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Health Impact Assessment (2014-2016) of Proposed Code Changes Regarding Individual Sewerage Systems in Suffolk County, New York

Summary Report of Main Findings and Recommendations

Office of Research and Development
U.S. Environmental Protection Agency

Notice

The Health Impact Assessment (2014-2016) of Proposed Code Changes Regarding Individual Sewerage Systems in Suffolk County, New York was supported by U.S. Environmental Protection Agency (EPA) staff and contractors. EPA's Sustainable and Healthy Communities research program and existing contracts within its Office of Research and Development (ORD) partially funded and provided personnel for the research described here; and the U.S. Federal Emergency Management Agency (FEMA) Sandy Recovery Office provided funding for travel through an Interagency Agreement with EPA. Members of Suffolk County, New York government; non-government organizations; and community residents also provided input for the Health Impact Assessment (HIA) Report. The HIA Report is located at www.epa.gov/healthresearch/health-impact-assessments.

This document provides a summary of the main findings and decision considerations from the HIA. It has been subjected to review by ORD and approved for publication. The views expressed in this report are those of the authors and do not necessarily represent the views or the policies of the U.S. Environmental Protection Agency.

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Acronyms and Abbreviations

ACS	American Community Survey
CDC	U.S. Centers for Disease Control and Prevention
C-OWTS	conventional onsite wastewater treatment system
DSP	diarrhetic shellfish poisoning
EEE	eastern equine encephalitis
EEEV	eastern equine encephalitis virus
EPA	U.S. Environmental Protection Agency
FEMA	U.S. Federal Emergency Management Agency
FIB	fecal indicator bacteria
GIS	geographic information systems
HAB	harmful algal bloom
HIA	Health Impact Assessment
I/A OWTS	innovative/alternative onsite wastewater treatment system
IMM	integrated marsh management
kg	kilograms
L	liters
mg	milligrams
NYSDOH	New York State Department of Health
ORD	Office of Research and Development
OSDS	onsite sewage disposal system
OWTS	onsite wastewater treatment system
PSP	paralytic shellfish poison
PTSD	posttraumatic stress disorder
RPA	Regional Plan Association
SAV	submerged aquatic vegetation
SCDHS	Suffolk County Department of Health Services
SLOSH	sea, lake, and overland surges from hurricanes
SWP	Subwatersheds Wastewater Plan
TAC	Technical Advisory Committee
TN	total nitrogen
USFWS	U.S. Fish and Wildlife Service
WNV	West Nile Virus
yr	year

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Background

This summary report documents the main findings and recommendations from a health impact assessment (HIA) conducted on proposed changes to the Suffolk County Sanitary Code for single-family residential individual sewerage systems. Suffolk County, New York is the eastern region of Long Island, the second largest county in total area in New York (including land and water), and, with a population of nearly 1.5 million people, has more people than 11 U.S. states. In a town hall meeting held January 23, 2014, County Executive Steven Bellone announced "nitrogen pollution is public enemy number one for our bays, waterways, drinking supply and the critical wetlands and marshes that protect us from natural disasters like Super Storm Sandy…. Nitrogen pollution adversely affects our coastal resiliency, our environment, our economy, our land value, our tourism industry, and our recreational use of our waters" [1].

Much of the nitrogen pollution in Suffolk County has been linked to unsewered, single-family residences that rely on individual sewerage systems – cesspools (onsite sewage disposal systems; OSDS) or septic tank-leaching pool systems ("conventional" onsite wastewater treatment systems; C-OWTS) – to manage their wastewater [2]. These individual sewerage systems provide no treatment of nutrients (e.g., nitrogen) and limited treatment of pathogens (i.e., viruses, bacteria, and protozoa that can cause disease) before discharging the wastewater into the ground [3, 4].

Revisions to the Suffolk County residential standards went into effect on January 1, 1973, requiring the use of C-OWTS for single-family residences. However, individual sewerage systems constructed prior to 1973 were grandfathered in, and since that time, residents have been allowed to replace the systems in-kind (i.e., cesspools have not been required to be upgraded to C-OWTS to meet the County standards) [5]. Suffolk County Department of Health Services (SCDHS) is proposing changes to the Suffolk County Sanitary Code that would require upgrading existing individual sewerage systems to meet current County sanitary code and standards (in place as of September 2016)[1], as one of many strategies for addressing nitrogen pollution in Suffolk County's waterways [5]. The overarching goal of updating the Suffolk County Sanitary Code is to improve water quality and help protect public health. Suffolk County anticipates the code changes will help decelerate 1) the impairment of regional waters; 2) the frequency of harmful algal blooms; and 3) the loss of native eelgrass and wetland area, which are important for coastal resiliency [5].

This report documents the HIA as it was conducted, including the conditions, sanitary code in effect, and proposed code changes under consideration by Suffolk County at the time of analysis (December 2014 – September 2016). It should be noted that since completion of the HIA analysis and reporting of preliminary findings and recommendations to the decision-makers and stakeholders in the fall of 2016, Suffolk County entered into a period of robust activity working to change the local nutrient pollution paradigm. This included,

[1] At the time the HIA started, the Suffolk County Sanitary Code (Suffolk County Code Chapter 760, revised November 2011) and its implementing standards were in effect. The standards and articles of code applicable to the decision, and considered in the HIA, include Article 6 (6/28/1995), General Guidance Memorandum #12 (6/8/2000), and Standards for Approval of Plans and Construction for Sewage Disposal Systems for Single Family Residences (1/9/2004). During the course of the HIA analysis, Article 19 was added to the Sanitary Code (7/2016) and interim revisions were adopted to the Standards for Approval of Plans and Construction for Sewage Disposal Systems for Single Family Residences (9/21/2016).

among other things, consideration of different sanitary code changes than those assessed in this HIA. The activities and code changes undertaken after completion of the HIA analysis are noted throughout the report for informational purposes, but were not considered in the HIA analysis. A summary of actions and proposed wastewater upgrade recommendations that have occurred since the time of the HIA analysis can be found in the County's Subwatersheds Wastewater Plan, available at: https://reclaimourwater.info/TheSubwatershedsWastewaterPlan.aspx.

Why was an HIA performed?

The U.S. Environmental Protection Agency (EPA) has identified HIA as one of many decision-support tools that can be used to provide science-based resources and information for community-driven initiatives and to promote sustainable and healthy communities. An important factor in deciding to conduct the HIA was the potential human health and environmental consequences of high-density, substandard (e.g., inadequately designed, sited, or maintained), and/or malfunctioning individual sewerage systems in Suffolk County – namely cumulative loading of nutrients and pathogens to groundwater. In Suffolk County, groundwater is the sole source of public drinking water and has a major influence on recreational waters and waters of economic importance. An HIA would broaden the health discussion and could be used to not only show how the proposed changes could impact health directly, but also indirectly through various health determinants like those identified by Suffolk County Executive Steve Bellone – the environment, coastal resiliency, economy, property value, tourism, and recreational water use. Suffolk County agreed to host an HIA, supported by EPA, to help inform the decision about the proposed code changes.

Who performed this HIA?

Staff in EPA guided the HIA process. They established the HIA Project Team, which consisted of EPA staff, contractors, research fellows, and professional stakeholders (e.g., individuals from academia; community organizations; local, county, and state government agencies; and environmental organizations) who served on the HIA Leadership Team and/or HIA Research Team. The HIA Project Team conducted the HIA with input and guidance from an HIA Technical Advisory Committee (TAC), made up of technical experts and representatives from several stakeholder groups. A TAC and Community Stakeholder Steering Committee (CSSC) were both initially established for the HIA, but the CSSC was later consolidated into the TAC due to low participation.

What methods were used in this HIA?

HIA is "a systematic process that uses an array of data sources and analytical methods and considers input from stakeholders to determine the potential effects of a proposed policy, plan, program or project on health of a population and the distribution of those impacts within the population. HIA provides recommendations on monitoring and managing those effects" [6]. The systematic HIA process includes six steps – S*creening, Scoping, Assessment, Recommendations, Reporting,* and *Monitoring and Evaluation* [6, 7, 8, 9, 10].

This HIA utilized a variety of methods to inform the assessment of health impacts, including the methods listed below. Beyond community and stakeholder engagement activities, this HIA did not involve primary data collection efforts, such as water sampling, water quality testing, or administration of human health surveys.

- ✓ Pre-existing and publicly-available data
- ✓ Geographic information systems (GIS) modeling, mapping, and spatial analyses
- ✓ Statistical and graphical analysis
- ✓ Systematic literature review
- ✓ Community engagement and expertise from local public health professionals, researchers, and other stakeholders
- ✓ Measurable (quantitative) and relative (qualitative) characterization of impacts

NOTE: Although scientific literature is useful and informative, it may sometimes be limited in its generalizability and broad applicability.

What was the scope of this HIA?

This HIA assessed the potential health impacts of four decision scenarios under consideration at the time of the HIA (Table 1) – the baseline (i.e., the existing conditions, should none of the alternatives be implemented) and the three alternatives outlined by SCDHS in the proposed code changes [5].

Based on input from stakeholders, including community members, scientific experts and decision-makers, the HIA Project Team identified pathways through which the proposed code changes could potentially impact health. The five pathways that were prioritized for assessment included:

- Individual Sewerage System Performance and Failure;
- Water Quality;
- Resiliency to Natural Disaster;
- Vector Control; and
- Community and Household Economics.

The HIA assessed each of these pathways by answering the following questions:

- What are the current conditions?
- How will each decision alternative impact the current conditions?
- What is the connection to health?
- How might health be impacted by each decision alternative?

Table 1. Decision Scenarios Assessed

Decision Scenarios	Details
Baseline*	The existing conditions at the time of the HIA analysis.
Alternative I	All existing individual (onsite) sewage disposal systems† serving single-family residences must conform to current County Sanitary Code and standards (in place as of September 2016). All existing cesspools must be upgraded to the County-defined C-OWTS‡ – a septic tank and leaching pool.
Alternative II	All existing individual (onsite) sewage disposal systems serving single-family residences in high priority areas§ must conform to current County Sanitary Code and standards (in place as of September 2016). All existing cesspools on lots located in high priority areas must be upgraded to the County-defined C-OWTS – a septic tank and leaching pool.
Alternative III	All existing individual sewerage systems (either cesspool-only systems or C-OWTS)‖ serving single-family residences in high priority areas must be upgraded to SCDHS-approved innovative/alternative OWTS¶,**.

* The baseline is used as a point of comparison. The baseline does not represent the future state if no upgrades to individual sewerage systems are made.

† Onsite sewage disposal system (OSDS) describes the pre-1973 type of individual sewerage system that includes a disposal unit alone (i.e., a cesspool) serving single-family residences in Suffolk County.

‡ "Conventional" onsite wastewater treatment system (C-OWTS) describes the post-1973 type of individual sewerage system that includes a septic tank and disposal unit (leaching pool) serving single-family residences in Suffolk County.

§ At the time of the HIA analysis, SCDHS designated "high priority areas" as areas in the 0-50 year groundwater contributing zone to public drinking water wells fields, areas in the 0-25 year groundwater contributing zone to surface waters, areas located in SLOSH (Sea, Lake, and Overland Surges from Hurricanes) zones, and areas located where groundwater is less than 10 feet below grade. Priority area designations have since been revised and can be found in the Subwatersheds Wastewater Plan released by the County (https://reclaimourwater.info/TheSubwatershedsWastewaterPlan.aspx).

‖ Individual sewerage system describes the overall category of individual (onsite) systems used to treat and/or dispose of wastewater from single-family residences in Suffolk County.

¶ Innovative/alternative onsite wastewater treatment system (I/A OWTS) describes the innovative (pending approval) type of individual sewerage system designed for nitrogen reduction/control used as an alternative to the C-OWTS serving single-family residences in Suffolk County.

