surfactant used to make many cleaning and hygiene products less abrasive and better foaming. Like other ethers (such as MTBE) it does not readily bind to soils, and readily leaches to groundwater and is highly soluble. It is resistant to naturally occurring biodegradation processes in groundwater, but can be biodegraded by a number of pathways in surface waters, and has a low toxicity to aquatic life. 1, 4-dioxane is difficult and expensive to remove from drinking water (i.e., it is not effectively removed by granular activated carbon (GAC) and air-stripping).

When found in water, it is at µg/L levels. There is currently no federal drinking water standard for 1,4-dioxane; however NYSDOH regulates this compound at 50 ppb as an unspecified organic contaminant (UOC). The current USEPA 10^{-6} lifetime risk value for 1,4-dioxane is 0.35 µg/L and the noncancer lifetime Health Advisory (HA) is 200 µg/L based upon non-cancer effects (USEPA, 2012). 1,4-dioxane is currently being evaluated under the USEPA's Unregulated Contaminant Monitoring Rule (UCMR3) and is likely to be regulated due to its characterization as a probable human carcinogen. California and Illinois have reduced their drinking water guidance level to 1 µg/L, while Massachusetts set its guidance level at 0.3 µg/L. California Department of Public Health has

posted a notification level of 1 µg/L based upon an evaluation of new evidence of dioxane's carcinogenic activity in animals, and the limits of the current standard analytical detection.

SCWA has been analyzing well samples for 1,4-dioxane since 2003. Testing performed by the SCWA in 2013 and 2014 identified the presence of 1,4-dioxane at low levels in approximately 45 percent of the wells tested in 2013 and 2014 as illustrated by **Figure 3-30**. The contaminant was detected in wells screened in both the Upper Glacial and the Magothy aquifers. 1,4-dioxane was found in 53% of the Upper Glacial supply wells tested at concentrations ranging from the detection limit of 0.07 µg/L up to 3.02 µg/L and in 39% of Magothy wells at concentrations ranging from the detection limit of 0.07 µg/L up to 15.2 µg/L.

Chlorate may be introduced to the environment as a byproduct of hypochlorite used for disinfection or as an herbicide.

Chlorate

Chlorate may be introduced to the environment as a byproduct of hypochlorite used for disinfection, or as an herbicide. Chlorate is used as a decoloring or bleaching agent in food (e.g., flour) production, and may be introduced indirectly from food packaging. When used as a pesticide, sodium chlorate targets broadleaf weeds. It is highly soluble, with a high runoff and leaching potential (The Potential Regulatory Implications of Chlorate, AWWA, 2014). USEPA has established a health reference level (HRL) of 210 µg/L.

USEPA has established a health reference level of 210 µg/L for chlorate. Chlorate levels in untreated water samples collected from SCWA supply wells in 2013 and 2014 ranged from non-detect at the detection limit of 20 µg/L to 989 µg/L. The average concentration in upper glacial supply wells was 223 µg/L.

Samples collected from untreated water at SCWA community supply wells in 2013 and 2014 revealed an average concentration in Upper Glacial wells of 223 µg/L. Chlorate levels in individual raw water samples from Upper Glacial wells ranged from ND at the detection limit of 20 µg/L to a maximum concentration of 989 µg/L.

Hexavalent Chromium

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 specific MCL for Cr-6, USEPA has established an MCL of 100 µg/L for total chromium. Between January 2013 and October 2014, the results of SCWA public supply well monitoring for Cr-6 ranged from non-detect at < 0.030 µg/L to 11.7 µg/L with an average concentration of 0.48 µg/L. Cr-6 has a high mobility in groundwater due to its anionic nature. The average Cr-6 level in untreated samples collected from the SCWA distribution system during the same time period was 0.36 µg/L.

Contaminants of Concern from Composting Facilities

After SCDHS identified contaminants above drinking water standards in samples collected from a private drinking water supply well, SCDHS, NYSDEC

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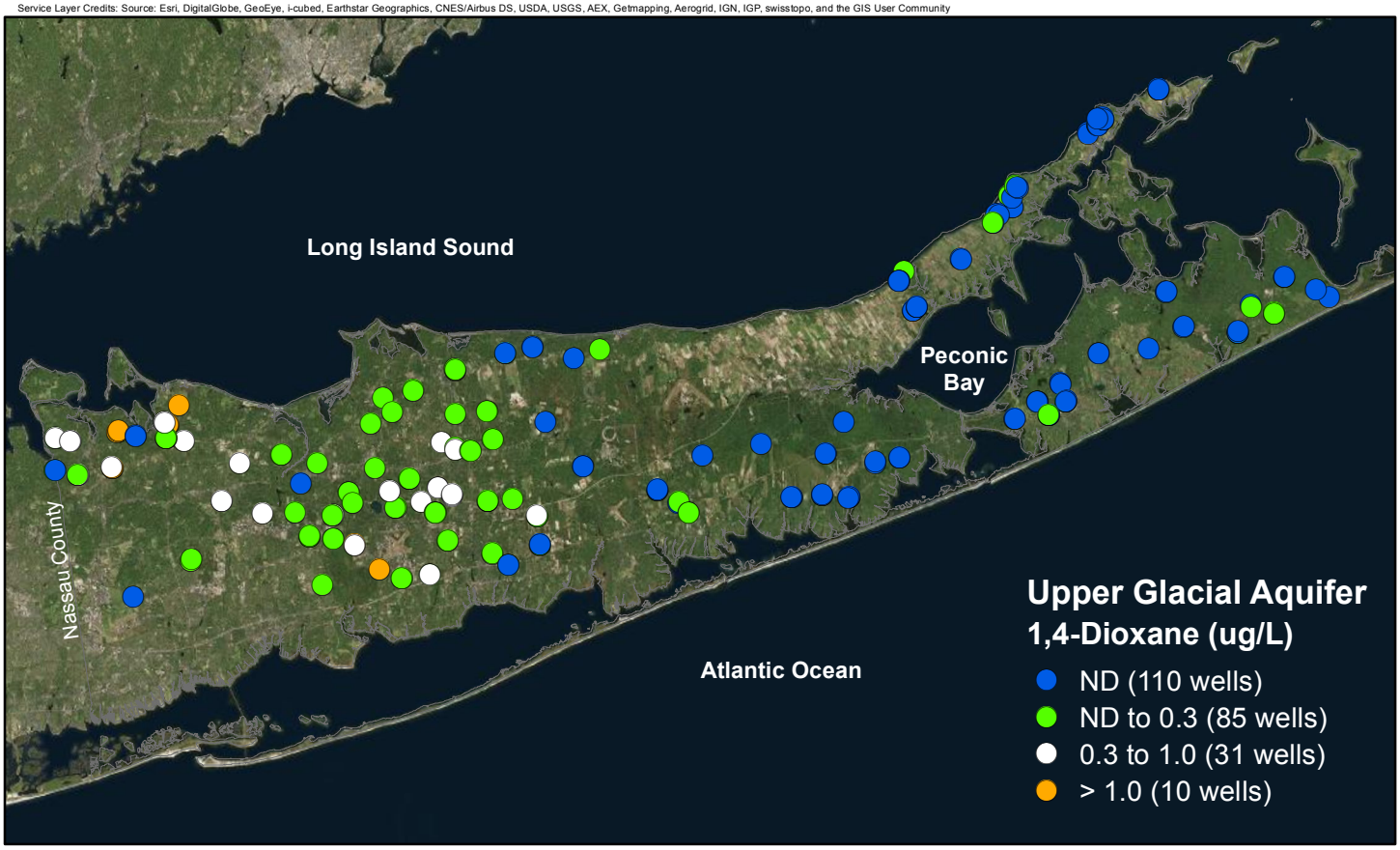
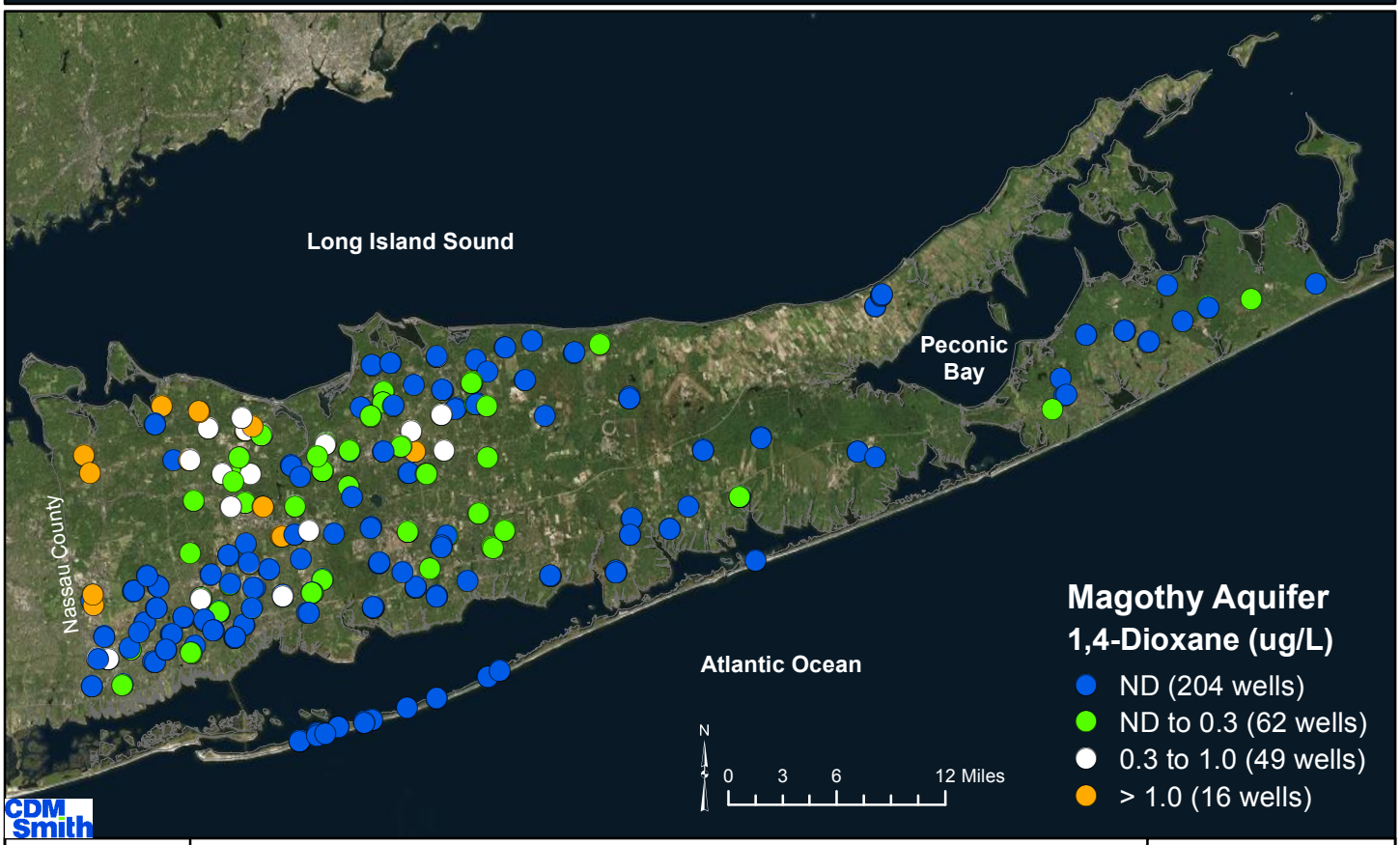




CDM Smith

Average Concentrations of 1,4-Dioxane in the Upper Glacial & Magothy Aquifers Suffolk County Water Authority Wells (2013-2014)

Suffolk County Comprehensive Water Resources Management Plan

Figure 3-30

and NYSDOH collaborated on a series of investigations in the vicinity of the adjacent Vegetative Organic Waste Management (compost) facility. The groundwater investigations concluded that concentrations of a variety of contaminants were significantly greater in samples collected from wells downgradient of the facility than in samples collected from upgradient wells. Manganese, gross alpha, gross beta, thallium and ammonia were all detected above the drinking water standard in samples collected downgradient of the compost facility. These results prompted evaluation of groundwater quality at a second compost facility and investigation of surface water run-off at composting facilities without monitoring wells, which yielded similar results. Investigations identified the presence of other contaminants of concern including contaminants typically associated with wastewater (e.g., ammonia, pharmaceuticals and personal care products, and methylene blue activated substances) and other metals.

Analyses of compost and soil at these facilities did not identify the presence of these contaminants at levels of concern, however the investigation prompted the SCDHS to identify the need for operational changes at these facilities. Residences with private wells in the area were connected to public water supply and NYSDEC and the facility agreed that operational changes would be implemented at the facility. NYSDEC is considering potential revisions to regulations regarding vegetative organic waste management facilities to protect against impacts to groundwater and surface water, and SCDHS is continuing to investigate other similar locations to assess potential groundwater quality impacts.

3.1.1.7 Summary

Considering the 1.5 million Suffolk County residents who live, work and play above our sole-source aquifer, the quality of the County's groundwater remains remarkably good. However, while implementation of regulations and management activities protecting groundwater quality have been effective in reducing the impacts of human development, the continued effects of overlying land uses on groundwater quality are evident.

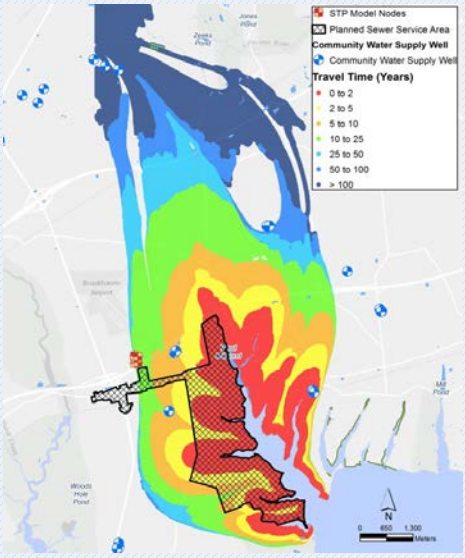
Concentrations of nitrate continue to slowly increase in all three aquifers, as a result of sanitary wastewater management and fertilization practices. Increased detections of low levels of volatile organic compounds throughout the County indicate widespread use and release to the environment, while higher levels of VOC contamination are associated with industrial, commercial, transportation or institutional land uses. Pesticides continue to be detected in groundwater downgradient of agricultural areas and more sophisticated analytical techniques have enabled detection of very low levels of

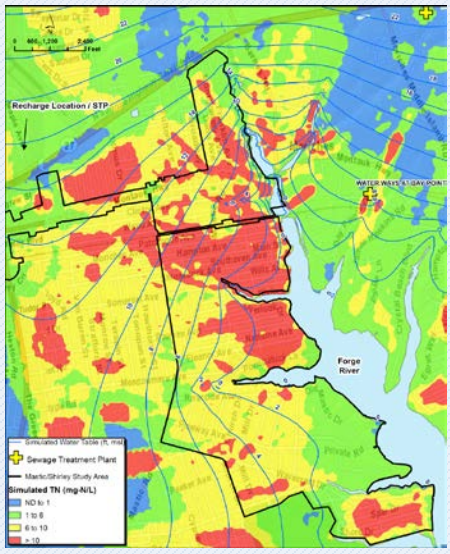
EVALUATION OF WASTEWATER TREATMENT PLANT SITING

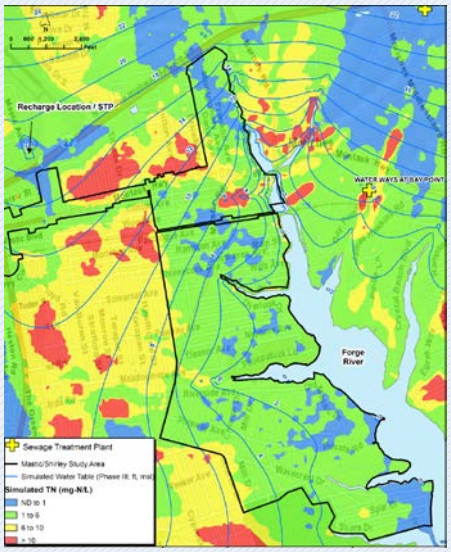
Draft Mastic Shirley Case Study

While wastewater treatment is implemented to protect ground and surface water quality from the impacts of the contaminants associated with untreated sanitary sewage, Suffolk County is mindful that the environmental impacts of construction and operation of a wastewater treatment plant must also be identified, and mitigated to the extent possible. SCDHS has developed guidance on the siting of wastewater treatment plants to avoid unnecessary water quality impacts to sensitive water resource features such as water supply wells and surface waters. Facilities that are sited within these areas are also required to achieve more stringent effluent limits.

The impacts of the recharge of treated sanitary effluent on downgradient water quality are evaluated to provide an estimate of the anticipated water quality improvements; this may be required as part of the State Environmental Quality Review Act (SEQRA) process. One of the priority areas that the County is considering sewering is the densely developed area within the contributing area of the Forge River. The County considered the stream contributing area while defining the sewer service area, and evaluated the potential improvements to nitrogen levels as well as the potential for groundwater mounding at the recharge area.







The first figure illustrates how the red area, contributing groundwater baseflow to the Forge River within two years, guided identification of the area to be sewered. Simulated nitrogen levels in groundwater prior to sewering (second figure) and after sewering and treatment using best available technology (figure 3) were also evaluated. The water table contours identify predicted changes to the local flow field.

Given that the County's fresh surface water features derive much of their baseflow from groundwater, the County also carefully considers the impact of sanitary sewering on the water table elevation (which impacts wetlands) and on stream flows. When groundwater is removed from the aquifer for water supply, and sanitary wastewater is treated at a regional wastewater treatment plant and discharged off-shore, as is the case in the County's southwest sewer district (SWSD), the groundwater table can be lowered, and groundwater baseflow to streams, ponds and wetland areas may be reduced. The County evaluates these potential impacts on a case-by-case basis as the magnitude of the impacts is dependent on the size of the wastewater treatment facility, the locations of the groundwater withdrawals and local hydrogeology, and the proximity of downgradient streams, ponds and wetlands.

Given concerns that wetlands within the SWSD would be impacted by sewering, the County consulted with USEPA and NYSDEC and monitored vegetation at wetlands sites within and to the east of the SWSD for over a decade to assess any changes in wetlands ecology (e.g., progression from obligate wetland to facultative to upland vegetation) that might require mitigation. Stream headwaters locations, stream baseflows and depth to groundwater, identified as the most important indicator, were also monitored.

new contaminants such as PPCPs throughout our aquifer, which demonstrate the continued effects of human activity in the watershed. Based on the increasing levels of these contaminants that have been observed over the past two decades, the County's continued commitment to implementation of groundwater quality protection programs will be essential to ensure that the resource remains available to future generations.

3.1.2 Groundwater Quantity

Previous studies have documented that Suffolk County's aquifer system is capable of providing an adequate quantity of water to supply the County's residents; re-evaluation of the permissive yield defined in the ***1987 Comp Plan***, or development of permissive sustained yield values were not included in this project scope. Instead, the calibrated Main Body, North Fork, South Fork and Shelter Island groundwater models were used to develop water balances that provided additional insight into the groundwater system. In addition, the models were used to begin to consider the magnitude of the impacts that could result from predicted increases in sea level.

Construction and operation of sanitary sewer systems discharging to surface waters results in a net loss of groundwater from the aquifer system, potential reduction in the local water table elevation and potential reduction in stream baseflow. Consideration of these potential impacts requires site-specific evaluation.

Construction and operation of sanitary sewering systems that discharge to surface waters result in a net loss of groundwater from the aquifer system, and a potential reduction in the local water table elevation. Because groundwater provides the baseflow for the County's fresh surface water features, sanitary sewering with surface water discharge can also result in a loss of stream baseflow. Consideration of these impacts requires site-specific evaluation. The impacts of sanitary sewering in the County's largest sewer district, Sewer District No. 3, Southwest (SWSD) on groundwater elevations and stream baseflow have been previously documented (CDM, 1995, 2002). The localized impacts of sewer system extension in the Kings Park area, and implementation of a new sewer system in the Mastic/Shirley area were also considered as part of this study; the results of these site-specific evaluations may be found in Task Memoranda 5-2 and 15 respectively. Suffolk County considers the potential impacts of sanitary sewering on groundwater levels – whether it be an increase in the water table resulting from recharge of treated effluent, or a decline in the water table that results when treated effluent is discharged to a surface water body – as part of their evaluation of sewering feasibility.

3.1.2.1 Water Balances

The calibrated Main Body, North Fork, South Fork, and Shelter Island groundwater models were used to develop water balances to characterize aquifer conditions that would have existed at the turn of the century, prior to extensive development, and to characterize current conditions, which are defined by recent levels of public water supply pumping and the presence of

existing stormwater and wastewater collection and management facilities. Recent levels of public water supply pumping assigned in the model simulations were based on those used for the Long Island Source Water Assessment Program evaluations (SWAP, 2003). Pumping from wells categorized as non-community water supply, industrial, commercial, private, or agricultural was not included in the water balance simulations because their combined contribution to the total County-wide groundwater withdrawals is estimated to be much less than the approximately 200 million gallons per day (mgd) currently withdrawn from community water supply wells, and because a significant portion of withdrawals from these types of wells is believed to be returned to the aquifer system (with the exception of agricultural supply well pumping during the growing season).

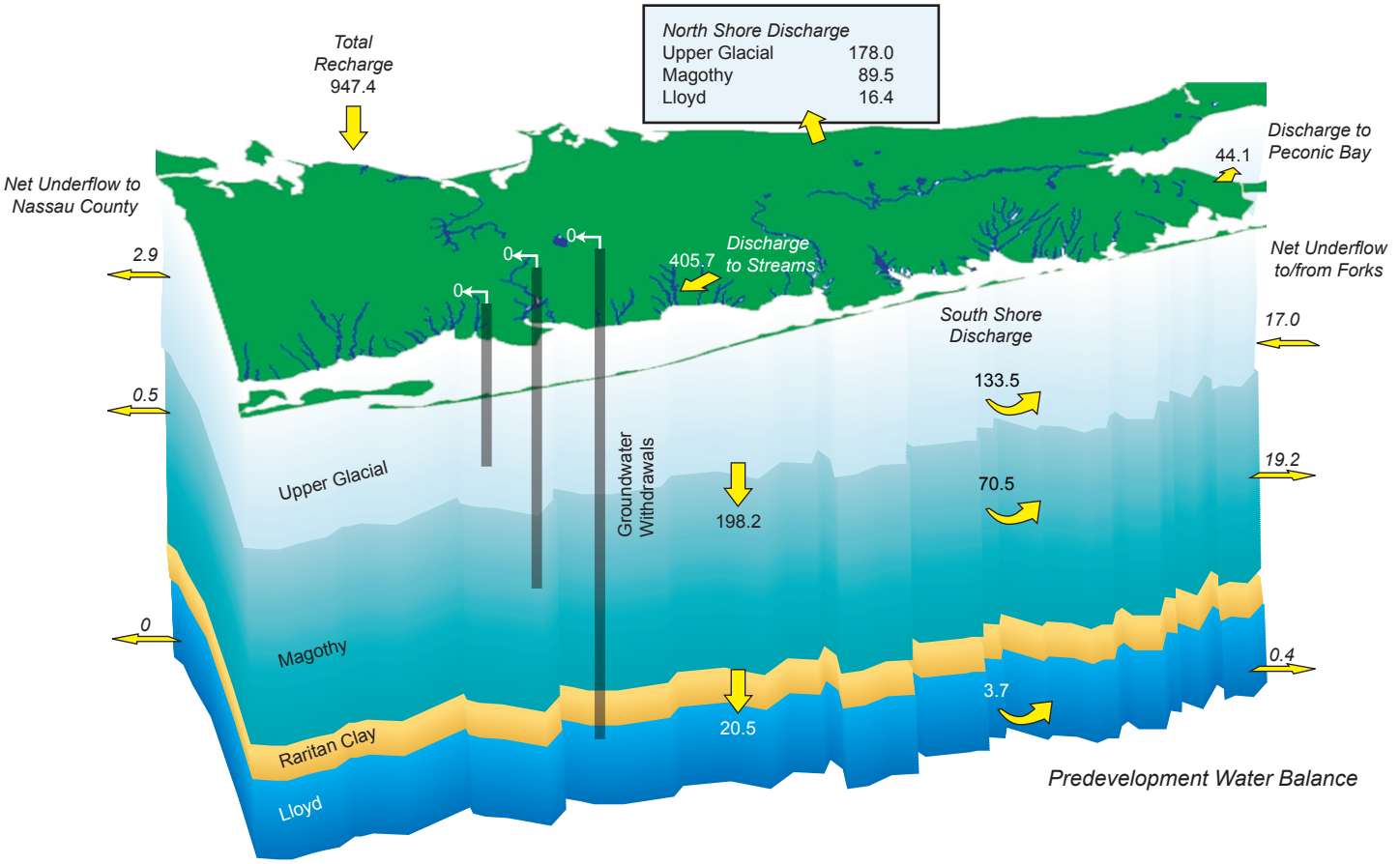
Geographically, four water balances were developed. The Main Body flow model was used to develop a water balance for the main part of Suffolk County, from the Nassau-Suffolk border on the west, to Shinnecock Inlet (on the South Fork) and Mattituck Creek (on the North Fork) on the east. The North Fork, South Fork, and Shelter Island freshwater/saltwater interface models were used as the basis for development of separate water balances for the North Fork east of Mattituck Creek, the South Fork east of Shinnecock Inlet and for all of Shelter Island.

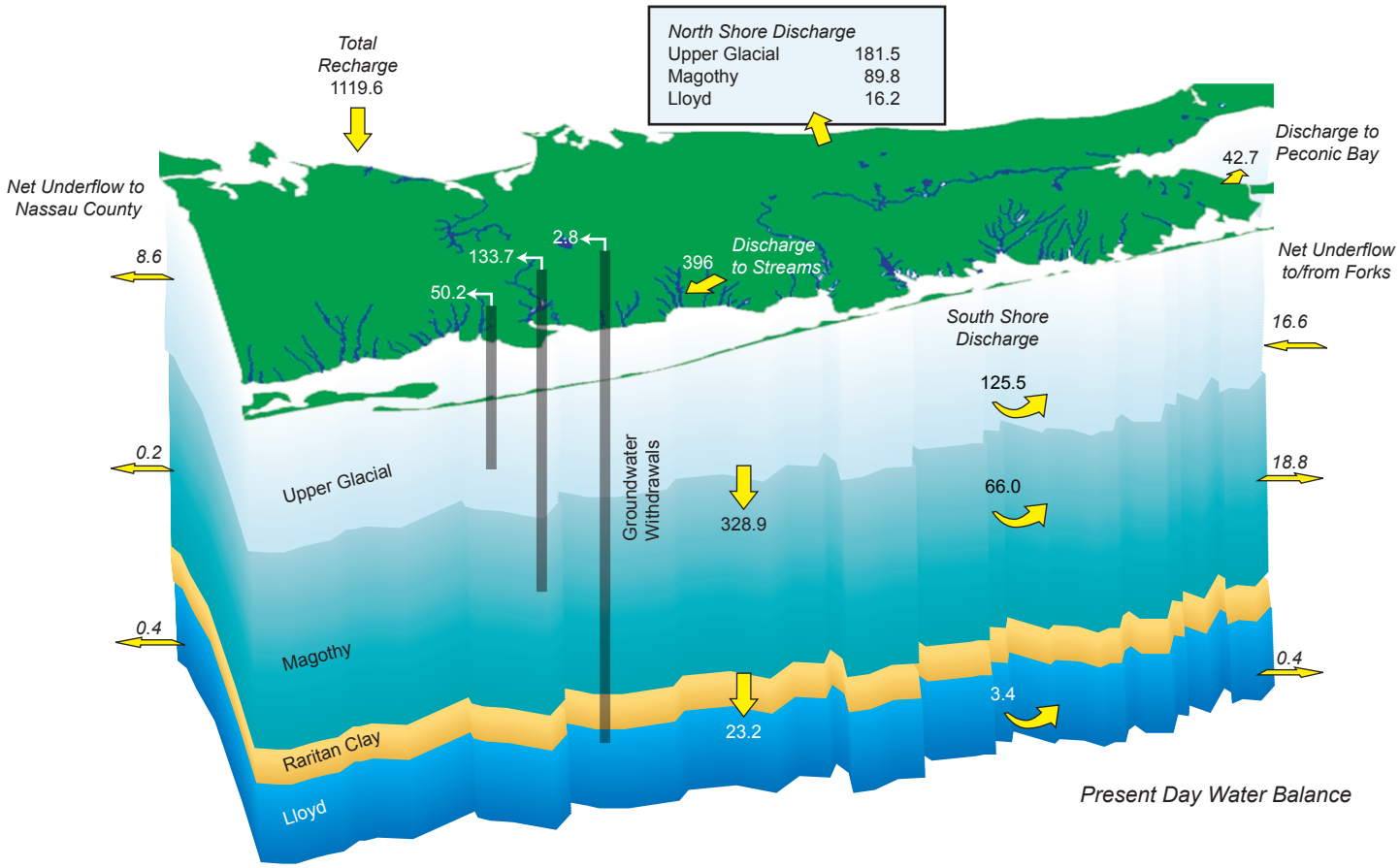
Long term average recharge rates were based on precipitation records obtained from one of four climate weather stations, each of which has over 50 years' worth of precipitation records that are readily available from the National Climatic Data Center. Data from the Mineola and Brookhaven National Laboratory (BNL) stations were used for the Main Body water balance, data from the Riverhead station was used for the Shelter Island and North Fork water balances; and data from the Bridgehampton station was used for the South Fork water balance. The Mineola station was used to assign recharge for the Nassau portion of the Main Body flow model and was not a significant factor in the development of the water budget for the Suffolk County portion of the Main Body model.

Details of the model development and application may be found in the Task 4 memoranda.

3.1.2.2 Main Body Water Balance

The Main Body flow model was used to develop predevelopment and present day water balances for Suffolk County west of Mattituck Creek and Shinnecock Inlet. The predevelopment and present day water balances are depicted graphically by **Figure 3-31** and are summarized in **Tables 3-18** and **3-19.** Under predevelopment conditions, precipitation, the only source of recharge to the





NOTE: The stratigraphic depictions do not represent actual thicknesses or depths

CDM

Figure 3-31
Main Body Flow Model
All Values in Million Gallons per Day

Table 3-18 Main Body Flow Model – Predevelopment Water Balance (All Flows in MGD)

Upper Glacial		
Flow	**Inflow**	**Outflow**
Total Recharge	945.4	
Water Supply Withdrawals		0.0
Streams		405.7
North Shore		178.0
South Shore		133.5
Magothy		198.2
Peconic Bay Shore		44.1
East End	17.0	
Nassau County		2.9
Total:	**962.4**	**962.4**

Magothy		
Flow	**Inflow**	**Outflow**
Total Recharge	2.0	
Water Supply Withdrawals		0.0
Streams		0.0
North		89.5
South		70.5
Upper Glacial	198.2	
Lloyd		20.5
East End		19.2
Nassau County		0.5
Total:	**200.2**	**200.2**

Lloyd		
Flow	**Inflow**	**Outflow**
Total Recharge	0.0	
Water Supply Withdrawals		0.0
Streams		0.0
North Shore		16.4
South Shore		3.7
Magothy	20.5	
East End		0.4
Nassau County		0.0
Total:	**20.5**	**20.5**

All Aquifers		
Flow	**Inflow**	**Outflow**
Total Recharge	947.4	
Water Supply Withdrawals		0.0
Streams		405.7
North Shore		283.9
South Shore		207.7
East End	17.0	63.7
Nassau County		3.4
Total:	**964.4**	**964.4**

Table 3-19 Main Body Flow Model Present Day Water Balance

Upper Glacial		
Flow	**Inflow (MGD)**	**Outflow (MGD)**
Total Recharge	1116.8	
Water Supply Withdrawals		50.2
Streams		396.0
North Shore		181.5
South Shore		125.5
Magothy		328.9
Peconic Bay Shore		42.7
East End	16.6	
Nassau County		8.6
Total:	**1133.4**	**1133.4**

Magothy		
Flow	**Inflow (MGD)**	**Outflow (MGD)**
Total Recharge	2.8	
Water Supply Withdrawals		133.7
Streams		0.0
North		89.8
South		66.0
Upper Glacial	328.9	
Lloyd		23.2
East End		18.8
Nassau County		0.2
Total:	**331.7**	**331.7**

Lloyd		
Flow	**Inflow**	**Outflow**
Total Recharge	0.0	
Water Supply Withdrawals		2.8
Streams		0.0
North		16.2
South		3.4
Magothy	23.2	
East End		0.4
Nassau County		0.4
Total:	**23.2**	**23.2**

All Aquifers		
Flow	**Inflow**	**Outflow**
Total Recharge	1119.6	
Water Supply Withdrawals		186.7
Streams		396.0
North Shore		287.5
South Shore		194.9
East End	16.6	61.9
Nassau County		9.2
Total:	**1136.2**	**1136.2**

groundwater system, traveled down through the aquifer system, until it was ultimately discharged to surrounding coastal waters, either as stream baseflow or as underflow. Groundwater could also leave the Suffolk County water budget area as underflow to neighboring Nassau County on the west or to the forks on the east.

Under predevelopment conditions, total recharge to the Main Body of Suffolk County was estimated to be about 947 mgd, of which nearly 43 percent (406 mgd) discharged directly to streams as baseflow. Fifty-two percent of recharge was estimated to eventually discharge to Long Island Sound or Great South Bay. The remaining five percent of recharge left the aquifer system beneath the Main Body of the County as underflow to the east or west, or as discharge to Peconic Bay. Flow from the upper glacial aquifer down to the Magothy aquifer was estimated to be 198 mgd, or nearly 21 percent of total recharge from precipitation. Flow from the Magothy to the Lloyd aquifer was estimated to be just over 20 mgd.

The present day water balance reflects the impacts of development, most notably groundwater withdrawals of 187 mgd, which account for 17 percent of total recharge. Although the installation of sanitary sewers in portions of the County has reduced the amount of water returned directly to the groundwater system, total recharge to the system — estimated to be 1,120 mgd — is calculated to be greater than total predevelopment recharge. This is a result of the construction of a network of storm sewers and recharge basins. During the growing season, the storm sewers capture stormwater runoff that would have been lost to evapotranspiration, and convey it to recharge basins, where it recharges the aquifer system. The model estimate of average present day discharge to stream baseflow is 396 mgd, a reduction of only 2 percent compared to predevelopment conditions. However, discharge to streams presently accounts for 35 percent of recharge, compared to 43 percent prior to development. Currently, 43 percent of recharge eventually discharges to Long Island Sound or Great South Bay. The remaining five percent of recharge leaves as underflow to the east or west, or as discharge to Peconic Bay. The greater downward gradient resulting from 134 mgd of groundwater withdrawals for public supply in the Magothy aquifer has increased the flow from the upper glacial aquifer down to the Magothy from 198 mgd to 329 mgd. Likewise, flow from the Magothy to the Lloyd aquifer is estimated to have increased from just over 20 mgd to 23 mgd.

The flow of groundwater from Suffolk to Nassau County (underflow) is relatively small under both predevelopment and present day conditions, when compared to the magnitude of the other flows. This is to be expected, considering that groundwater flow at the Nassau-Suffolk border is primarily

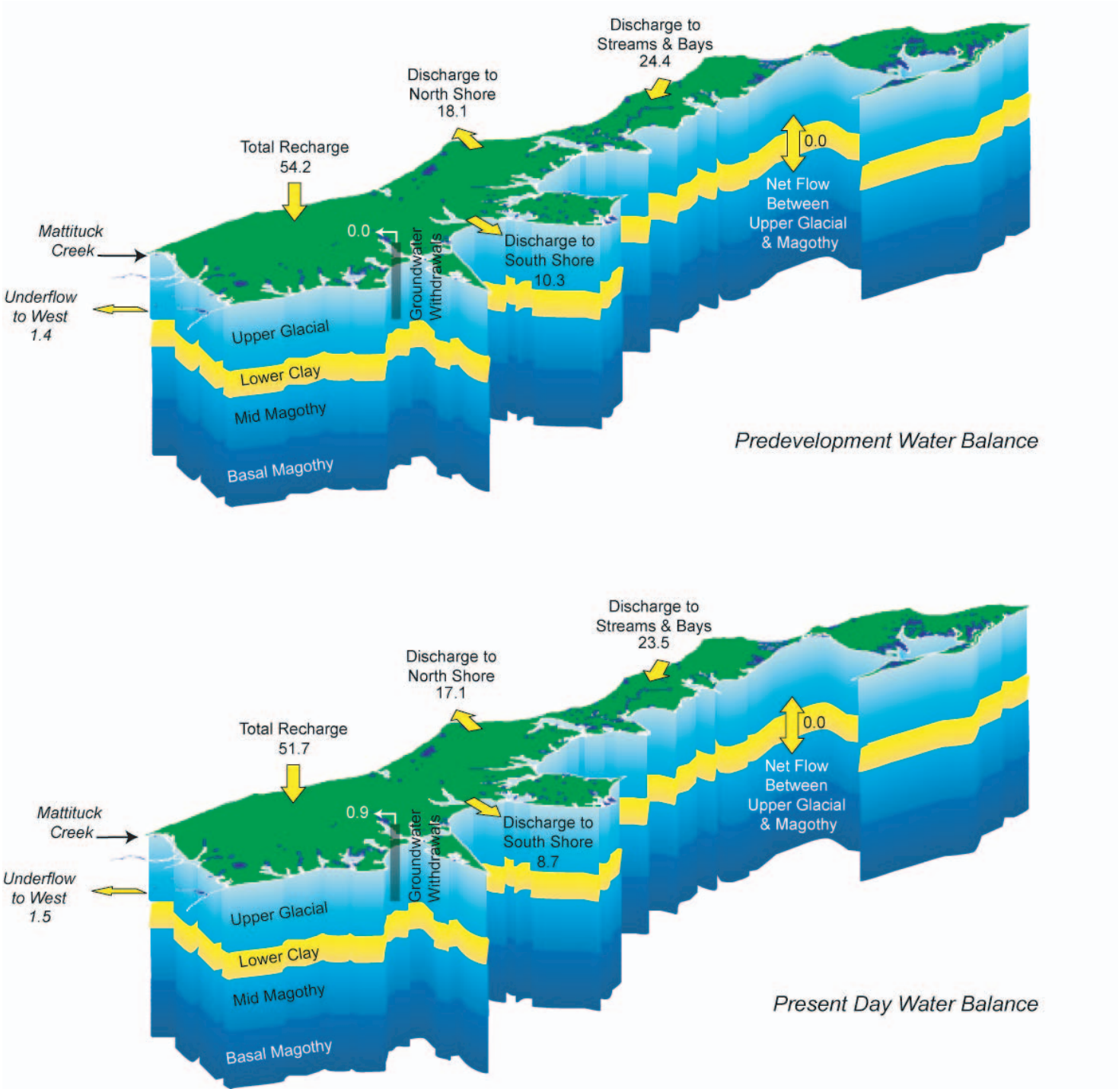
parallel to the border, with groundwater north of the groundwater divide flowing towards the north towards surface water discharge, and groundwater south of the divide flowing to the south towards surface water discharge. However, water supply pumping in Nassau County has modified groundwater flow patterns, resulting in an increase in underflow to Nassau County from 3.4 mgd prior to development, to an estimated present day amount of 9.0 mgd.

3.1.2.3 North Fork Water Balance

The North Fork freshwater/saltwater interface model was used as the basis for development of predevelopment and present day water balances for Suffolk County's North Fork, east of Mattituck Creek. The predevelopment and present day water balances are depicted by **Figure 3-32** and **Tables 3-20** and **3-21**. Under predevelopment conditions, total recharge to the North Fork east of Mattituck Creek was estimated to be about 54.2 mgd, of which 45 percent (24.4 mgd) discharged directly to streams and bays. Fifty-two percent of recharge is simulated to eventually discharge to Long Island Sound or Peconic Bay. The remaining three percent of recharge left the North Fork as underflow to the Main Body of Suffolk County to the west.

Table 3-20 North Fork Flow Model Predevelopment Water Balance (All Flows in MGD)

	Upper Glacial		Magothy		All Aquifers	
Flow	**Inflow**	**Outflow**	**Inflow**	**Outflow**	**Inflow**	**Outflow**
Total Recharge	54.2		0.0		54.2	
Water Supply Withdrawals		0.0		0.0		0.0
Streams and Bays		24.4		0.0		24.4
North Shore		18.1		0.0		18.1
South Shore		10.3		0.0		10.3
Magothy <->Upper Glacial (Net)		0.0	0.0		0.0	0.0
Main Body		1.4		0.0		1.4
Total:	**54.2**	**54.2**	**0.0**	**0.0**	**54.2**	**54.2**



NOTE: The stratigraphic depictions do not represent actual thicknesses or depths

Figure 3-32
North Fork Flow Model
All Values in Million Gallons per Day

CDM

Table 3-21 North Fork Flow Model Present Day Water Balance (All Flows in MGD)

	Upper Glacial		Magothy		All Aquifers	
Flow	**Inflow**	**Outflow**	**Inflow**	**Outflow**	**Inflow**	**Outflow**
Total Recharge	51.7		0.0		51.7	
Water Supply Withdrawals		0.9		0.0		0.9
Streams and Bays		23.5		0.0		23.5
North Shore		17.1		0.0		17.1
South Shore		8.7		0.0		8.7
Magothy <->Upper Glacial (Net)		0.0	0.0		0.0	0.0
Main Body		1.5		0.0		1.5
Total:	**51.7**	**51.7**	**0.0**	**0.0**	**51.7**	**51.7**

The inflows and outflows characterizing the present day water balance are quite similar to those prior to development. Under current conditions, total recharge is estimated to have been reduced by 2.5 mgd, to 51.7 mgd, as a result of the installation of storm sewers along the south shore of the North Fork that collect stormwater runoff that would have recharged the aquifer, and discharge it directly to Peconic Bay and its tributaries. Two percent of the groundwater recharged on an annual basis is withdrawn for water supply, and it is estimated that 50 percent discharges to Long Island Sound or Peconic Bay, and the remaining three percent leaves as underflow to the west.

Under both predevelopment and present day conditions, some freshwater in the center of the fork flows from the upper glacial aquifer down to the Magothy aquifer. The same amount of water flows back up through the upper glacial aquifer near the coast, prior to discharge along the north or south shore of the fork.

3.1.2.4 South Fork Water Balance

The South Fork freshwater/saltwater interface model was used as the basis for the development of predevelopment and present day water balances for Suffolk County's South Fork, east of Shinnecock Inlet as depicted by **Figure 3-33**, and **Tables 3-22** and **3-23**.

Under predevelopment conditions, total recharge to the South Fork east of Shinnecock Inlet is estimated to have been about 183.4 mgd, of which 47 percent (86.6 mgd) discharged directly to streams and bays. Fifty-three percent of the groundwater recharged on an annual average basis eventually discharged to Peconic Bay or marine waters to the south. Less than 1 percent of recharge was estimated to have left the South Fork aquifer system as underflow to the west. The inflows and outflows characterizing the present day water balance are quite similar to those prior to development. Under current conditions, total recharge is estimated to have been reduced by 5 mgd, to 178.4 mgd, as a result of the installation of storm drains along the north shore of the South Fork. The storm sewers in this area collect stormwater runoff that would have recharged the aquifer system, and convey it directly to discharge to Peconic Bay and its tributaries. Five percent of the groundwater recharged is withdrawn by water supply wells, 48 percent is estimated to discharge to south shore bays or the Peconic Bay, and less than one percent leaves as underflow to the west.

As on the North Fork, some precipitation recharging the center of the South Fork flows from the upper glacial aquifer down to the Magothy aquifer. Under present day conditions, some of the flow into the Magothy (0.8 mgd) is withdrawn by water supply wells. The water recharging the Magothy that is not withdrawn from water supply wells flows back up through the upper glacial aquifer near the coast, as it travels to discharge along the north or south shore of the fork. Therefore, the net flow in the Magothy is zero.

3.1.2.5 Shelter Island Water Balance

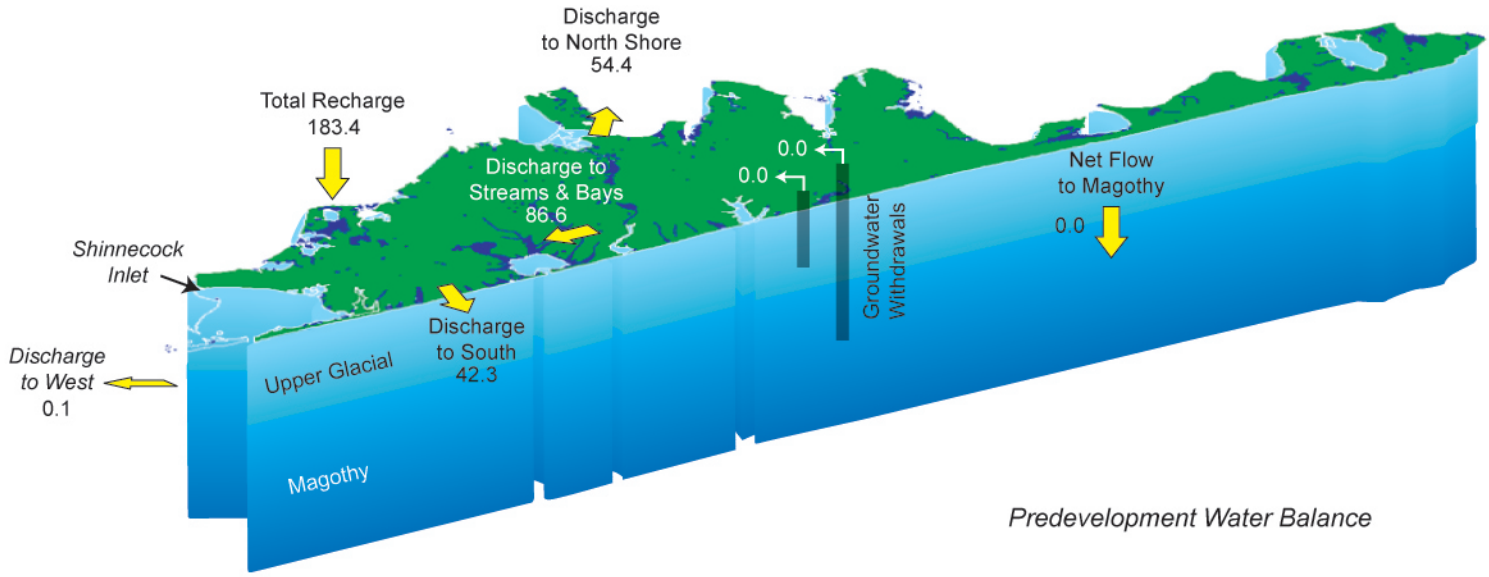
The Shelter Island freshwater/saltwater interface model was used as the basis for creation of predevelopment and present day water balances for Shelter Island. Freshwater is only expected to be present in significant amounts within the upper glacial aquifer, therefore the model was used to simulate conditions to the top of the underlying marine clay. As such, the water balance accounts for freshwater flow in the upper glacial aquifer only. The amount of freshwater discharge to the island's coast was calculated within each of four separate areas – the north and west shores; Coecles Harbor; the south and east shores; and West Neck Bay. The predevelopment and present day water balances are depicted graphically on **Figure 3-34** and on **Tables 3-24** and **3-25**.

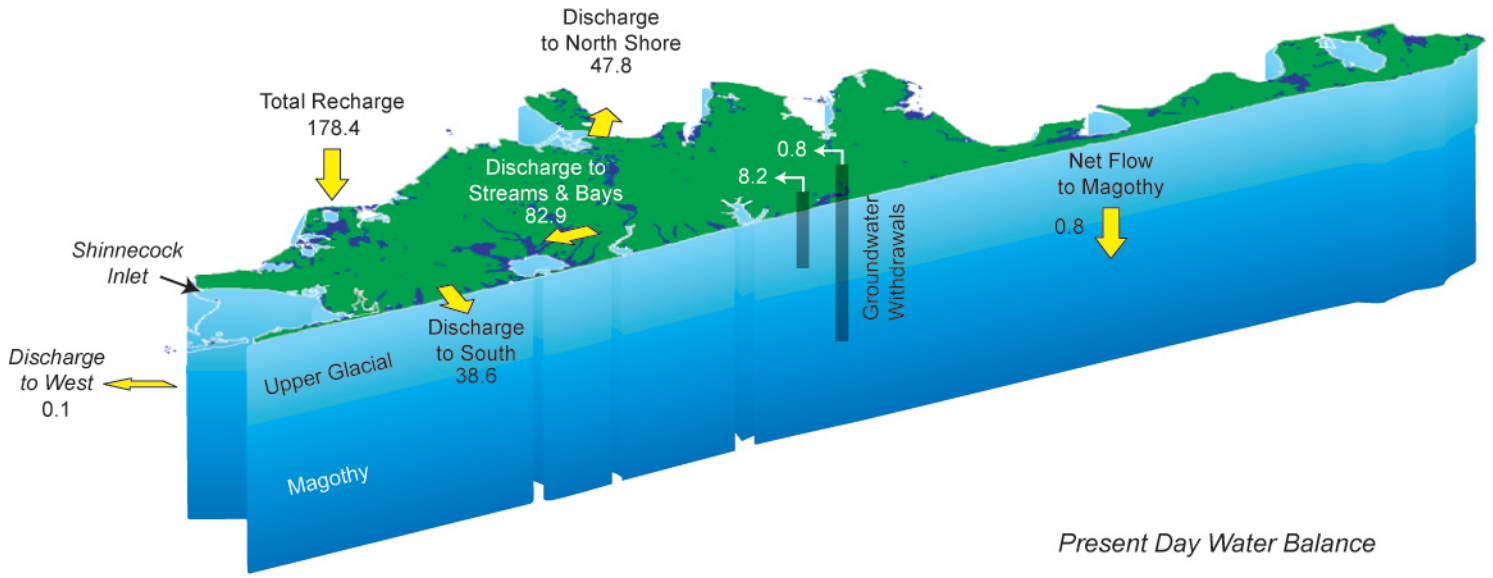
Table 3-22 South Fork Flow Model Predevelopment Water Balance (All Flows in MGD)

	Upper Glacial		Magothy		All Aquifers	
Flow	**Inflow**	**Outflow**	**Inflow**	**Outflow**	**Inflow**	**Outflow**
Total Recharge	183.4		0.0		183.4	
Water Supply Withdrawals		0.0		0.0		0.0
Streams and Bays		86.6		0.0		86.6
North Shore		54.4		0.0		54.4
South Shore		42.3		0.0		42.3
Magothy <->Upper Glacial (Net)		0.0	0.0		0.0	0.0
Main Body		0.1		0.0		0.1
Total:	**183.4**	**183.4**	**0.0**	**0.0**	**183.4**	**183.4**

Table 3-23 South Fork Flow Model Present Day Water Balance (All Flows in MGD)

	Upper Glacial		Magothy		All Aquifers	
Flow	**Inflow**	**Outflow**	**Inflow**	**Outflow**	**Inflow**	**Outflow**
Total Recharge	178.4		0.0		178.4	
Water Supply Withdrawals		8.2		0.8		9.0
Streams and Bays		82.9		0.0		82.9
North Shore		47.8		0.0		47.8
South Shore		38.6		0.0		38.6
Magothy <->Upper Glacial (Net)		0.8	0.8		0.8	0.8
Main Body		0.1		0.0		0.1
Total:	**178.4**	**178.4**	**0.8**	**0.8**	**179.2**	**179.2**

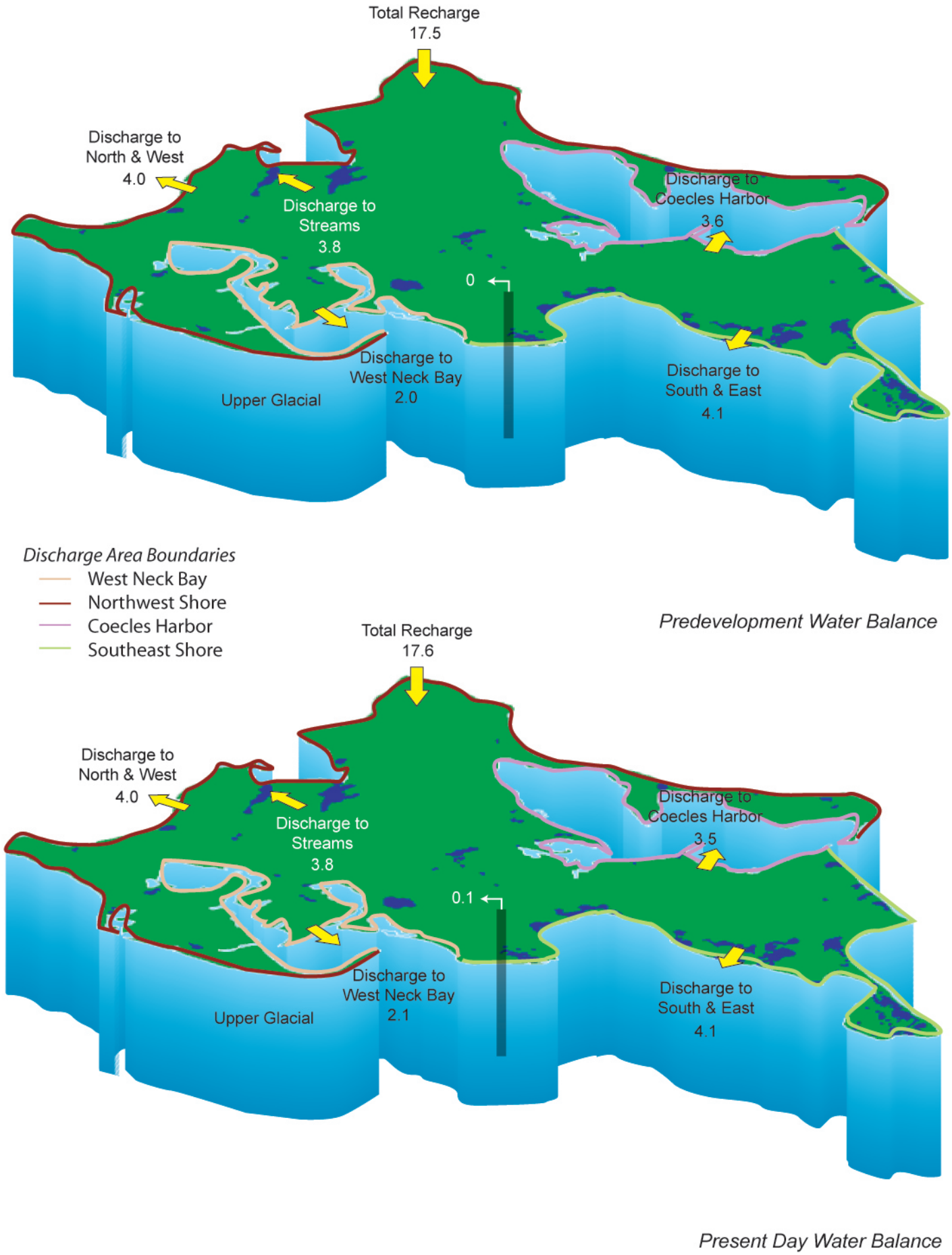




NOTE: The stratigraphic depictions do not represent actual thicknesses or depths

Figure 3-33
South Fork Flow Model
All Values in Million Gallons per Day

CDM



NOTE: The stratigraphic depictions do not represent actual thicknesses or depths

Figure 3-34
Shelter Island Flow Model
All Values in Million Gallons per Day

CDM

Table 3-24 Shelter Island Flow Model Predevelopment Water Balance (All Flows in MGD)

	Upper Glacial	
Flow	**Inflow**	**Outflow**
Total Recharge	17.5	
Water Supply Withdrawals		0.0
Streams and Small Bays		3.8
North and West		4.0
Coecles Harbor		3.6
South and East		4.1
West Neck Bay		2.0
Total:	**17.5**	**17.5**

Table 3-25 Shelter Island Flow Model Present Day Water Balance (All Flows in MGD)

	Upper Glacial	
Flow	**Inflow**	**Outflow**
Total Recharge	17.6	
Water Supply Withdrawals		0.1
Streams and Small Bays		3.8
North and West		4.0
Coecles Harbor		3.5
South and East		4.1
West Neck Bay		2.1
Total:	**17.6**	**17.6**

Under predevelopment conditions, total recharge to Shelter Island was 17.5 mgd, of which 22 percent (3.8 mgd) discharged directly to streams and bays. The remaining groundwater that recharged the upper glacial aquifer discharged to coastal waters. Because the present day total water demand on Shelter Island is only 0.1 mgd, there is virtually no difference in the present day and predevelopment water balances. Total recharge is estimated to have increased (after rounding) by 0.1 mgd due to the return of groundwater in unsewered areas.

3.1.2.6 Countywide Water Balances

The predevelopment and present day water balances for all of Suffolk County, as determined by combining the results of the four flow models, are provided in **Tables 3-26** and **3-27** respectively.

Table 3-26 Suffolk County Predevelopment Water Balance (All Flows in MGD)

All Aquifers			Outflow as a Percentage of Total Recharge
Flow	**Inflow**	**Outflow**	
Total Recharge	1202.5		
Water Supply Withdrawals:			
Upper Glacial		0.0	0%
Magothy		0.0	0%
Lloyd		0.0	0%
Streams		520.5	43%
North Shore		302.0	25%
South Shore		250.0	21%
Peconic Bay		126.6	11%
Nassau County		3.4	<1%
Total:	**1202.5**	**1202.5**	

Table 3-27 Suffolk County Present Day Water Balance (All Flows in MGD)

All Aquifers			Outflow as a Percentage of Total Recharge
Flow	**Inflow**	**Outflow**	
Total Recharge	1367.3		
Water Supply Withdrawals:			
Upper Glacial		59.4	4%
Magothy		134.5	10%
Lloyd		2.8	<1%
Streams		506.2	37%
North Shore		304.6	22%
South Shore		233.5	17%
Peconic Bay		117.1	9%
Nassau County		9.2	<1%
Total:	**1367.3**	**1367.3**	

Only minor differences in inflows and outflows exist in the predevelopment and present day water balances. The construction of stormwater recharge basins has resulted in an increase in total recharge from 1,203 mgd prior to development, to a present day total of 1,367 mgd. Groundwater withdrawals for water supply total 197 mgd, or 14 percent of total recharge. As a result of groundwater withdrawals, and to a lesser extent, a decline in total recharge on the forks, discharge to stream baseflow has decreased by about 3 percent, from 521 mgd to 506 mgd. Outflows to the surrounding saltwater bodies as a percentage of total recharge have decreased by 2 to 4 percent; however, discharge to Long Island Sound is actually simulated to have increased by 2.6 mgd.

The slight reduction in total recharge on the North and South Forks, coupled with the water supply withdrawals may have, over the long-term, reduced net flow into the upper glacial and Magothy and resulted in localized increases in underflow from the surrounding saltwater bodies.

A slight acceleration of saltwater intrusion would therefore be expected. However, since the changes in total recharge and groundwater withdrawals on the forks are minor, year to year variations in recharge may overshadow any long-term and wide-scale movement of the interface as a result of present day stresses, except in localized areas.

3.1.2.7 Summary of Water Balance Results

On a County-wide basis, the aquifer system can sustain current and projected levels of water supply pumping.

The water balances confirm earlier assessments that on a County-wide basis, the aquifer system can sustain current and projected rates of water supply pumping. While development of a 'safe' or sustainable aquifer yield was not within the scope of this project, the water balances show that average water supply pumping is only approximately 15 percent of the average recharge rate. In fact, much of the water withdrawn in the County is returned to the aquifer system via on-site wastewater disposal systems. Consequently, throughout much of the County, significant declines of stream baseflow have not been observed. The construction of recharge basins in many parts of the island has increased recharge during the growing season (Ku, et al), so that on an annual basis, recharge to the aquifer is actually slightly higher than during pre-development conditions.

Global warming is predicted to accelerate the rate of rising sea level.

The water balances also identify the net loss of baseflow to area streams and to coastal areas that occurs in those parts of the County where water supply pumping is not returned to the aquifer via on-site septic systems or small sewage treatment plants discharging to recharge beds. Suffolk County has evaluated the impacts of sanitary sewering in the SWSD on streams and wetlands areas within that district. The post-sewering reduction in baseflow in the Carlls River is shown on **Figure 3-35**, as compared to baseflow during the same time frame in the Carmans River, just to the east of the study area, shown on **Figure 3-36**. Potential impacts of development on streams, ponds, wetlands and inter-tidal areas are best considered on a localized basis, considering area water supply pumping, development and stormwater management approaches, and sanitary wastewater management.

3.1.2.8 Sea Level Rise

In the past, sea level had been rising along the East Coast at a reported rate of between 0.34 and 0.43 inches per decade (**Climate Risk Information**, 2009). Over the past century, the rate of sea level rise has been increasing, with average sea level rise since 1900 now at 1.2 inches/decade. Global warming is predicted to further accelerate the rate of rising sea level, both as a result of the expansion of the warming oceans, and as a result of ice melt.

Figure 3-35 Carmans River Runoff and Baseflow

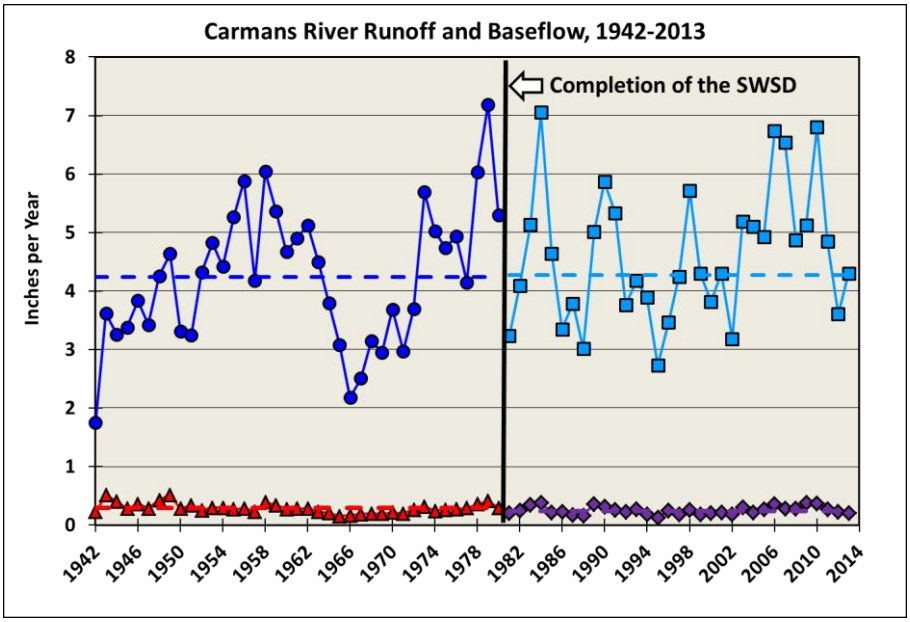
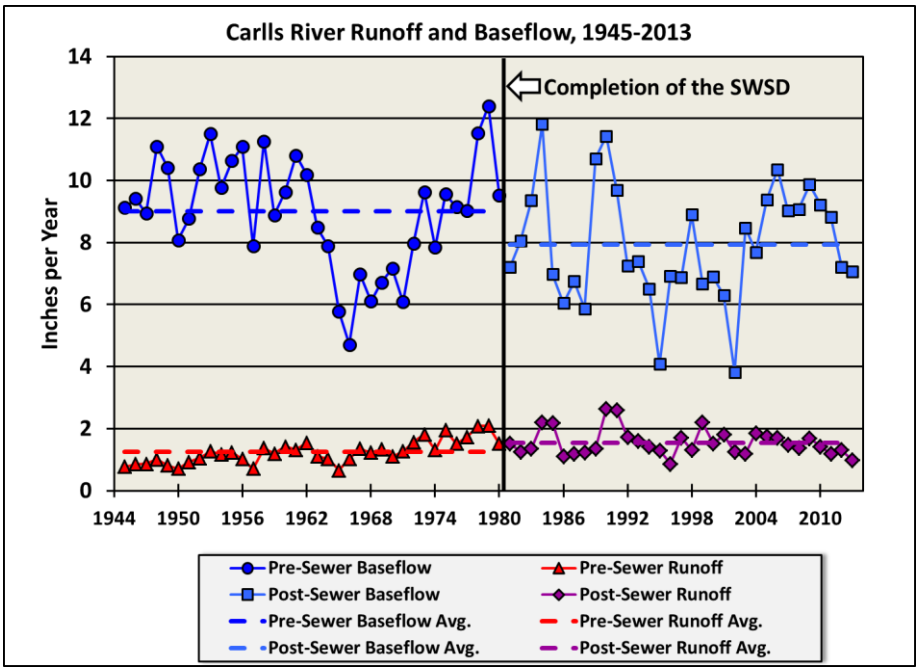
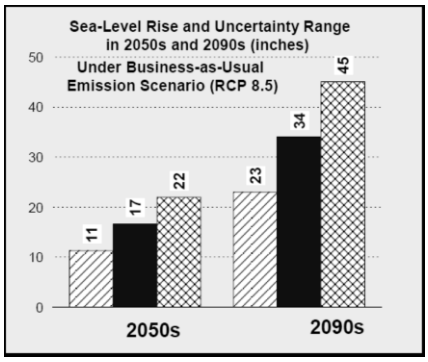


Figure 3-36 Carlls River Runoff and Baseflow





Projected sea-level rise in Nassau and Suffolk Counties based on a pessimistic "business as usual" scenario. Solid blue bars are mean values and the hatched bars indicate the 95% uncertainty range (from Zhang et al., 2014

When the draft 2010 Comprehensive Water Resources Management Plan was developed, global climate models (GCMs) used to predict increases in sea level projected the following increases in sea level elevation in the New York City area:

Decade	Increase
2020s	2 to 5 inches
2050s	7 to 12 inches
2080s	12 to 23 inches

Based on information available when the analyses were conducted, (IPCC, 2001), sea level was predicted to rise at a rate of approximately 0.192 inches/year. Based on this predicted rate, a sea level rise of 2.0 feet would have occurred over a span of approximately 125 years and a sea level rise of 1.0 foot would have occurred over a span of approximately 63 years. The sensitivity of model results to increased sea level rises of 1.0 and 2.0 feet above NGVD 29 was assessed for the Main Body flow model, and the North and South Fork models as described in the Task 4.4 Memorandum.