**Effluent nitrogen concentrations of 19 mg/L or less are a requirement for I/A OWTS approval.

Quality Assurance

The HIA Project Team reviewed more than 80 existing HIAs and other HIA practice guidance documents to direct the development of this HIA. The Minimum Elements and Practice Standards for Health Impact Assessment [9] served as the benchmarks for HIA tasks. In addition, the HIA Report and supporting documents underwent extensive review by several members of the HIA Research Team and members of the TAC from the following organizations: Suffolk County Government, New York State Department of State, FEMA, Suffolk County Water Authority, Stony Brook University, Earlham College, and the Nature Conservancy. Furthermore, external peer review was conducted by a nutrient transport and coastal waters expert at UNC Coastal Studies Institute and an HIA expert from Georgia Health Policy Center. For more information on QA practices utilized in this HIA, see the full HIA Report, Appendix G. Quality Assurance, HIA Methodology, and Data Sources.

Main Findings of the HIA and Recommendations for Decision-makers

Wastewater and Water Quality in Suffolk County

Nitrogen loading to waterbodies can come from a number of present-day sources, including wastewater, atmospheric deposition, fertilizer use, as well as legacy sources (i.e., past land use practices) [2, 11, 12, 13, 14, 15, 16]. Wastewater effluent from individual sewerage systems (and sewage treatment plants) has been shown to be a major source of nitrogen loading to Suffolk County waters [2, 11, 12, 13, 15, 17]. The type of individual sewerage system, its design, siting, operation, and maintenance all determine the ability of the system to control the wastewater constituents discharged to the environment, including nitrogen and pathogens [18, 19]. These systems discharge wastewater effluent into the soil, where it can make its way into the groundwater – the sole source of drinking water for the County [2, 4]. Due to hydrogeology and soil composition, constituents in wastewater discharged into the soil can also have a major influence on surface, recreational, and, ultimately, coastal waters [2, 4].

Although modeling shows that not all sewerage-derived nitrogen loading to the environment reaches receiving waters (i.e., waterbodies downgradient in the watershed) [11], some modeling efforts indicate 60-70% of the nitrogen in individual sewerage system effluent may make its way through the groundwater to the estuaries of Long Island [17]. This nitrogen loading can impact not only the water quality of Suffolk County estuaries but, through subsurface flow and overland transport of groundwater during heavy precipitation and overflow events (e.g., shallow groundwater flooding), can also affect freshwater resources and wetlands [20, 21, 22, 23]. In addition to nitrogen, wastewater can contain pathogens and other constituents that make their way through the aquifer and can impact the quality of groundwater and surface waters, cause human illness, and affect the local fish and shellfish economy [20, 24, 25].

Nutrient and pathogen loading to Suffolk County waters can come from a number of sources. Regardless of source, potential problems associated with nitrogen and pathogen loading to Suffolk County waters include human illness; harmful algal blooms; beach closures; contamination and/or loss of fish and shellfish; promotion of mosquito habitat; coastal wetland loss; declines of stabilizing vegetation and eelgrass; declines in residential property values; and loss of revenue and employment from tourism, aquaculture, and recreation industries [2]. Declines in coastal wetlands, stabilizing vegetation, and eelgrass can ultimately have an impact on shoreline resiliency to coastal flooding and lower-intensity storms [2, 26].

Predicted Impacts of the Proposed Sanitary Code Changes

Soil characteristics, load rate to the system, age of the system, and operation and maintenance all play roles in the treatment performance of individual sewerage systems. The "conventional" OWTS (C-OWTS) or septic tank-leaching pool systems called for in Decision Alternatives I and II can potentially provide a 1-$\log_{10}$ (10-fold)[2] reduction in pathogens in the effluent coming from the system, but are essentially ineffective at reducing nutrients (e.g., nitrogen) [3, 27]. As a result, there would be no change in nitrogen loading and a limited reduction in pathogen loading to the environment expected with Alternatives I or II as compared to the baseline (current conditions). The innovative/alternative OWTS (I/A OWTS) in Alternative III, however, can provide a considerable reduction in nitrogen as compared to the baseline (particularly if the 19 mg/L or less total nitrogen effluent concentration required for SCDHS approval of these systems is achieved) and potentially a 1-$\log_{10}$ or greater reduction in pathogens in individual sewerage system effluent, when treatment/disinfection options are included.

The HIA demonstrated that the proposed decision alternatives could have both positive and negative effects on health through a number of health determinants (i.e., factors known to directly or indirectly impact human health), but **only Alternative III would result in a net positive public health impact** (Figure 1).

The HIA also determined that there might be unequal sharing of the burdens and/or benefits of the proposed code changes within the population. Some subgroups within the population may be more sensitive to or more affected by the changes in the physical and natural environment, social environment, and/or economic environment as a result of the decision, including:

- low-income households,
- minority households,
- young children (under 5 years of age),
- pregnant and/or nursing women,
- older (over 65 years of age) and physically-disabled adults,
- populations residing in unsewered residences constructed over 25 years ago or in flood-prone or high-groundwater areas,
- residents with individual sewerage systems and private drinking water wells, and
- coastal populations and those living and working in areas experiencing Sea, Lake, and Overland Surges from Hurricanes (i.e., SLOSH zones).

[2] "Log reduction" is a mathematical term used to show the relative number of pathogens eliminated by treatment or disinfection. A 1-$\log_{10}$ reduction means lowering the number of pathogens by 10-fold. That is, if the raw wastewater going into the individual sewerage system had 100,000 pathogens in it, a 1-$\log_{10}$ reduction would reduce the number of pathogens in the liquid effluent—what comes directly out of the individual sewerage system, taking into account settling/treatment within the system and pumping from the system (if any)—to 10,000. This level of reduction may not be protective of human health.

Figure 1. Predicted impacts of the proposed sanitary code changes on health and health determinants through five pathways examined in the HIA.

Recommendations for Managing These Impacts

EPA Office of Research and Development (ORD), the scientific research arm of EPA, supported this HIA. ORD conducts research for EPA that informs Agency decisions, provides the foundation for credible decision-making to safeguard human health and ecosystems from environmental pollutants, and supports the emerging needs of EPA stakeholders, including the Agency's state, tribal, and community partners. Although the HIA was conducted to help inform a county-level policy decision around sanitary code changes, it is important to note that policy-making is outside the purview of EPA ORD. As indicated in the Notice (on page i), the views expressed in this summary report are those of the authors and do not necessarily represent the views or the policies of the EPA.

The HIA Project Team identified recommendations for maximizing the potential positive health impacts (e.g., utilizing I/A OWTS), minimizing or avoiding the potential negative health impacts (e.g., provide financial assistance to mitigate the cost of system upgrades), and offering decision alternatives and health supportive measures. It should be noted that the HIA recommendations are not regulatory in nature; they are offered as suggestions for future action to improve the impact of the decision on health. Adoption of the recommendations is entirely voluntary and at the discretion of Suffolk County, as they must balance health considerations with the other technical, social, political, and economic considerations related to the decision.

Recommendations were developed related to:

- General Recommendations;
- Planning and Implementation of the Proposed Code Changes;
- Outreach and Communication;
- I/A OWTS Evaluation;
- System Siting, Design, and Installation;
- System Maintenance;
- Cost Control and Funding Measures;
- Employment and Hiring; and
- Protection of Water Resources.

In addition to these recommendations related to the proposed sanitary code changes themselves, additional recommendations beyond the code changes were developed to address some of the issues identified by the County (e.g., nitrogen loading and resiliency). These health-supportive measures relate to Wetland Protection/ Restoration, Wetland/Green Infrastructure Creation, and Resiliency Planning.

The pages that follow summarize the main findings and recommendations for each of the five pathways assessed in the HIA. For supporting information and the complete analysis, see the full HIA Report (EPA/600/R-21/186), available online at EPA's HIA website (https://www.epa.gov/healthresearch/health-impact-assessments).

Individual Sewerage System Performance and Failure

How is individual sewerage system performance and failure related to health?

The ability of individual sewerage systems to manage wastewater influences how wastewater constituents, including nutrients (e.g., nitrogen) and pathogens (i.e., viruses, bacteria, and protozoa) are passed into the environment [20]. In addition to their treatment performance, these systems are also subject to failure – both structurally and hydraulically [28]. Historically, cesspools were constructed with brick and mortar or concrete blocks that break down over time, making them increasingly susceptible to collapse [5]. Structural failure (i.e., the collapse, deterioration, and/or cover malfunction/removal) of a system is a falling hazard that may lead to human injury and/or death. Newer-age leach pools can be constructed with reinforced precast concrete, which make them less susceptible to collapse. Like structural failure, hydraulic failure (i.e., when untreated wastewater backs up into the home and/or surfaces or ponds above ground) [28, 29, 30, 31, 32, 33, 34, 35], also poses a direct health risk to humans and animals. Health hazards associated with exposure to untreated wastewater include gastrointestinal illness, upper respiratory illness, rash or itchy skin, eye ailments, earache, or infected cuts [20, 36, 37, 38, 39].

Key findings

There are two predominant individual sewerage systems in use by single-family residences in Suffolk County – the septic tank-leaching pool system (C-OWTS) and the cesspool (only) system (referred to as OSDS in Suffolk County). There are also a very small number of septic tank-soil absorption field systems in use. Revisions to the Suffolk County Sanitary Code went into effect on January 1, 1973, requiring the use of C-OWTS for single-family residences. However, individual sewerage systems constructed prior to 1973 were grandfathered in, and since that time, residents have been allowed to replace the systems in-kind (i.e., cesspools have not been required to be upgraded to "conventional" OWTS to meet the County standards).

Replacements and Retrofits of Existing Systems

Since completion of the HIA analysis, Suffolk County has amended Article 6 of the Sanitary Code to require a permit for replacements and retrofits of existing systems. Beginning July 1, 2019, the installation of new cesspools in Suffolk County will be prohibited (i.e., existing systems will no longer be replaced in-kind), as all OSDS will have to be upgraded to meet the SCDHS standards (a septic tank-leaching pool or I/A OWTS). See the full HIA Report, Appendix K for more information.

Proposed sanitary code changes

SCDHS is proposing changes to the Suffolk County Sanitary Code (Suffolk County Code Chapter 760) that would require existing individual sewerage systems to be upgraded to meet current County code and standards (in place as of September 2016; https://www.reclaimourwater.info/regulatory.aspx), as one of many strategies for addressing nitrogen pollution in Suffolk County's waterways. See Table 1 on page 4 for more details.

Types of individual sewerage systems in Suffolk County

Septic Tank-Leaching Pool System (C-OWTS)

The septic tank-leaching pool system that serves single-family residences in Suffolk County is known as the "conventional" OWTS (Figure 2) [40, 41]. It utilizes the septic tank as basic or primary treatment. Wastewater enters the underground septic tank, where natural processes physically separate the liquid component from heavier solids and lighter oils [29, 42]. Oil and grease float to the top forming "scum" and the larger solids and organic matter settle at the bottom forming "sludge." Although highly dependent on other variables (usage, volume, etc.), after approximately 24 to 48 hours, the liquid portion leaves the tank as "effluent" and drains to the leaching pool, where it is stored until it is distributed and absorbed into the surrounding soil. Some anaerobic digestion of organic matter may take place in the septic tank [43], along with a limited (1-$\log_{10}$) reduction in pathogens [27].

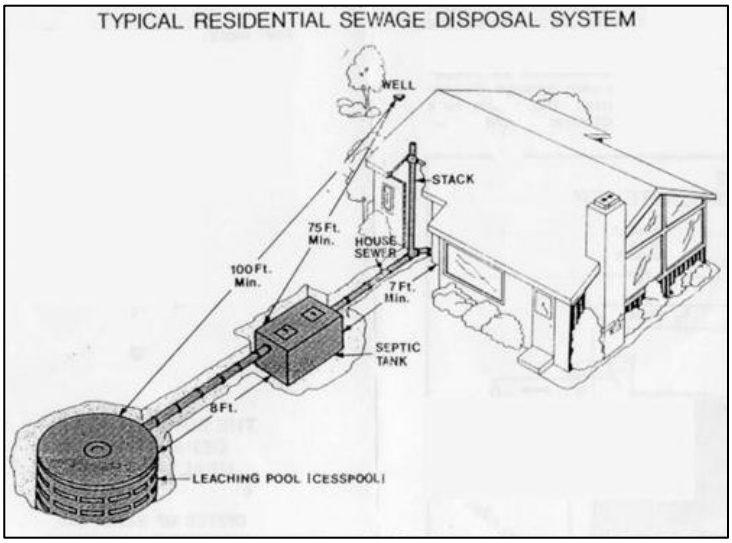


Figure 2. "Conventional" OWTS in Suffolk County consisting of a septic tank and leaching pool. Source: [2]

A leaching pool is a pit with precast perforated walls, an open bottom and a removable metal or concrete slab covering just below the ground surface. The leaching pool, although the same in design, is by name different from a cesspool because a leaching pool accepts septic tank effluent rather than untreated (raw) wastewater [40, 41].