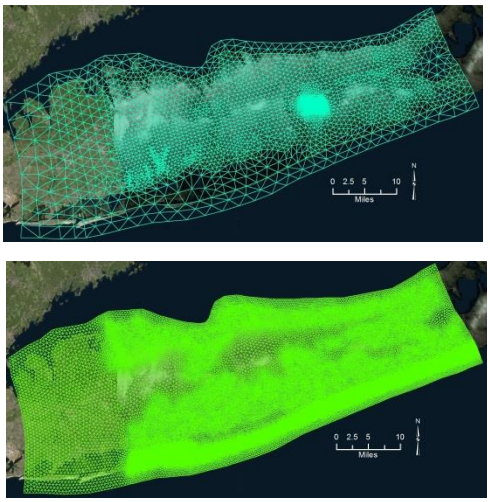
More recent sea level rise projections have concluded that the pace of sea level rise is greater than anticipated just a few short years ago and the groundwater model simulations were refined to incorporate the most recent sea-level rise projections. For example, recent model projections indicate that sea level rise by the end of the 21st century may be as high as 45 inches, based on a reference period of 1985-2004 (Zhang et al, 2014).

As a conservative approach, the mean sea-level rise projection under the "business as usual" case as presented in Zhang et al. (2014) was utilized, projecting an increase in sea level of 34 inches. For consistency purposes, a baseline value of 0.5 feet was used as the beginning mean sea level in all model simulations. These simulation results were used to assess the potential impact to on-site sewage disposal systems, as discussed in Section 8. Model simulations were run through 2099 assuming an increase in sea level of 34 inches.

Main Body Flow Model

The Main Body flow model was updated to recent (2013) conditions of community water supply pumpage. In addition, the finite element mesh was significantly refined around the coast and coastal waterways so that resulting

increases in the water table near the coast are refined to evaluate the potential impact to on-site waste disposal systems. In order to better represent baseflow to smaller streams, the updated mesh was intersected with surface elevation from LiDAR data obtained from the Suffolk County Department of Economic Planning. **Figure 3-37a** shows the predicted increase in upper glacial water levels assuming a 34-inch rise in sea level. The change in water level varies from 2.8 feet to less than 0.25 feet, with most of the model area showing an increase of 1 foot or less. Similar to the original sea level rise scenarios (Task 4.4), the predicted change in water level is much lower along the south shore, compared to the north shore, because increases in stream baseflow limit the water level rise in the vicinity of the non-tidal portion of the south shore streams.

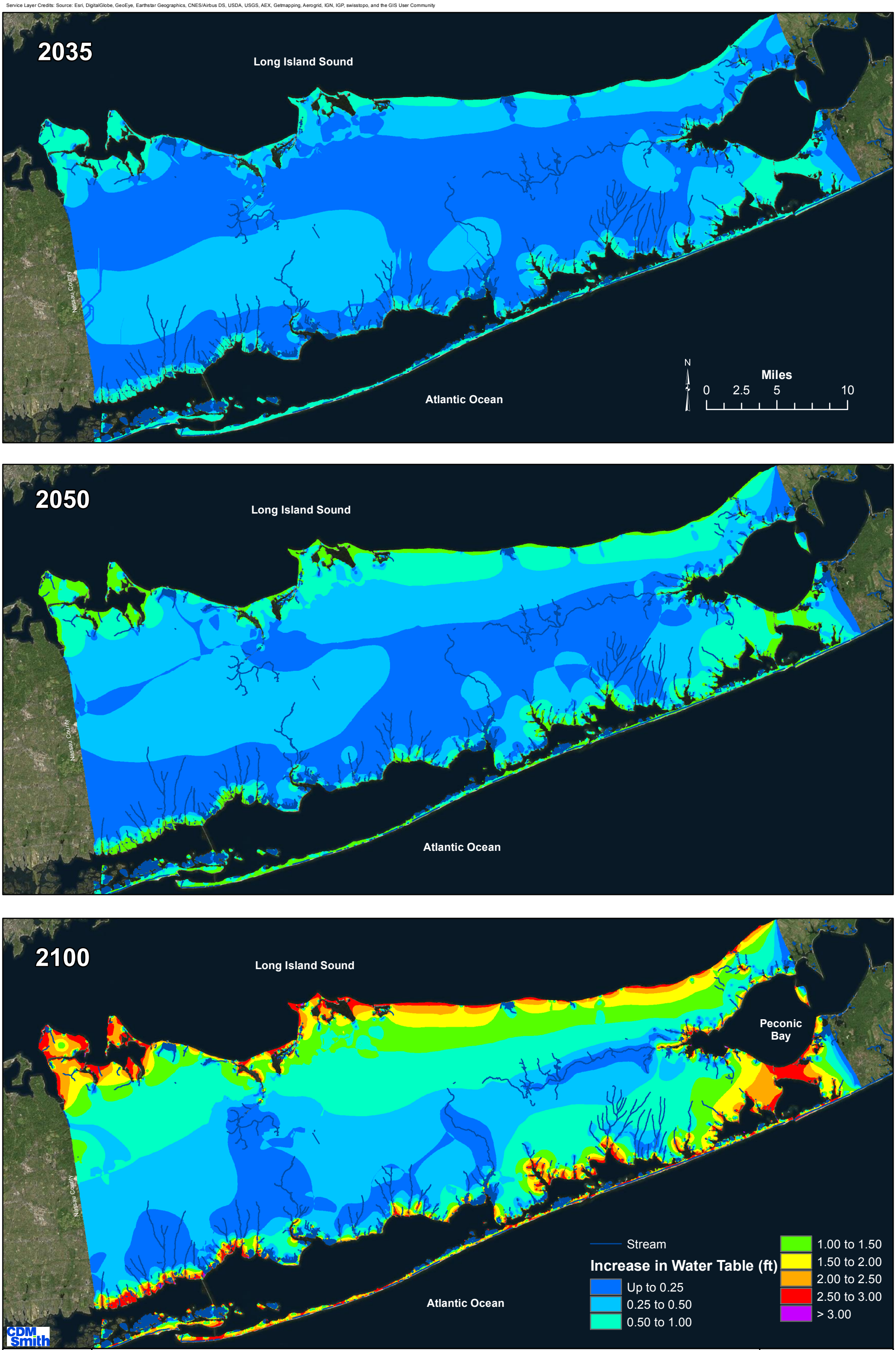


Main Body flow model finite element mesh. Top: original model; bottom: refined for sea level rise analysis.

Incorporating the LiDAR elevation data resulted in increased discharge to smaller streams resulting in a reduced mounding along the south shore. As these smaller streams were not represented in the original analysis, mounding is somewhat higher along the south shore in the original evaluation. **Figures 3-37b** and **3-37c**, depicting the simulated changes in Magothy and Lloyd aquifer heads to a 34-inch rise in sea level, also show a more significant head increase along the north shore compared to the south shore. Comparison of the three figures shows that the variability in head impacts between the north and south shores decreases with depth, as does the overall change in head from the current (steady-state) conditions. Total baseflow in the non-tidal portion of the south shore streams (based on present day configuration of the tidal portion) is simulated to increase by approximately 48 percent in response to a 34-inch rise in sea level. This increase accounts for many of the smaller streams and wetlands that were incorporated in the model refinement and inclusion of LiDAR data. Baseflows in the Peconic River and Nissequogue River are simulated to increase by approximately 11 percent and 2 percent respectively, similar to the results presented in Task 4.4.

Water Body	Projected Increase in Baseflow Resulting from Projected Sea Level Rise		
	2035	2050	2100
All Non-Tidal (South Shore)	10%	19%	48%
Nissequogue River & Tributaries	1%	1%	2%
Peconic River & Tributaries	2%	4%	11%

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

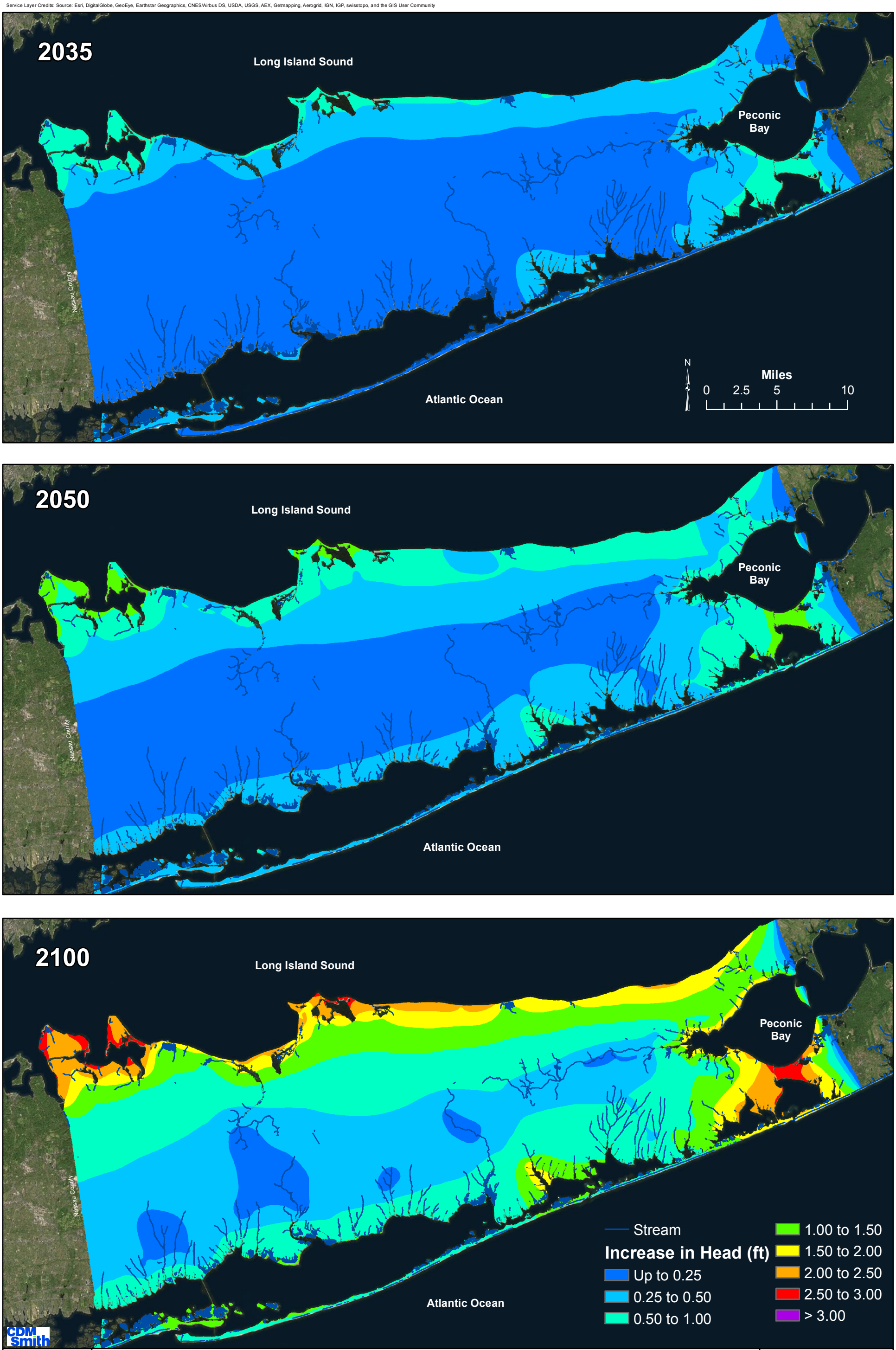


Simulated Increase in Water Table Elevation Due to a Sea Level Rise of 34 Inches by 2100

Suffolk County Comprehensive Water Resources Management Plan

Figure 3-37a

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

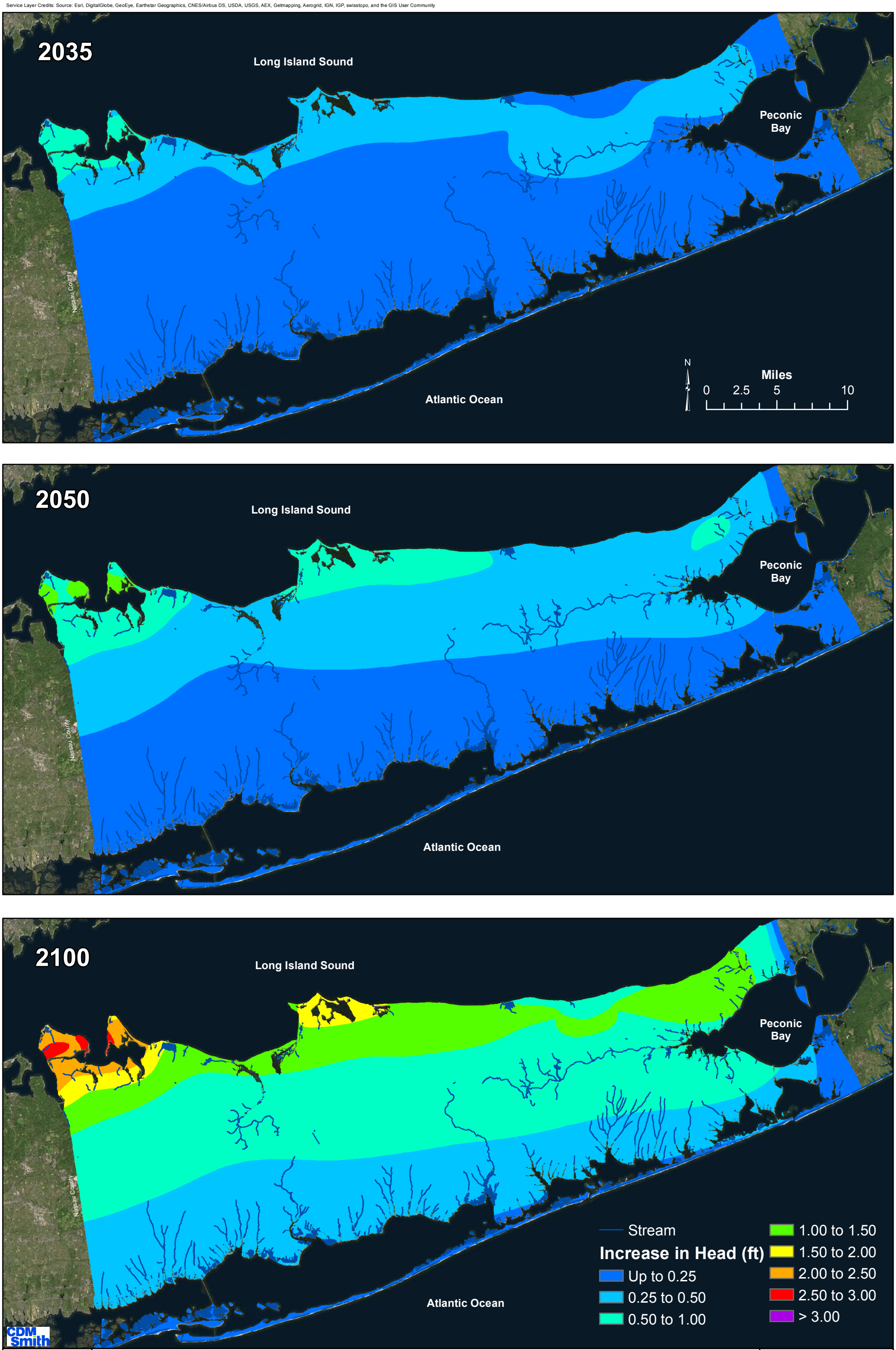


Simulated Increase in Head in the Magothy Aquifer Due to a Sea Level Rise of 34 Inches by 2100

Suffolk County Comprehensive Water Resources Management Plan

Figure 3-37b

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 Increase in Head in the Lloyd Aquifer Due to a Sea Level Rise of 34 Inches by 2100

Suffolk County Comprehensive Water Resources Management Plan

Figure 3-37c

North Fork Freshwater/Saltwater Interface Model

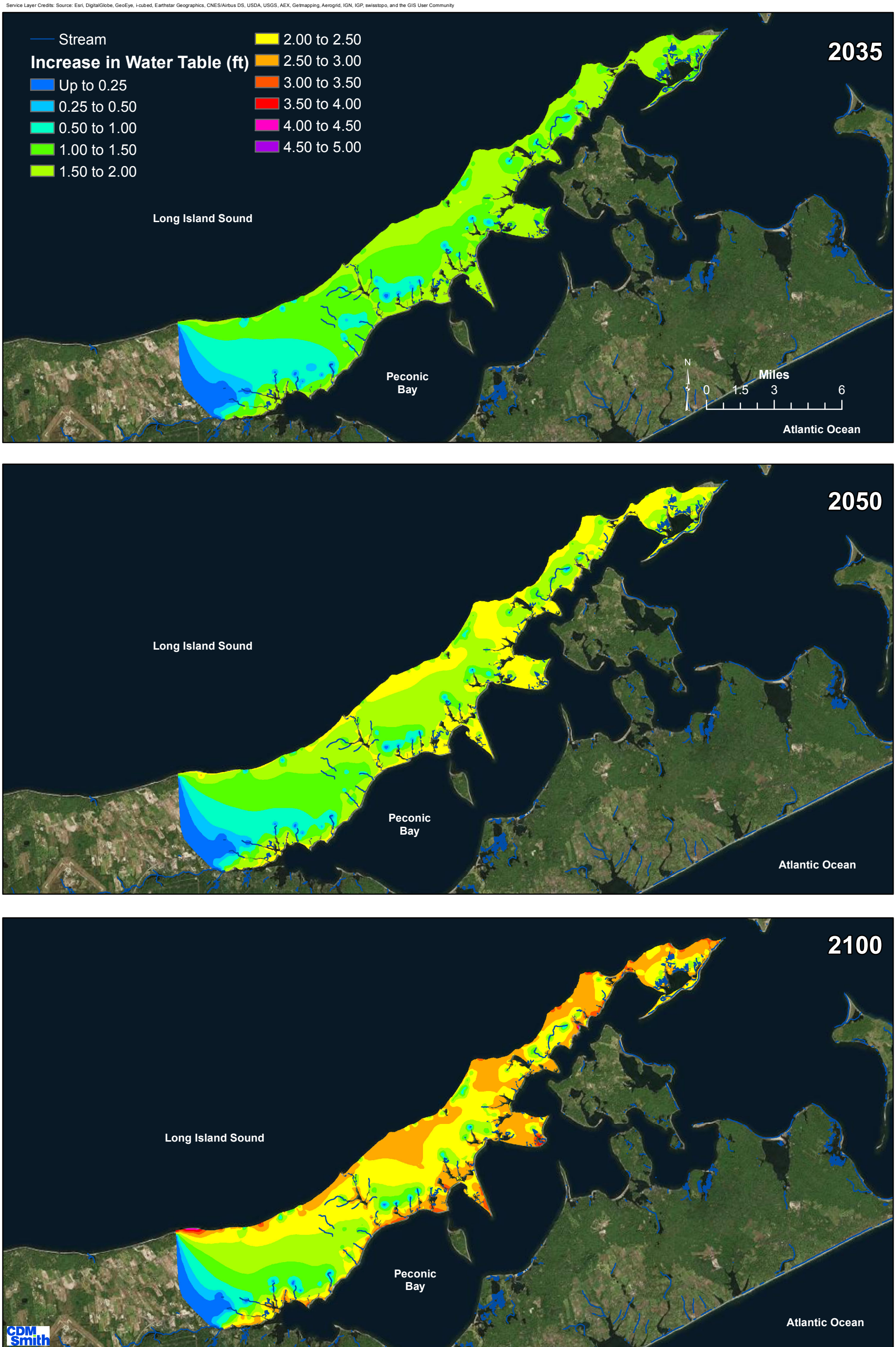
Figure 3-38 shows the predicted change in upper glacial water levels assuming a 34-inch rise in sea level. As in the Main Body flow model, the surface elevation of the North Fork model was refined by incorporating LiDAR data, thereby better representing smaller creeks. Over most of the North Fork, the change in water level varies from 1 to 2 feet. Short, non-tidal segments of streams along the southern shore of the North Fork locally limit the water level increase because of increases in stream baseflow. The relative extent of the water table impacts in the North Fork is markedly more extensive than that simulated by the Main Body flow model. This is to be expected given that the distance between water bodies (Long Island Sound and the Great South Bay) is four times greater for the Main Body compared to the North Fork (Long Island Sound and Peconic Bay).

The increase in water level beyond 3 feet around some of the tidal creeks is an anomaly resulting from the use of the regional model; detailed representations of the increased lengths of the tidal portion of the tributary creeks to the inlet that would occur as a result of the increased sea level were not incorporated in the regional model evaluation. Changes in the lengths of tidal creeks would have to be incorporated into the model to allow additional adjustment of boundary conditions along the length of the creeks to correctly simulate increased groundwater discharge to the creek, rather than the mounding that is currently depicted. The simulated freshwater/saltwater interface position following a 34-inch rise in sea level is shown in cross section on **Figure 3-39**, in black. The red line represents the current interface position. The depth to the interface is reduced most in areas where water level rise is limited by increased stream baseflow (i.e. the south shore). As shown on the figure, the simulation suggests that the interface moves inland by approximately 800 feet.

South Fork Freshwater/Saltwater Interface Model

Figure 3-40 shows the simulated change in upper glacial water levels assuming a 34-inch rise in sea level. Over most of the South Fork, the simulated change in water level varies from 1 to 2 feet. The non-tidal segments of streams throughout the South Fork locally limit the increase in water table elevation because of increases in stream baseflows. The simulated freshwater/saltwater interface position following a 34-inch rise in sea level is shown on **Figure 3-41**, in black. The red line represents the current interface position. As shown on the cross-section, the simulated interface migrates approximately 1,000 feet inland in the shallow aquifer along portions of the south shore.

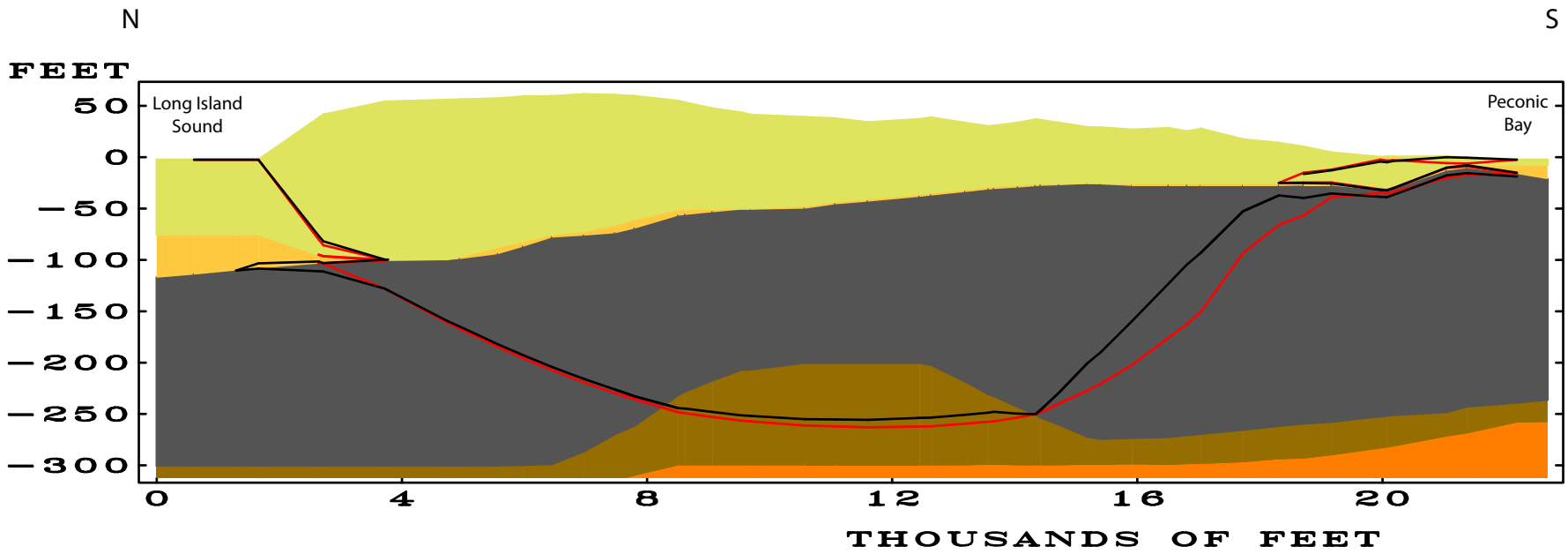
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community



Simulated Increase in the Water Table on the North Fork Due to a Sea Level Rise of 34 Inches by 2100

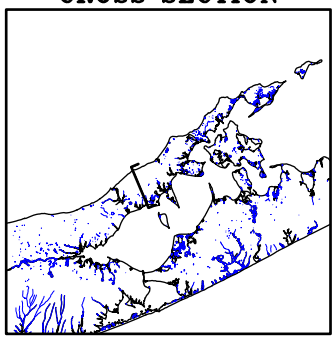
Suffolk County Comprehensive Water Resources Management Plan

Figure 3-38



Harbor Hill Outwash
Ronkonkoma Drift
Lower Clay
Lower Drift
Magothy

CROSS SECTION



Black line represents the simulated saltwater interface after a 34-inch rise in mean sea level (time = 2100)
Red line is the simulated saltwater interface at present (time = 2014)

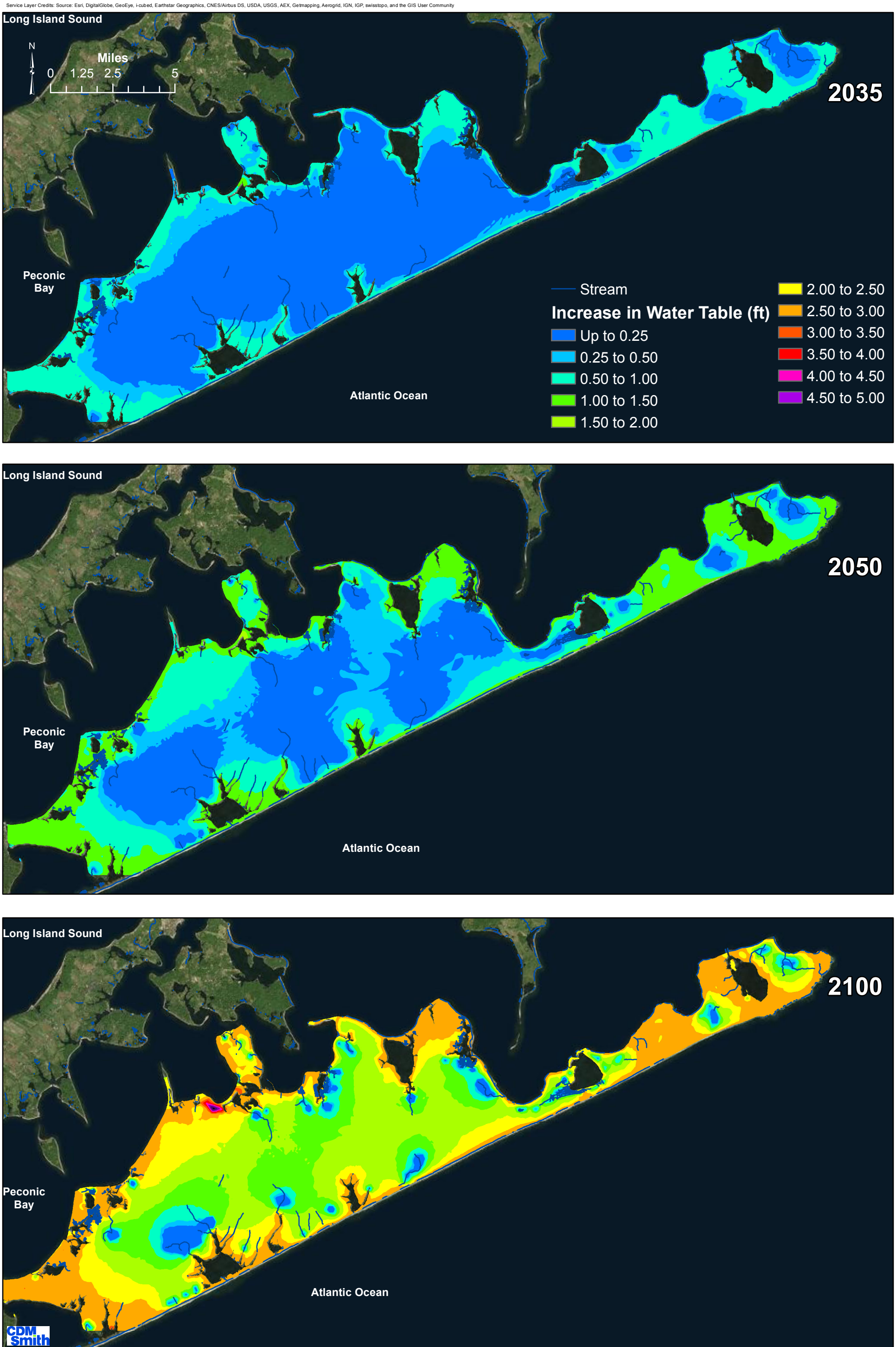
CDM Smith

North Fork Cross-Section - Simulated Impact of a 34-inch Rise in Mean Sea Level; Simulated Time = 2100

Suffolk County Comprehensive Water Resources Management Plan

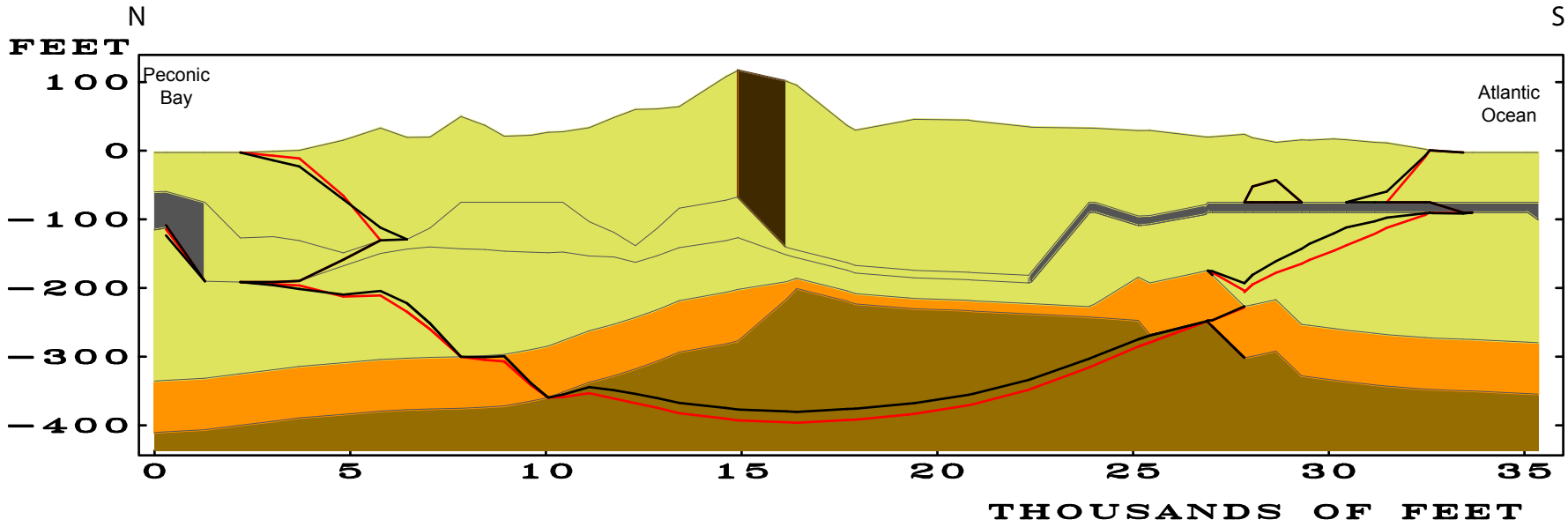
Figure 3-39

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



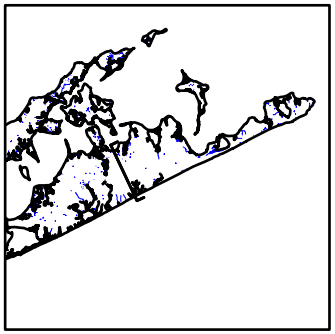
Simulated Increase in the Water Table on the South Fork Due to a Sea Level Rise of 34 Inches by 2100
DRAFT
Suffolk County Comprehensive Water Resources Management Plan

Figure 3-40



Outwash
Till
Upper Glacial Clay
Magothy (upper)
Magothy (middle)

CROSS SECTION GG



Black line represents the simulated saltwater interface after a 34-inch rise in mean sea level (time = 2100)
Red line is the simulated saltwater interface at present (time = 2014)

CDM Smith

South Fork Cross-Section - Simulated Impact of a 34-inch Rise in Mean Sea Level; Simulated Time = 2100; DRAFT

Suffolk County Comprehensive Water Resources Management Plan

Figure 3-41

Shelter Island Freshwater/Saltwater Interface Model

Figure 3-42 shows the simulated change in upper glacial water levels resulting from a 34-inch rise in sea level. Over most of the island, water levels are predicted to increase from 1.5 to 2 feet. The relative extent of the water table impacts in Shelter Island are similar to those simulated on the North and South Forks. The water table increases are reduced in the vicinity of Gardiner Creek (south of Dering Harbor) due to increased discharge to the creek. Similarly, water table mounding is subdued in areas surrounding West Neck Bay and Menantic Creek. The simulated freshwater/saltwater interface position following a 34-inch rise in sea level is shown in **Figure 3-43,** in black. The red line represents the current interface position. The cross section cuts from Hay Beach Point in the north to Wards Point in the south. The figure depicts a slight thinning of the freshwater lens in the upper glacial aquifer beneath the island, with some significant (>1,000) landward migration of the saltwater interface. To the south. As shown on **Figure 3-44**, the interface also becomes shallower in this area by approximately 20 to 25 feet. Similar to the Barrier Island on the Main Body, areas within Shelter Island discharge at the surface due to the increase in the water table, particularly on the Ram Island peninsula (**Figure 3-45**).

Sea level rise is projected to have significant impacts on low lying coastal areas, particularly on the forks, and along the south shore.

In the coming decades, Suffolk County will need to address the impacts of projected increases in sea level elevation. There are many uncertainties associated with the impacts of climate change, but much work has been documented by the Intergovernmental Panel on Climate Change (IPCC) and others. Recent studies and Global Climate Models indicate that sea level will continue to rise at an accelerated pace. Additional evidence indicates that precipitation is increasing in this part of the world, and that the number of extreme precipitation events is also increasing in the northeastern United States, including Suffolk County.

Sea level rise may have profound impacts on low lying coastal areas, particularly along the south shore, and on the forks. The impacts of sea level rise on the location of the saltwater interface must also be monitored and addressed from a water supply perspective. Extreme precipitation events will exacerbate existing drainage problems; significant flooding has already been observed in parts of Suffolk County (for example, Riverhead, Shelter Island and St. James).

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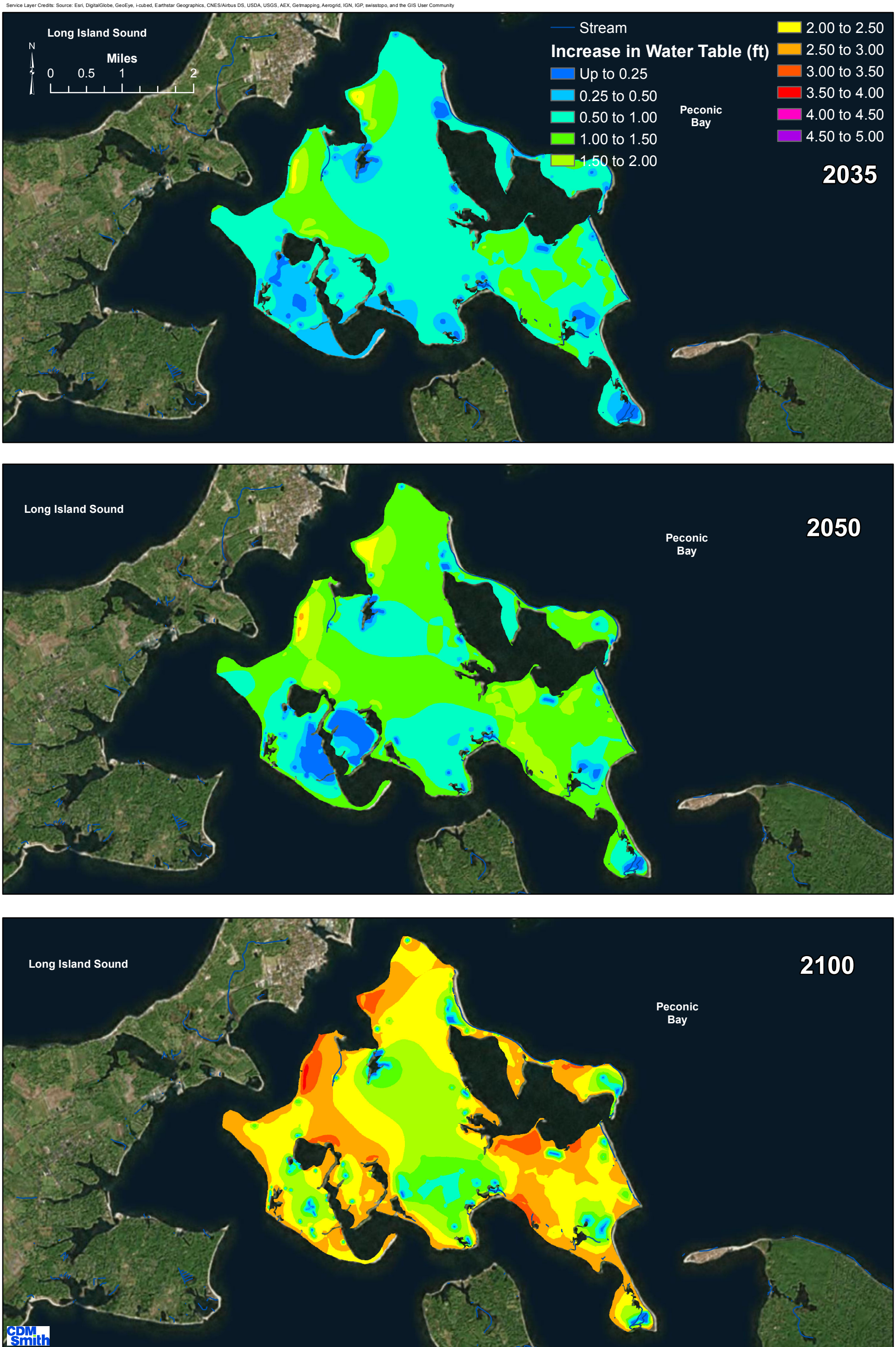
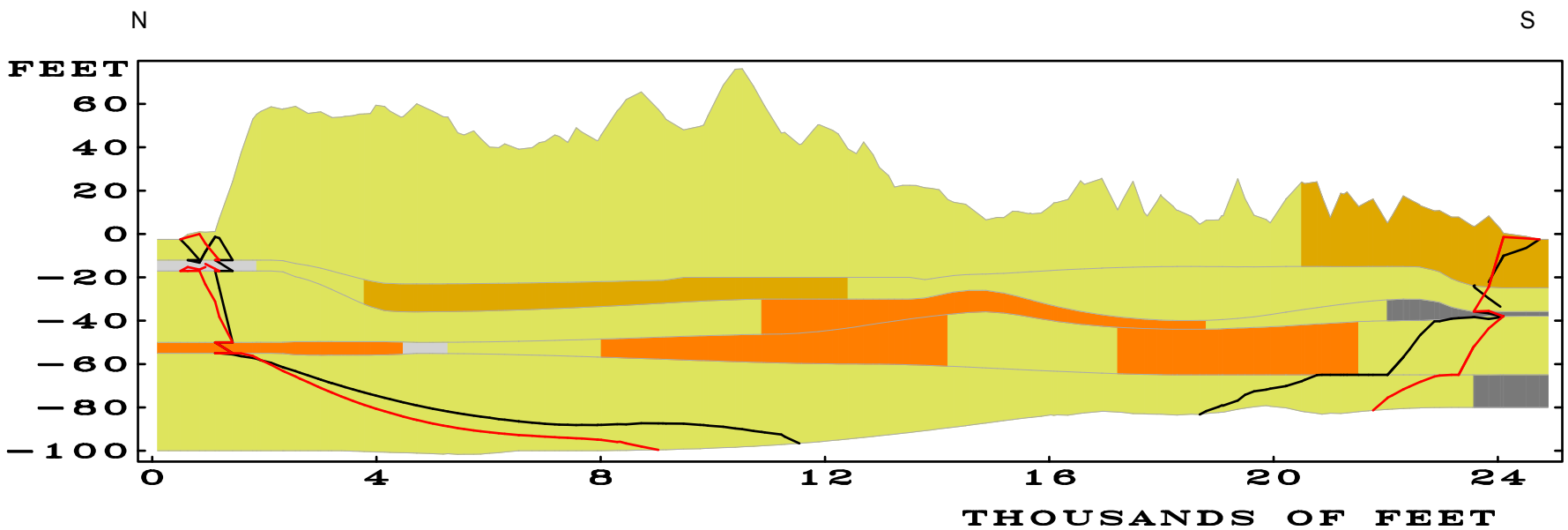


Simulated Increase in the Water Table on Shelter Island Due to a Sea Level Rise of 34 Inches by 2100

Suffolk County Comprehensive Water Resources Management Plan

Figure 3-42

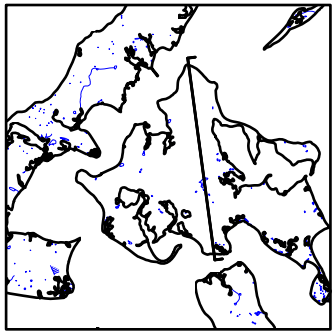


Upper Glacial Aquifer

Outwash, Sand, Gravel

Clay and Silt

CROSS SECTION



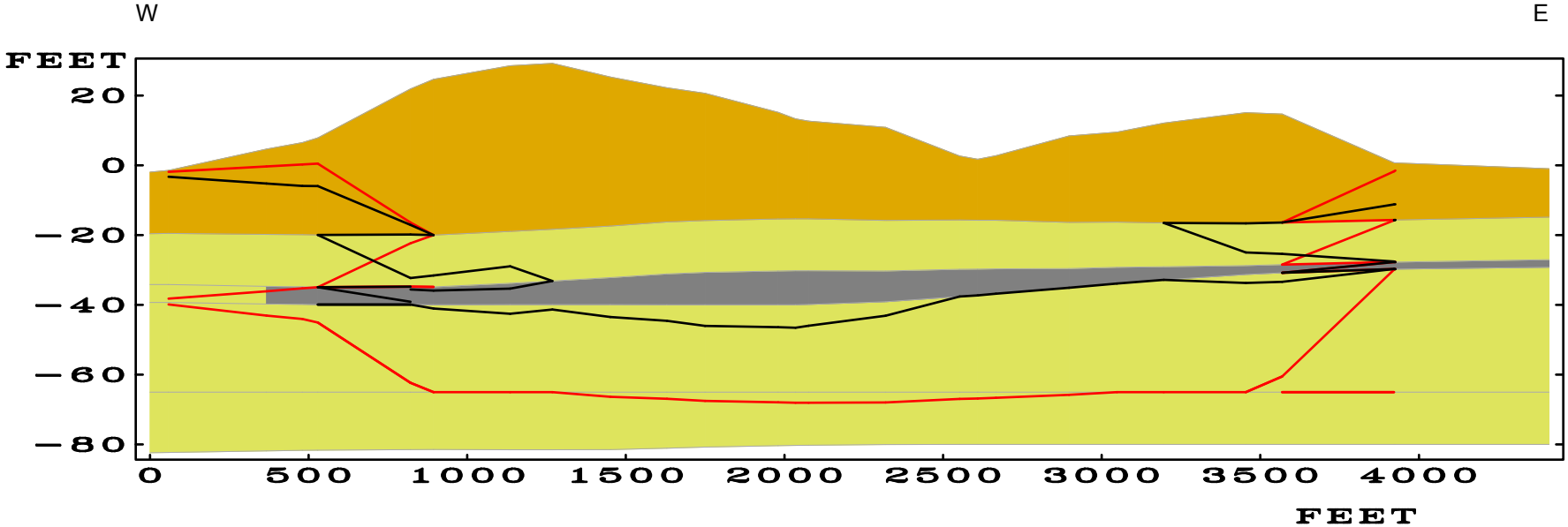
Black line represents the simulated saltwater interface after a 34-inch rise in mean sea level (time = 2100)
Red line is the simulated saltwater interface at present (time = 2014)

CDM Smith

Shelter Island Cross-Section - Simulated Impact of a 34-inch Rise in Mean Sea Level; Simulated Time = 2100

Suffolk County Comprehensive Water Resources Management Plan

Figure 3-43

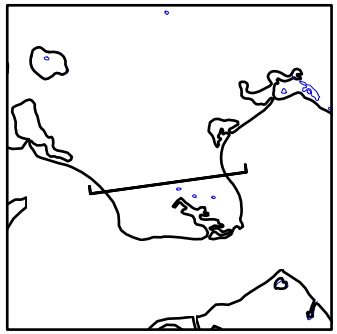


Upper Glacial Aquifer

Outwash, Sand, Gravel

Clay and Silt

CROSS SECTION



Black line represents the simulated saltwater interface after a 34-inch rise in mean sea level (time = 2100)
Red line is the simulated saltwater interface at present (time = 2014)

CDM Smith

Shelter Island Cross-Section - Simulated Impact of a 34-inch Rise in Mean Sea Level; Simulated Time = 2100

Suffolk County Comprehensive Water Resources Management Plan

Figure 3-44

Onshore Discharge Nodes in Shelter Island Groundwater Model Baseline and Following a 34-inch Sea Level Rise (2100)

Suffolk County Comprehensive Water Resources Management Plan

Figure 3-45

3.1.2.9 Sea Level Rise Summary

Water balances developed using the Main Body and East End groundwater flow models confirm that recharge greatly exceeds water supply pumping rates, and the County's aquifer system can continue to meet current and projected rates of water supply pumping on a County-wide basis. Nevertheless, fresh supplies are limited in some coastal areas, including Shelter Island, as described further in Section 4. The water balances also identify the net loss of baseflow to area streams and to coastal areas in those parts of the County where water supply pumping is not returned to the aquifer via on-site septic systems or small sewage treatment plants discharging to recharge beds. Potential impacts of development on streams, ponds, wetlands and inter-tidal areas are best considered on a localized basis, considering area water supply pumping, development and stormwater management approaches, and sanitary wastewater management.

Recharge greatly exceeds water supply pumping and the County's aquifer system can continue to meet current and projected water supply pumping rates on a County-wide basis but fresh supplies are limited in some coastal areas such as Shelter Island.

While there are many uncertainties associated with the impacts of climate change, published research and the results of Global Climate Models consistently indicate that sea level will continue to rise at an accelerated pace. Additional evidence indicates that precipitation is increasing in this part of the world, and that the number of extreme precipitation events is also increasing in the northeastern United States, including Suffolk County. In the coming decades, Suffolk County will need to address the impacts of projected increases in sea level elevation. The impacts of rising sea level could be very significant in coastal areas and along the forks, with significant implications for water supply, storm water and sanitary waste management, as well as more widespread flooding. The impacts of sea level rise on the location of the saltwater interfaces must also be monitored and addressed from a water supply perspective. The impacts of both sea level rise and more frequent extreme precipitation events should also be monitored so that wastewater and stormwater runoff management strategies can be developed and implemented. Potential implications for wastewater management are described in more detail in Section 8 of this document.

The impacts of climate change, including sea level rise, may be significant, particularly in coastal areas. Impacts on salt water interfaces, wastewater management and stormwater runoff must be considered.

3.2 Groundwater Resource Management Goals and Objectives

Working together with the Steering Committee, a set of groundwater resource management goals and objectives was identified, as summarized on **Table 3-28**. These goals and objectives are targeted to protect and manage groundwater quality and quantity through 2030. Although it is acknowledged that full achievement of these goals within the next twenty years may not be realized, implementation of the recommendations presented in Section 3.3 will

result in progress towards maintenance of a groundwater resource that can continue to provide a reliable high quality supply of potable water for future generations of Suffolk County residents.

The goals and objectives are consistent with the policy declarations that are articulated in the Suffolk County Sanitary Code:

§760-701: *" The designated best use of all groundwaters of Suffolk County is for public and private water supply, and of most surface waters for food production, bathing and recreation .... it is hereby declared to be the policy of the County of Suffolk to maintain its water resources as near to their natural condition of purity as reasonably possible for the safeguarding of the public health, and to that end, to require the use of all available practical methods of preventing and controlling water pollution from sewage, industrial and other wastes, toxic or hazardous materials, and stormwater runoff."*

Table 3-28 Groundwater Resource Management Goals and Objectives

Table 3-28
Groundwater Resource Management Goals and Objectives

GOAL 1: All groundwater shall be in compliance with the stricter of New York State Ambient Groundwater standards and guidance values or maximum contaminant level goals (MCLGs) to the greatest extent feasible. Water quality that is better than the existing standards should be preserved.

OBJECTIVES:

All groundwater should be in compliance with the stricter of New York State Ambient Groundwater standards and guidance values or MCLGs to the greatest extent feasible to protect, preserve and restore drinking water supplies and the ecological health of the County's surface waters.

GOAL 2: Nitrogen loading should be reduced for the protection of current and future drinking water supplies and to restore/maintain ecological functions of streams, lakes, estuaries and marine waters. Arrest and reverse the trend of increasing nitrogen concentrations in ground and surface waters to the greatest extent feasible and practical by decreasing the nitrogen loading from septic systems and fertilizers.

OBJECTIVES:

Nitrogen levels should be consistent with the Groundwater Management Zone targets for all areas developed subsequent to adoption of Article 6 of the Suffolk County Sanitary Code. For areas of pre-existing, non-conforming lots, nitrogen levels should be as close to Groundwater Management Zone targets as is reasonably achievable.

GOAL 3: Concentrations of other regulated and unregulated contaminants in groundwater should be minimized to protect current and future drinking water supplies and to restore/maintain ecological functions of streams, lakes, estuaries and marine waters. Reduce the discharge of volatile organic compounds and other regulated and other regulated contaminants to groundwater.

OBJECTIVES:

1. Measured levels of VOCs should be reduced from baseline (2005) levels.
2. Detections of regulated VOCs in monitoring and supply wells should be reduced from baseline (2005) levels.
3. Measured levels of pesticides should be reduced from baseline (2005) levels to the extent feasible and practical.
4. Detections of regulated pesticides in monitoring and supply wells should be reduced from baseline (2005) levels to the extent feasible and practical.
5. Measured levels of pharmaceuticals and personal care products in groundwater should be reduced from baseline (2005) levels to the extent feasible and practical.

Table 3-28 (Continued)
Groundwater Resource Management Goals and Objectives

GOAL 4. Land use patterns should be consistent with the protection of the County's groundwater and surface water resources, including the protection of existing and future drinking water supplies.

OBJECTIVES:

1. Advanced wastewater treatment and expansion of existing sewer districts should be utilized to reduce contaminant loading from sanitary wastewater.
2. Sub-regional areas in need of sewering to reduce contaminant loading from sanitary wastewater should be identified.
3. Areas appropriate for Transfer of Development Rights (TDRs) and for siting of new wastewater treatment plants (WWTPs) that are not located in the most sensitive public supply well contributing areas and surface water discharge areas should be identified.

GOAL 5: Groundwater levels should be maintained to protect and preserve the County's drinking water supply.

OBJECTIVES:

1. Critical areas where additional groundwater withdrawals could result in unacceptable impacts to existing wells (e.g., saltwater intrusion, reduced capacity) should be defined.
2. Unacceptable impact thresholds, such as magnitude and duration of unacceptable impacts should be defined.

GOAL 6: Groundwater levels should be maintained to protect and preserve the long term sustainability and ecological functions of existing surface water resources.

OBJECTIVES: Unacceptable impact thresholds should be defined within the twenty-five year contributing area to the County's surface water features.

GOAL 7: Existing programs to monitor, prevent contamination of, and manage Suffolk County groundwater resources should be enhanced and improved to provide the data necessary to protect the groundwater resource that provides the County's drinking water supplies, and to provide the information necessary to develop a long term approach to mitigate expected impacts of sea level rise upon existing infrastructure.

OBJECTIVES:

1. Groundwater quality and quantity monitoring programs (e.g., wells, facilities, spills) should be identified and documented.
2. The data should be entered into a database developed to facilitate data review, identification of trends and water quality concerns, and the data evaluation necessary to protect the County's drinking water supply and infrastructure.
3. Existing tools, (e.g., SWAP coverages, contributing area coverages) should continue to be maintained, updated and made available to water resource managers.

3.3 Recommendations

3.3.1 Introduction

Working together with project stakeholders, a variety of alternative approaches to protect groundwater from further contamination, to manage the impacts of existing development on the County's water resources, and to implement the additional studies needed to identify necessary targeted management plans have been identified. These recommendations generally address:

- Guidance to reduce the impacts of new development on groundwater resources;
- Recommendations for structural and non-structural methods to reduce the impacts of existing developed areas on groundwater quality;
- Establishment of a framework and programs to collect and evaluate the additional information needed to fully accomplish the resource protection goals articulated in this Plan, and
- An approach to engage County residents in resource protection.

Over the past few years, Suffolk County has integrated groundwater, surface water, and coastal habitat and resiliency objectives into a more comprehensive resource management framework. Given that sanitary wastewater is the major source of contamination affecting our water resources, the County has initiated a number of actions to address wastewater treatment and disposal, primarily focusing upon nitrogen. Recommendations to reduce nitrogen discharges to the environment are briefly identified here, but are described in more detail in Section 8 of this document. This study has not sought to duplicate on-going efforts, but instead builds upon the framework of water resource protection and management programs that have already been established in Suffolk County.

3.3.2 New Development

3.3.2.1 Recommendation for Open Space Preservation

It has been well documented that preservation of open space is the most effective means of protecting ground and surface water resources (USEPA, AWWA, Trust for Public Land). Studies throughout the country have established that open space preservation is also often the most cost-effective approach to protect source water quality. Major cities such as New York and Boston purchased land in their water supply source areas over a century ago,

to protect the resource for future generations. Recent research has confirmed the foresight of earlier generations, concluding that "allowing water quality to degrade, in addition to threatening public health, increases treatment and capital costs." (AWWA, 2004).

Water quality data collected by SCDHS and the County's water suppliers, and evaluations relating groundwater quality to land use within a well's source water area completed as part of this study also confirm that groundwater quality downgradient of areas of open space in Suffolk County (Task 5.1 and 5.2 memoranda) does not exhibit the level of contamination that is evident downgradient of commercial, industrial, residential or agricultural land uses. Because contaminants of concern such as nitrates, VOCs and pesticides are not used, stored or disposed of in protected open space areas, the potential to contaminate downgradient resources is significantly reduced, or even eliminated.

From a national perspective, the costs and benefits of open space preservation have been considered in a variety of different ways. Because there are many societal benefits associated with open space preservation, the techniques used to assess the costs and benefits consider a much broader range of criteria than water quality protection. Some researchers have concluded that it is not possible or appropriate to attempt to assign a 'cost' to the non-tangible benefits afforded by open space, which could be characterized instead as "invaluable."

A summary of 83 studies completed by the American Farmland Trust concluded that the cost of providing services such as schools, roads, police and fire protection, etc. to a property developed for residential use was greater than the tax revenue provided by that property, while the cost of providing community services to land maintained as farmland or forest was only about one third of the tax revenue that a community could expect to collect. This type of analysis does not consider secondary or long-term impacts however (e.g., that commercial/industrial development often instigates residential development or that the presence of open space can increase surrounding property values, for example). A 2010 report by the New York State Office of the Comptroller reports that even if a municipality purchases development or full ownership rights of a property, on a long term pay-back period of 15 years or longer, the municipalities realized net fiscal benefits, as a result of the maintenance of ecosystem services and limiting the growth of the demand for services.

A 2002 study of 27 water suppliers (mostly surface water supplies) reported by the Trust for Public Land and AWWA's Source Water Protection Committee

found that for every 10 percent increase in forest cover in the supplier's source area (up to about 60 percent), water treatment and chemical costs were reduced by 20 percent. New York City spent $1.5 billion to purchase upstate land in their source water area watershed, as a more cost-effective alternative to spending an estimated $6 billion to $8 billion to construct filtration facilities, and an additional $300 million each year in operating costs should the land have been developed (NCPIRG 2004, NOAA, 2010). As open space preservation in the source water area was the most cost-effective means of providing a reliable and safe supply of water to City residents, the City passed an environmental bond in 1997 to begin to fund the preservation of land in the watershed.

In Suffolk County, the SCWA has reported that based on the increased treatment required, it costs ten times more to provide water from a well with a developed contributing area than from a well where the contributing area is preserved open space (S. Jones, 2009).

Over the past six decades, Suffolk County has purchased more than 53,000 acres of land at a cost of more than $1 billion to preserve important environmental resources and significant ecological areas including wetlands, river corridors and upland habitat in addition to land for active recreation, hamlet parks, and historic and/or cultural uses. The County has also acquired the rights to 10,000 acres of productive farmland. The result of this preservation is a permanent benefit to the health and quality of life for current and future generations of Suffolk County residents. As of 2013, more than 162,500 acres, or more than 25 percent of the County has been preserved. Overall, 38,000 acres of the 55,000 Central Pine Barrens core preservation area are now in public ownership (NYS Office of Comptroller). Based on the land use information provided by the Suffolk County Department of Economic Development and Planning (2014), it is estimated that there are approximately 35,000 acres of vacant land available for development throughout Suffolk County, with the majority of that acreage located in the five eastern towns and Brookhaven. While properties purchased in the past often exceeded 100 acres, most vacant parcels that remain available today are considerably smaller. In addition to County programs, Town-specific programs such as the Community Preservation Fund, have been successful in preserving thousands of additional acres.

Continued open space preservation is recommended from a water resource protection perspective, as the most effective way to achieve the groundwater and surface water resource management goals.

The enabling legislation for the new Drinking Water Protection Program requires that a property being proposed for acquisition must meet at least one of the following five criteria:

- Freshwater/tidal wetlands and buffer lands for same
- Lands within the watershed of a coastal stream as determined by a reasonable planning or hydrological study
- Any tract of land located fully or partially within a statutorily designated Special Groundwater Protection Area
- Lands determined by the County Department of Planning to be necessary for maintaining the quality of surface or groundwater in Suffolk County
- Lands identified by the South Shore Estuary Reserve (SSER), Peconic Estuary Program (PEP), and/or the Long Island Sound Comprehensive Conservation and Management Plan (LICMP) as needed to protect coastal water resources

Within this overall planning context articulated by the Suffolk County Department of Economic Development and Planning, it is further recommended that parcels within the 50 year contributing area to public supply wells be specifically identified and assigned a high priority for purchase, particularly when there is a significant opportunity to protect and preserve existing ground or surface water quality. The areas contributing to public supply wells, based upon supplier projections of future water supply pumpage have been identified during this study and were documented as part of Task 5.5. (Please see the end of this section for an example of public supply well contributing area mappings.) These mappings will help to assess property compliance with criteria 4, above. Based on the latest available land use information provided by the Department of Economic Development and Planning there are currently over three thousand parcels (or parts thereof) located within the 50 year contributing area to community supply wells, as shown on **Figure 3-46**.

The New Drinking Water Protection Program, approved by voter referendum, is an important indication of the public's belief in the importance of Open Space preservation. It is funded by ¼% of the sales tax collected in the County. The Save Open Space program is funded through the issuance of $75 million in serial bonds ($30 million of which was targeted specifically for open space preservation), and the Environmental Legacy Fund has committed $50 million

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Data from Suffolk County Department of Economic Development and Planning

Vacant Land within the 50 Year Contributing Area to Community Supply Wells

Suffolk County Comprehensive Water Resources Management Plan

Figure 3-46

from the County's capital budget, to be used in partnership with other municipalities and non-profit organizations. The cost of historic land purchases for open space preservation programs has averaged about $17,700/acre. It is anticipated that future per-acre costs will be somewhat greater, as the value of the more limited land available for development increases, the size of the remaining vacant parcels decreases, and because a number of the properties initially purchased were in the Central Pine Barrens with more limited development potential. While preservation of open space is the most effective way to protect ground and surface water quality from a water resources management perspective, it is acknowledged that many other interests also require consideration. Therefore, open space preservation must continue to be considered within a comprehensive planning framework.

Land acquisitions and preservation continue to be accomplished in Suffolk County under the auspices of a variety of programs that have different goals and objectives. Recently, the County undertook an effort to review, update and consolidate prior disparate Open Space "Master Lists" that included properties proposed for acquisition that were identified as important for open space preservation. The 2012 Comprehensive Master List Update identified 86 proposed open space sites and assemblages totaling 4,650 acres that are recommended for future open space acquisitions.

In 2013, the Suffolk County Legislature amended Chapter 1070 of the Code of Suffolk County for Real Estate Appraisal, Acquisition and Disposition Legislation to streamline the acquisition of open space, farmland and active recreation parcels. The procedure, known as "Triple A" (referencing the appraisal, acquisition and approval steps of the planning process) provides more information to lawmakers earlier in the acquisition process, and allows for the prioritization of properties to be acquired by Suffolk County through the Drinking Water Protection Program, which funds open space farmland and active recreation acquisitions.

The procedural refinement builds on work by the Department of Economic Development and Planning to evaluate and rank all properties on the County's four master lists. Taken together, the new procedural tool and the Comprehensive Master List will be used to determine the best use of limited funds based on objective criteria, including environmental rating, appraisal value, recommendations from Planning Staff and available funding.

3.3.2.2 Recommendations for New Developments

As described above, sanitary wastewater management is the most important factor affecting nitrate levels in groundwater throughout most of the County. Due to the significant contribution of groundwater baseflow to the County's

surface waters, improved sanitary wastewater management practices can also affect nitrate levels in surface waters.

In 1980 Suffolk County amended Article 6 of the Suffolk County Sanitary Code to specifically address the impacts of sanitary wastewater on the County's groundwater. Since 1980, in accordance with Article 6, on-site wastewater disposal is permitted for residential parcels in new residential subdivisions with lot sizes greater than or equal to one acre in Groundwater Management Zones III, V and VI, and greater than or equal to one half acre in all other zones; undersized lots existing prior to 1981 are exempt. Residential development on lot sizes smaller than one acre within GMZs III, V, and VI, and one half acre in all other zones, require the use of a community sewage system for wastewater treatment and disposal.

However, many existing residences with on-site wastewater disposal systems had already been constructed on smaller parcels prior to 1980. While sufficient information to quantify the number of residential parcels that were developed with on-site sanitary wastewater disposal prior to enactment of Article 6 was not available, the number of parcels less than or equal to one half acre and zoned for residential use was identified.

As previously described, data provided by the Suffolk County Department of Economic Development and Planning showed that over fifty percent of the unsewered residential parcels in the County are less than or equal to one half acre. Because the populations of the west end towns have not increased significantly since 1970, it is evident that a large portion of the smaller parcels were constructed prior to enactment of Article 6, and rely upon on-site septic systems for wastewater disposal. Nitrate levels in groundwater reflect these conditions. In fact, approximately one third of the residentially zoned properties in Brookhaven and Huntington are even smaller, at less than or equal to one quarter acre. More than three quarters of the residential properties in Babylon are less than or equal to one quarter acre; groundwater contamination resulting from the on-site septic systems prompted the implementation of the SWSD in the 1970s. Groundwater data collected by both SCDHS and the Nassau County Department of Public Works (2005) has confirmed that sanitary sewering programs have successfully reduced groundwater nitrate levels in the sewered areas.

The observed nitrogen levels in groundwater, which have continued to increase since the ***1987 Comp Plan***, result from a combination of the Article 6-compliant and the older non-compliant parcels.

As described above in Section 3.1.1.3, a modeling assessment of the impacts of unsewered residential areas of alternative densities on nitrate levels in

groundwater showed that nitrate levels are likely to exceed 10 mg/L in areas with ¼ properties, and that nitrate levels in areas with 1 acre properties would remain below 4 mg/L. New development occurs within the framework of properties that have already been developed; many pre-1980 developments include parcels that are less than ½ acre or even ¼ acre in size, hence background nitrogen levels would have already been elevated above the zero assumed background for the modeling evaluations. Building upon the body of SCDHS work over the past decades, the evaluations relating land use to observed nitrate levels completed as part of this study (e.g., documented in task memoranda 5.1, 5.2, and 18), review of density/nitrate relationships established elsewhere in the country, and these most recent model results, the Suffolk County Board of Health should consider modifying Article 6 to require a minimum lot size of one acre for unsewered properties throughout all hydrogeologic zones, ***unless*** provision is made for a higher level of treatment than is provided by a typical on-site wastewater treatment system, or, the development rights from existing undeveloped open space controlled by the developer are transferred, in accordance with standards adopted by the SCDHS in 1995.

Zone specific evaluations considering costs and benefits within the framework of other management alternatives should be completed. Hydrogeologic Zone IV is the highest priority for this consideration. Suffolk County should consider amendment of the Transfer of Development Rights (TDR) standards and Board of Review findings in accordance with these recent evaluations and in coordination with the Pine Barrens Joint Planning and Policy Commission. SCDHS transfer of development rights standards should be re-evaluated to assure protection of sensitive areas, including the 50 year contributing area to public supply wells and the 25 year contributing area to surface water features shown on **Figure 3-47**.

While this recommendation focuses upon nitrogen criteria, it was also developed in recognition of the fact that many other contaminants of potential concern such as PPCPs can also be introduced to the subsurface from on-site wastewater disposal.