Cesspool (referred to as OSDS in Suffolk County)

A cesspool is a pit with perforated walls, an open bottom, and a metal or concrete slab cover. Although the same design as a leaching pool, a cesspool accepts untreated (raw) wastewater instead of septic tank effluent. Historically, cesspools were constructed with brick and mortar or concrete blocks that break down over time, making them increasingly susceptible to collapse. Newer cesspools can be constructed with reinforced, precast concrete, which make them less susceptible to collapse. However, many cesspools in Suffolk County were installed before 1973 and are assumed not to be reinforced.

I/A OWTS Provisional Approvals

Two I/A OWTS were provisionally-approved during the timeframe of the HIA analysis. Since that time, Suffolk County has provisionally-approved additional I/A OWTS technologies for residential use in Suffolk County. In January 2018, SCDHS issued a general guidance memo for review and approval of single-family residential I/A OWTS. See the full HIA Report, Appendix K for more information.

Innovative/Alternative OWTS (I/A OWTS)

The I/A OWTS are innovative types of individual sewerage system designed specifically for nitrogen control and reduction and were included in the proposed code changes as an alternative to C-OWTS. At the time the code changes were proposed, no I/A OWTS was approved for general use in Suffolk County. However, in December 2014, Suffolk County launched a Septic Demonstration Pilot Project to evaluate I/A OWTS technologies, and in July 2016, the Suffolk County Legislature gave SCDHS the authority to develop procedures, protocols, and standards for approving the use of I/A OWTS throughout the County. Six weeks later, the first I/A OWTS technology was provisionally approved for residential use. Since that time, additional I/A OWTS technologies have been provisionally approved for residential use in Suffolk County.

Alternate Leaching Demonstration

Since completion of the HIA analysis, Suffolk County has undertaken demonstration testing of pressurized shallow drainfields and other alternative leaching technologies and has updated the standards to include use of a pressurized shallow drainfield in conjunction with an I/A OWTS (in lieu of a conventional leaching pool). See the full HIA Report, Appendix K for more information.

Septic Tank-Soil Absorption System

In addition to OSDS and C-OWTS, there are a number of septic tank-soil absorption systems in use in Suffolk County; however, the use of absorption fields and beds is much less common according to the Suffolk County Stormwater Management Program [44]. In these systems, septic tank effluent discharges into soil through shallowly-buried perforated pipes, known as the soil absorption field, where it undergoes secondary treatment in a process called *nitrification and denitrification* [45]. The septic tank-soil absorption system relies on the soil for treatment and thus, "is limited to locations with moderately permeable soils and relatively high soil depths to the water table or impermeable strata" [46].

The NYSDOH Residential Onsite Wastewater Treatment Systems Design Handbook [19] acknowledges the reduced treatment capability of leaching pools and states if soil and site conditions are adequate for absorption trenches or beds, leaching pools shall not be used. However, NYSDOH has issued general waivers to allow the use of leaching pools in Suffolk County "due to the nature of construction, soil conditions and known hydrogeology" [19]. According to a survey of homeowners, only about 76 of these systems exist throughout the east end of the County [47].[3]

[3] In Suffolk County, the "conventional" OWTS is the septic tank-leaching pool (vertical) system. However, elsewhere in the professional and scientific literature, the septic tank-soil absorption (horizontal) system (originally patented by Mouras in 1881) is referred to as a conventional OWTS [206]. Although they are similar in terminology, the septic tank-soil absorption system is technologically different from the septic tank-leaching pool system; leaching pools have reduced treatment capability compared to absorption trenches and beds according to NYSDOH [19]. Because of the highly permeable soils present on Long Island, conventional septic systems there have not included a horizontal leaching field commonplace in most other parts of the U.S. It is important to keep this difference in terminology in mind when examining the existing literature on design, siting, and performance of conventional OWTS, as the data may not be relevant to Suffolk County's "conventional" systems.

Predicted impacts to individual sewerage system performance and failure

At the time of the HIA analysis, Suffolk County did not have a complete inventory of individual sewerage system locations or types; some towns and hamlets tracked this information, but not consistently. Suffolk County developed estimates of the number of OSDS (pre-1973 systems) and C-OWTS (post-1973 systems) countywide, but the methodology used to develop those estimates was unknown. Therefore, HIA estimates were developed by the HIA Project Team to allow for geographic analysis of the number and type of individual sewerage systems impacted by each decision alternative and to provide transparent, defensible documentation of the estimated number of households that could potentially be impacted by the code changes.

Individual Sewerage System Inventory

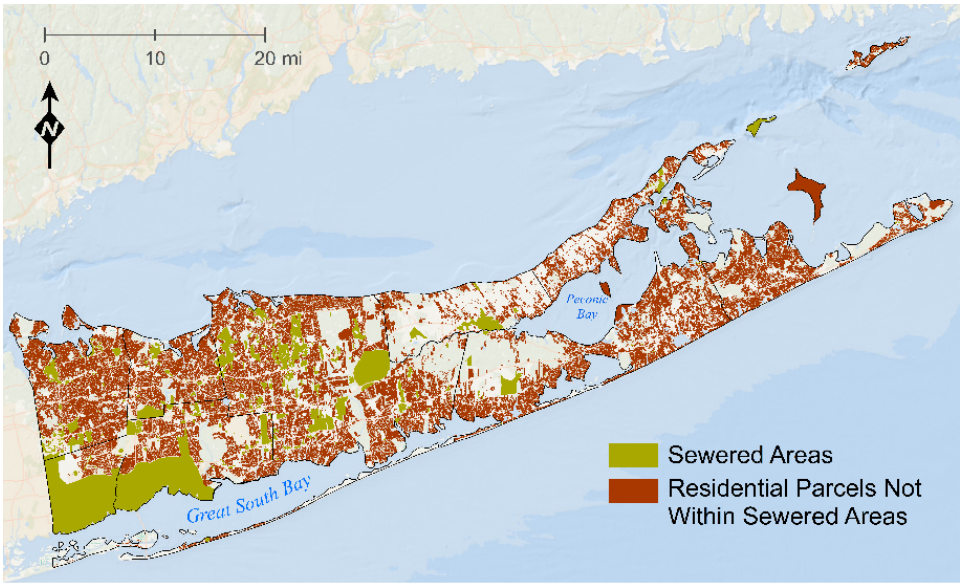
Since completion of the HIA analysis, Suffolk County has amended Article 6 of the Sanitary Code to require contractors or developers holding an active Liquid Waste License to notify SCDHS of all pumping, replacements, or retrofits of cesspools, septic tanks, I/A OWTS, grease traps, and leaching structures. See the full HIA Report, Appendix K for more information.

The HIA Research Team used parcel (property) shapefiles from the Suffolk County Real Property Tax Agency Service and overlaid them with the best available data from the U.S. Census Bureau, U.S. Geological Survey (USGS), National Oceanic and Atmospheric Association (NOAA), Suffolk County Government, and others using GIS-based methods. Residential parcel boundaries that were not contained within or did not intersect sewered areas were examined for their geographic proximity to high priority areas, and other factors. This approach is consistent with the approach used in other studies performed in Suffolk County, including Kinney and Valiela [11] and Lloyd [12].

The HIA Research Team calculated that there were 488,375 single-family residential properties (parcels) in Suffolk County. Of these properties, 385,117 were unsewered (shown in brown in Figure 3) and assumed to be served by an individual sewerage system.

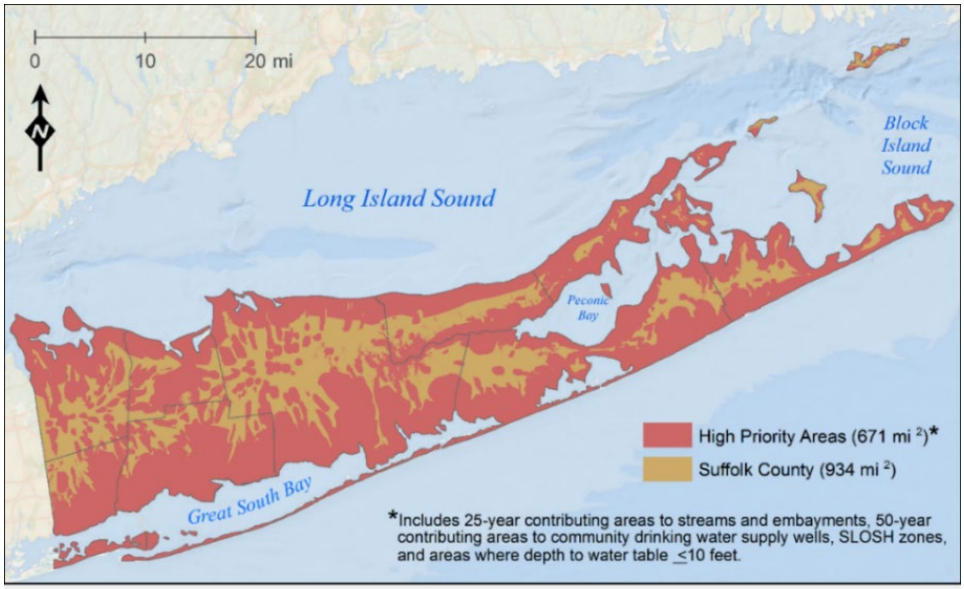
Of those 385,117 parcels assumed to be served by an individual sewerage system, 251,502 (65.3%) were located in Suffolk County Department of Health Services (SCDHS)-designated high priority areas shown in red in Figure 4[4] and would be required to be upgraded to I/A OWTS in Alternative III. Using existing data from national and local surveys/studies, the HIA Research Team determined that a *reasonable estimate* for the number of existing, individual sewerage systems that precede the 1973 standards, would be at least 50% of unsewered, single-family residential parcels. This estimate is consistent with those used in other studies performed in Suffolk County, including Lloyd [12], Stinnette [13], and Gobler [15]. It is important to note that this value may actually underestimate the public health impacts associated with the proposed sanitary code changes.

[4] For more information on actions taken since the HIA analysis to develop a Suffolk County Subwatersheds Wastewater Plan and refine the priority areas, see the Conclusions section of this Summary Report.



Base Map: Esri, Garmin, GEBCO, NOAA NGDC, and other contributors
Sewered Areas: Suffolk County Department of Economic Development and Planning, 2012.
Parcels: Suffolk County Real Property Tax Service.

Figure 3. Sewered and unsewered single-family residences in Suffolk County.



Base Map: Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors
High Priority Areas: Based on Suffolk County Comprehensive Water Resource Management Plan, 2015.

Figure 4. Designated high priority areas for reduction of wastewater-derived nitrogen.

This means that Alternative I would require that 192,558 OSDS be upgraded to C-OWTS and Alternative II would require the upgrade of 125,751 OSDS to C-OWTS. Alternative III would require 251,502 OSDS and C-OWTS to be upgraded to I/A OWTS. For a detailed explanation of the methodology used in the HIA to estimate the number of OSDS and C-OWTS in Suffolk County and the rationale for any discrepancies with Suffolk County estimates, see the full HIA Report, Appendix G.

Total nitrogen (TN) in effluent from cesspools, septic tanks, and leaching pools are considered equivalent to untreated wastewater, and TN loading to the environment from an individual OSDS or C-OWTS is estimated to be 14.65 kg (32.30 lbs) TN per year (assuming 60 mg/L TN in effluent, at an average flow of 60 gal/person/day, and 2.93 persons/household) [3, 4, 27]. Cesspools are not specifically designed to control nitrogen or pathogens in effluent. Septic tank – leaching pool systems are not specifically designed to control nitrogen, but can offer a limited reduction in pathogens, although treatment performance can be highly variable [27]. Given this, there would be **no change in nitrogen loading and a potential reduction in pathogen loading to the environment expected with Alternatives I or II as compared to the baseline (current conditions)**.

If the I/A OWTS achieve Suffolk County's requirement of 19 mg/L TN in effluent, at an average flow of 60 gal/person/day and 2.93 persons/household, the resultant TN loading from an individual I/A OWTS would be 4.63 kg (10.21 lbs) TN per year. It is assumed that I/A OWTS would achieve the minimum reduction in pathogen loading seen by adding a septic tank (i.e., a 1-$\log_{10}$ reduction), although a greater reduction in pathogens may occur, as some I/A OWTS can treat pathogens and emerging contaminants of concern (e.g., personal care products and pharmaceuticals) when certain components (e.g., biofilters, microfiltration membranes, chlorination/disinfection units, and permeable reactive barriers) are part of or used in conjunction with the system. Given this, **with Alternative III, there would be a considerable reduction in nitrogen loading and possibly pathogens and emerging contaminants of concern, as compared to the baseline (current conditions), depending on the design of the systems**.

The individual sewerage system nutrient and pathogen loadings reported for each alternative are at the edge of the individual sewerage system. The loading values describe concentrations of nitrogen and pathogens in liquid effluent—what comes directly out of the individual sewerage system, taking into account settling/treatment within the system and pumping from the system (if any; Figure 5). Loading values do not account for processes that impact the concentration of nitrogen and pathogens in the effluent once discharged from the individual sewerage system (e.g., fate and transport through soil, particle association, efficacy, etc.). The amount of pathogens released from an individual sewerage system under any of the alternatives is undetermined because "the occurrence and concentration of pathogenic microorganisms in raw wastewater depend on the sources contributing to the wastewater, the existence of infected persons in the population, and environmental factors that influence pathogen survival rates" [20]. **Cumulative loading of pathogens cannot easily be quantified** without a primary data collection effort; therefore, pathogen concentrations in effluent as compared to pathogen concentrations in raw wastewater influent are instead utilized to approximate the differences in the magnitude of pathogen reduction one might expect under the various decision alternatives.

The I/A OWTS called for in Alternative III require routine management and monitoring, due to their specialized biological, mechanical, and electrical components, in order to remain operational and effective [29]. This may require a culture shift, as maintenance of existing individual sewerage systems varies widely but is often performed as part of a fix rather than as routine [48]. **There could be some challenges and barriers to making a culture shift like this.**

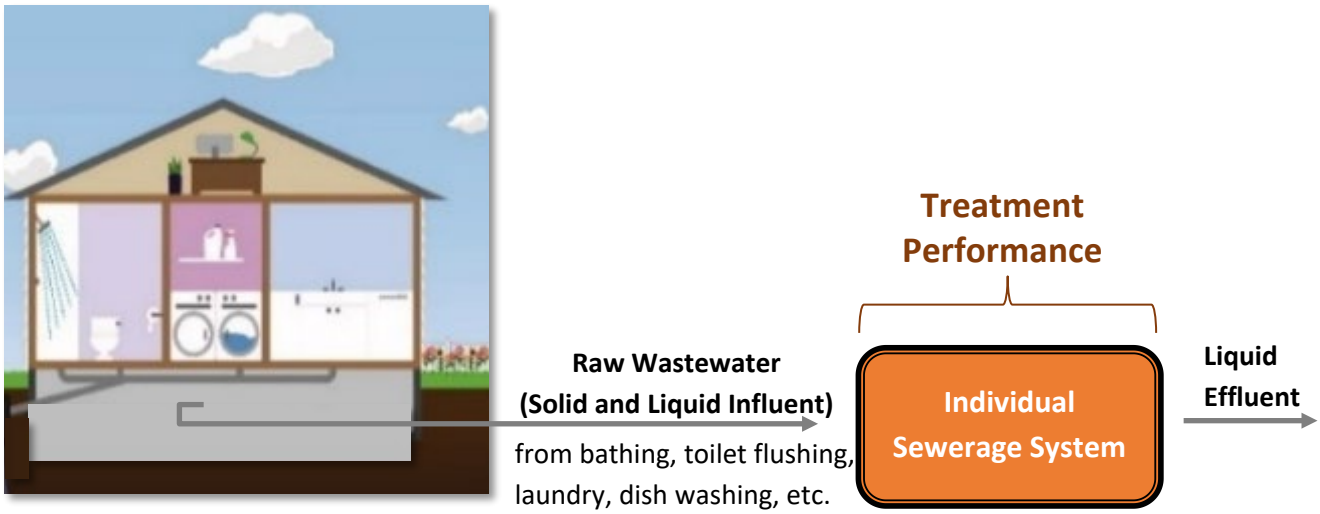


Figure 5. Individual sewerage system treatment performance describes changes in concentrations of nitrogen and pathogens in liquid effluent from the system—taking into account settling, treatment within the system, and pumping from the system (if any)—and is reported as compared to nitrogen and pathogen concentrations in raw wastewater.

A number of variables can contribute to the failure of an individual sewerage system, including improper operation and maintenance, improper siting, inadequate design, the age of the system, and changes in wastewater loading to the system [30, 31, 49, 50]. Suffolk County estimates close to a 10% rate of hydraulic failure each year of existing individual sewerage systems [2], although reported hydraulic failures are much lower than the estimated failure rates. There was no systematic reporting mechanism found for structural failures of individual sewerage systems, although seven instances of individual sewerage system structural failures (i.e., collapse or cover missing/removed) that resulted in human injury or death were reported in Suffolk County media sources through Fall of 2016 – with one incident each occurring in 1987, 2001, 2007, 2010, and 2011, and two in 2006.[5] It is likely that structural failures that occurred without human injury or death were not reported in the media and therefore, media reports probably underrepresent the actual number of structural failures of individual sewerage systems in Suffolk County. **Due to the design and materials used, older cesspools – especially those that have exceeded the expected life span of 25 years – pose risks for illness, injury and/or death were the system to collapse, surcharge above ground, or backflow into the home.** Older systems are subject to higher rates of structural failure and systems in flood-prone/high-groundwater areas are at higher risks of hydraulic and structural failure.

Alternatives I and II would eliminate the use of cesspools and increase the number of systems using reinforced materials for the leaching pool, thus reducing the risk of structural failure (as long as the existing system components are no longer present or, if present, are filled with soil or gravel). At the time of the HIA analysis it was yet to be determined whether existing system components would be removed and a complete

[5] One additional structural failure (a cesspool hole collapse) was reported in the media in 2017; it is not included in the data reported above because it occurred after completion of the HIA analysis.

septic tank-leaching pooling system installed or whether a septic tank might just be added upstream of an existing cesspool to create a septic tank-leaching pool system. **The use of a septic tank would also help prevent solids from carrying-over to the leaching pool, which could help prevent catastrophic hydraulic failure of the system.** However, flood-prone areas and areas influenced by groundwater and tidal waters still pose failure hazards (both hydraulic and structural), even for septic tank–leaching pool systems. Proper design and maintenance of the systems would be key to reducing the risk of hydraulic failure. **Installing I/A OWTS (Alternative III) would eliminate cesspools and older C-OWTS in the high priority areas and may help to reduce the risk of structural failure (as long as the existing system components are no longer present or, if present, are filled with soil or gravel) and hydraulic failure (as long as the system is designed to withstand flooding and influences from high groundwater and tidal waters and is properly maintained).**

Predicted health impacts

- The use of a septic tank in combination with a leaching pool (Alternatives I and II) or installation of an I/A OWTS (Alternative III) is **highly-likely to reduce the risk of structural failure** (as long as the original system components are no longer present or, if present, are filled with soil or gravel) and **likely to reduce the risk of hydraulic failure** and resultant close-contact exposure to untreated wastewater for people living in the single-family residences required to upgrade their systems, as long as the systems are properly designed and maintained. However, flood-prone areas and areas influenced by groundwater and tidal waters still pose failure hazards (both hydraulic and structural).
- These reductions in risk benefit health by **reducing the risk of injury or death** from a structural failure and **protecting people from illness** as a result of exposure to untreated wastewater. There is limited evidence in Suffolk County linking system failure to human injury, death and illness, but strong evidence, in general, that exposure to untreated wastewater is linked to a number of illnesses.
- Communities with a high proportion of unsewered residences constructed over 25 years ago and/or in flood-prone/high-groundwater areas and those more susceptible to illness (e.g., young children, the elderly and the immuno-compromised) could experience a greater health benefit from individual sewerage system upgrades.
- The health benefits of upgrading individual sewerage systems are expected to be long-lasting, but may not be seen for a long time, given the potential lag in implementing the upgrades.

Recommendations

While the analysis in this pathway showed all three alternatives would reduce the risk of structural failure (as long as the original system components are not present) and would likely reduce the risk of hydraulic failure, evaluation of treatment performance showed only Alternative III (I/A OWTS) would result in reduced nitrogen loading and possibly reduced loading of pathogens and emerging contaminants of concern, depending on the system design. The recommendations that follow suggest consideration of a fourth alternative requiring upgrade of individual sewerage systems to I/A OWTS across the entire county, as well as recommendations on planning and implementation of the proposed code changes; outreach and communication; I/A OWTS evaluation; system siting, design, and installation; and system maintenance:

- A fourth alternative could be considered, requiring upgrade of individual sewerage systems to an innovative/alternative technology across the entire county, with prioritization given to parcels in the

high-priority areas (e.g., proactive upgrades in priority areas and upgrades elsewhere in the county, upon transfer, failure/replacement, significant and new construction).

- Ensure that sites with individual sewerage systems that are required to be upgraded as part of the changes to the Suffolk County Sanitary Code tie into sewer if they fall within a sewer district and the approved sewer system is accessible and has capacity.
- Consider potential barriers to implementing and enforcing policies related to individual sewerage systems and develop strategies to overcome such barriers.
- Develop tools that cesspool/septic service contractors can easily and consistently deploy to determine whether a system is in need of maintenance, repair, or upgrade and document the issue(s), such as a checklist or logic framework for use in the field and/or an open-access, web-based platform for documenting issues and reporting properties that need to upgrade their individual sewerage systems.
- Create an inventory of existing individual sewerage systems, including their geolocation, design type, and (if possible) maintenance schedule to aid in identifying residences affected by the decision and enforcing the code change. This inventory can be accomplished through sewage industry reporting of cesspool, septic tank, and I/A OWTS pump outs, retrofits, and replacements.
- Given its current population and the expectation that Suffolk County may reach its saturation population[6], further research is needed to ascertain the capacity of Suffolk County soils to effectively manage wastewater effluent (regardless of whether systems are upgraded or not).
- Perform homeowner outreach early and often and provide information on each system design, including the average life span, operation and maintenance needs, average treatment performance, signs of system failure, and the benefits of routine inspections and maintenance (e.g., increase in system longevity, reduced costs over the life of the system).
- Focus educational outreach and/or professional and financial assistance in areas where frequent failures are occurring and allow homeowners to upgrade/replace existing systems to more sustainable sewerage options that lower the risk of system failure.
- Pathogen and/or fecal indicator bacteria monitoring could be conducted for I/A OWTS, so that data can be obtained to better evaluate pathogen control of these systems. Pathogens have implications for human health and the economy.
- Given the additional reduction in nitrogen and pathogen loading from soil absorption drainfields and the potential for drainfields to break down many other pollutants (per the NYSDOH Residential Onsite Wastewater Treatment System Design Handbook [19]), consider changes to the Sanitary Code requiring cesspools and conventional OWTS be upgraded to septic tank-soil absorption systems when site conditions permit. At a minimum, the language in the code for Alternatives I and II could identify upgrades to a septic tank-soil absorption system, conditions permitting, as an alternative to the C-OWTS. For residences with inadequate space for a soil absorption field, a mound OWTS could provide improved treatment performance over the C-OWTS.