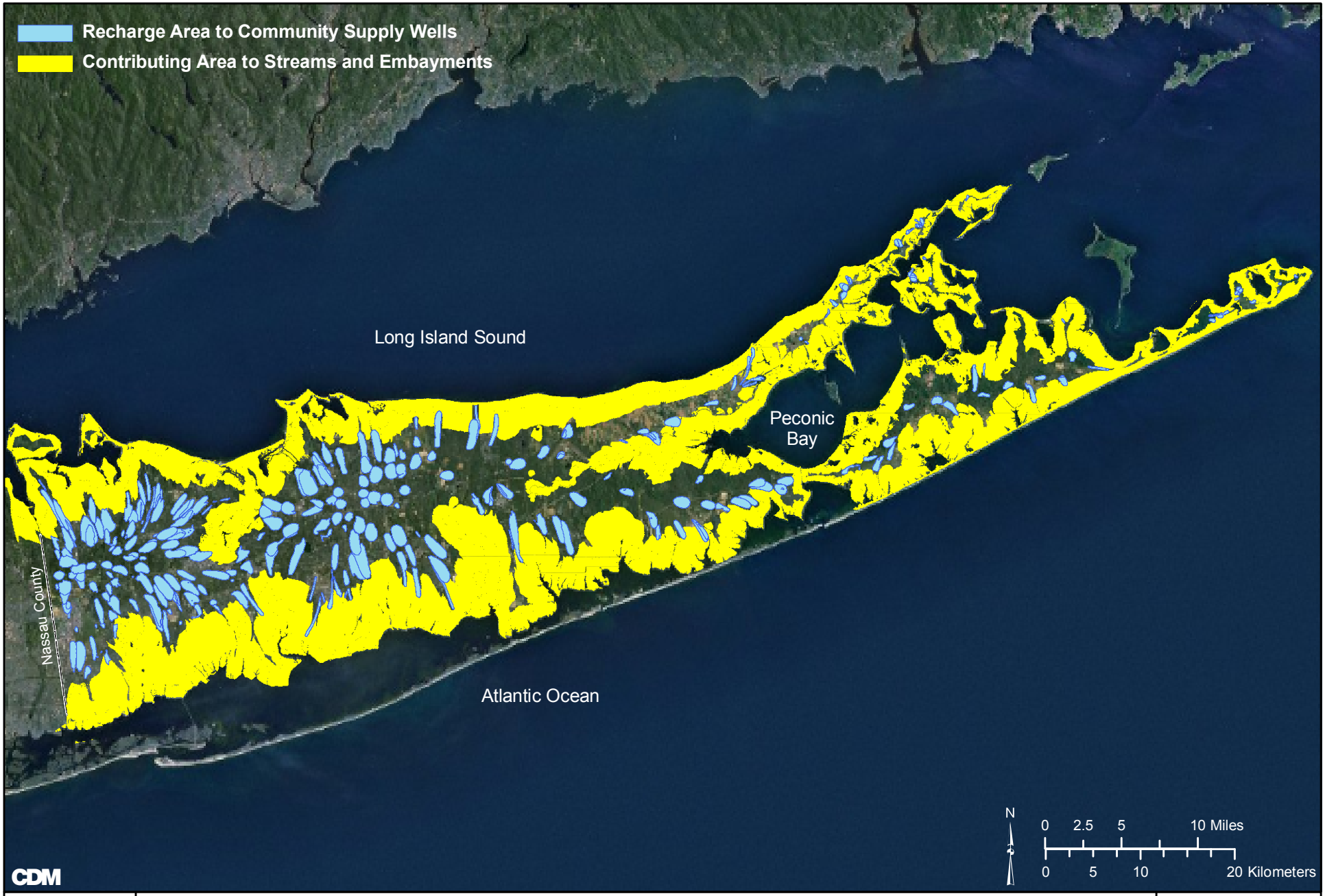
EXCLUSION ZONE ANALYSIS

Identification of Areas Requiring Special Protection

Existing water quality protection programs limit development density in the County's deep recharge zones to manage the amount of contamination introduced to the aquifer system from overlying land use. The SCDHS also considers mappings of the land surface area contributing recharge to public supply wells when reviewing development plans, to discourage siting of facilities or developments with the potential to discharge contamination that could impact a public supply well. Unsewered areas that contribute groundwater baseflow to surface water resources also have the potential to affect surface water quality.

Mappings of areas warranting special protections, strictly from a water resources management perspective, based upon criteria developed by the SCDHS to protect drinking water, groundwater recharge and surface waters were mapped. In order to accommodate "smart growth" initiatives that incorporate higher density developments, areas that did not fall within one of these protected areas could be considered further as potential receiving zones for transfer of development rights, or where increased development density could be considered. It should be noted that this evaluation does not provide a comprehensive mapping of all natural resource criteria that would necessarily be included in a siting study; it does, however identify areas of the County where development or wastewater management restrictions could be considered to be less critical from a water resource protection standpoint.

The first figure depicts the model-simulated areas contributing recharge to public supply wells within fifty years and surface waters within twenty-five years. The second figure shows the land area remaining after the deep recharge zone and special groundwater protection areas are also included. Many of these remaining areas would not be appropriate for higher density development due to their locations within environmentally sensitive areas; high density development would not be permitted based upon existing local zoning in most of the areas identified on the East End.



Areas Contributing to Community Supply Wells and Surface Waters

Suffolk County Comprehensive Water Resources Management Plan

Figure 3-47

Developments of increased density (in areas permitted by local zoning regulations) discharge to sewage treatment plants. Because most new sewage treatment plants discharge to groundwater, the SCDHS Office of Wastewater Management (OWM) reviews the proposed discharge location to minimize potential impacts on downgradient resources, including public supply wells. SCDHS has published guidance for siting new or expanded wastewater treatment plants (WWTPs) advising 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 and requires that an advanced treatment process be provided if a WWTP is located within this zone (SCDHS, 2014).

3.3.3 Existing Developed Areas

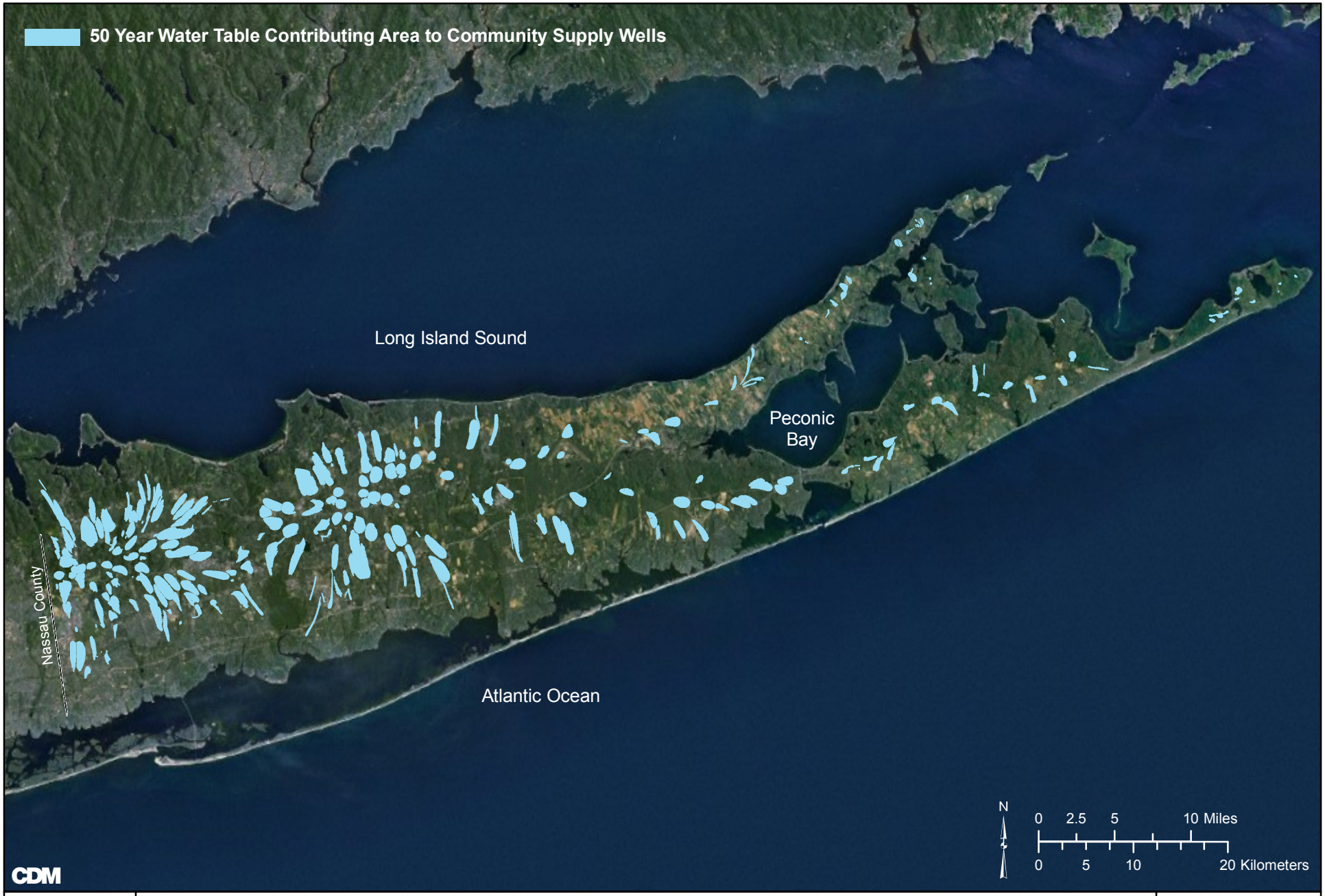
While the preceding pages outlined an approach to protect groundwater from the impacts of additional development, the following recommendations were developed to respond to the impacts of the 1.5 million existing residents of the watershed.

3.3.3.1 Recommendations to Evaluate Sanitary Wastewater Treatment and Disposal Options

Sanitary wastewater disposal and fertilization practices are the two largest sources of nitrate to the aquifer system. As described in section 3.1.1.3, unsewered areas where property sizes are less than an acre are likely to cause groundwater nitrogen concentrations that exceed target levels of 6 mg/L. In areas where property sizes are ¼ acre or smaller, groundwater levels are predicted to exceed 10 mg/L, as has been observed in several SCDHS studies.

Recognizing the impact that densely developed unsewered areas has on groundwater and surface water quality, Suffolk County has already initiated projects to reduce the impacts of sanitary wastewater disposal on groundwater. The County is prioritizing and addressing wastewater management in developed areas through a series of projects targeting study areas identified by the Suffolk County Sewer District Wastewater Treatment Task Force:

- Sewer District Capacity Study for seven unsewered areas (CP 8189)
- Expanding districts of four existing sewered areas (CP 8185)
- Expansion of Southwest Sewer District No. 3 (CP 8139)



Area Contributing Recharge to Community Supply Wells within Fifty Years

Suffolk County Comprehensive Water Resources Management Plan

Figure 3-48

- Expansion of Kings Park Sewer District

In addition, SCDHS has conducted a study of alternative on-site sewage system technologies that could reliably reduce nitrogen levels to 10 mg/L for individual residences or smaller sub-divisions, to identify alternative systems that could provide viable, low cost systems to protect public health. This study will include monitoring those most promising alternative technologies to collect data establishing system effectiveness and to identify cost-effective alternatives to centralized sewage collection and treatment.

Following the release of the draft Comprehensive Water Resources Management Plan, Suffolk County initiated a program to establish watershed-specific nitrogen loads, identify and approve improved on-site sewage disposal system technologies, expand and/or create new Suffolk County-operated sewage districts and create privately operated decentralized sewer districts. A number of County representatives toured other states on the east coast that currently utilize alternative on-site sewage disposal technologies to reduce the impact of nitrogen from sanitary wastewater disposal on water resources. Suffolk County is currently conducting an innovative/alternative on-site wastewater treatment systems (OWTS) demonstration project for single-family residences. Four manufacturers are installing a total of nineteen demonstration systems that will be monitored throughout 2015 to assess their ability to reduce effluent nitrogen to less than or equal to 19 mg/L. The benefits and costs of these actions are being assessed, and will be used in a County-wide assessment of wastewater management, as described below and in more detail in Section 8.

It is recommended that Suffolk County complete the demonstration study, and utilize the results along with the GIS-mappings of areas contributing recharge to public supply wells and surface waters and relationships between density and nitrate levels developed during this study in a County-wide wastewater planning study that considers density, conventional wastewater treatment collection and treatment systems, alternative treatment systems, alternative on-site systems, and operational and maintenance guidelines for existing on-site systems.

The County-wide evaluation should identify any additional high priority areas within the County where a new approach to wastewater treatment and disposal is required to achieve ground and surface water quality criteria for nitrates. SCDHS can use the evaluation approach piloted for the Montauk Highway Corridor (please refer to Section 3.1.1.3) to assess the benefits of proposed sewering programs on groundwater quality. The planning study should also consider projected impacts of sea level rise upon the on-site

wastewater disposal systems in coastal areas, and include further evaluation of both the separation distance between on-site systems and the groundwater table and inspection upon property sale. It will also be essential for the County to establish an I/A OWTS program that includes the establishment of a Responsible Management Entity (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 establishment of an I/A OWTS program.

The question of whether Article 6 of the Sanitary Code should be amended to regulate the equivalent density of accessory apartments in unsewered areas has been raised occasionally. Currently, Article 6 does not provide the authority to regulate legal accessory apartments that are ancillary to a single-family dwelling. A reliable data set that identifies the locations of legal accessory apartments does not currently exist; an inventory of illegal accessory apartments would be even more difficult to develop. In general, legal accessory apartments are regulated by towns and villages. Both data and model simulations indicate that nitrogen levels in the aquifer are increasing, due in part to the larger household size considered, which would include the accessory apartments. Based on available information, Code revision to regulate accessory apartments is not recommended at this time; however as additional information becomes available, the issue should be re-evaluated.

3.3.3.2 Recommendations with Respect to Nitrate Loads from Fertilization

Suffolk County has developed and is implementing a plan to reduce the impacts of fertilizer on ground and surface water features. The Suffolk County Legislature established a goal of reducing fertilization in residential areas by 10 to 25 percent, and in 2007 passed Local Law 41-2007 to reduce nitrogen pollution by reducing the use of fertilizer throughout the County. The law notes that "*the quality of our water should be considered a higher priority than the aesthetics of lawns, and that high maintenance lawns require more nitrogen and are more likely to leach excess nitrogen, so that high maintenance lawns should be discouraged.*"

The Plan mandated by the widely acclaimed legislation includes the following components:

- A Countywide ban on fertilizer application between November 1 and April 1, to avoid applying fertilizer to frozen ground;

- A ban on fertilization of County properties, except for golf courses, athletic fields, the Suffolk County farm, and new turf establishment at public works properties;
- Codifying the County's Organic Parks Maintenance Plan, limiting fertilizer application to 3 pounds of nitrogen for each 1,000 square feet of golf course;
- Use of Best Management Practices (BMPs) at the County Farm;
- Expansion of educational programs to encourage reduction of fertilization rates and increase the use of slow-release fertilizers;
- Establishment of an inter-active website for residents to establish fertilization needs (www.healthylawns.suffolkcountyny.gov/)
- Requirement that licensed landscapers (approximately 1,200 in Suffolk County) complete a turf management course;
- Requirement that retail establishments selling fertilizers post signs, and provide educational materials describing proper fertilization rates and practices;
- Preparation of annual reports summarizing the amount and types of fertilizers sold by the County; and
- Beginning in 2014, preparation of reports at five year intervals summarizing the effectiveness of this Law.

Suffolk County Development of Economic Development and Planning has documented that sales of fertilizer in Suffolk County have declined by over 11 percent since the law took effect in 2009 (**Framework for the Future, Suffolk County Comprehensive Master Plan 2035**). Nevertheless, Suffolk County residents continue to use significantly more fertilizer than residents of any other county in New York State, indicating that additional efforts are required.

In July 2010, New York State adopted the Dishwasher Detergent and Nutrient Runoff Law to reduce phosphorus loading to the state's ground and surface waters. Reducing the amount of phosphorus that is released to the environment is much more effective and cost-effective than collecting and treating contaminated stormwater, or implementing treatment processes to reduce phosphorus levels in sanitary wastewater. Beginning in August, 2010, the sale of newly stocked phosphorus-containing dishwasher detergent for

residential use was prohibited, and the sale of dishwasher detergent containing phosphorus for commercial use was prohibited beginning July 2013.

Beginning on January 1, 2012:

- Lawn fertilizers containing phosphorus were prohibited, except for establishment of new lawns, or if data confirms that phosphorus is required;
- Application of lawn fertilizers on impervious surfaces was prohibited;
- Application of lawn fertilizers was prohibited within 20 feet of a surface water body except in cases where a vegetative buffer of ten feet or more exists, or special application techniques are employed;
- Application of fertilizer between December 1 and April 1 was prohibited state-wide.

The state-wide law does not affect agricultural or garden fertilization practices. However, to date, over 300 local vegetable, nursery, sod, and fruit farms and vineyards have participated in the tiered strategy of the Agricultural Environmental Management (AEM) Program. The AEM Program is a state-wide voluntary, incentive based process that helps farmers to make common sense decisions to achieve their business objectives while protecting and conserving natural resources and groundwater quality. Through the AEM program, the Suffolk County Soil and Water Conservation District, partners at Cornell Cooperative Extension of Suffolk County (CCE), NRCS and private sector planners and crop consultants provide on-farm environmental assessments, conservation planning and technical services.

It is recommended that farmers that participate in County preservation programs, purchase of development rights, and other programs should be encouraged to participate, by agreement, in the AEM program and adopt best management practices (BMPs) to minimize or prevent contamination from fertilizers, considering use of improved timing of fertilizer application, choice of product (e.g., slow-release formulations) and new technologies to limit fertilizer leaching and run-off.

Approximately 80 on-farm demonstration projects have been held by Cornell Cooperative Extension's agricultural research specialists in the County-funded Agricultural Stewardship program to evaluate the costs and benefits of using alternative nutrient management practices to protect groundwater quality while maintaining crop viability, and 22 sweet corn and 16 potato farms have

participated in Controlled Release Nitrogen Fertilizer demonstration projects. As conservation plans and BMPs are implemented, collection of groundwater quality data would help to assess the effectiveness of the program in reducing nutrient levels.

Suffolk County continues to work with Cornell University and Cornell Cooperative Extension to reduce nitrogen loads from fertilizer. One of the activities, the golf course challenge, is seeking to implement best management practices at East End golf courses, so that nitrate levels in downgradient groundwater are maintained at less than 2 mg/L. The County should evaluate the effectiveness of the fertilizer BMPs and based upon the results, consider working together with golf courses throughout the County for wider implementation.

Finally, Suffolk County is evaluating and updating the 2004 Suffolk County Agricultural Stewardship Program, to address current needs of the farming community and the County, including the need to protect the quality of the County's water resources, soil and natural habitats. The collaborative effort includes participants from the farming community as well as Suffolk County Department of Economic Development and Planning, SCDHS, the Peconic Estuary Program (PEP), Cornell Cooperative Extension of Suffolk County, SCWA, the Suffolk County Soil and Water Conservation District, NYSDEC, and the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS). The updated Program describes the need for collaborative cooperation to reduce the nutrient loads from agriculture to the County's ground and surface water resources while maintaining a strong, viable agricultural industry. The primary goal of the program is to increase Suffolk County farmer completion of Tier III in the AEM program to at least 90 percent. The program will encourage participation by funding research to develop BMPs to reduce nitrogen impacts, by providing educational programs to encourage implementation of nitrogen reducing BMPs, and providing funding to continue to improve BMPs to reduce nitrogen impacts.

3.3.4 Recommendations to Address Volatile Organic Compound Contamination

Review of water quality data has shown that the highest levels of VOCs are found in wells with industrial, commercial, transportation or institutional uses within their source water areas. Nevertheless, low levels of VOCs were widely detected in groundwater throughout the County, indicating a more widespread low-level source of the observed contaminants, such as residential septic systems.

The goal of the SCDHS Office of Pollution Control (OPC) is to prevent – and mitigate – the release of toxic contaminants to groundwater and the environment. There are currently over 20,000 industrial and commercial facilities in the OPC's database; these include gas stations, dry cleaners, pharmaceutical manufacturers, metal plating and fabrication facilities, repair and fleet service facilities and other facilities using or storing hazardous substances (SCDHS, 2014). OPC has prioritized these facilities based on the contaminants used, the potential for release to the environment, and historical enforcement actions. Facilities with permitted storage are routinely inspected; those facilities with a medium or low ranking are inspected less frequently than high priority sites, due to staffing limitations. OPC has reported that in a typical year, approximately 4 percent of the 3,500 medium priority establishments and only about 1 percent of the 12,000 low or unknown priority establishments are inspected. Because the use of a particular property may change over time, the priority assigned to a particular property may remain out of date for years, until the facility is inspected again.

Consequently, as a result of the infrequent inspections, information provided by others (e.g., data developed by environmental assessments during property transfers) often identifies the release of contamination to the environment. As a result, in the past, OPC has overseen hundreds of remedial actions at medium and low priority sites each year, to mitigate contaminants that have been released to the environment via on-site septic systems.

Based on the facility location information included in the SCDHS OPC database, almost eighty percent of the regulated facilities are located in unsewered areas. Many of these facilities do not use or store significant quantities of hazardous materials on-site; however, those facilities that do utilize hazardous materials have a higher potential to introduce contamination to groundwater.

Before targeted recommendations to reduce the release of VOCs to the County's groundwater can be developed, a better understanding of the potential sources of the observed contamination is required. SCDHS OPC has developed a two phase VOC Action Plan to respond to the observed VOC contamination. The first phase of the Plan is being implemented, five new staff have been hired to allow annual inspections of underground gasoline storage facilities and dry cleaners, and increased sampling and analysis. Suffolk County has developed a scope of work for a Reducing Toxics capital project to evaluate existing industry in the County using or storing hazardous materials, including the volume of materials stored, location of storage, historical spills, potential for release and assessment of contaminant fate and transport. The contaminant inventory and characterization should form the basis for a

revised facility ranking system, and identification of potential new regulations, storage requirements, operator training requirements or inspection/enforcement procedures to improve the effectiveness of OPC programs, and to reduce the further release of toxic contaminants, including VOCs to the environment.

It is recommended that Suffolk County continue to implement this program as a priority.

As an additional task to that program, the SCDHS should also further explore the role that residential areas have in terms of VOC contamination. If residential areas are determined to be a significant source of the observed low level VOC contamination, SCDHS should respond by:

- Incorporating information on the types of household products that may contain VOCs, and preferred alternatives into the education and outreach program described below,
- Potentially regulating the use and disposal of specific contaminants of concern (e.g., household cleaners, etc.), and
- Incorporating relevant information on appropriate use and disposal of household products using VOCs into public education and outreach and school curricula development programs.

In the meantime, the high priority facilities located within the contributing areas of public supply wells that have been rated as having high or very high susceptibility to VOC contamination should be inspected.

3.3.4.1 Recommendations to Address Volatile Organic Compounds from Soil Vapor

The presence of VOCs in groundwater (e.g., at or near a USEPA or NYSDEC listed Superfund or Brownfield site) can also result in contaminated soil vapor. Contaminants in the vapor phase can migrate through the soil and eventually enter buildings through cracks in basement floors, walls, foundations, and gaps near utility conduits and sump pits. Vapor intrusion is the general term given to migration of hazardous vapors from a subsurface contaminant source, such as contaminated soil or groundwater, through the soil and eventually into indoor air. Vapor intrusion can occur in a broad range of land use settings, including residential, commercial, and industrial, and affect buildings with virtually any foundation type (e.g., basement, crawl space, or slab on grade). Vapor intrusion is similar to radon intrusion in that the mechanism of vapor transport and entry into a structure is the same. The SCDHS Department of Environmental Quality (DEQ) currently requires facility owners of VOC

release sites that have the potential to cause vapor intrusion, to perform a soil vapor investigation. SCDHS then reviews the results and determines whether further monitoring or mitigation is required. If mitigation is warranted, systems can be installed to minimize or prevent potential soil vapor exposures, enabling use and development of the overlying property.

In many cases, installation of mitigation systems prior to building construction is a proactive approach that is worthy of consideration. The costs associated with installing a system at the time of a building's construction are often significantly less than the costs associated with retrofitting a system to the building after construction is completed. These systems also have the potential to reduce any naturally occurring low-level radon gas levels and control humidity in basements. DEQ now reviews all new construction applications to determine whether a site has the potential for soil vapor intrusion. SCDHS considers this procedure to represent a precautionary approach for addressing potential soil vapor intrusion prior to construction when applications are received that are on, or in close proximity, to a NYSDEC or USEPA listed site where there is a source that can potentially contaminate soil vapor.

DEQ's review is limited in scope and may result in a recommendation to the applicant to contact the NYSDOH or NYSDEC case managers for those spill sites for information on the extent of contamination and potential control measures, where necessary.

3.3.5 Recommendations to Address Pesticides

Pesticide contamination of Suffolk County groundwater is primarily associated with agricultural land uses on the East End. Multiple programs are in place to help reduce non-point pesticide sources from agriculture; however, the overuse of pesticides on agricultural lands continues to be one of the most significant sources of contamination in agricultural areas. Programs such as the AEM program described above in Section 3.3.3.2 are being implemented to address these issues. The AEM Program is a state-wide voluntary, incentive based process that helps farmers to make common sense decisions to achieve their business objectives while protecting and conserving natural resources and groundwater quality. Through the AEM program, the Suffolk County Soil and Water Conservation District, partners at Cornell Cooperative Extension of Suffolk County (CCE), NRCS and private sector planners and crop consultants provide on-farm environmental assessments, conservation planning and technical services.

It is recommended that farmers that participate in County preservation programs, purchase of development rights, and other programs should be encouraged to participate, by agreement, in the AEM program and adopt best

Pharmaceuticals and Personal Care Products in the Environment

Suffolk County's approach to PPCPs includes monitoring, removal of PPCPs from wastewater whenever possible, research into treatability and education, including:

- Collaboration with USEPA, NYSDEC, SCWA and USGS to develop and implement a PPCP monitoring plan that tests public and private supply wells and the groundwater resource.
- Expansion of existing analytical methods to identify the presence of contaminants of concern.
- Development and implementation of a plan to monitor PPCPs in wastewater, and to test the efficacy of wastewater treatment technologies – including onsite wastewater treatment systems - in removing PPCPs.
- Support of Town STOP programs to reduce improper disposal of PPCPs to prevent them from entering the environment.
- Public education and outreach and support of consumer turn-in programs.
- Work with medical facilities to optimize management and disposal procedures

management practices (BMPs) to minimize or prevent contamination from pesticides, considering integrated pest management or products that are safer alternatives to the pesticides that have been observed to impact the County's groundwater.

Suffolk County and Cornell Cooperative Extension should continue to work closely with the agricultural community to identify crop-specific practices (e.g., integrated pest management) or products that provide safer alternatives to the pesticides that have been observed to impact the County's groundwater. It would be useful if monitoring well installation and groundwater sampling and analysis were also included to help determine the effectiveness of BMPs in reducing ground and surface water contamination. As BMPs are implemented, groundwater quality data would assess the effectiveness of the program in reducing pesticide levels. It is recommended that the agricultural community, Suffolk County and Cornell Cooperative Extension work together to install monitoring wells, and conduct targeted sampling, analysis and reporting to help assess the effectiveness of BMPs in reducing ground and surface water contamination from pesticide application.

Suffolk County is evaluating and updating the 2004 Suffolk County Agricultural Stewardship Program, to address current needs of the farming community and the County, including the need to protect the quality of the County's water resources, soil and natural habitats. The collaborative effort includes participants from the farming community as well as Suffolk County Department of Economic Development and Planning, SCDHS, the Peconic Estuary Program (PEP), Cornell Cooperative Extension of Suffolk County, SCWA, the Suffolk County Soil and Water Conservation District, NYSDEC, and the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS). The updated Program describes the need for collaborative cooperation to reduce pesticide loading from agriculture to the County's ground and surface water resources while maintaining a strong, viable agricultural industry. The primary goal of the program is to increase Suffolk County farmer completion of Tier III in the AEM program to at least 90 percent. The program will encourage participation by funding research to develop BMPs to reduce pesticide impacts, by providing educational programs to encourage implementation of pesticide reducing BMPs, and providing funding to continue to improve BMPs to reduce pesticide impacts.

As part of the Agricultural Stewardship Program, fifteen orchards are currently implementing integrated pest management plans.

3.3.6 Recommendations to Address Pharmaceuticals and Personal Care Products

New information is published nearly every day on the detection, fate and transport characteristics, or potential effects of one or another of the PPCPs. It is recommended that SCDHS continue to monitor the literature and regulatory initiatives concerning PPCPs, including research on:

- Development of methods (e.g., analytical techniques) to identify PPCPs at the very low concentrations expected in the environment, development of efficient methodologies to analyze mixtures of compounds, development of cost-effective analytical methods;
- Identification of priority or target compounds that can be used for rapid/cost effective screening for PPCPs;
- Fate of PPCPs in the environment (including subsurface environment/groundwater);
- Exposure;
- Effects of low levels of PPCPs on human health and the environment;
- Establishment of sensible analytical detection limits and treatment goals;
- Additive effects of PPCPs with similar modes of action, and finally
- Treatability.

It is just not possible to monitor for all of the contaminants of emerging concern (CECs), including PPCPs that could potentially be present in the environment, given that more than 88 million organic and inorganic chemicals have been registered with Chemical Abstracts Services, and thousands of new chemicals are listed each day. It should not be necessary to monitor for all of these parameters, however the subset of compounds with potential human-health impacts that ultimately should be monitored has not yet been identified. In addition, analytical methods to detect the extremely low levels of some PPCPs and their metabolites that may exist in the environment are not yet available. While analytical protocols to detect some PPCPs have been developed, cost effective methods to rapidly detect the presence of many of the other compounds that may be present have not.

SCDHS should continue to conduct targeted monitoring as summarized below:

- Increase the number of sample analyses available from the Public and Environmental Health Laboratory (PEHL) to analyze each sample from all community supply wells as part of annual facility inspections, as well as samples from non-community and the private drinking water wells;
- To the extent staffing permits, the PEHL should explore expansion of existing analytical methods to increase the number of PPCPs analyzed, particularly focusing on those already identified in our groundwater resources, summarized on **Table 3-29** below.
- Continue targeted monitoring, focusing on wells downgradient of laundromats, hospitals and nursing homes, using a similar approach to the focused plan implemented for the Pesticides Monitoring Program;

Table 3-29 Recommended New Analytes for SCDHS PEHL

PCCP	Use
Cotinine	Metabolite of nicotine
Diltiazem	Antihypertensive
Hydrochlorothiazide	Diuretic
Meprobamate	Anti-anxiety agent
Metropolol	Antihypertensive
Naproxen	Anti-inflammatory
4-Nonylphenol	Surfactant, known estrogen disruptor
Phenobarbital	Barbituate
Sulfamethoxazole	Antibiotic
Tramadol	Analgesic
Tributyl phosphate (TBP)	Plasticizer and solvent
Triphenyl phosphate (TPP)	Plasticizer
Tri (2-butoxy-ethyl) phosphate (TBEP)	Plasticizer
Tri (2-chloro-ethyl) phosphate (TCEP)	Plasticizer and flame retardant
Tri (2-dichlorisopropyl) phosphate	Plasticizer, suspected estrogen disruptor

As of January 1, 2015, Suffolk County requires that public supply wells be tested for 1,4-dioxane (http://legis.suffolkcountyny.gov/Resos2014/i1334-14.pdf). A

new chemist will join the SCDHS PEHL to analyze samples for this contaminant.

SCDHS and SCWA are embarking on a cooperative agreement to expand monitoring of CECs to begin to immediately address this recommendation. Initially, SCWA will analyze approximately 50 SCDHS samples from small public supply and private wells for seven PPCPs and one CEC. This cooperative initiative will enable SCHDS to begin to assess the occurrence of these potential contaminants so that follow-up monitoring and management actions can be implemented, in cooperation with NYSDOH.

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, pharmaceuticals ingested by mammals are often excreted as the unaltered parent compound to only a small degree and 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). Thus in addition to studying the parent compound, it is necessary to examine the metabolic by-products of these compounds. For example, gemfibrozil, a lipid regulating pharmaceutical, is excreted mostly as the glucuronide conjugate, with less than 2% excreted as unchanged gemfibrozil (RxList, 2014).

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 a seemingly unsurmountable task.

With respect to monitoring for potential biological impacts, 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 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).

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 publicly 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 reduce 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).

In addition to monitoring, Suffolk County should continue to collaborate with water management colleagues and review the latest findings from other jurisdictions. Of equal importance, is continued public outreach and education efforts to encourage appropriate disposal of pharmaceuticals through take-back programs at pharmacies or other collection programs, such as "Operation Medicine Cabinet".

3.3.7 Recommendations – Wastewater Treatment

Sanitary wastewater management is one of the most significant issues facing Suffolk County in terms of groundwater resource protection in both existing developed areas and in currently undeveloped areas. Prior to development, precipitation falling on the ground surface recharged the aquifer system, and the recharged precipitation travelled down through the aquifer system to eventual discharge to fresh streams, intertidal areas, harbors, coastal embayments or other marine waters. Prior to extensive development, private wells were used to withdraw potable supply from the aquifer; most of the water withdrawn was returned to the aquifer system via on-site cesspools or septic systems. The sanitary wastewater introduced nitrogen and bacteria to the aquifer system, but this was successfully diluted by the greater volume of recharging precipitation and did not cause widespread impacts. Eventually, the sanitary wastewater recharged by more and more residents exceeded the assimilative capacity of the resource in densely developed areas, causing noticeable impacts to the aquifer, drinking water supply and surface water ecology, and prompting implementation of wastewater management measures.

Sanitary wastewater management options were implemented to protect the groundwater resource, as indicated by compliance with the 10 mg/L drinking water standard for nitrogen. As mentioned above, there are currently three sanitary wastewater management options utilized in Suffolk County – discharge to a centralized sewage collection and treatment system, discharge to an alternative community treatment system, and discharge to an on-site sanitary wastewater disposal via septic systems or cesspools in accordance with Article 6 density requirements.