[6] According to the Suffolk County Department of Planning, Suffolk County's saturation population (i.e., the population expected if all available land were developed according to existing zoning) is estimated to be 1.75 million people - a 17% increase over the 2010 population; this population figure may be reached by the year 2040 [208].

- Take into consideration good practice in the siting, design, installation, and maintenance of individual sewerage systems.[7]
- Adopt a standard management plan for each system design to ensure individual sewerage systems are properly maintained and replaced/upgraded when needed. The management plan could include good management practices.
- Perform routine pumping of OSDS and OWTS in order to reduce the risk of hydraulic failure, retention of standing water, and associated health impacts.
- Due to the design and materials used, older cesspools – especially those that have exceeded the expected life span of approximately 25 years – pose risks for illness, injury and/or death were the system to collapse, surcharge above ground, or backflow into the home. Ideally, homeowners could replace such systems with a modern design (e.g., septic tank-soil absorption system or I/A OWTS) or connect to a cluster system or public sewer.
- Completely fill unused or abandoned systems with soil or gravel, both to eliminate a source of standing water and to avoid potential collapse and injury.
- Homeowners or non-licensed professionals should not approach or attempt to investigate a collapsed or failing septic tank or cesspool. Cornell University – Suffolk County Extension Office recommends that if the surface of the ground above the septic tank or cesspool is wet, the area should be fenced off and a professional called to diagnose and address the problem.

[7] Examples of best practices for siting, design, installation, and maintenance of individual sewerage systems are detailed in Section 5 of the full HIA Report.

Water Quality

How is water quality related to health?

Universally, water quality is a key health determinant because living and non-living substances in the water, including pathogens (i.e., bacteria, viruses, parasites, and other organisms that cause disease) and toxic substances (e.g., heavy metals, pesticides, toxins from harmful algal blooms, etc.), can cause illness in humans through direct contact and ingestion. Typical symptoms of this type of illness include gastrointestinal illness (e.g., diarrhea, vomiting, and abdominal pain), but complications can arise leading to more severe illness and even death [51]. A number of other health problems have been associated with contaminated water, including lung and skin irritation, cancer, kidney, liver, and nervous system damage.

Water is one of the most important landscape elements, both physically and visually, in the relationship between the environment and health. Water spaces can reduce stress, enhance mood, increase mental attention, provide opportunities for recreation, and facilitate social connections by serving as spaces for social activities. Humans may also feel a spiritual and emotional connection to water. The appreciation of waterbodies has been correlated with better quality of life and may be beneficial to health [52]. These health and human well-being benefits of water are often dependent on the perceptions of the water, including water quality and clarity.

Key findings

Suffolk County's water resources are an integral part of its economy, social and cultural identity, and security. Water resources, such as groundwater and surface waters (e.g., rivers, lakes, streams, estuaries, and coastal shorelines), provide invaluable ecosystem services, such as drinking water, habitat for food sources, recreational opportunities, protection from storms and/or tidal surges, and social and cultural benefits. Growing concerns related to excess nitrogen, increasing algal blooms, beach closures, contamination and loss of shellfish and submerged vegetation, and the future integrity of the sole-source for drinking water are the driving forces of the **perceived quality of water resources** in Suffolk County.

Individual sewerage systems and most Suffolk County sewage treatment plants discharge wastewater effluent into the soil where it makes its way into the groundwater, the sole source of drinking water for the County [2, 4]. Due to the hydrogeology and soil composition in Suffolk County, constituents in wastewater effluent discharged into the soil can also have a major influence on surface, recreational, and, ultimately, coastal waters [2, 4]. **Local and regional experts identified nitrogen pollution from wastewater sources, such as individual sewerage systems and sewage treatment plants, as a considerable contributor of nitrogen** to the Peconic Estuary,

Modeled Nitrogen Sources

Since completion of the HIA analysis, Suffolk County undertook countywide nitrogen loading modeling as part of the development of a Subwatersheds Wastewater Plan. This modeling showed that the majority of nitrogen reaching Suffolk County surface waters emanates from individual sewerage systems.

Long Island Sound, Great South Bay, and South Shore Estuary Reserve [2, 11, 12, 13, 15, 17, 53, 54].[8] In addition to wastewater sources, agricultural activity and residential fertilizer use were also identified as major sources of pollution to Suffolk County groundwater and surface water [2]. It should be noted that wastewater may be one potential source of pathogens, but stormwater runoff, wildlife populations, and pets may also serve as important sources of pathogen pollution discharging to Suffolk County surface water bodies [2].

Nitrogen and pathogen loading to Suffolk County waters can come from a number of sources, and some of these sources may originate outside of Suffolk County (e.g., Nassau County or New York City). Regardless of source, **consequences of nutrient and pathogen loading to Suffolk County waters** have included:

- Private drinking wells in the Upper Glacial Aquifer testing above the EPA standard for nitrate (i.e., above the maximum contaminant level of 10 mg/L);
- Hypoxic waters in Long Island Sound and depletion of soluble oxygen;
- Reoccurring *en masse* die-off of turtles (in Flanders Bay), fish, and shellfish;
- Odors emitting from surface waters (e.g., Forge River);
- Closure of swimming/bathing beaches around lakes and bays due harmful algal blooms and/or fecal indicator bacteria (FIB);
- Receding area of submerged vegetation (specifically eelgrass) and wetland acreage, and erosion of soils;
- Loss of revenue from tourism, aquaculture, and recreation industries, and employment loss in shellfish industry;
- Increased susceptibility to damage from storm and tidal surge and subsequent cost of damage; and
- Degradation of perceived surrounding environment and subsequent loss of property value [2].

Drinking water

Suffolk County sources all of its drinking water from groundwater, so a key concern for the County is the integrity of its groundwater. SCDHS monitors and enforces safe drinking water regulations for public water supplies within the County [55]. Public drinking water supplies are monitored for levels of nitrogen and the presence of specific organisms that are used to indicate the possibility of fecal contamination (i.e., fecal indicator bacteria; FIB), among other compounds. Prior to distribution, public drinking water is treated to reduce microbial pathogens and other compounds. **In 2015, all public drinking waters in Suffolk County met both federal (EPA) and state (NYSDOH) standards for drinking water quality** [56]. Private drinking water wells, however, do not typically include treatment for nitrates and rarely include treatment for pathogens. **Because private wells generally pump from the shallower, Upper Glacial Aquifer (making them more susceptible to contamination from near surface activities) and may lack the levels of treatment, management, and testing required of public water supply systems, they are considered to be a higher-risk drinking water source** [2, 57, 58]**.** In addition, areas without public water connections are often also unsewered; as a result, **contaminant loading from individual sewerage systems can travel through the**

[8] While groundwater travel times along the coasts of Long Island range from 0-10 years, groundwater travel times from the middle of Long Island to the shore can take decades to hundreds of years [11, 204, 205]. Given the long travel times from parts of the aquifer, it is important to note that some of the nutrients and contaminants hitting the bays today are from past land use practices (i.e., legacy nitrogen loading), such as agriculture, industry, and residential development [14, 16].

groundwater supply and impact the quality of water in private drinking water wells. Monitoring and testing of private wells can help ensure the quality of drinking water provided from these wells. SCDHS does provide monitoring of private drinking water wells in Suffolk County on a voluntary basis at a fee of $100 for existing wells or $350 for new wells. While the SCDHS private well testing program "has discovered many instances of severe well water contamination… analyses show that the majority of wells tested in Suffolk County meet drinking water standards that have been set for health-related reasons" [59]. Less than 2% of private wells are tested by SCDHS each year, according to the Suffolk County Comprehensive Water Resources Plan [2].

Use of private drinking water wells and individual sewerage systems have not been associated with specific cases of disease in Suffolk County. However, the combination of risk factors suggests a possibility that current conditions could contribute to water-related illness in the community.

Surface waters

As mentioned previously, wastewater effluent discharged into the soil can also have a major influence on surface, recreational, and, ultimately, coastal waters; however, **not all nitrogen that enters a watershed reaches receiving waters** (i.e., waterbodies downgradient from the watershed). Some modeling of individual sewerage system-derived nitrogen contributions to Long Island estuaries shows that the majority of nitrogen from individual sewerage systems makes its way to Long Island estuaries. The Nitrogen Loading Model (NLM) used in many of the Long Island nitrogen modeling studies [11, 12, 13, 15, 17, 54] assumes that 35% of the nitrogen is retained in the watershed, but Lloyd [12] noted that the NLM likely underestimates the total nitrogen loading; other experts suggest only 10-20% of the nitrogen is retained in the watershed. At the time of the HIA, the NLM modeling of individual sewerage system-derived nitrogen contributions to Long Island estuaries provided the best available data and it showed that approximately 30-40% of the nitrogen is retained in the watershed; meaning that **60-70% of the nitrogen from individual sewerage systems makes its way to Long Island estuaries** [17]. Because this was the best available data at the time of the HIA analysis, this was used to estimate nitrogen loading to surface waters for the alternatives assessed in the HIA. The countywide nitrogen loading modeling performed by Suffolk County since completion of the HIA analysis shows a fair amount of variability in nitrogen loading among subwatersheds in the County.

Nitrogen Loading Modeling

Since completion of the HIA analysis, Suffolk County undertook county-wide nitrogen loading modeling as part of the development of a Subwatersheds Wastewater Plan. This modeling was used to establish travel times and nitrogen loading estimates for each subwatershed, establish nitrogen load reduction goals based upon specific human health and environmental endpoints, and refine priority areas in which to focus those efforts. See the full HIA Report, Appendix K for more information.

Nutrients play an important role in the environment. In aquatic environments, nitrogen and phosphorous support the growth of phytoplankton, algae, and aquatic plants, which provide food and habitat for fish, shellfish, and smaller organisms that live in water [60]. However, **too much nitrogen and phosphorous can accelerate the degradation of surface waters by causing algae to grow faster than the ecosystem can balance** (www.epa.gov/nutrientpollution/problem), contributing to the formation of algal blooms [61, 62, 63]. Excess algal growth and eutrophication result in visual changes to the water, including muddled or discolored water (i.e., decreased water clarity) and in some cases, foul odors. Not all algal blooms are harmful, but **when some algae multiply in large numbers, they can have negative impacts on humans, the environment, and coastal**

economies [64]**. These algae produce harmful algal blooms (HABs)**. Some freshwater and marine HAB species produce toxins that are harmful to humans, while others are a major cause of eelgrass, fish, shellfish, and other plant and animal die-off in marine waters, affecting commercial fishing and shellfishing industries.

Harmful Algal Bloom Action Plan

In September 2017, SCDHS released its Harmful Algal Bloom Action Plan, which includes a comprehensive strategy to address harmful algae blooms that threaten both Suffolk County's environment and economy [207].

In addition to increased algal bloom occurrences, **pathogens are another source of risk to surface water quality**. Pathogen monitoring in surface waters is impractical, given the relatively lower concentrations of pathogens compared to other microorganisms, and because each type of bacteria, virus or protozoan requires a different test [65]. Instead, fecal indicator bacteria (FIB) are often used to indicate that fecal contamination may have occurred. If relatively high numbers of FIB are found, there is an increased likelihood of pathogens being present [65, 66]. Coliform indicators do not always infer human sewage contamination, however, because FIB can come from wildlife and other animal sources and can survive and proliferate in subsurface sands and sediment (under certain conditions) for an extended period [67]. **Several studies, in locations other than Suffolk County, have demonstrated the link between elevated levels of FIB and unsewered areas or waters impacted by individual sewerage systems** [68, 69, 70, 71]. It should be noted that many of these studies were likely conducted on septic tank-soil absorption systems. Although these systems are technologically different from the cesspools and septic tank-leaching pool systems utilized in Suffolk County, **it is reasonable to expect the link between elevated levels of FIB and waters impacted by individual sewerage systems to exist in Suffolk County**.

All three major estuary systems in Suffolk County – the Peconic Estuary, South Shore embayments, and Long Island Sound – **have been declared impaired due to pathogens and/or nitrogen contaminants** [72, 73]. Depleted dissolved oxygen, increased nitrogen loading, harmful algal blooms, and decreased wetland acreage have been observed in all three estuaries. These conditions can impact human health, recreational use of waters, tourism, and the economy, including impacts to the fishing and shellfishing industries.

Recreational waters, beaches, and shellfisheries are routinely monitored and closures and/or health risk advisories are issued as needed to protect human health [74]. In 2015, **water quality advisories and closures** were issued at 36% of Suffolk County beaches (https://watersgeo.epa.gov/beacon2/reports.html), encompassing 3.6% of total beach-days during the season (i.e., sum of days with beach actions across all beaches vs. sum of days each beach is seasonally open). The majority, 96%, were rain advisories issued preemptively due to anticipated stormwater discharges. Fourteen (14) beach closures were associated with unsafe levels of FIB. As noted previously, the presence of FIB does not always infer human sewage contamination; FIB can come from human waste, wildlife, and other animal sources. **Shellfishing restrictions** affect 13% of the Suffolk County waters designated for shellfishing, and pathogen contamination is responsible for 92% of that impact [24]. It is important to note that the source of FIB or pathogens in Suffolk County waters has not been directly linked to individual sewerage systems (although it is reasonable to expect that link to exist), nor does the presence of FIB or pathogens always correlate with incidence of disease. Like pathogens, several freshwater and marine species of HABs have also been responsible for shellfish bed closures and beach closures. While advisories and closures can reduce illness risks, they cannot be expected to prevent all illnesses.

Individuals can potentially be exposed to pathogens, toxins, and other irritants present in surface waters. In recreational waters contaminated with fecal and biological contaminants, such as those from wastewater, the **health impacts can include gastrointestinal and respiratory illnesses, and illness of the eyes, ears, and skin** [39, 75, 76]. In general, the most commonly reported recreational water illness is diarrhea, which can be caused by germs, such as *Cryptosporidium*, *Giardia*, *Shigella*, noroviruses, and *E. coli* O157:H7, all of which are pathogens that can be found in human waste [77].

In addition to pathogens, **HABs also pose a risk of human illness**. Cyanobacteria, also called blue-green algae, are often the cause of algal blooms in fresh water and occasionally in marine water; they are most commonly associated with illness from contact and/or inhaled HAB toxins [78]. Cyanobacteria can cause rashes and gastrointestinal illness and produce toxins that can be consumed, aerosolized, or absorbed through the skin to damage tissues of the liver, nervous system, and skin of both humans and animals [79, 80]. Children are most at risk to the effects of cyanobacteria because of their lower body weight, behavior (i.e., greater time spent in the water and amount of water swallowed), and the effects of toxins on development [81]. Other marine HAB species produce toxins and compounds that can cause paralytic shellfish poison (PSP) and diarrhetic shellfish poisoning (DSP) in humans that consume shellfish or other marine animals contaminated with the compounds [82, 83]. Symptoms of PSP include numbness and tingling of lips, tongue, face, and limbs; loss of motor control; respiratory distress; and even death [63]. Symptoms of DSP include diarrhea, vomiting, and nausea and abdominal pain [84, 85]. In addition to these direct health impacts, the **coloring of Suffolk County waters with these algae can also deter water-based recreation (e.g., boating, swimming, and fishing) and affect other sectors, such as tourism and real estate** [86, 87, 88, 89].

Predicted impacts to water quality

It should be noted that individual sewerage systems are not the only source of wastewater inputs to Suffolk County waters, and likewise, wastewater inputs are not the only source of nitrogen and pathogen loading to waters in the County. This HIA, however, only assessed the contributions from individual sewerage systems, as these systems are the target of the proposed code changes. It is important to note that no modeling was conducted in the HIA to estimate pollutant loading to Suffolk County waters. The assessment of impacts to surface water quality focuses on impacts to estuarine and coastal waters, given the available modeling of nitrogen loading to Suffolk County estuaries, the documentation of algal blooms in marine waters, and the implication of estuarine and marine waters on shoreline resiliency. It is assumed that the impact of the decision alternatives would be similar for Suffolk County freshwater resources, such as rivers and lakes. Cumulative loading estimates for each decision alternative are presented two ways: 1) in terms of the TN and pathogen loading in liquid effluent at the edge of the system (i.e., at the point of discharge from the individual sewerage system) for all individual sewerage systems across the County; and 2) based on results of prior NLM efforts which suggests that up to 70% of nitrogen from individual sewerage systems may load to Suffolk County estuarine and coastal waters.

For both Alternatives I and II, there would be **no appreciable change in nitrogen loading to the environment** as compared to the baseline, as stated previously**.** If the average TN load coming from the septic tank is 5 kg (11 lbs) TN per person per year, at an average 2.93 persons per residence and a total of 385,117 unsewered, single-family parcels, cumulative **TN loading to the environment from these systems equates to an estimated 5.64 million kg** (12.41 million lbs) **TN per year**. Assuming an estimated 70% of TN loading reaches receiving waters in

a watershed (i.e., 30% retention within the watershed), then about **3.95 million kg (8.70 million lbs) TN per year from individual sewerage systems could eventually reach receiving waters (e.g., estuaries and coastal waters) across Suffolk County**. There **may be a reduction in pathogen loading** from upgrading the residences served by OSDS to C-OWTS, **given the potential 1-$\log_{10}$ reduction in pathogen loading** by using a septic tank in combination with a leaching pool. The existing impairments to Suffolk County surface waters (depleted dissolved oxygen, increased nitrogen loading, harmful algal blooms, reduced water clarity, etc.) would continue under Alternatives I and II, along with impacts to stress and overall health and well-being.

For Alternative III, there would be a **considerable reduction in nitrogen loading to the environment**. If the upgraded I/A OWTS in the high priority areas achieve Suffolk County's goal of 19 mg/L TN concentration in effluent from each system, this would result in an estimated **cumulative reduction in TN loading to the environment** from individual sewerage systems in Suffolk County **of 2.52 million kg (5.56 million lbs) TN per year.**[9] Assuming an estimated 70% of TN loading reaches receiving waters in a watershed (i.e., 30% retention within the watershed), then about **2.19 million kg (4.82 million lbs) TN per year from individual sewerage systems could eventually reach receiving waters (e.g., estuaries and coastal waters) across Suffolk County**. There **may also be a reduction in pathogens (and emerging contaminants of concern)** given the **potential 1-$\log_{10}$ reduction or more in pathogen loading** depending on the components of the I/A OWTS.[10] However, pathogen loading from the residences outside of the high-priority areas would continue at baseline rates. The changes in water quality that would result from implementation of Alternative III could result in increased dissolved oxygen; reduced algal blooms, fish and shellfish kills, advisories, and shellfishing and beach closures; increased water clarity; and more. These improvements in water quality can lead to improved perceptions of Suffolk County waters, reduced stress regarding water quality condition, and improvements to overall health and well-being.

There **may be an improvement in the microbial quality of private drinking well water in unsewered areas and of surface waters under Alternatives I and II**, given the limited (1-$\log_{10}$) reduction in pathogen loading [27] by adding a septic tank. And with the reduction in nitrogen and pathogen loading of I/A OWTS**, improvements in the nitrogen levels and microbial quality of private drinking well water and surface waters are possible under Alternative III**. Given the low prevalence of microbial contamination currently observed in community supply groundwater wells; the routine monitoring of distributed water quality; the adaptive capacity of the SCWA to address degraded conditions; and the additional protections offered by well depth and disinfection of waters, the proposed code changes are unlikely to impact public drinking water quality. However, Alternatives I and II do

[9] For an estimated 251,502 unsewered, single-family residences, at an average 2.93 persons per residence, and a loading of 1.58 kg (3.48 lbs) TN per person per year (assuming the I/A OWTS achieve Suffolk County's requirement of 19 mg/L TN loading in effluent), TN loading from upgraded systems in Suffolk County high-priority areas would equate to 1.16 million kg (2.56 million lbs) TN per year. The 133,615 systems outside of the high-priority areas would continue at a loading rate of 5 kg (11 lbs) of TN per person per year, contributing 1.96 million kg (4.32 million lbs) TN per year. This would equate to 3.12 million kg TN per year from individual sewerage systems; a 2.52 million kg TN reduction from the 5.64 million kg baseline.

[10] Some I/A OWTS can treat pathogens and emerging contaminants of concern (e.g., personal care products and pharmaceuticals) when certain components are part of or used in conjunction with the system, such as biofilters, microfiltration membranes, chlorination/disinfection units, and permeable reactive barriers; because the final designs of the systems are unknown, the measured pathogen or fecal indicator bacteria control performance of the systems is unknown. It is assumed, however, that I/A OWTS will achieve the minimum reduction in pathogen loading seen by adding a septic tank (i.e., a 1-$\log_{10}$ reduction), regardless of any additional components in the system.

nothing to address nitrogen loading of individual sewerage systems, which could lead to continued increases in the nitrate-nitrogen levels in the Upper Glacial and Magothy Aquifers, making treatment of public drinking water more expensive.

Predicted health impacts

- Under **Alternatives I and II (installation of C-OWTS),** the **continued risk of illness from aquatic recreation** due to pathogens and HABs **is possible** and **illness from private and non-community drinking water supply wells is possible,** as these alternatives provide no reduction in nitrogen loading and only a limited reduction in pathogens. Under Alternatives I and II, **impacts to stress and overall health and well-being** would remain unchanged given continued perceptions and concerns of Suffolk County water quality. Given the reduction in nitrogen loading and pathogen loading expected under **Alternative III (installation of I/A OWTS), reductions in beach closures and the risk of illness** due to exposure to pathogens and algal blooms during aquatic recreation **are possible.** The risk of **illness from private and non-community drinking water supply wells is unlikely** under Alternative III, **provided that disinfection technologies are utilized**. Under Alternative III, improved water quality could positively influence perceptions of Suffolk County waters, **reduce stress, and improve overall health and well-being**. Under all alternatives, illness from public/community drinking water supplies remain unlikely.
- **The risk of exposure to pathogens in recreational waters and private drinking water could affect a high number of people**, considering private (individual) wells and non-community systems serve about 13% of residents (approx. 194,000 people). However, the number of illnesses of this type are low. Monitoring of surface waters and private drinking water wells can help minimize these risks. **Impacts to stress and well-being from perceived water quality are likely to be experienced by a moderate number of people**.
- The **health implications of exposure to sewerage-contaminated recreational and drinking water** are typically minor to moderate (e.g., gastrointestinal illness, respiratory illness, rashes, and illness of the eye, ear, and skin) but can be more severe and long-lasting for exposures to toxic algal blooms (e.g., liver damage and nervous system damage) and for those at higher risk of illness. Health impacts of stress and well-being are minor and could easily change.
- These **health impacts (or their potential reduction) would be disproportionately experienced** by recreational water users; those with private/non-community drinking water supply wells and individual sewerage systems; those more susceptible to pathogens (e.g., young children, the elderly, and the immunocompromised); those more at risk to the effects of toxic algal blooms (e.g., children); and those more at risk to nitrate toxicity in drinking water (e.g., pregnant women and infants under 6 months). **Impacts to stress and well-being would be disproportionately experienced** by low-income populations, recreational water users, coastal populations, and individuals with existing mental health conditions.