Centralized sewage treatment and collection systems such as SWSD No. 3 were established to reduce levels of observed wastewater parameters in groundwater located beneath densely developed areas. Provision of a centralized sanitary wastewater collection and treatment is an effective way to reduce the impacts of development on ground and surface water features; conventional treatment schemes remove suspended solids, organic material, and deactivate pathogens via disinfection. More advanced treatment processes can be used to remove nutrients such as nitrogen to protect drinking water and prevent eutrophication and destruction of ecological communities. As previously described, nitrogen levels in sanitary wastewater vary considerably; typical secondary wastewater treatment processes reduce influent total nitrogen concentrations by 50 percent or less. Additional treatment processes utilized at biological nutrient removal (BNR) facilities can further reduce nitrogen levels to less than 10 mg/L, and sometimes to as low as 4 to 6 mg/L.

In addition to the significant economic costs associated with centralized sewage collection and treatment, there are other potential environmental impacts. For example, discharge of the treated effluent off-shore results in a net loss of water from the aquifer system that may have detrimental impacts on area streams, pond levels and wetlands as the elevation of the groundwater table declines and baseflow contributions are reduced. In addition, the energy requirements associated with operating a treatment plant, and treating and disposing of sludge, greatly exceed the requirements associated with passive on-site disposal systems, and conventional wastewater treatment does not address all contaminants of concern, such as some organics and PPCPs.

There are currently close to 200 of the alternative treatment systems permitted by SCDHS and NYSDEC that are in operation in the County today; these systems are required to meet effluent nitrogen limits of 10 mg/L. The effectiveness and utilization of alternative technologies has been widely considered in other coastal areas; most notably in Massachusetts at the Massachusetts Alternative Septic System Test Center (MASSTC), in Rhode Island, and in New Jersey. The MASSTC, a collaborative effort of the Massachusetts Office of Coastal Zone Management, the Barnstable County

Department of Health and the Environment, UMass Dartmouth School of Marine Science and Technology, Massachusetts Environmental Trust, and the Massachusetts Department of Environmental Protection, has studied the effectiveness of nitrogen removal of alternative systems for close to ten years. The results indicate a wide variety of effectiveness, and demonstrate that over half of the systems (referred to as innovative/alternative systems, or I/A systems) were not successful in consistently achieving the 19 mg/L state standard. The MASSTC work highlighted an important study conclusion: "Towns that contemplate the wide-scale use of I/A systems to address nutrient issues should understand that the oversight of operation and maintenance of I/A systems is an essential part of ensuring a level of success. Quite simply, I/A systems that are not regularly inspected and occasionally monitored will not achieve treatment objectives." (**Performance of Innovative Alternative Onsite Septic Systems for the Removal of Nitrogen in Barnstable County, Massachusetts, 1999-2007**). This finding is consistent with the experience of SCDHS OWM, as documented in the Task 5.2 memorandum (**Future Land Use Impacts**, CDM, 2008).

In 2007 and 2008, SCDHS OWM began to work even more closely with treatment plant owners and operators to improve facility operations, and a new policy requiring legal action and mandatory fines for violations was implemented. Effluent quality data available from 2008 showed that within that first year, treatment had improved such that nearly 70 percent of the plants had achieved the 10 mg/L discharge limit for nitrogen. SCDHS OWM is also revising Suffolk County Sanitary Code Article 7 Sewage or Industrial Waste Treatment Facilities Operation and Maintenance Standards. These revised standards, which will clearly define the increased responsibilities of plant operators, engineers, will help the County continue to improve treatment effectiveness and protect groundwater quality.

When effectively operated, these STPs successfully remove a significant nitrogen load from the County's groundwater. SCDHS estimated that the total flow currently discharged to groundwater from these STPs totals approximately 10.8 MGD and introduces less than 900 pounds of nitrogen per day to the aquifer. By comparison, if the areas served by these facilities were developed in accordance with Article 6 density limitations for use of on-site wastewater treatment systems, approximately 1,800 pounds of nitrogen, or double the cumulative STP load, would be discharged.

When successfully operated and maintained, these systems are, in many cases, capable of significantly reducing the nitrogen load to groundwater. However, they do require considerable operator attention to consistently and successfully operate, they require considerable SCDHS oversight, and they do

not necessarily remove all organics and PPCPs that may be contained in the effluent. Recognizing the impact that densely developed unsewered areas has on groundwater and surface water quality, Suffolk County has already begun to develop projects to reduce the impacts of sanitary wastewater disposal on groundwater. For example, as described above, SCDHS is conducting a study of alternative on-site sewage system technologies that could reliably reduce nitrogen levels to 10 mg/L for individual residences or smaller sub-divisions, to identify alternative systems that could provide viable, low cost systems to protect public health.

The last wastewater management alternative described above, on-site wastewater disposal systems, is currently utilized by approximately 74 percent of County residents. Septic systems are widely used throughout the world, they are passive systems that successfully reduce organic loading to the environment. However, reported nitrogen removal rates within household systems vary widely and are not always easy to assess. In fact, influent nitrogen concentrations are also highly variable, depending on factors such as number of loads of laundry being washed, number of showers taken, etc.

While some jurisdictions require frequent septic system pump out, this is primarily to prevent scum or solids overflow from clogging the leaching field. In fact, some research has shown that this practice can actually reduce the level of treatment provided within a properly sized tank, as it takes two to three years for microbe diversity to be established sufficiently for digestion. Hence, more frequent pump-outs should not be required for most properly designed and operating systems. In addition, existing wastewater treatment plants in the County currently do not have adequate capacity to accept the increased scavenger waste load that would be generated should pumping be required at the frequent intervals that are sometimes proposed. SCDHS Office of Wastewater Management should continue to monitor the literature and experience elsewhere in coastal areas, coordinate with SCDPW's scavenger wastewater treatment planning efforts and revisit this issue if new information becomes available.

SCDHS currently requires a three foot separation distance between high groundwater elevation and the bottom of a leaching pool (with limited exception in areas of shallow groundwater where two foot separations may be acceptable for systems with five leaching pools). SCDHS monitoring has shown that this separation has been adequate for conversion of ammonia to nitrate in the unsaturated aerobic zone. Considering the predicted impacts of increasing sea level, SCDHS will be required to address this issue, particularly in coastal areas, in the coming years as described further in Section 8. As described below, SCDHS should continue to monitor groundwater levels. Within the

context of an overall County planning effort to respond to rising sea levels, SCDHS will need to develop an approach to address wastewater management in areas where the separation distances are predicted to decline.

When properly sited (e.g., appropriate density), all three of these approaches are capable of enabling the groundwater resource to achieve the 10 mg/L groundwater standard for nitrate on a regional basis. However, lower nitrate levels in groundwater discharging to some surface waters may be required to meet water body-specific water quality and ecologic goals. Either nitrogen or phosphorus may be the limiting nutrient in a particular surface water body. In general, phosphorus is typically the limiting nutrient for algal growth and productivity in fresh water systems, and nitrogen is usually the limiting nutrient in marine water bodies. Like nitrogen, phosphorus may be introduced to the aquifer system by sanitary wastewater or by fertilization. Unlike nitrogen, dissolved phosphorus is more likely to sorb onto sediments, and is not as mobile. Therefore, most discussions of nutrient loads to surface waters from groundwater baseflows focus on nitrogen.

One of the most significant impacts of human development is discharge of toxic contaminants, including VOCs. As described above in Section 3.3.4, approximately 80 percent of the facilities in the SCDHS OPC database discharge to septic systems; approximately 20 percent are located within sewered areas. Nassau County reports a significant decline in VOC levels in groundwater over the past twenty years, which they attribute to the installation of sanitary sewers and other regulatory programs. The County reports that during the mid-1980s, VOCs exceeded 5 µg/L in 50 percent of raw water samples from both upper glacial and Magothy monitoring wells, while VOCs exceeded the 5 µg/L threshold in only 15 percent of samples collected from 2000 to 2003 (NCDPW, 2005). Nevertheless, while some level of VOC removal in the small sewage treatment plants can be expected, they are designed to provide treatment of sanitary wastewater rather than VOCs that may be introduced to the waste stream.

In addition to MTBE, PCE, TCE, and 1,1,1-TCA have been among the VOCs most frequently reported in Suffolk County groundwater and surface waters in recent years. All three have had industrial, commercial and household uses in the past. PCE, a cleaning agent used by over 80 percent of United States dry cleaners and in many household consumer products, is reportedly the most widely detected VOC in groundwater at Superfund sites. In the past, 1,1,1-TCA was used extensively in household products such as adhesives and adhesive cleaners, lubricants, general purpose liquid cleaners and spray degreasers, oven cleaners, spot removers, shoe polish, and fabric finishes; however, it is no longer used in common household products. Manufacture of 1,1,1-TCA after

January 1, 2002 was banned, due to its impact on the ozone layer. Groundwater quality data confirms that levels of 1,1,1-TCA and MTBE have indeed declined as a result of being banned. As a result of regulatory initiatives, and as manufacturers move towards 'greener' products and production alternatives, it is anticipated that potential sources of PCE and TCE will also be reduced.

Nevertheless, these, and other VOCs should be analyzed as part of the County's comprehensive data collection program in an effort to identify the major source(s) of these contaminants to the environment so that the most cost-effective approaches to reduce their release can be identified and implemented.

A comprehensive discussion of the County's expanded efforts to plan, develop and implement a wastewater management program to address nitrogen reduction needs is presented in Section 8 of this document.

3.4 Establishment/Enhancement of Groundwater Monitoring Programs

Monitoring the County's groundwater resource is an essential function in terms of protecting human health (e.g., compliance with MCLs or drinking water standards, early identification of contamination) that should not be compromised. Monitoring data also provides the information necessary to identify areas and/or contaminants of concern and to evaluate cause and effect relationships with respect to sources of contamination and resulting water quality. Summaries of the monitoring programs that should be continued and/or implemented are provided below.

Through the decades, SCDHS has implemented a number of County-wide and focused local groundwater monitoring programs to characterize water quality and water quantity for a wide variety of purposes. These programs have ranged from County-wide evaluations to site-specific investigations and have been implemented to respond to a wide variety of objectives, as indicated by the following examples:

- Monitoring groundwater levels to construct County-wide water table mappings used by builders for site plan development;
- Routine monitoring of water supply wells to confirm that public supplies are in compliance with applicable water quality standards;
- Regional assessments such as the study of groundwater levels and water quality within the SWSD to evaluate the impacts of sanitary sewering;

- Focused studies to assess the impacts of specific land use types such as the program exploring the impacts of vineyards and golf courses on pesticides levels, and
- Site-specific investigations at areas of known or suspected contaminant release to the environment.

Existing data collected over the years is sufficient to provide a baseline with which to track future trends for almost all water quality and water quantity parameters. A County-wide monitoring program should continue to be implemented to provide the data necessary to ably manage and protect the County's groundwater resource, and to assess the success of groundwater management programs.

In general, efficient and successful groundwater monitoring programs need to consider a number of factors, including:

- Aquifer thickness;
- Degree of aquifer confinement;
- Pumping intensity, screened interval and location;
- Aquifer properties; and
- Expected parameter variability.

Because the Suffolk County program is already well established, the recommendations below suggest a continuing program that is focused on the critical issues identified during this study, rather than a program design based on a goal of statistical extrapolation of limited results to the entire County.

Monitoring is broken into two sub-programs addressing water quality and water quantity.

3.4.1 Groundwater Quality Monitoring

The current condition of the aquifer system has been extensively documented through prior and on-going sampling programs that include routine monitoring of community water supply wells by individual water suppliers and the SCDHS, routine monitoring of non-community supply wells, targeted monitoring of private wells in areas of known or suspected contamination, and sampling and analysis of monitoring wells, primarily in areas of known or suspected contamination. Baseline values for a wide range of parameters have been developed, and contaminants of concern have been identified as described in the task 4.1 memorandum. Most PPCPs are not currently

monitored – and in fact, cannot be monitored at this time. There are potentially hundreds, if not thousands of PPCPs and their metabolites and breakdown products that may be released to the environment. Although not all are PPCPs, Chemical Abstracts Services reports that 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).

It should not be necessary to monitor for all of these parameters, however the subset of compounds with potential human-health impacts that ultimately should be monitored has not yet been identified. In addition, analytical methods to detect the extremely low levels of some PPCPs and their metabolites that may exist in the environment are not yet available. While analytical protocols to detect some PPCPs have been developed, cost effective methods to rapidly detect the presence of many of the other compounds that may be present have not. More information on potential monitoring approaches for PPCP was described in Section 3.3.5, above.

The primary objectives of an on-going water quality monitoring program are to:

- Continue to track and evaluate trends in key water quality parameters such as nitrates, VOCs and pesticides by comparing them to current conditions;
- Identify the main causes of any trends of deteriorating water quality;
- Characterize the extent of any contamination threatening drinking water supplies or downgradient surface water features; and
- Identify emerging contamination concerns and their sources.

It is recommended that this be accomplished by the continued use of data obtained from a variety of sources, including public supply well monitoring and monitoring well sampling and analysis, supplemented by the results of private well sampling and special studies, such as the on-going pesticides monitoring program. All samples should be analyzed for the comprehensive set of parameters that can be provided by the SCDHS PEHL, as summarized on **Table 3-30**. Proposed components of the program are summarized below.

3.4.1.1 Drinking Water Supply Well Monitoring

In accordance with the regulatory requirements of both the Safe Drinking Water Act and Part 5 of the New York State Sanitary Code, SCDHS requires all public suppliers to monitor source water. In general, sampling frequency varies

from quarterly to tri-annually, although suppliers such as the SCWA proactively sample more frequently and for more parameters than are required. The list of parameters is extensive, and includes inorganic compounds, principal organic contaminants, unspecified organic contaminants, and pesticides. The program is described in the Task 7.2 memorandum. SCDHS also monitors each community and non-community source (well) on an annual basis; the program includes testing for many contaminants of concern that do not currently have established drinking water quality criteria.

Because Suffolk County water suppliers obtain their supply from an aquifer overlain by the homes of some 1.5 million residents, it is recommended that SCDHS continue the current drinking water supply monitoring program that exceeds Federal and State monitoring requirements, to continue to ensure that safe potable water in compliance with all applicable criteria is provided to County residents.

Long term SCDHS monitoring data collected from approximately 941 public supply wells, as summarized on **Table 3-31**, provides a good regional perspective on water quality and water quality trends. The wells monitored vary from year to year, but in general provide a very good County-wide distribution of monitoring points. Overall, this component of the program would provide samples from hundreds of monitoring points, including 378 from the Magothy aquifer, the aquifer that provides the majority of the County's public supply. Because there is a long period of record of water quality data collected at public supply wells, it provides a valuable overview of water quality status and trends, allowing assessment of decade's long changes in water quality.

Groundwater quality data obtained from water supply wells can provide a very different representation of water quality than data obtained from monitoring wells. In general, the supply well screens are much longer (e.g., 50 feet or more) than monitoring well screens, and hence characterize a much greater zone within an aquifer. Supply wells withdraw water at a much greater rate than monitoring wells; the water is recharged over a much greater area, and consequently is more likely to reflect water quality from a variety of land use types than a monitoring well. Historical water quality data, as represented by samples from untreated public supply wells, has shown considerable variation over time at some wells (Task 4.1 Groundwater Quality) in response to variations in water supply pumping. In addition, public supply wells tend to be

SUFFOLK COUNTY DEPARTMENT OF HEALTH SERVICES - WATER ANALYSIS

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Location: 123 MAIN ST., HAUPPAUGE
Sample Location: TEST
Treatment: TEST

Request No.: PR14-0003
Sample Date: 12/15/2014
Sanitarian: SCDHS LABORATORY
Field No.: 001-777-14-12-15

Notes: '<' symbol means "less than" indicating no detection. mg/L = milligrams per liter; ug/L = micrograms per liter. Alkalinity is reported as mg/L as CaCO3. '*' symbol means level found exceeds the maximum contaminant level (MCL), or action level for lead and copper. Moderately restricted sodium diet should not exceed 270 mg/L. Severely restricted should not exceed 20 mg/L. The MCL for nickel is a proposed limit. Any MCL's not shown below have not been established.

		Result	MCL				Result	MCL	
===== Results for Sample Group: ALDICARB PESTICIDES analyzed by Suffolk County Department of Health Services =====									
Total Aldicarb (calc)	<	0.		ug/L	Carbaryl	<	0.5	50.00	ug/L
Aldicarb	<	0.5	3.00	ug/L	1-Naphthol	<	0.5	50.00	ug/L
Aldicarb-Sulfoxide	<	0.5	4.00	ug/L	Methomyl	<	0.5	50.00	ug/L
Aldicarb-Sulfone	<	0.5	2.00	ug/L	Propoxur (Baygon)	<	0.5	50.00	ug/L
Carbofuran	<	0.5	40.00	ug/L	Methiocarb	<	0.5	50.00	ug/L
3-Hydroxycarbofuran	<	0.5	50.00	ug/L	Methiocarb sulfone	<	0.5	50.00	ug/L
Oxamyl	<	0.5	50.00	ug/L					
===== Results for Sample Group: BACTERIOLOGICAL analyzed by Suffolk County Department of Health Services =====									
TColi	<	ABSENT	ABSENT		EColi	<	ABSENT	ABSENT	
===== Results for Sample Group: CHLORINATED PESTICIDES analyzed by Suffolk County Department of Health Services =====									
alpha-BHC	<	0.2	5.00	ug/L	4,4-DDD	<	0.2	5.00	ug/L
beta-BHC	<	0.2	5.00	ug/L	4,4-DDT	<	0.2	5.00	ug/L
gamma-BHC (Lindane)	<	0.02	0.20	ug/L	Endrin	<	0.01	2.00	ug/L
delta-BHC	<	0.2	5.00	ug/L	Endrin aldehyde	<	0.2	5.00	ug/L
Heptachlor	<	0.04	0.40	ug/L	Chlordane	<	0.2	2.00	ug/L
Heptachlor epoxide	<	0.02	0.20	ug/L	Alachlor	<	0.2	2.00	ug/L
Aldrin	<	0.2	5.00	ug/L	Methoxychlor	<	0.1	40.00	ug/L
Dieldrin	<	0.2	50.00	ug/L	Endosulfan II	<	0.2	5.00	ug/L
Endosulfan I	<	0.2	5.00	ug/L	Endosulfan Sulfate	<	0.2	50.00	ug/L
Dacthal	<	0.2	50.00	ug/L	1,2-dibromoethane	<	0.01	0.05	ug/L
4,4-DDE	<	0.2	50.00	ug/L	1,2-dibromo-3-chloropropane	<	0.02	0.20	ug/L
===== Results for Sample Group: DACTHAL PESTICIDES analyzed by Suffolk County Department of Health Services =====									
Monomethyltetrachloroterephthalate	<	5.	50.00	ug/L	Tetrachloroterephthalic acid	<	5.	50.00	ug/L
===== Results for Sample Group: HERBICIDE METABOLITES analyzed by Suffolk County Department of Health Services =====									
Didealkylatrazine (G-28273)	<	0.8	50.00	ug/L	Dichlorvos	<	0.6	50.00	ug/L
Deisopropylatrazine (G-28279)	<	0.2	50.00	ug/L	Propamocarb hydrochloride	<	0.3	50.00	ug/L
Desethylatrazine (G-30033)	<	0.4	50.00	ug/L	2,6-Dichlorobenzamide	<	0.5	50.00	ug/L
Imidacloprid	<	0.2	50.00	ug/L	Ibuprofen	<	0.2	50.00	ug/L
Imidacloprid Urea	<	0.2	50.00	ug/L	Gemfibrozil	<	0.4	50.00	ug/L
Alachlor OA (Oxanilic Acid)	<	0.4	50.00	ug/L	Metalaxyl	<	0.2	50.00	ug/L
Alachlor ESA (Sulfonic Acid)	<	0.2	50.00	ug/L	Metolachlor	<	0.2	50.00	ug/L
Metolachlor metabolite (CGA-37735)	<	0.2	50.00	ug/L	Tebuthiuron	<	0.3	50.00	ug/L
Metolachlor OA (CGA-51202)	<	0.3	50.00	ug/L	Caffeine	<	0.2	50.00	ug/L
Metolachlor ESA (CGA-354743)	<	0.3	50.00	ug/L	Dinoseb	<	0.3	7.00	ug/L
Metolachlor metabolite (CGA-41638)	<	0.3	50.00	ug/L	Bisphenol A	<	0.2	50.00	ug/L
Metolachlor metabolite (CGA-40172)	<	0.3	50.00	ug/L	Diuron	<	0.2	50.00	ug/L
Metolachlor metabolite (CGA-67125)	<	0.3	50.00	ug/L	Phenytoin (Dilantin)	<	0.2	50.00	ug/L
2-HydroxyAtrazine (G-34048)	<	0.3	50.00	ug/L	4-Hydroxyphenytoin	<	0.5	50.00	ug/L
Malaoxon	<	0.2	50.00	ug/L	Diethyltoluamide (DEET)	<	0.2	50.00	ug/L
Trichlorfon	<	0.3	50.00	ug/L	Acetaminophen	<	0.2	50.00	ug/L
Siduron	<	0.3	50.00	ug/L					
===== Results for Sample Group: METALS analyzed by Suffolk County Department of Health Services =====									
Beryllium (Be)	<	0.2	4.00	ug/L	Cadmium (Cd)	<	1.	5.00	ug/L
Aluminum (Al)	<	5.		ug/L	Antimony (Sb)	<	0.2	6.00	ug/L
Titanium (Ti)	<	1.		ug/L	Tellurium	<	0.5		ug/L
Vanadium (V)	<	1.		ug/L	Barium (Ba)	<	1.	2000.00	ug/L
Chromium (Cr)	<	1.	100.00	ug/L	Mercury (Hg)	<	0.3	2.00	ug/L
Manganese (Mn)	<	0.001	0.30	mg/L	Thallium (Tl)	<	0.2	2.00	ug/L
Cobalt (Co)	<	1.		ug/L	Lead (Pb)	<	1.	15.00	ug/L
Nickel (Ni)	<	0.2	100.00	ug/L	Thorium (Th)	<	2.		ug/L
Copper (Cu)	<	5.	1300.00	ug/L	Uranium	<	0.5	30.00	ug/L
Zinc (Zn)	<	5.	5000.00	ug/L	Calcium	<	0.1		mg/L
Germanium	<	0.5		ug/L	Iron (Fe)	<	0.1	0.30	mg/L
Arsenic (As)	<	1.	10.00	ug/L	Iron + Manganese (Combined, Calc)	<	0.	0.50	mg/L
Selenium (Se)	<	1.	50.00	ug/L	Potassium	<	0.1		mg/L
Strontium	<	1.		ug/L	Magnesium	<	0.1		mg/L
Molybdenum (Mo)	<	1.		ug/L	Sodium (Na)	<	1.		mg/L
Silver (Ag)	<	2.5	100.00	ug/L					
===== Results for Sample Group: PERCHLORATE analyzed by Suffolk County Department of Health Services =====									
Perchlorate	<	0.2	18.00	ug/L					
===== Results for Sample Group: RADIOLOGICAL analyzed by Suffolk County Department of Health Services =====									
Gross alpha	<	1.	15.00	pCi/L	Tritium	<	200.	20000	pCi/L
Gross beta	<	1.	50.00	pCi/L					

RESULTS CONTINUED ON NEXT PAGE....

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Location: 123 MAIN ST., HAUPPAUGE
Sample Location: TEST
Treatment: TEST

Request No.: PR14-0003
Sample Date: 12/15/2014
Sanitarian: SCDHS LABORATORY
Field No.: 001-777-14-12-15

Notes: '<' symbol means "less than" indicating no detection. mg/L = milligrams per liter; ug/L = micrograms per liter. Alkalinity is reported as mg/L as CaCO3. '*' symbol means level found exceeds the maximum contaminant level (MCL), or action level for lead and copper. Moderately restricted sodium diet should not exceed 270 mg/L. Severely restricted should not exceed 20 mg/L. The MCL for nickel is a proposed limit. Any MCL's not shown below have not been established.

RESULTS CONTINUED FROM PRECEDING PAGE

===== Results for Sample Group: STANDARD INORGANICS analyzed by Suffolk County Department of Health Services =====

		Result	MCL	
pH-Lab	=		su	
Specific Conductivity-Lab	=		um/cm	
Chloride (Cl)	<	3.	250.00	mg/L
Sulfate (SO4)	<	5.	250.00	mg/L
Ammonia (NH3-N)	<	0.5		mg/L
Nitrite (NO2-N)	<	0.1	1.00	mg/L
Nitrate	<	0.5	10.00	mg/L
Bromide	<	0.5		mg/L
Orthophosphate	<	0.5		mg/L
Fluoride	<	0.2	2.20	mg/L
T. Alkalinity	<	1.		mg/L
Hexavalent Chromium	<	0.03		ug/L

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===== Results for Sample Group: SEMI-VOLATILE ORGANICS METHOD 525 analyzed by Suffolk County Department of Health Services =======

		Result	MCL	
1,2,4 Trichlorobenzene	<	0.2	5.00	ug/L
1-Methylnaphthalene	<	0.2	50.00	ug/L
2-Methylnapthalene	<	0.2	50.00	ug/L
Acenaphthene	<	0.2	50.00	ug/L
Acenaphthylene	<	0.2	50.00	ug/L
Acetochlor	<	0.2	50.00	ug/L
Alachlor	<	0.2	2.00	ug/L
Allethrin	<	0.2	50.00	ug/L
Anthracene	<	0.5	50.00	ug/L
Atrazine	<	0.1	3.00	ug/L
Azoxystrobin	<	0.2	50.00	ug/L
Benfluralin	<	0.5	50.00	ug/L
Benzo(A)Anthracene	<	0.5	50.00	ug/L
Benzo(B)Fluoranthene	<	0.2	50.00	ug/L
Benzo(GHI)Perylene	<	0.2	50.00	ug/L
Benzo(K)Fluoranthene	<	0.2	50.00	ug/L
Benzo(A)Pyrene	<	0.02	0.20	ug/L
Benzophenone	<	0.2	50.00	ug/L
Benzyl butyl phthalate	<	0.2	50.00	ug/L
Bis(2-ethylhexyl)adipate	<	0.5	50.00	ug/L
Bis(2-ethylhexyl)phthalate	<	3.	6.00	ug/L
Bisphenol A	<	0.5	50.00	ug/L
Bloc	<	0.2	50.00	ug/L
Bromacil	<	0.5	50.00	ug/L
Butachlor	<	0.2	50.00	ug/L
Butylated hydroxyanisole	<	1.	50.00	ug/L
Butylated hydroxytoluene	<	0.5	50.00	ug/L
Carbamazepine	<	0.5	50.00	ug/L
Carbazole	<	0.2	50.00	ug/L
Carisoprodol	<	0.5	50.00	ug/L
Chlordane	<	0.2	2.00	ug/L
Chlorofenvinphos	<	0.2	50.00	ug/L
Chlorothalonil	<	1.	50.00	ug/L
Chloroxylenol	<	0.2	50.00	ug/L
Chlorpyriphos	<	0.2	50.00	ug/L
Chrysene	<	0.2	50.00	ug/L
Cyfluthrin	<	0.2	50.00	ug/L
Cypermethrin	<	0.5	50.00	ug/L
Dacthal	<	0.2	50.00	ug/L
Deltamethrin	<	0.5	50.00	ug/L
Dibenzo(A,H)Anthracene	<	0.2	50.00	ug/L
Dibutyl Phthalate	<	1.	50.00	ug/L
Dichlobenil	<	0.2	50.00	ug/L
Dichlorvos	<	0.5	50.00	ug/L
Dieldrin	<	0.2	50.00	ug/L
Diethyl phthalate	<	1.	50.00	ug/L
Diethyltoluamide (DEET)	<	0.2	50.00	ug/L
Dimethyl phthalate	<	0.2	50.00	ug/L
Dioctyl Phthalate	<	0.2	50.00	ug/L
Disulfoton	<	0.5	50.00	ug/L
Disulfoton sulfone	<	0.2	50.00	ug/L
Endosulfan Sulfate	<	0.2	50.00	ug/L
EPTC	<	0.2	50.00	ug/L
Ethofumesate	<	0.2	50.00	ug/L
Ethyl Parathion	<	0.2	50.00	ug/L
Fluoranthene	<	0.2	50.00	ug/L
Fluorene	<	0.2	50.00	ug/L
Hexachlorobenzene	<	0.1	1.00	ug/L
Hexachlorobutadiene	<	0.2	5.00	ug/L
Hexachlorocyclopentadiene	<	0.1	5.00	ug/L
Hexachloroethane	<	1.	5.00	ug/L
Hexazinone	<	1.	50.00	ug/L
Indeno(1,2,3-cd)Pyrene	<	0.2	50.00	ug/L
Iodofenphos	<	0.2	50.00	ug/L
Iprodione	<	0.5	50.00	ug/L
Isofenphos	<	0.5	50.00	ug/L
Kelthane	<	0.5	50.00	ug/L
Malathion	<	0.5	50.00	ug/L
Metalaxyl	<	0.2	50.00	ug/L
Methoprene	<	0.2	50.00	ug/L
Methoxychlor	<	0.1	50.00	ug/L
Methyl Parathion	<	0.2	50.00	ug/L
Metolachlor	<	0.2	50.00	ug/L
Metribuzin	<	0.2	50.00	ug/L
Naled (Dibrom)	<	0.2	50.00	ug/L
Naphthalene	<	0.2	50.00	ug/L
Napropamide	<	0.2	50.00	ug/L
Pendimethalin	<	0.2	5.00	ug/L
Pentachlorobenzene	<	0.2	50.00	ug/L
Pentachloronitrobenzene	<	0.2	50.00	ug/L
Permethrin	<	0.2	50.00	ug/L
Phenanthrene	<	0.2	50.00	ug/L
Piperonyl butoxide	<	0.5	50.00	ug/L
Prometon	<	0.5	50.00	ug/L
Prometryne	<	0.2	50.00	ug/L
Propachlor	<	0.2	50.00	ug/L
Propiconazole (Tilt)	<	0.2	50.00	ug/L
Pyrene	<	0.5	50.00	ug/L
Resmethrin	<	0.2	50.00	ug/L
Ronstar	<	0.2	50.00	ug/L
Simazine	<	0.07	4.00	ug/L
Sumithrin	<	0.2	50.00	ug/L
Tebuthiuron	<	0.5	50.00	ug/L
Terbacil	<	0.5	50.00	ug/L
Triadimefon	<	0.5	50.00	ug/L
Triclosan	<	0.5	50.00	ug/L
Trifluralin	<	0.5	50.00	ug/L
Vinclozolin	<	0.5	50.00	ug/L
Total Triazines + Metabolites (Calc)	<	0.	4.00	ug/L

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===== Results for Sample Group: SURFACTANTS analyzed by Suffolk County Department of Health Services =====

Surfactants-MBAS	<	0.1	mg/L

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RESULTS CONTINUED ON NEXT PAGE....