Recommendations

The analysis in this pathway showed only Alternative III (I/A OWTS) would result in reduced nitrogen loading to Suffolk County surface waters and ground water and possibly reduced loading of pathogens and emerging contaminants of concern (depending on the system designs); these conditions would lead to improvements in water quality, although the timing and extent of improvements is unknown. A recommendation was made previously suggesting a fourth alternative be considered requiring upgrade of individual sewerage systems to I/A OWTS across the entire county, with prioritization given to parcels in the high-priority areas (see Individual Sewerage System Performance and Failure pathway). The recommendations that follow focus on outreach and communication; system siting, design, and installation; and protection of water resources:

- To achieve improvements in perception of water quality, engage and inform the public with accurate information, set realistic expectations of outcomes, and effectively communicate results when improvements in water quality and its associated ecosystem services (recreation, economy, etc.) are experienced.
- Increasing vegetated land cover and green infrastructure between individual sewerage systems may prevent further transport of sewerage-derived pollutants (and other nitrogen loading) in stormwater runoff and/or shallow groundwater movement [11].
- Vigilance in controlling pollution from individual sewerage systems is important especially when individuals are obtaining drinking water from private wells. Continue efforts to expand public drinking water supply.
- Expansion of connections to community supply systems could continue to reduce dependency on private wells, which can reduce the overall magnitude of potential effects of wastewater on drinking water.
- Require good practice in the siting, design, installation, and maintenance of individual sewerage systems to ensure the protection of groundwater and drinking water sources, especially in areas served by private drinking water wells.

Resiliency to Natural Disasters

How is resiliency related to health?

Resiliency is "the ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events" [90]. The NYS 2100 Commission [91] defined resilience as "the ability of a system to withstand shocks and stresses while still maintaining its essential functions." In coastal resiliency, this means reducing vulnerabilities and potential exposures to natural hazards (e.g., storms) and their impacts before they occur in hopes of decreasing the consequences of the events. These vulnerabilities can affect health in a number of ways, including direct exposure to the storm, secondary hazards (e.g., falling trees, rising waters, electrocution, and carbon monoxide poisoning), disruption of services, evacuation and displacement, trauma and stress, and clean-up and recovery activities, and can range from changes in overall health and well-being to injury, illness, and death.

This pathway was included in the HIA based on messaging from Suffolk County and stakeholder discussions indicating that the proposed code changes would increase resiliency against future storms like Hurricane Sandy, through improvements to water quality and subsequent gains in the health and extent of coastal and tidal wetlands and eelgrass populations in Suffolk County. As a result, the analysis focused on the potential impacts of the proposed code changes on wetlands and their ability to provide protection to severe storms, storm and/or tidal surges, and coastal and inland flooding. Although the impact analysis focused primarily on wetlands and eelgrass populations and their contribution to shoreline and community resiliency, the discussion was expanded to include other existing factors and features in Suffolk County that also play a role in wetland health and extent, resiliency of the shoreline to storm and/or tidal surges, and community resiliency. This was done because **there are stressors beyond nitrogen affecting Suffolk County wetlands and eelgrass populations, and other factors beyond wetlands that determine shoreline and community resiliency.**

Key findings

The highest risk natural hazards for Suffolk County, as a whole, are Nor'easters, severe winter storms, severe storms, and hurricanes, and medium-risk natural hazards include coastal erosion and flooding [21]. **Because of Suffolk County's location and low-lying southern coastline, it is exposed to coastal storms, their associated storm surges, and coastal and inland flooding**. While hurricanes and tropical storms are the primary cause of coastal flooding in New York [21], **nuisance or "sunny day" flooding (i.e., shallow coastal flooding in the absence of storms, caused by sea level rise) is also becoming more frequent** [92, 93, 94, 95, 96].

Shoreline resiliency

Shoreline resiliency to storm and/or tidal surges is primarily dependent on a number of physical factors (e.g., geomorphology, coastal slope, relative sea-level change, shoreline erosion, mean tide, mean wave height) and the presence of natural habitats (e.g., wetlands, dunes, beaches) and engineered solutions (e.g., seawalls, bulkheads, jetties, and rip-rap-walls).

Wetlands provide a number of ecosystem services (e.g., ecological, economic, and social benefits). **Wetlands** regulate the movement of water within watersheds; **hold and slowly release precipitation, flood water, and snow melt**; **recharge groundwater**; **act as filters to cleanse water of impurities and sediment; recycle nutrients such as nitrogen**; **reduce erosion; and provide habitat for fish, wildlife, and a variety of plants**. Wetlands are nurseries for many saltwater and freshwater fishes and shellfish of commercial and recreational importance [97] and provide recreation and wildlife viewing opportunities for millions of people [98]. Eelgrass beds are also valuable habitat for several species that are important to Long Island's seafood and fishing industries, such as bay scallops, crab, striped bass, sea bass, and more [99]. Brackish and saltwater coastal wetlands also help **provide protection from wave erosion and provide a natural buffer from storm and tidal surges and coastal flooding**.

Between the early 1900s and 2004, Suffolk County lost more than 21,000 acres of freshwater and tidal wetlands, including over 51% of its freshwater and 39% of its tidal wetlands [100]. The population boom in Suffolk County between 1940 and 1970 led to the destruction of many wetlands, which were drained, dredged, and/or filled to support the residential, commercial, and industrial development that accompanied the boom. Recent studies have pointed to **excess nitrogen nutrient loading** from wastewater (i.e., from individual sewerage systems and wastewater treatment plants), fertilizer, and atmospheric deposition **as a significant factor in coastal/tidal wetland loss in Suffolk County** [2, 101, 102]. Local and regional experts have identified nitrogen pollution from wastewater as a considerable contributor of nitrogen to the Peconic Estuary, Long Island Sound, Great South Bay, and South Shore Estuary Reserve [2, 11, 12, 13, 15, 16, 53, 54].

There has also been considerable pressure on a unique wetland feature in Suffolk County – eelgrass beds (i.e., aquatic beds or submerged aquatic vegetation [SAV]). Eelgrass beds can help to slow currents and waves, trap sediments, and stabilize the seafloor to prevent shoreline shifting and erosion. In addition, they sequester nutrients such as nitrogen to help them grow, and trap sediments in the water column, to improve water quality. Historic photography and records indicate that there may have been as many as 200,000 acres of eelgrass in Suffolk County in 1930, but today, less than 22,000 acres remain [103, 104, 105]. **A number of stressors continue to lead to eelgrass population decline,** including algal blooms (e.g., brown tide), sediment and nutrient runoff, disease, physical disturbance (e.g., from boating, dredging, shellfishing, and normal use of sea grass beds by animals, such as crabs and waterfowl), hardened shorelines, climate change, and sea level rise [106].

Eelgrass (Zostera marina)

Nitrogen loading can contribute to the loss of native eelgrass and wetlands, which play important roles in shoreline resiliency to storm and tidal surges, flooding, and erosion, especially during lower-intensity storms and coastal flooding. Excess nitrogen loading overwhelms the capacity of wetlands to remove nitrogen; leads to the decline of stabilizing vegetation; alters the sediment regime; and in the case of coastal/tidal wetlands, compromises the wetland's ability to grow vertically to keep up with sea level rise. **As sea level rises, coastal/tidal wetlands must grow vertically and horizontally to avoid submersion (i.e., converted from vegetated wetland to unvegetated mud flat or even open water).** In New York, some coastal/tidal wetlands seem to be keeping pace with sea level rise, but many are not. **Water quality, and specifically nutrient-related water quality, is an important factor in maintaining wetlands health and their ability to grow vertically** to

keep up with sea level rise. Research has shown that increased nutrient loading has negative impacts on wetland structure, function, and substrate condition, especially that of salt marshes [107, 108, 109, 110, 111, 112]. Although nutrient enrichment stimulates above-ground plant growth, recent studies show that nutrient enrichment reduces below-ground root and rhizome biomass (which help stabilize wetland shores against erosion and wetland plant stability against storms and wave action), organic matter accumulation, and peat formation [107, 109, 111, 113, 114, 115]. In addition to the impact of nutrients on a wetland's ability to grow vertically, another factor influencing the ability of Suffolk County's coastal/tidal wetlands to keep up with sea level rise is their ability to grow horizontally. **Many of the shorelines in Suffolk County are hardened (i.e., lined with riprap, seawalls, or bulkheads), which prevents wetlands from being able to migrate landward (i.e., grow horizontally) to compensate for increasing water levels.**

Example of a hardened shoreline

Wetlands, which make up 45% of the approximately 67,574 acres of Suffolk County's land area that exists in coastal or riverine floodplains [97], **are estimated to be able to dissipate more than half of normal wave energy within the first three meters of marsh vegetation** [116]. Emergent vegetation (i.e., vegetation reaching the water surface and above) has been shown to be more effective at reducing wave height than submerged vegetation such as eelgrass, indicating that water depth is critical to wave attenuation [117, 118, 119, 120]. **Storm surge is considerably different from normal wave action,** however, and several studies have found that **as storm waters became more turbulent and wave heights increased, the ability of marsh vegetation and seagrass to attenuate waves decreased** [121, 122, 123]. Natural coastal features, such as wetlands, are dynamic ecosystems that provide significant benefits, but they are also among the most susceptible ecosystems to sea level rise [124]. Sea level rise not only amplifies storm surges, but also allows normal waves to reach further inland, increasing the risk of erosion, barrier island loss, inundation, and nuisance flooding [95, 125, 126].

Although **wetlands and eelgrass beds cannot be expected to stop storm surges and flooding associated with large storm events, like hurricanes**, **the friction provided by the vegetation can reduce wave energy somewhat, which is important for reduced wave damage, flooding, and erosion, especially during lower-intensity storms and coastal/tidal flooding** (e.g., nuisance "sunny day" flooding that occurs in the absence of storms due to rising sea levels), which are experienced more regularly [26].

Impacts of natural disasters

The Nature Conservancy [127] estimates that there are almost 12 million people and trillions of dollars of property and infrastructure in New York's coastal counties along the Atlantic Coast. **Severe weather and inundation can cause extensive and expensive damage to coastal properties, and in some cases, can debilitate entire communities.** Damage can be the direct result of storm and/or tidal surges and flooding or it can occur more gradually, through erosion or salt water inundation from rising sea levels [125]. Damage can include flooded and impaired roadways and transportation systems; overwhelmed and/or failed stormwater, drinking water and wastewater systems; damaged gas lines, and communication and power systems; mold and contamination; weakened structures and deteriorated infrastructure not designed to withstand exposure to salt water; foundation failure; complete structural loss; and more. All of these have potential health implications, as

exposure to hazards, living conditions, housing expenditures, and loss of services are factors known to impact health.

Individual sewerage systems are not immune to the impacts of storm and/or tidal surges, flooding, and sea level rise. **Depth to groundwater, potential for persistent flooding, rising groundwater, and storm and/or tidal surges pose a structural and hydraulic failure risk for individual sewerage systems.** Heavy rains, flooding, and storm and/or tidal surges can cause the ground to become saturated, keeping individual sewerage systems from operating properly. Under these conditions, the soil around the sewerage systems is unable to provide any treatment capability and contaminants from wastewater can make their way into groundwater and surface waters [128, 129, 130]. If the ground becomes too saturated and there is no place for the wastewater in individual sewerage systems to drain, hydraulic failure of the systems can occur, causing wastewater and solid waste to back up into homes or pool above ground, mixing with floodwaters [128, 129, 130]. Under flooded conditions, individual sewerage systems can also collapse or even float out of position [129]. Storm and/or tidal surges and flooding can also impact and cause damage to public wastewater treatment facilities and infrastructure, causing the release of untreated or partially treated wastewater; overwhelm stormwater systems; and impact private wells, public water treatment plants, and water distribution systems [131].

As sea levels rise, Suffolk County may see increased erosion, greater extent and frequency of coastal flooding, and storm surges that extend further inland. This could result in inordinate increases in the number of people, buildings, and critical facilities affected, along with increased property losses [26, 92, 125, 131]. Shepard, et al. [132] indicated that a moderate 19.7-inch rise in sea level by 2080 is estimated to result in a 33% increase in the amount of land inundated, a 47% increase in the number of people impacted by storm surge, and a 73% increase in property damage along the southern shores of Long Island over present day levels in the case of a Category 3 hurricane. Unlike with storms, flood waters due to sea level rise will not recede; instead, areas will become permanently inundated [133, 134]. The Regional Plan Association (RPA) [134] projects that 7,122 residents on Long Island could be permanently inundated with 12 inches of sea level rise; 41,023 residents with 36 inches of sea level rise; and 164,592 residents with 72 inches of sea level rise. These projections loosely correlate with the New York State low (15 inches), medium (34 inches), and high (72 inches) sea level rise forecasts for the Long Island Region (http://www.dec.ny.gov/regulations/103877.html).