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RESULTS CONTINUED FROM PRECEDING PAGE

===== Results for Sample Group: VOLATILE ORGANICS analyzed by Suffolk County Department of Health Services =====

		Result	MCL				Result	MCL	
Chlorodifluoromethane	<	0.5	5.00	ug/L	Ethylbenzene	<	0.5	5.00	ug/L
Dichlorodifluoromethane	<	0.5	5.00	ug/L	o-Xylene	<	0.5	5.00	ug/L
Chloroethane	<	0.5	5.00	ug/L	m & p-Xylene	<	0.5	5.00	ug/L
Bromomethane	<	0.5	5.00	ug/L	m-Xylene	<	0.5	5.00	ug/L
Chloromethane	<	0.5	5.00	ug/L	p-Xylene	<	0.5	5.00	ug/L
Trichlorofluoromethane	<	0.5	5.00	ug/L	Total Xylenes	<	0.5	5.00	ug/L
Vinyl Chloride	<	0.5	2.00	ug/L	2-Chlorotoluene	<	0.5	5.00	ug/L
Methylene Chloride	<	0.5	5.00	ug/L	3-Chlorotoluene	<	0.5	5.00	ug/L
1,1 Dichloroethane	<	0.5	5.00	ug/L	4-Chlorotoluene	<	0.5	5.00	ug/L
trans 1,2 Dichloroethene	<	0.5	5.00	ug/L	Diethyl Ether	<	0.5	50.00	ug/L
Chloroform	<	0.5	80.00	ug/L	Acrylonitrile	<	0.5	5.00	ug/L
1,2 Dichloroethane	<	0.5	5.00	ug/L	Ethyl Methacrylate	<	0.5	50.00	ug/L
1,1,1 Trichloroethane	<	0.5	5.00	ug/L	T. Chlorotoluene	<	0.5	5.00	ug/L
Carbon Tetrachloride	<	0.5	5.00	ug/L	1,3,5 Trimethylbenzene	<	0.5	5.00	ug/L
1-Bromo-2-Chloroethane	<	0.5	5.00	ug/L	1,2,4 Trimethylbenzene	<	0.5	5.00	ug/L
1,2 Dichloropropane	<	0.5	5.00	ug/L	m,p-Dichlorobenzene	<	0.5	5.00	ug/L
Trichloroethene	<	0.5	5.00	ug/L	1,2 Dichlorobenzene (o)	<	0.5	5.00	ug/L
Chlorodibromomethane	<	0.5	80.00	ug/L	1,3-Dichlorobenzene (m)	<	0.5	5.00	ug/L
2-Bromo-1-Chloropropane	<	0.5	5.00	ug/L	1,4-Dichlorobenzene (p)	<	0.5	5.00	ug/L
Bromoform	<	0.5	80.00	ug/L	p-Diethylbenzene	<	0.5	5.00	ug/L
Tetrachloroethene	<	0.5	5.00	ug/L	1,2,4,5 Tetramethylbenzene	<	0.5	5.00	ug/L
cis-1,2-Dichloroethene	<	0.5	5.00	ug/L	1,2,4 Trichlorobenzene	<	0.5	5.00	ug/L
Freon 113	<	0.5	5.00	ug/L	1,2,3 Trichlorobenzene	<	0.5	5.00	ug/L
Dibromomethane	<	0.5	5.00	ug/L	Ethenylbenzene (Styrene)	<	0.5	5.00	ug/L
1,1 Dichloropropene	<	0.5	5.00	ug/L	Isopropylbenzene	<	0.5	5.00	ug/L
Methyl Isothiocyanate	<	2.	50.00	ug/L	n-Propylbenzene	<	0.5	5.00	ug/L
Carbon Disulfide	<	0.5		ug/L	tert-Butylbenzene	<	0.5	5.00	ug/L
Methyl Methacrylate	<	0.5	50.00	ug/L	sec-Butylbenzene	<	0.5	5.00	ug/L
n-Propane	<	2.	50.00	ug/L	p-Isopropyltoluene	<	0.5	5.00	ug/L
1,1 Dichloroethene	<	0.5	5.00	ug/L	n-Butylbenzene	<	0.5	5.00	ug/L
Bromodichloromethane	<	0.5	80.00	ug/L	Hexachlorobutadiene	<	0.5	5.00	ug/L
2,3 Dichloropropene	<	0.5	5.00	ug/L	Methyl-Tert-Butyl-Ether (MTBE)	<	0.5	10.00	ug/L
cis-1,3-Dichloropropene	<	0.5	5.00	ug/L	Naphthalene	<	0.5	50.00	ug/L
trans-1,3-Dichloropropene	<	0.5	5.00	ug/L	1,4-Dichlorobutane	<	0.5	5.00	ug/L
1,1,2 Trichloroethane	<	0.5	5.00	ug/L	Methyl Sulfide	<	0.5	50.00	ug/L
1,1,1,2 Tetrachloroethane	<	0.5	5.00	ug/L	Dimethyldisulfide	<	0.5	50.00	ug/L
1,1,2,2-Tetrachloroethane	<	0.5	5.00	ug/L	Bromobenzene	<	0.5	5.00	ug/L
1,2,3 Trichloropropane	<	0.5	5.00	ug/L	2-Butanone (MEK)	<	20.	50.00	ug/L
2,2 Dichloropropane	<	0.5	5.00	ug/L	Tetrahydrofuran	<	20.	50.00	ug/L
1,3 Dichloropropane	<	0.5	5.00	ug/L	Allyl chloride	<	0.5	5.00	ug/L
Bromochloromethane	<	0.5	5.00	ug/L	Methacrylonitrile	<	0.5	5.00	ug/L
tert-Butyl-Ethyl-Ether	<	0.5	50.00	ug/L	d-Limonene	<	0.5	50.00	ug/L
tert-Amyl-Methyl-Ether	<	0.5	50.00	ug/L	Propanal	<	15.	50.00	ug/L
Benzene	<	0.5	5.00	ug/L	Isobutane	<	2.	50.00	ug/L
Toluene	<	0.5	5.00	ug/L	n-Butane	<	2.	50.00	ug/L
Chlorobenzene	<	0.5	5.00	ug/L					

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Table 3-31 Public Supply Well Monitoring Points

Town	Community Wells[1]			Non-Community Wells[2]			Total
	Upper Glacial	Magothy	Lloyd	Upper Glacial	Magothy	Lloyd	
Babylon	3	64	0	3	0	0	**70**
Brookhaven	79	110	0	13	0	0	**202**
East Hampton	43	5	0	15	0	0	**63**
Huntington	43	58[3]	5	0	0	0	**106**
Islip	14	87	0	0	0	0	**101**
Riverhead	10	14	0	1	0	0	**25**
Shelter Island	13	0	0	11	0	0	**24**
Smithtown	15	42	0	0	0	0	**57**
Southampto n	52	24	0	10	0	0	**86**
Southold	54	4	0	11	0	0	**69**
Total	**326**	**408**	**5**	**64**	**0**	**0**	**803**

Notes:
1. Based on wells with nitrogen samples from 2009-2014 in the SCDHS Blacksmith Database, 2014. Not all wells are/were active as of 2014.
2. Based on non-community supply wells in Blacksmith database sampled for nitrogen between 2009-2014.
3. Three wells are designated as being screened into the Raritan, as per SCWA.

sited in areas where good water quality is expected, to minimize any public health concerns and to minimize treatment costs. An assessment of water quality based completely upon untreated samples from public supply wells therefore does not provide a complete picture of aquifer water quality, and it is also important to characterize aquifer conditions based on discrete samples collected from monitoring wells, as described below.

3.4.1.2 Countywide Groundwater Quality Trend Monitoring

Until 1996, SCDHS sampled more than 500 monitoring wells on an annual basis as part of a countywide water quality monitoring program. In recent years, this program has been significantly curtailed due to budget and staffing constraints. It is recommended that this program be resumed, albeit on a more limited basis consistent with available resources, to support the objectives of tracking countywide and aquifer-wide trends in key water quality parameters.

The wells should be distributed throughout the County, considering:

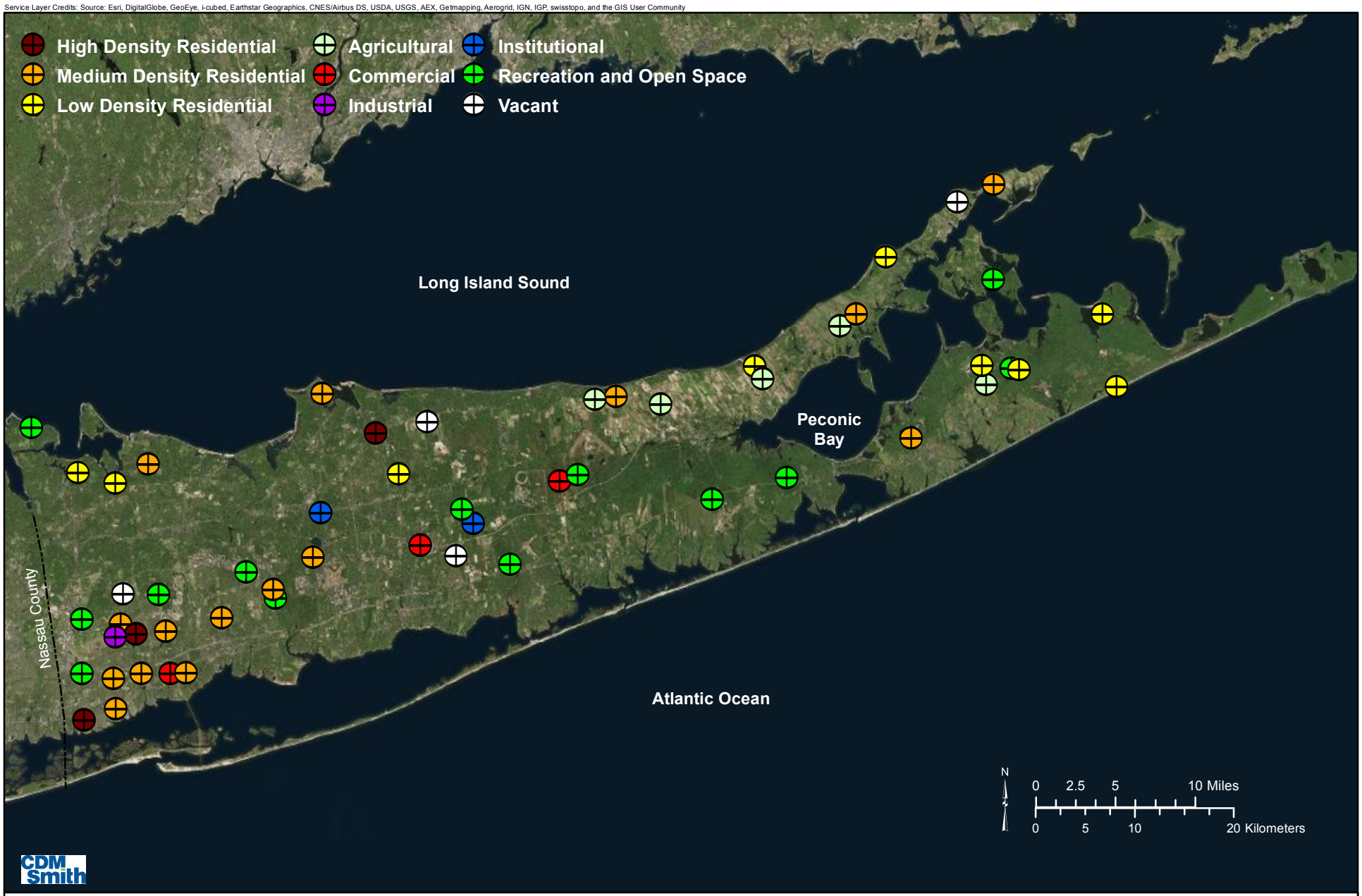
- Greater coverage in areas of greatest use;
- Coverage downgradient of each of the major land use categories;
- At least three wells on the North Fork, three wells on the South Fork, and three wells on Shelter Island;
- Selection of wells that already have a reasonably long sampling history.

The USGS National Water Quality Assessment Program recommends that a minimum of 20 to 30 wells per aquifer or one well per 100 square kilometers is needed to track regional trends in groundwater quality. Given the size of Suffolk County, this would mean at least 60 wells within each of the three major aquifers (Upper Glacial, Magothy, and Lloyd).

Given the current distribution of public supply wells in the County, it is recommended that a monitoring network including sixty wells in the upper glacial aquifer, and approximately a dozen existing wells in the Magothy aquifer be used to supplement the water quality data that SCDHS obtains from the community supply wells on an annual basis, as shown on **Figure 3-49**. The shallow upper glacial aquifer is the first to be affected by contaminants introduced at the ground surface; water quality in the unconfined aquifer presages future water quality of the deeper aquifers. Therefore the greatest number of monitoring wells is proposed for the upper glacial aquifer.

The Lloyd Aquifer is confined by the Raritan Clay, and water supply pumping is limited to water withdrawn from seven wells located in the northwest part of the County. While monitoring the Lloyd aquifer would provide valuable information on the state of the resource, it is not currently one of the highest monitoring priorities. Should the SCWA begin to utilize water from the Lloyd aquifer in the future, a more extensive Lloyd monitoring network should be established at that time.

SCDHS maintains a well drilling crew and equipment that is capable of installing monitoring wells of various depths throughout the County, installing wells and evaluating groundwater quality in offshore areas using an offshore barge that has a mounted Geoprobe unit, and applying all associated Geoprobe tools (geophysics through the resistivity probe, monitoring of VOCs through the membrane interface probe (MIP), etc.). In addition, the SCDHS has their own geophysical tools, including gamma logging capability to evaluate stratigraphy and induction logging to evaluate the location of the saltwater interface in coastal regions.



Land Use and Monitoring Wells

Suffolk County Comprehensive Water Resources Management Plan

Figure 3-49

It is recommended that SCDHS consider addition of new monitoring points in uncharacterized zones of the deeper aquifers, such as coastal areas of the north shore, and the Magothy and Lloyd aquifers on the south shore, as time and resources allow. Comprehensive sampling of the wells identified on **Figure 3-49** and **Table 3-31** should occur on an annual basis. The upper glacial wells have been selected to be generally consistent with the percentage of each major land use type present in Suffolk County at this time, as summarized on **Table 3-32**. This sampling should be further coordinated with the surface water monitoring described in Section 5. All samples should be analyzed by the SCDHS Public and Environmental Health Laboratory, for the list of contaminants identified in **Table 3-30**, above.

3.4.1.3 Saltwater Intrusion Monitoring

There are several areas of potential saltwater intrusion, primarily located on the North and South Forks, on Shelter Island, and in other coastal areas of the North Shore. In addition, the saltwater interface in the Magothy aquifer along the south shore is currently located offshore south of the barrier island. The saltwater interface is believed to be slowly moving northward as a result of the long term increase in sea level over the past 18,000 years, as the system moves towards a new equilibrium.

Saltwater intrusion is a relatively slow moving occurrence, with rates of advance generally in the tens of feet per year. The slow advance, combined with the relatively sharp transition from saltwater to fresh water, makes tracking the advance particularly challenging. For most SCWA well locations, upconing is also an important consideration. As of 2014, SCWA closely monitors wells at thirteen wellfields for chlorides and/or specific conductance; these results are reported to NYSDEC.

It is recommended that SCDHS site two saltwater intrusion outpost wells in each of the areas of potential future saltwater intrusion, with one or more wells located as close to the current position of the zone of transition as possible, and one situated between the nearest public supply or group of private wells and the estimated position of the saltwater – fresh water interface. Saltwater intrusion monitoring wells should be constructed of PVC, to allow electromagnetic induction logging along the entire casing to identify any zones of saltwater intrusion. The wells should be screened near the bottom of the aquifer being monitored.

In-situ measurements of specific conductance at saltwater interface sentinel wells using instruments such as the Solinst Levelogger® and associated telemetry system or equivalent would provide useful and timely information relating any movement of the saltwater interface in response to increased

water supply or irrigation pumping to allow for prompt response if appropriate. Alternatively, sampling could be conducted on a quarterly basis, with all samples analyzed for chlorides.

Table 3-32 Monitoring Wells and Suffolk County Land Uses

Land Use Type	Number of Monitoring Wells	Well List (NYSDEC ID or "S-Number")
Low Density Residential	**9**	*1512, 45053, 46962, 48438, 48580, 51582, 58961, 61015, 78170*
Medium Density Residential	**15**	*22660, 45212, 46284, 51578, 52649, 53329, 56347, 62405, 63811, 63823, 64202, 64212, 64853, 66580, 92395*
High Density Residential	**3**	*47974, 56350, 64216*
Commercial/Industrial/Utilities	**4**	*47226, 47756, 64535, 67539*
Institutional	**2**	*47675, 62404*
Open Space	**13**	*43811, 43820, 45718, 47224, 47228, 47232, 48437, 48583, 66134, 67553, 69934, 75441, 92403*
Agriculture	**5**	*10390, 48426, 51567, 51580, 71573*
Vacant	**6**	*47746, 47976,67538, 72782*

Looking ahead to the future, airborne electromagnetic (AEM) geophysics is a relatively new technique that has been used to identify saltwater intrusion in freshwater coastal aquifers in Australia and Italy. Airborne electromagnetics

can increase the data quality and coverage of the occurrence of saline groundwater in tidal and coastal areas, lagoons, estuaries, and river deltas while reducing the acquisition costs and time. The application of airborne electromagnetics for groundwater monitoring and modeling has increased in the past decade due to better systems and processing and inversion methodologies. Airborne electromagnetic systems have increased their penetrating power and their data quality, and application to depths below 300 feet exist (Viezzoli et al, 2009). To date, no successful applications have been identified in the United States, and little about its applicability in developed areas with surface interference has been published. The development and application of Airborne Electromagnetics technology to regional saltwater intrusion studies should be tracked, as it could have potential application for the North and South Forks.

3.4.1.4 Special Studies Monitoring

The County-wide groundwater quality trend monitoring program described above should be kept completely separate from monitoring associated with known or expected areas of contamination so that regional trends, or broader relationships between land use and water quality can be better established. For areas that have been identified as areas of concern, targeted monitoring programs should be established or continued. Wells associated with these areas should have a different identifier, and sampling should be targeted to the specific contaminants that are associated with each area.

Special studies areas are described in more detail below.

Agricultural Area Monitoring – Agricultural monitoring would be primarily focused on the forks. The existing network of shallow monitoring wells in Aquebogue, Jamesport, Orient, Sagaponack and Water Mill that have been sampled on a quarterly basis for nitrates since March 2003 should continue to be sampled and analyzed in March, June, September and December. In addition to nitrates and pesticides, the crop(s) planted in the upgradient fields should be noted during the growing season sampling events, as nutrient requirements and downgradient nitrogen levels are known to be crop-specific. This sampling will be important to assess the effectiveness of AEM programs, and to identify any additional nitrogen and pesticide control needs.

These wells can overlap with the regional water quality network of wells. The number of agricultural wells used in the regional quality study should be limited to approximately five, to maintain the same ratio of agricultural wells to total wells sampled as the ratio of agricultural land use to total land area.

Pesticides Monitoring **–** Pesticides monitoring should continue in accordance with the existing on-going program to continue to monitor levels of pesticides and their degradates in the environment, and to assess any trends resulting from changes in pesticides used, changes in pesticide application resulting from BMP implementation and relationships between crop types and pesticide detections.

Industrial Areas and WWTP Discharge Areas - There have been numerous site investigations associated with known releases of contamination to groundwater. These investigations are designed to identify and map contaminant plumes with the goal of identifying potentially impacted water supplies, and developing remediation strategies to protect public health. The wells installed and sampled as part of these site investigations should not be part of the overall County monitoring program. The results of water quality sampling of wells that are monitored as part of on-going investigations and remedial efforts should be reported to SCDHS DEQ OWR for incorporation into the database.

In other areas where contaminant levels are higher than background and cause for concern, up to three wells specific to each area should be identified and sampled annually. Wells should be located considering the contributing areas of the nearest public supply wells to provide a network of early warning wells where appropriate; well siting should also consider location with respect to facilities identified as "high" priority by SCDHS OPC. Wells associated with investigation of these contaminant areas should be flagged with a separate well identifier from the Countywide monitoring well system.

Based on current land use in the County, only a single well would be included in the set of wells used for regional water quality evaluations, to maintain the same ratio of industrial area wells to total wells sampled as the ratio of industrial land use to total land area in the County.

3.4.1.5 Summary

An overview of a minimum proposed monitoring program is presented here. The monitoring program should be developed in more detail by review of historical monitoring data and assessment of continued well accessibility and integrity. SCDHS should replace wells that are not readily accessible, and wells that do not have significant periods of record with wells within the contributing area of the same land use type that have longer periods of record.

3.4.2 Groundwater Quantity Monitoring

Suffolk County historically has had a very strong water level monitoring program in cooperation with the USGS. This has allowed production of

detailed water level contour maps for the upper glacial aquifer. To assess trends in water quantity, it is important to continue to measure water levels on an annual basis. When combined with stream baseflow measurements, a complete picture of water quantity trends can be documented each year.

3.4.2.1 Water Levels

In the past, quarterly water level sampling was conducted to track seasonal changes as well as annual trends in water levels. This study has shown that consumptive use of water in Suffolk County is relatively low when compared to the amount of water recharged and the extent and depth of the aquifer system. It is, therefore, not necessary to maintain quarterly water level readings for the complete monitoring well network. Currently, SCDHS collects a synoptic set of water level readings from 300 wells each year in March, in coordination with the USGS taking water levels in 125 wells. This program should be continued. Wells in the network that have the longest record of water level readings should be included in particular.

SCDHS should use this information to confirm the continued ability of the groundwater models to reliably represent conditions in the aquifer system. Then, based upon historical precipitation events, the model should be used to simulate the water table elevation resulting from a period of wetter than average non-growing season conditions. This predicted seasonal high water table mapping, supplemented by the required on-site boring information, can then be used by the Office of Wastewater Management as they conduct site plan reviews. In conjunction with groundwater modeling efforts, this data should be utilized to support evaluation of localized flooding in areas such as Lake Ronkonkoma.

3.4.3 Data Management and Reporting

As a minimum, all drinking water, ground water quality and quantity and surface water quality and quantity information should be entered into a new integrated database. Field data should be entered via portable hand held devices (e.g.; tablet such as an iPad or other mobile device) to reduce the time needed for transcription, data entry and data availability. Field and laboratory data should be regularly reviewed after routine uploading. SCDHS DEQ OWR should be responsible for maintaining this database. This database would comprise a portion of the proposed Capital Project 4081, the Environmental Health Information Management System (EHIMS) described by SCDHS that would encompass all of the Environmental Health programs. In addition to the groundwater, surface water and drinking water supply data, the database would incorporate data currently located within 30 different databases, including:

- Community, Non-Community and Bottled Water Supply Plant Inspections
- Private Well Inspection and Sampling
- Groundwater Pollution Investigations and Sampling
- Community Water Supply Plan Review
- Bathing Beaches
- Individual Water and Sewer Construction Plan Review
- Reality Subdivision Water and Sewer Plan Review
- State Pollutant Discharge Elimination System (SPDES)
- Sewage Treatment Plant Monitoring
- Petroleum Bulk Storage Tank Plan Review Inspection and Registration
- Enforcing Toxic and Hazardous Materials Storage regulations, which involve plan review, inspection and permitting of commercial and industrial facilities
- Sampling of Marine and Surface Waters for Chemical, Bacteriological and Algal Quality
- Environmental Remediation
- Public and Environmental Health Laboratory (PEHL) Laboratory Information Management System data integration with water quality databases
- State Environmental Quality Review (SEQR) Reviews

Integration of all of the existing databases addressing water quality and water quantity, as well as the factors affecting water quality and water quantity (e.g., facilities, spills, etc.) into a single database that could be viewed using a GIS interface would provide a number of benefits. For example, all of the datasets could be accessed by any user, instead of limiting access to an individual or group with access to and knowledge of a particular type of software; information currently residing within different databases could be mapped simultaneously to help assess water resource implications, and the data back-

up would protect against the impacts of any hardware malfunctions (e.g., individual personal computer failure) or facility disaster (e.g., paper records).

Alternatively, it could be part of a larger, comprehensive Countywide database as recommended by IBM's Smarter Cities Challenge Report. The data would be readily available to all departments within the County to help to identify public health concerns and water resources issues, to identify appropriate management actions, to assess priorities and guide decision making. This data would be readily accessible so that queries relating to ground or surface water quality or data trends can be readily answered, issues can be rapidly and appropriately addressed, and the County can have the information to develop responses to long range concerns such as sea level rise. Finally, the data should be made available to other stakeholders outside the County such as SCWA, NYSDEC, the estuary programs, etc., so that timely decisions can be made based on the best available information.

It is recommended that SCDHS prepare a concise annual report summarizing the results of the countywide groundwater and surface water quality and quantity monitoring.

The report should contain, at a minimum, the following information:

- Background information on precipitation over the sampling period;
- Water supply pumping from each of the major water use categories, and monthly pumping from community supplies;
- Mapping of ground water levels, and figures depicting baseflow and stream flow; figures showing groundwater baseflow as a percentage of total stream flow;
- "Dot plot" type graphics depicting countywide water quality within each aquifer for each parameter of concern (e.g., nitrates, most often detected VOCs, pesticides, PPCPs);
- Statistics on water quality comparing annual water quality with baseline (1987, 2005 and 2013) years (baseline year dependent upon parameter of concern);
- Trend graphs of contaminants of concern for selected indicator wells, as well as trends in the minimum, mean, and maximum concentrations from all the wells;
- Water level graphs of selected indicator wells showing trends;

- Saltwater interface monitoring results depicting chloride concentrations with time;
- Results of nitrogen and pesticide analyses in monitoring wells characterizing agricultural areas;
- Identification of any newly observed contaminants of concern for future targeting;
- Tables summarizing surface water quality data identifying any contaminants of concern identified;
- Figures depicting trends in nitrate concentrations at sampling stations in the Long Island Sound, Peconic Estuary and South Shore Estuary; and
- Tables summarizing water quality data at the estuary program sampling locations and figures showing time histories of nitrogen and dissolved oxygen at key estuary program sampling locations.

In addition, each document should identify the apparent most significant issues affecting the resource and identify any additional priorities for monitoring and/or research.

Over the years, new monitoring tools and improved analytical capabilities have facilitated the identification of increasing numbers of contaminants in the environment, and the presence of these constituents can be detected at lower and lower concentrations. In addition, new tools and more powerful computer capabilities have facilitated the synthesis of various types of data and information (e.g., GIS information, groundwater modeling output and groundwater quality data for example) and are conducive to presentation of data and results in comprehensive graphical representations, which are more robust and much faster to produce than in years past. The need to utilize and enhance the ability to use, analyze and share data within a GIS framework has previously been documented in the draft 2010 Comprehensive Water Resource Management Plan and supporting task memoranda going back as far as 2008.

As appropriate, the data should be used to update the groundwater models, and for model application to:

- Support site investigations;
- Evaluate impacts of changing conditions (e.g., simulation of the impacts of sea level rise on the water levels and the saltwater

interface, simulation of the impact of drought on water levels, stream base flows and saltwater interfaces);

- Evaluate remedial alternatives;
- Delineate source water areas for new or proposed wells;
- Assess the impacts of proposed developments on downgradient water quality, in accordance with the procedure documented in the Task 5.2 memorandum (Future Land Use Impacts, CDM 2008).

It is presumed that the County would assign a groundwater model caretaker (it would be appropriate for this professional to be assigned to SCDHS DEQ OWR) who would also review the modeling section of any reports (e.g., remedial investigations/feasibility studies, remedial design reports, etc.) submitted for County review. A single individual would fulfill both the model caretaker function and would support other on-going County programs. A brief summary of the model revisions and subsequent verification of the model calibration should be prepared for incorporation into the annual groundwater and surface water quality report. The monitoring report should be distributed to other County agencies, NYSDEC, SCWA and water suppliers to support their resources management efforts and should also be made available electronically via the Suffolk County website.

3.5 Public Outreach and Education

Because Suffolk County residents live within the recharge areas for all of the public supply wells and surface water resources, it is critical that all take an active role in protecting these resources. A wide variety of public education and outreach programs are already in place at the federal, state, County and local levels to address topics such as stormwater pollution, lawn fertilization, conservation, proper use and disposal of hazardous household wastes and pharmaceuticals and personal care products, etc. However, the slow increase in nitrate levels in our aquifers, the continued detection of low levels of various contaminants in the ground and surface waters and the increasing demands upon the water supply infrastructure for landscape irrigation indicates that a more assertive effort is required.

A report prepared in 2005 by the National Environmental Education & Training Foundation (NEETF) entitled **Environmental Literacy in America** reported that 78 percent of the American public does not understand that runoff from agricultural land, roads, and lawns is now the most common source of water pollution and nearly half of Americans (47 percent) believes that industry accounts for most water pollution. Similar questions were posed

to residents of the Long Island Sound watershed as part of a survey conducted in 2006 by the Stony Brook University Center for Survey Research as part of a USEPA grant. The results were analyzed by resident location; 49 percent of Long Island respondents believed that waste dumped by factories is the main source of water pollution. The role of personal responsibility and environmental stewardship needs to be emphasized in the County's public outreach efforts, given our dependence on our groundwater supply, and the significance of our surface waters must be more widely conveyed.

The Task 10 memorandum described a number of existing and overlapping public education programs, and identified a variety of potential enhancements. Overall, the existing programs are reaching a very small percentage of the County's 1.5 million residents. The IBM Smarter Cities Challenge Report (IBM, 2014) also identified the need for the County to engage County residents and visitors to embrace their role as stewards of water quality and motivating them to take action. A more ambitious approach is required and recommended here.

It is recommended that the SCDHS re-establish their public outreach and education program. The coordinator should work closely with the Suffolk County Department of Public Works (SCDPW, stormwater program), the SCDEE (fertilization program), the water suppliers (conservation programs), the Long Island Sound (LIS), Peconic Estuary Program (PEP) and South Shore Estuary Reserve (SSER) program coordinators, and the Towns (Stop Throwing Out Pollutants, STOP), to identify opportunities to leverage outreach opportunities and venues and coordinate water resources protection messages. Development of a school-based program is recommended to reach hundreds of thousands of residents annually. Members of this target audience will bring the message home to their families to further disseminate the information and hopefully motivate broad-based changes in behavior throughout the County. As the students themselves age, the information will be part of the knowledge base that motivates their behavior.

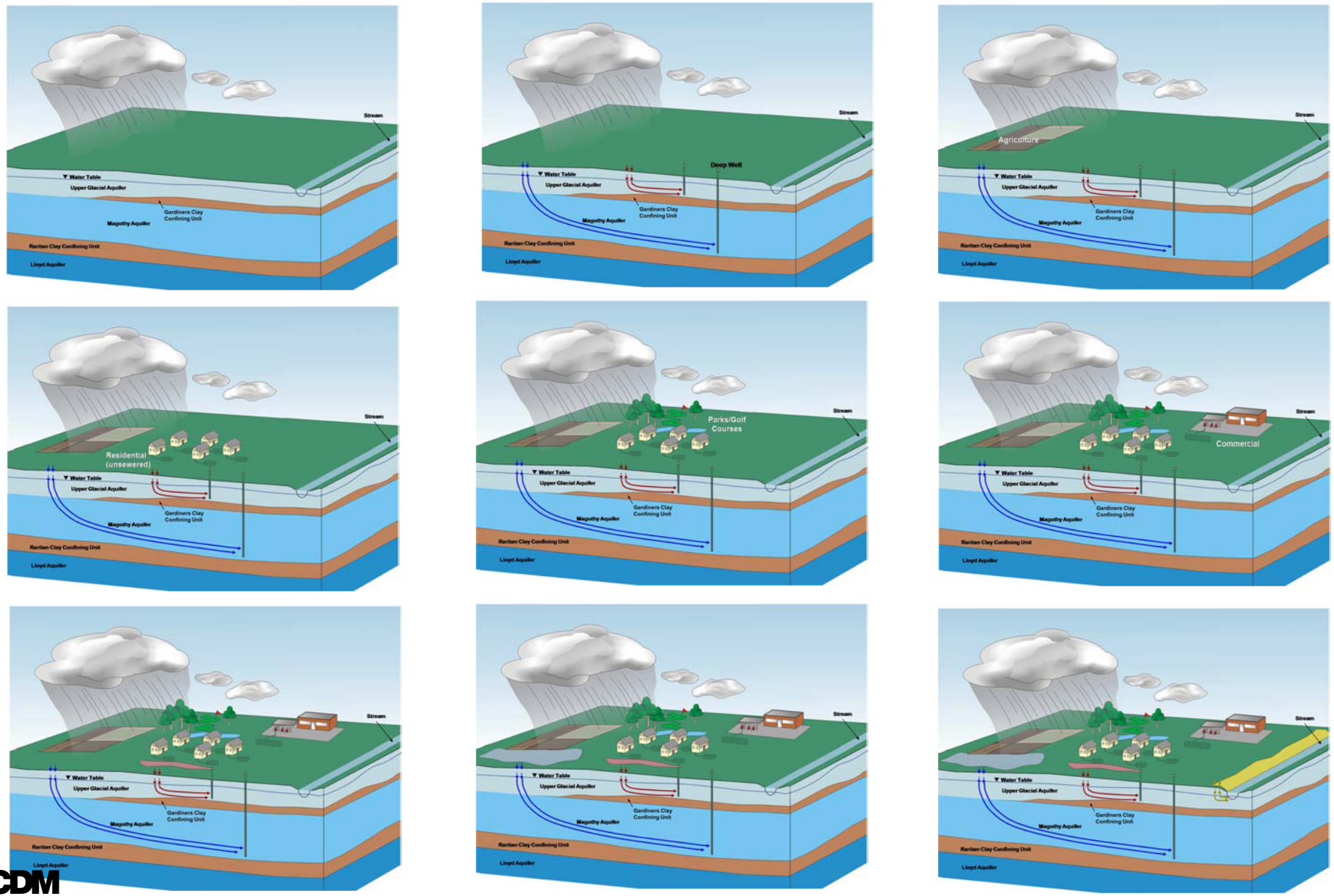
Initially, a series of at least three lesson plans (for primary school, middle school and Earth Science target audiences) should be prepared and provided to all school districts in the County, either for integration into the science curriculum, or for delivery on Earth Day. The 45-minute sessions could be developed using materials already available at http://www.epa.gov/epahome/students.htm ,http://water.usgs.gov/education.html, http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=browse&Rbutton=detail&bmp=8&minmeasure=1), http://www.classroomearth.org, the National Environmental Education Foundation website (http://neefusa.org/programs/classroom_earth.htm), the Water Environment

Federation website or estuary program websites such as longislandsoundstudy.net. Materials obtained from these websites could also be modified to PowerPoint-based presentations using Suffolk County-specific materials. An example simple set of PowerPoint slides that could be used to introduce the County's source of potable water, how human activity can impact groundwater quality, and groundwater's contribution to stream baseflow is provided by **Figure 3-50**.

Each year's lesson should begin with a brief 'quiz' or survey to assess both the knowledge and the behavior of the student with respect to water resources. The knowledge assessment portion of the survey would include questions such as "Where do you get your water from?" the behavior assessment section of the survey would pose questions such as "How often do you clean up after your dog?" and "Do you water your lawn every day?" Survey questions should be grade-appropriate.

The lesson plans should address:

- Overview of the importance of clean water;
- Overview of Suffolk County water supply, the Suffolk County aquifer system and water cycle;
- Overview of the County's surface water resources;
- Example of how above-ground activities affect groundwater quality and surface water quality, including introduction to stormwater runoff and wastewater disposal;
- Identification of specific actions that students and their families should take to protect and preserve ground and surface water resources;
- Visual aids and discussion opportunities – students respond better to seeing things/stories than words on paper;
- Use of hands-on activities, including lab or field work if possible to engage the students; and
- Hands-on homework, such as identifying the nearest storm drain to their home, or completing one of the on-line activities on the USEPA website.



CDM

Sample Power Point Lesson:
Potential Groundwater Pathways to Supply Wells & Surface Waters

Suffolk County Comprehensive Water Resources Management Plan

Figure 3-50

Classes should close with another quiz or survey. While the knowledge assessment would remain the same as prior to the lesson, to assess how effectively the lesson was in communicating the material to the students, the behavior assessment would be slightly different than the pre-lesson assessment. The post-lesson behavior questions would be posed as "how likely are you to clean up after your dog?" and "how often will you water your lawn?"

Both the pre-lesson and post-lesson survey should be comprised of multiple choice questions (e.g. how often do you clean up after your dog would be answered all of the time, most of the time, some of the time, hardly ever, or never) so that they can be readily scored. The results should be compiled on a grade and district basis, and forwarded to the County's public education coordinator.

The survey results should be monitored to assess the program's success, to identify the knowledge base of each age group, to identify existing behavior's contributing to pollution, and to modify subsequent year's messages to achieve the desired outcomes.

3.6 Summary of Recommendations

Groundwater management recommendations are summarized on **Table 3-33.**

Table 3-33 Groundwater Protection Recommendations

Table 3- 33
Groundwater Protection Recommendations

Undeveloped Areas

Within the existing Suffolk County Open Space Preservation planning context, parcels within the 50 year contributing area to public supply wells should be identified and assigned a high priority for purchase, particularly when there is a significant opportunity to protect and preserve existing groundwater quality.

Consider modifying Article 6 to require one acre density throughout all hydrogeologic zones, *unless* provision is made for a higher level of treatment than is provided by a typical on-site wastewater treatment system, or, the development rights from existing undeveloped open space controlled by the developer are transferred, in accordance with SCDHS standards. This would be subject to a zone-specific evaluation considering the extent and location of affected areas, resulting benefits, and costs in relation to other management alternatives.

SCDHS TDR standards should be re-evaluated to ensure protection of areas contributing recharge to public supply wells. Development rights should not generally be transferred into a public supply well contributing area without a local offset; and no more than two dwelling units per acre should be considered unless provision is made for a higher level of treatment than is provided by a typical on-site wastewater treatment system.

Existing Developed Areas (*Wastewater Management Recommendations are Described in More Detail in Section 8 of this Document)*

SCDPW should complete the alternative on-site wastewater management system pilot program and develop a range of approvable advanced alternative on-site wastewater treatment options for residential and non-residential applications.

The results of SCDHS and SPDPW wastewater management studies should be used along with the GIS-mappings of areas contributing recharge to public supply wells and relationships between density and nitrate levels developed during this study in a County-wide wastewater planning study that considers density, conventional and alternative wastewater treatment collection and treatment systems, alternative on-site systems, and operational and maintenance guidelines for existing on-site systems. Any additional high priority areas within the County where a new approach to wastewater treatment and disposal is required to achieve groundwater quality criteria for nitrates should be identified.

SCDHS OWM should continue to maintain active involvement with small sewage treatment plant system manufacturers, owners and operators, to maintain compliance with 10 mg/L nitrate effluent limits.

The effectiveness of Local Law 41-2007 in reducing groundwater nitrogen levels should be carefully evaluated and documented. If it does not achieve the objective of reducing fertilization by 10 to 25 percent, Peconic Estuary Program fertilization recommendations should be implemented on a County-wide basis.

Farmers that participate in County preservation programs, purchase of development rights, and other programs should be encouraged to participate, by agreement, in the AEM program and implement BMPs to reduce nitrogen release to groundwaters.

Table 3- 33 (Continued)
Groundwater Protection Recommendations

VOC Reductions

The SCDHS Office of Pollution Control should continue to implement the VOC Action Plan, to identify and inspect high priority facilities, initiate enforcement actions to bring non-compliant facilities into compliance and implement clean-up activities as necessary. Inspection priorities should be reassessed annually.

The SCDHS OPC Reducing Toxics Capital Program should be implemented to develop an approach to prioritize inspection of facilities using, storing or disposing of regulated contaminants, inspect the facilities in accordance with the established approach, and initiate enforcement and clean-up activities. Inspection of facilities within the 50-year source water area of supply wells with high or very high susceptibility to VOC impacts should be prioritized.

The SCDHS should continue to identify the sources of observed VOC contamination, identify source reductions and investigate the role of household products. If residential areas are identified as significant sources, the County should respond by:

- Incorporating information on the types of household products that may contain VOCs, and preferred alternatives into the education and outreach program
- Increasing awareness of and participation in Town STOP programs
- Identifying viable alternatives to harmful products and incorporating information on appropriate use and disposal of household products using VOCs into the public education and outreach and school curricula development programs

Pesticides

The County should work with NYSDEC to develop a comprehensive pesticide management strategy, including establishment of a pesticide rating/testing system guiding registration and re-registration.

The County should continue to update the Agricultural Stewardship Program.

Farmers that participate in County preservation programs, purchase of development rights, and other programs should be encouraged to participate, by agreement, in the AEM program and implement BMPs to reduce pesticide release to groundwaters.

Alternative pest management approaches or products should be identified to provide the agricultural community with safer alternatives to protect both groundwater quality and crops.

Outreach and education should be conducted to increase public and commercial applicator awareness of pesticide impacts and encourage use of safer replacements when possible.

Table 3-33 (Continued)
Groundwater Protection Recommendations

Pharmaceuticals and Personal Care Products

Existing PEHL analytical methods should be expanded to include the PPCPs cotinine, diltiazem, hydrochlorothiazide, meprobamate, metropolol, naproxen, 4-nonylphenol, phenobarbital, sulfamethoxazole, tramadol, Tributylphosphate (TBP), Triphenylphosphate (TPP), Tri (2-butoxy-ethyl) phosphate (TBEP), Tri (2-chloro-ethyl) phosphate (TCEP), Tri (2-dichloroisopropyl) phosphate (TDPP) and the Ames test.

A targeted monitoring program, possibly focusing on wells downgradient of laundromats, hospitals and nursing homes, should be conducted to assess the level and extent of any PPCP contamination using a similar approach as developed for the Pesticides Monitoring Program.

Findings from other jurisdictions should be reviewed and assessed to guide water management and policy decisions.

Public outreach and education efforts encouraging appropriate disposal of pharmaceuticals should be continued.

Groundwater Monitoring Programs

The existing Drinking Water Supply Well Monitoring program should be continued.

The Countywide groundwater quality trend monitoring program should be reinstated to assess trends, provide early warning of water quality concerns, and assess Plan effectiveness in improving groundwater quality.

Saltwater intrusion monitoring should be initiated to identify any impacts of water supply or irrigation pumping, drought, or sea level rise on the saltwater interfaces.

The existing Agricultural Area Monitoring program should be continued.

A targeted program of monitoring industrial areas and sewage treatment plant discharge areas should be implemented to better quantify the impacts of these land use types and wastewater management alternatives upon groundwater quality.

The existing cooperative annual water level monitoring program with USGS should be continued to assess trends in water levels and identify any flooding, drought and sea level rise impacts. The predicted high water table should be modeled.

Table 3-33 (Continued)
Groundwater Protection Recommendations

Database Development and Reporting
A new user-friendly, integrated geo-spatially referenced database should be developed to include all well, pumping, water quality, facility and discharge information so that data can be readily accessed and shared with stakeholders. This comprehensive database should be integrated with surface water data and wastewater management data (inspection records, discharge monitoring reports, on-site wastewater management systems).

Annual reports on groundwater quality should be published.

Health impacts of closed sites with groundwater contamination should be re-evaluated considering the vapor pathway.

SCHDS should use new data to update the County's groundwater models, apply the models to evaluate water resources issues, update the Source Water Assessment Evaluations (SWAP) as appropriate and share the results with stakeholders by incorporation into the annual water quality reports.

Public Outreach and Education
Suffolk County should coordinate with federal, state and local stakeholders, the three estuary programs and water suppliers to leverage public education and outreach concerning water resources protection, non-point sources, conservation, household hazardous waste, PPCPs, fertilization, etc. The County should work with Suffolk County schools to integrate specific lesson plans into Earth Day and Earth Science curricula throughout the County.

3.7 Implementation

3.7.1 Implementation Framework

The framework for implementation of the groundwater resource management recommendations is included in Section 9. The recommendations are intended to provide the framework to guide groundwater quality protection in the years ahead, within the context of adaptive management. **Table 9-1** identifies the "owner", or entity responsible for initiating and coordinating implementation of each key milestone that must be achieved or action that must be taken to fully implement each recommendation, along with other stakeholders or collaborators whose participation will be required. The time frame for implementation of each recommendation is identified as short term (less than five years), medium (five to ten years) or long term (over ten years). Successful implementation of each recommendation is subject to a variety of variables, including funding availability, as well as other factors that will influence the timing of implementation, or even whether the recommendation can be fully implemented (e.g., community support). Most of the key activities associated with protection of groundwater quality have already been initiated.

It is the County's intention that this table provide a flexible framework to guide water resource management, acknowledging that implementation of each recommendation is likely to be affected by changing priorities and opportunities and the availability of key resources, including funding.

The recommendations to improve groundwater quality will also support the ability to provide a safe and reliable potable supply to Suffolk County residents (please see Section 4). Because the County's surface waters are groundwater fed, implementation of recommendations to improve groundwater quality will also help to improve surface water quality (please see Section 5). Recommendations to implement wastewater management are explained in detail in Section 8 and a complete set of recommendations may be found in Section 9 of this Plan. There are numerous direct and indirect costs and benefits associated with various Plan recommendations. A comprehensive analysis of these costs and benefits was out of the scope of this Plan, and should be further explored as implementation of individual recommendations is considered, to the extent practicable.

Clean potable water supply and sanitation are often cited as the most important needs in developing countries and as the most effective means of protecting public health. Due to the efforts of water resource managers on federal, state, county and local levels, Suffolk County residents have access to both. It is critical that County residents do not take access to a safe, reliable supply of clean water for granted; it will continue to be

available only to the extent that existing regulations are enforced and enhanced as necessary to protect the aquifer from contamination.

When the British Medical Journal polled experts in 1999 about what they considered to be the greatest medical advance since 1840 (the year the Journal's precursor began publishing), the majority picked public sanitation, ranking it above both antibiotics and anesthesia. "Without a doubt, the widespread adoption of sanitation systems and indoor plumbing in the early 20th century was the most significant innovation in nearly doubling the average lifespan of Europeans and Americans, rapidly decreasing deadly diseases and creating a healthier, more comfortable living environment for the modern world" and "Experts in the early 1900s estimated that public sanitation systems saved thousands, perhaps millions of lives by preventing the spread of infectious diseases" (Hutchinson, 1999). Johan P Mackenbach, professor of public health at the University Medical Center Rotterdam in the Netherlands quantified the benefits of public supply and sanitation in that country, "In the Netherlands .... the first large municipality with piped drinking water was Amsterdam (1854) .... by the end of the century around 40 percent of Dutch people had piped drinking water, and in the early 20th century sewerage systems covered more than half the population. Between 1870 and 1970 age standardised mortality in the Netherlands fell by almost 75 percent. "

The cost to Suffolk County associated with implementation of the groundwater resource management recommendations will be primarily associated with:

- Implementing the sewering and on-site wastewater management programs described further in Section 8 of this document
- Continuing to fill vacant positions/restoring positions within the County to fully implement the VOC Action Plan and Reducing Toxics programs, and pesticide and PPCP initiatives as well as enhancement of existing monitoring programs in response to changing needs and priorities (e.g., increase the analyses that can be performed by the PEHL) and
- Funding Capital Project 4081 to establish and implement an integrated data management program, to:
  - Improve efficiency and effectiveness;
  - Enhance collaboration with other stakeholders
  - Support public outreach and education opportunities.

Full implementation of Plan goals is a long-term process, which will need to be accomplished in phases. It will require coordination and collaboration with agencies and organizations on the federal, state, county and local level, a careful reevaluation of resource allocation issues, and will also necessitate exploring grant opportunities and other innovative and alternative funding mechanisms. Suffolk County should continue to work with state and federal agencies and stakeholders to explore implementation options to cost-effectively execute Plan recommendations.

Water quality management includes water quality protection through improved methods of collecting, organizing, evaluating and communicating data and facility inspections to County water resource managers and to other agencies and water purveyors. Prevention of releases of contamination to groundwater by improved and more efficient inspection, record keeping and communication helps to preserve the integrity of the aquifer through prevention of contaminant releases.

Protecting the resource by prevention of contaminant releases is typically much more cost effective than the cost of clean-up or the cost of a lost resource.

Protecting the resource by prevention of contaminant releases is typically much more cost effective than the cost of clean-up or the cost of a lost resource. EPA has documented the average cost of clean-ups of a variety of types of contaminated sites, ranging from the least costly category, underground storage tanks at $125,000/site, to drycleaners at $403,000/facility, through Manufactured Gas Plants (MGPs) whose clean-ups typically range from $3M to $10M/site to RCRA corrective actions that averaged $11.4M/facility. The average cost of operating a pump and treat system to remediate a DNAPL site was reported as $10M (EPA, 2004). Given the number of these sites that are undergoing cleanup in Suffolk County (over 100 listed Superfund sites, and over 200 sites remediated annually under SCDHS oversight, avoiding Superfund listing), the above remediation costs are clearly well in excess of the costs of programs targeted at prevention and management.

From a strictly economic viewpoint, it is clear that investment in the resources to inspect, monitor and regulate facilities with the potential to introduce contamination to the environment will reduce the need to spend significantly more funds to remediate a site and/or mitigate impacts.

SCDHS's well drilling crew's ability to respond quickly and effectively to well drilling needs has enabled them to support groundwater projects for a variety of cooperators, including:

- Cornell Cooperative Extension
- New York State Department of Environmental Conservation
- New York State Department of Health
- Peconic Estuary Program
- Riverhead Water Authority
- Southampton University
- Suffolk County Department of Parks
- Suffolk County Department of Public Works
- Suffolk County District Attorney's office
- Suffolk County Water Authority
- SUNY at Stony Brook
- Town of Islip
- Town of Shelter Island
- Town of Southampton
- United States Department of Agriculture
- United States Drug Enforcement Agency
- United States Environmental Protection Agency
- United States Geological Survey

The County's ability to mobilize quickly and investigate the impacts of contaminant releases in a timely manner provides a significant public health benefit.

3.7.2 Implementation Responsibilities

Responsibilities for many of the groundwater resources management activities identified are currently shared by a number of agencies, on the federal, regional, state, county, town and local levels as previously documented in the Task 2.1, 2.2, 2.3 memorandum. Suffolk County has the authority to implement many of the groundwater protection recommendations identified in Section 9 and most of the groundwater protection recommendations would be implemented by SCDHS, SCDEDP and SCDPW. Other key collaborators who will support implementation efforts include SCWA, USEPA, USGS, NYSDOH, NYSDEC, Towns, Estuary programs and Cornell Cooperative Extension of Suffolk County.

Water quality data shows that groundwater quality has continued to decline despite management efforts on the federal, state, county and local levels, indicating that additional efforts and continued vigilance will be essential to protect and preserve the resources for continued use and enjoyment by future generations. It is essential that the County take a long term view with respect to water resource protection, as there will be no quick-fix solutions available if the current trends are permitted to continue.

With the regulatory authority provided in the Suffolk County Sanitary Code, SCDHS currently has the primary responsibility for implementing most of the recommendations identified. The IBM Smarter Cities Report has recommended that water resource management responsibilities be centralized under a single coordinator. While many other agencies share responsibility for various aspects of water resources management, continue to play very significant roles in water resource protection, and may administer similar overlapping programs, it is recommended that a single agency have primary responsibility for program coordination. Clearly defined roles and responsibilities will help to ensure that the work is completed as required to protect the County's water resources. SCDHS has an established framework for groundwater monitoring and data collection, regulatory authority to monitor drinking water supplies and potential point sources of contamination, and the capability of using powerful tools such as computer models and GIS to evaluate most contemporary water resources issues.

Nearly all of the proposed groundwater resource management recommendations are targeted to begin implementation in the short term; e.g., within five years. In fact, the County has already initiated many key actions (e.g., initiating identification and piloting of alternative on-site wastewater treatment systems). Nevertheless, full implementation of groundwater resources management recommendations is likely to take decades, and will also be contingent upon available resources.

Nonetheless, all agencies involved with water resources management must be responsible for sharing the information and the results of their evaluations to inform and guide programs being implemented under the auspices of County agencies, State and Federal regulators, Town and village governments, and water suppliers. Ready access to accurate information is increasingly important given the ramifications of land use and policy decisions that rely upon accurate and timely data and data interpretation.

3.7.3 Assessment Monitoring

Implementation monitoring has two objectives:

- To monitor implementation of the Plan recommendations, and
- To monitor the effectiveness of the Plan recommendations in achieving the Plan goals and objectives.

Specific groundwater management recommendations generally fall into one of

Implementation of the recommendation identified in the framework will be monitored. Monitoring has two objectives:

- To monitor implementation of the Plan recommendations, and
- To monitor the effectiveness of the Plan recommendations in achieving the Plan goals and objectives.

It is important to monitor the effectiveness of the Plan recommendations in achieving the stated goals and objectives, focusing on measures of progress that are quantifiable; the USEPA has reported that if indicators cannot be measured, then it is not possible to identify progress towards achieving goals. The effectiveness of these recommendations in achieving water resource protection goals and objectives will be assessed according to key performance indicators, summarized in **Appendix K**.

Annual monitoring of Plan effectiveness and early assessments of Plan effectiveness will allow the County to modify their approach within an adaptive management framework and make improvements as necessary – ineffective actions and programs should be discarded and those recommendations that are most effective can be further enhanced.

Well Number: **S-109750**

Owner (Purveyor): SCWA
Owner's Well Designation (Local #): 1
Location (Site Name): LANDSCAPE DRIVE
Town: Babylon
Screened Interval (MSL): -571.7 To -632.2
Aquifer: Magothy
Depth (ft below ground surface): 814
Simulated Pumping Rate (gpm): 325.3193
Minimum Time of Travel (Yrs): 34.4
Subgrids used in Model: 5

Table S-109750-1: Land Use Summary

Land Use Type	Land Use Area (Acres) in Time Of Travel							
	2	5	25	50	75	100	Total	%
Institutional Sewered				1.84	0.03	0.00	1.87	0.5
Institutional Unsewered					11.24	17.07	28.32	8.3
Low Density Residential Sewered				11.74	2.08	0.00	13.82	4.1
Low Density Residential Unsewered				7.62	73.47	0.40	81.48	23.9
Medium Density Residential Sewered				76.82	11.30	0.00	88.11	25.9
Medium Density Residential Unsewered				9.43	24.43	26.44	60.30	17.7
Open Space				11.63	9.73	33.03	54.38	16.0
Transportation				3.17	3.20	5.86	12.23	3.6
Totals				**122.24**	**135.47**	**82.80**	**340.51**	

Table S-109750-1A: Contaminant Prevalence Summary By Land Use

Contaminant Category	By Land Use				
	2	5	25	75	100
Nitrates					M
Pesticides				L	L
VOCs					L

Table S-109750-2: Potential Point Sources of Contamination

Source Type	# of Sources in Time Of Travel						
	2	5	25	50	75	100	Total
Petroleum Bulk Storage Facility				1			1
Totals				**1**			**1**

Table S-109750-2: Potential Point Sources of Contamination (Contd.)

Time Of Travel (Years): **50**

State ID #	Type	City	Zip
	PBSF	Huntington	

Table S-109750-3: Contaminant Prevalence Summary

Contaminant Category	By Land Use					By Point Source					Combined				
	2	5	25	75	100	2	5	25	75	100	2	5	25	75	100
Nitrates					M					L					M
Pesticides				L	L				L	N				L	L
VOCs					L					H					H

Table S-109750-4: Well Sensitivity

Contaminant Category	Sensitivity				
	2	5	25	75	100
Microbials	H	M	L		
Nitrates					H
Pesticides			H	M	L
VOCs					H

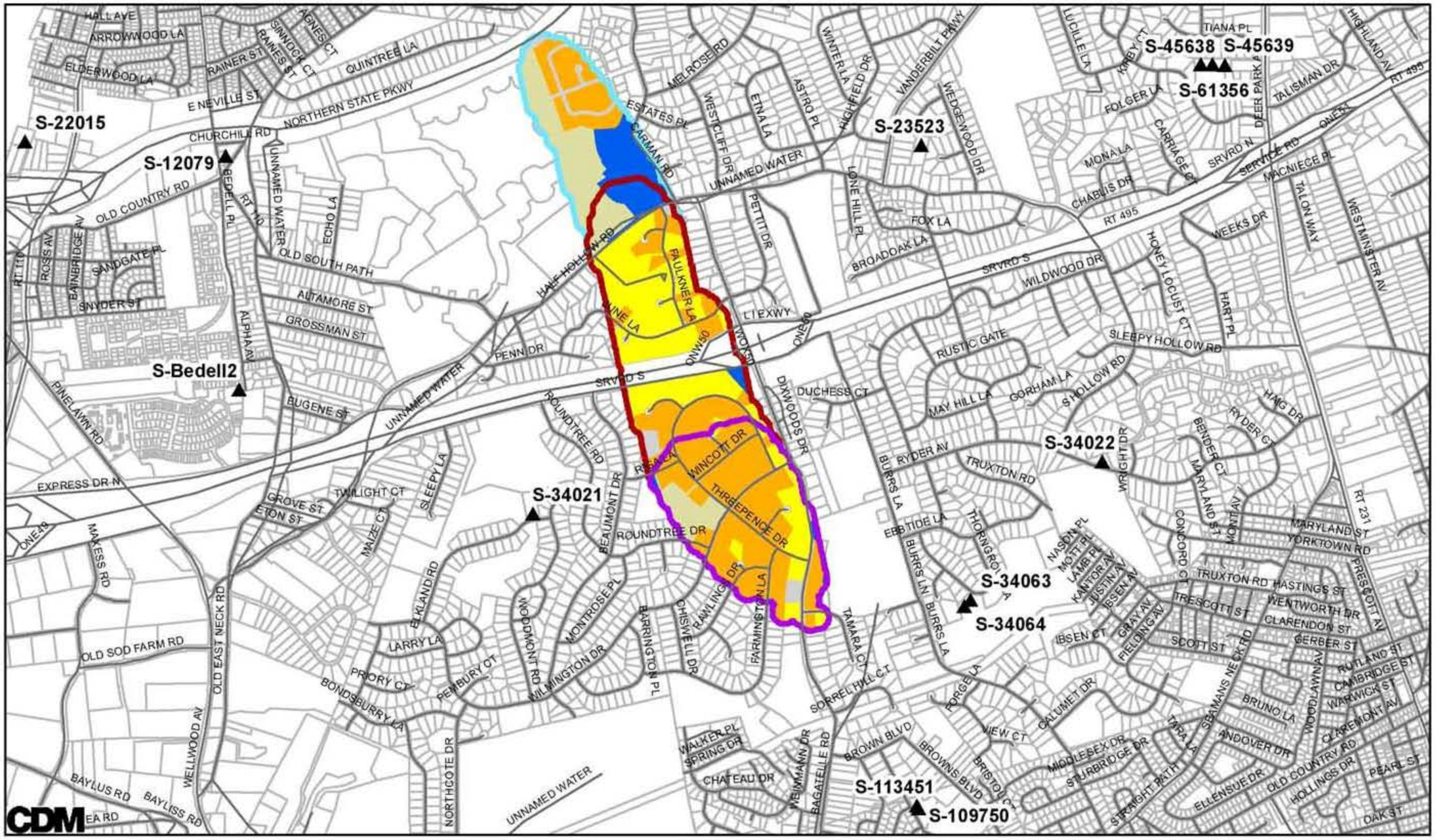
Table S-109750-5A: Well Susceptibility Determination

Contaminant Category	Susceptibility				
	2	5	25	75	100
Microbials			L		
Nitrates					H
Pesticides				L	L
VOCs					VH

Table S-109750-5B: Well Susceptibility Summary

	Contaminant Category			
	Microbials	Nitrates	Pesticides	VOCs
Susceptibility	L	H	L	VH

Notes:
1. Values shown in the Time Of Travel 100 column for VOCs and Nitrates are aggregates for the entire area
2. For microbials, Contaminant Prevalence assessments do not include any land use or point sources in contributing areas greater than 25-years Time of Travel.
3. For pesticides, all sources in times of travel below 25 years have been aggregated into the 25 column



Travel Time (Years)

- 0 to 2
- 2 to 5
- 5 to 25
- 25 to 50
- 50 to 75
- 75 to 100

Land Use Classifications

- Low Density Residential
- Med Density Residential
- High Density Residential
- Commercial
- Industrial
- Institutional
- Open Space
- Agricultural
- Vacant
- Transportation
- Utilities
- Water Handling & Maint
- Surface Waters

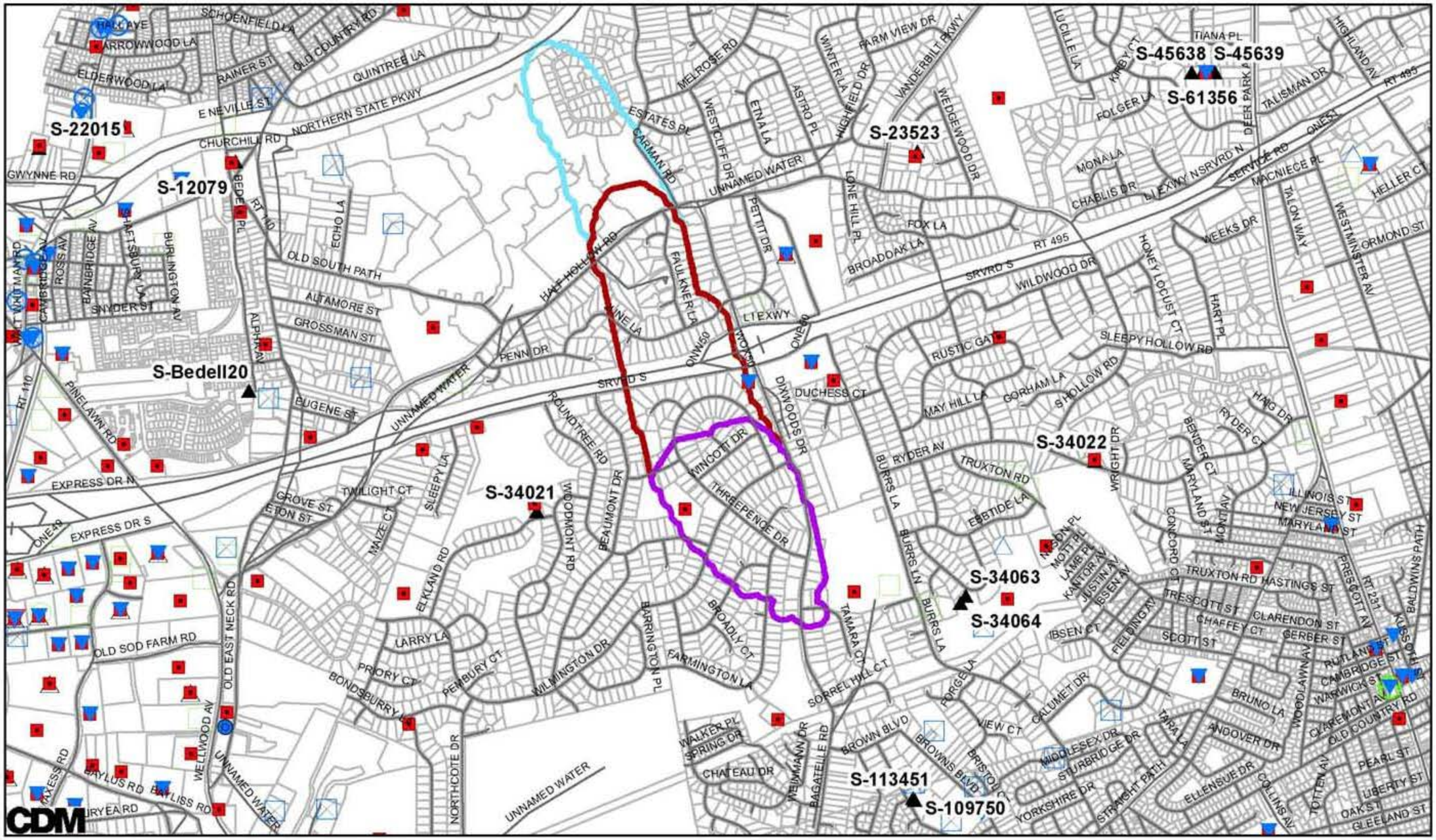
Contributing area to well number S-113451

- Lot Lines
- Public Supply Wells

N W E S

740 0 740 Feet

Map Date January 12, 2009



Travel Time (Years)

- 0 to 2
- 2 to 5
- 5 to 25
- 25 to 50
- 50 to 75
- 75 to 100

Potential Point Sources

- PBSF Facility
- Chemical Bulk Storage Facility
- CERCLA Facility
- Drycleaning Facility
- Hazardous Waste Site
- Landfill
- MOSF
- Salt Storage
- CLEARS Site
- PCS Facility
- RCRA Facility
- SPDES / Denit Facility
- Spill Site
- Gas Station

Contributing area to well number S-113451

- Lot Lines
- Public Supply Wells

930 0 930 Feet

Map Date April 14, 2009

Table S-109750-1B: Land Use Summary

Land Use Type	Land Use Parcels in Time Of Travel					
	2	5	25	50	75	100
Institutional Unsewered					4-260-1-1.011, 4-272-2-6.000, 4-272-3-40.000, 4-273-3-1.032	4-260-1-1.011, 4-272-2-6.000, 4-272-3-40.000, 4-273-3-1.032
Low Density Residential Unsewered				4-272-3-114.000, 4-272-3-115.000, 4-272-3-116.000, 4-272-3-117.000, 4-272-3-122.000, 4-272-3-123.000, 4-272-3-124.000, 4-272-3-46.000, 4-272-3-47.000, 4-272-3-49.000, 4-272-3-50.000, 4-272-3-81.000, 4-272-3-99.000, 4-272-4-11.005, 4-272-4-11.006, 4-272-5-	4-260-2-48.008, 4-260-2-48.009, 4-260-2-49.000, 4-260-2-50.001, 4-260-2-50.002, 4-260-2-51.000, 4-260-2-52.001, 4-260-2-52.004, 4-260-2-52.006, 4-260-2-53.001, 4-260-2-53.003, 4-260-2-53.004, 4-260-2-53.005, 4-260-2-53.006, 4-260-2-53.007, 4-260-2-53.009,	4-260-2-48.008, 4-260-2-48.009, 4-260-2-49.000, 4-260-2-50.001, 4-260-2-50.002, 4-260-2-51.000, 4-260-2-52.001, 4-260-2-52.004, 4-260-2-52.006, 4-260-2-53.001, 4-260-2-53.003, 4-260-2-53.004, 4-260-2-53.005, 4-260-2-53.006, 4-260-2-53.007, 4-260-2-53.009,
Medium Density Residential Unsewered				4-272-3-100.000, 4-272-3-101.000, 4-272-3-102.000, 4-272-3-103.000, 4-272-3-104.000, 4-272-3-105.000, 4-272-3-106.000, 4-272-3-107.000, 4-272-3-108.000, 4-272-3-109.000, 4-272-3-110.000, 4-272-3-111.000, 4-272-3-112.000, 4-272-3-113.000, 4-272-3-118.000,	4-260-2-53.008, 4-260-2-55.003, 4-260-2-55.004, 4-260-2-55.007, 4-260-2-55.008, 4-260-2-55.010, 4-260-2-55.011, 4-260-2-55.012, 4-260-2-55.016, 4-260-2-57.001, 4-260-2-59.000, 4-260-2-68.000, 4-260-2-69.000, 4-260-2-71.000, 4-260-2-78.000, 4-260-2-80.000,	4-243-5-19.000, 4-243-5-20.000, 4-243-5-21.000, 4-243-5-22.000, 4-243-5-23.000, 4-243-5-24.000, 4-243-5-25.000, 4-243-5-26.000, 4-243-5-27.000, 4-243-5-28.000, 4-243-5-29.000, 4-243-5-30.000, 4-243-5-31.000, 4-243-5-32.000, 4-243-5-33.000, 4-243-5-34.000,
Open Space					4-260-1-1.010, 4-260-1-1.020, 4-272-5-72.000, 4-272-5-73.000, 4-272-5-81.000	4-243-7-1.004, 4-243-7-1.005, 4-260-1-1.010, 4-260-1-1.018, 4-260-1-1.020, 4-272-5-72.000, 4-272-5-73.000, 4-272-5-81.000
Transportation				4-272-3-18.000, 4-273-1-77.000, 4-273-3-1.031	4-260-2-55.002, 4-260-2-65.000, 4-260-2-81.000, 4-272-3-1.000, 4-272-3-18.000, 4-273-1-77.000, 4-273-3-1.031	4-243-2-25.000, 4-243-3-1.000, 4-243-5-76.000, 4-260-2-55.002, 4-260-2-65.000, 4-260-2-81.000, 4-272-3-1.000, 4-272-3-18.000, 4-273-1-77.000, 4-273-3-1.031

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