Over time, the need for evacuation and risk of displacement are expected to rise because there will be more frequent and intense storms, increased coastal erosion, more frequent coastal flooding, and accelerated sea level rise. The population living and working in the Suffolk County SLOSH zones are directly affected by storm and/or tidal surge. There are also are **certain subpopulations that are particularly vulnerable to storm surges, coastal flooding, and the need for evacuation and/or displacement.** These include:

- those on the barrier islands with limited evacuation routes and locations nearer to storm paths;
- low-income populations, who are likely to weigh the risks of the storm against the economic impact to their family and may not have the funds to evacuate;
- the linguistically isolated, who may not understand emergency communications, evacuation notices, or the related risks of the storm; and
- the elderly and mentally and physically disabled, as they may have difficulty evacuating, likely require extra time or outside assistance to evacuate, and are more likely to need medical attention which may not be available due to isolation in a storm event.

In addition to causing significant property and infrastructure damage, storm and/or tidal surges and flooding have significant impacts on human health and well-being, ranging from mental health problems to disease and respiratory illness, injury, and death. Health effects from storm and/or tidal surges may occur through a number of pathways including: direct exposure, evacuation, post-impact hazards from power outages and inadequate housing/living conditions, disruption of services including healthcare, secondary hazards (such as standing water, which can harbor mosquitoes), displacement, mental health effects from traumatic and stressful experiences, and clean-up and recovery activities [135]. All of these can lead to stress and poor mental health, while some can have other far-reaching effects and impact household and community economics, opportunity for physical activity, and disease.

During storm events, drowning from storm surges and wind are major causes of death; however, deaths also occur post-storm due to hazards like electrocution from downed power lines, motor vehicle fatalities, chain-saw injuries, blunt trauma from falling trees, and carbon monoxide poisonings in households using generators for heat [135, 136, 137]. Storm surges and other flooding events can result in an increased risk of exposure to pathogens from drinking water and wastewater system failures (which has implications for health) and bacterial and fungal contamination of soil and housing. Water damage to homes and businesses from floodwaters create moist conditions where mold spores can grow and multiply. This mold contamination can lead to health effects such as respiratory conditions (e.g., chronic obstructive pulmonary disorder, bronchitis, and other respiratory infections); wheezing and difficulties breathing; cough; congestion; throat, eye, and skin irritation; and headaches [138, 139, 140]. Populations vulnerable to health effects from mold contamination are persons with allergies, asthma, and other breathing conditions [140, 141].

Immediately following storms and/or tidal surges, displacement, infrastructure damage, closed recreational areas and schools, safety concerns, and other factors can alter normal routines, including physical activity. Disaster-related displacement, relocation, loss of property and personal finances, injury, and loss of life have all been shown to be associated with mental health problems (e.g., anxiety, posttraumatic stress disorder [PTSD], and depressive disorder) in victims, emergency responders, and those in the healthcare field [95, 142, 143, 144].

Predicted impacts to resiliency

As noted earlier, individual sewerage systems are not the only source of wastewater inputs to Suffolk County waters, wastewater inputs are not the only source of nitrogen loading to Suffolk County waters, and nitrogen loading is only one of many factors affecting coastal/tidal wetland structure and function across the County. No reduction in nitrogen loading is expected with Alternatives I and II, but the reduction in nitrogen loading from innovative/alternative OWTS in **Alternative III should create conditions conducive to restoration of wetland structure and function and allow coastal/tidal wetlands and eelgrass to reduce wave damage, flooding, and erosion, especially during lower-intensity storms and coastal/tidal flooding**. **However, there are other competing factors contributing to loss of wetland structure and function across the County,** including accelerated sea level rise, other present-day nitrogen loading, and legacy nitrogen loading due to the long travel time of some groundwater through the aquifer. **Given these factors, it is uncertain the degree to which improvements in coastal/tidal wetland structure and function would be seen under Alternative III.** Should there be an attributable improvement in water quality and subsequently in coastal/tidal wetland structure and function due to the decision, it is unknown how long it would take for this improvement to be seen, considering groundwater travel times of 0-10 years along the coast and up to decades and even hundreds of years from the middle of Long Island.

Regardless of the decision alternative chosen, efforts should be taken to adapt to the rapid acceleration of sea level rise projected for the region. Given the many factors that contribute to making a community resilient to natural disasters, it is **uncertain the degree to which the proposed decision will have an impact on Suffolk County resiliency to storm and/or tidal surges or the associated health impacts of these events,** especially in light of the accelerated sea level rise projected for the region. Modeling and long-term monitoring will be necessary to make this determination.

Predicted health impacts

- The **negative health impacts of storm and/or tidal surges and coastal flooding are highly likely to continue regardless of the decision scenario chosen**, due to the confounding factors affecting community resiliency and its associated health impacts, including climate change, sea level rise, coastal development, and individual behaviors (such as willingness to evacuate).
- **Thousands of people live and work in the Suffolk County SLOSH Zones** (areas affected by Sea, Lake, and Overland Surges from Hurricanes) and **would be disproportionately affected** by hurricanes and storm events. However, advances in warning and evacuation systems reduce the number of people who experience these impacts. There are **certain subpopulations, however, that are particularly vulnerable to storm and/or tidal surges and coastal flooding** regardless of these advances, including those on barrier islands, the elderly, physically disabled, those with pre-existing conditions, low income populations, and the linguistically isolated.
- The health implications of storm and/or tidal surges and coastal flooding can range in severity from minor injuries and illness to mental health problems, disease, and injuries that require medical treatment or intervention, and even disabling injury and death. While these impacts are likely to be experienced immediately, many can potentially be long lasting (e.g., permanent disabling injury and death, mental health impacts, etc.).

Recommendations

The analysis in this pathway showed only the innovative/alternative OWTS in Alternative III could reduce nitrogen loading from individual sewerage systems. Decreased wastewater contributions to coastal/tidal wetlands would create conditions conducive to restoration of wetland structure and function, including restoration of eelgrass, and decreases in coastal/tidal wetland loss; all of these are important for improving coastal resiliency and reducing wave damage, flooding, and erosion, especially during lower-intensity storms and coastal/tidal flooding. The timing and extent of improvements is unknown, especially given the competing factors contributing to coastal resiliency. A recommendation was made previously to suggest a fourth alternative be considered requiring upgrade of individual sewerage systems to I/A OWTS across the entire county, with prioritization given to parcels in the high-priority areas (see Individual Sewerage System Performance and Failure pathway). What follows are recommendations, beyond the code changes themselves, that focus on health-supportive measures related to wetland protection/restoration, wetland/green infrastructure creation, and resiliency planning:

- Protect, restore, and create freshwater and coastal/tidal wetlands or other green infrastructure alternatives to improve shoreline resiliency and improve wetland functioning, including attenuation of nutrients. The USFWS inventory [145] identified 760 acres of potential wetland restoration sites in

southern Suffolk County and 12,543 acres of impaired Suffolk County wetlands that may be eligible for restoration.

- Integrate wetland protection priorities into community planning.
- Evaluate the use of hybrid approaches that combine natural habitats and built defense structures to improve resiliency.
- Undertake planning efforts and secure funding that address sea level rise adaptation in order to ensure shoreline resiliency to storm and/or tidal surges for the long-term.
- Ensure that the impacts of accelerated sea level rise and increased storm frequency and intensity are adequately examined and accounted for in the initial phases of all planning efforts.
- Undertake planning efforts and secure funding that addresses sea level rise adaptation of wetlands and other natural shoreline types (e.g., beaches and dunes) in order to enhance shoreline resiliency to storm and/or tidal surges for the long term.
- Consider activities, such as voluntary buyouts, that encourage local (town/village) land use and zoning regulations, and County-level disincentives to development, to reduce the infrastructure and people in vulnerable coastal areas and create more naturally-functioning coastal floodplains and provide space for coastal/tidal wetlands to retreat and expand.
- Prioritize resiliency efforts (e.g., habitat restoration, shoreline management, and planning activities) based on risk of exposure and social and economic vulnerability to sea level rise, severe storms, and storm and/or tidal surges.
- Undertake efforts in emergency management planning and outreach to ensure that individuals receive and comprehend evacuation messages and have the necessary capacity and resources to comply with them.

Vector Control

How is vector control related to health?

Insect vectors, especially mosquitoes, spread diseases such as West Nile Fever, Eastern Equine Encephalitis (EEE), and Zika. Excessive insect populations and high-visibility pesticide applications to control for those populations can create a negative perception of the environment and the community. Nuisance and irritation from the presence of biting insects, the risk of vector-borne disease, and pesticide applications can deter participation in outdoor activities, discouraging exercise and appreciation of nature, both of which have physical and mental health benefits.

Key findings

Mosquitoes affect human health and well-being in Suffolk County, not only through their irritating biting activity, but also through the spread of mosquito-borne disease [146]. Mosquito-borne disease has become a prominent public health issue in the U.S., with the appearance of emerging diseases such as those from West Nile virus (WNV), Eastern equine encephalitis virus (EEEV), and Zika virus. Although occasionally viewed as a public health crisis in Suffolk County, much effort has been devoted to educating the public about avoiding being bitten by mosquitoes, keeping yards free from mosquito habitats, and eliminating standing water. Some sources of mosquito habitat, such as marshlands and wetlands, cannot be drained and require the application of pesticides to inhibit or eliminate mosquito populations.

According to SCDHS, **Suffolk County is currently home to approximately 50 species of mosquitoes**. These mosquitoes can be characterized by their preferred breeding environment as summarized below.

- Container breeders – these mosquitoes, including the **WNV carriers *Culex pipiens, C. restuans,* and *Aedes albopictus*** [147], lay their eggs in shallow, stagnant water near human dwellings. Flower pots, discarded tires, wheelbarrows, unsealed septic tanks and cesspools, and rain gutters are among their larval habitats. These mosquitoes often lay their eggs in polluted, organically rich water, as their larvae are more tolerant to suboptimal conditions than predator species [148, 149, 150, 151].
- Freshwater breeders – these mosquitoes lay their eggs in natural freshwater environments, such as wetlands, puddles, drainage basins, or ponds. There is significant overlap between these and container-breeding mosquitoes. Some freshwater mosquitoes, such as *Anopheles*, can also breed in brackish water.
- Saltwater/salt marsh breeders – these mosquitoes lay their eggs in damp marshland, which then hatch *en masse* following tidal or rainfall events that inundate marshes. These include the **nuisance biter and potential EEEV and WNV vector *Aedes vexans*, *Aedes sollicitans***, as well as several species in the genera *Anopheles*. As their bites can transmit serious disease, vector control measures do target these mosquitoes in Suffolk County.

Individual sewerage systems can also contribute to nutrient loading and creation of mosquito habitat when wastewater ponds above ground (during hydraulic failure) and when wastewater effluent seeps into surface waters, either through overland transport during heavy precipitation and overflow events, or via subsurface groundwater flow. Mosquito larvae can thrive in water that would not sustain normal aquatic life, such as wastewater. The primary mosquito that transmits WNV in New York, *Culex pipiens*, feeds on organic detritus and biofilms in its larval form [152] and often selectively breeds in polluted water, including septage. In general, **improperly maintained septic tanks and cesspools can also serve as fertile breeding habitat for mosquitoes, producing hundreds to thousands of mosquitoes daily** [153, 154, 155, 156]. In addition to accessing open or cracked septic tanks, the U.S. Centers for Disease Control and Prevention (CDC) [154] and New York State Department of Health (NYSDOH) [157] also cite unsealed septic tanks (e.g., unsealed tank cover, uncovered ventilation pipe) as a possible route for mosquito access to these types of systems. Although individual sewerage systems in Suffolk County are typically placed lower in the soil than conventional OWTS in other locales, cesspools and septic tank-leaching pools in Suffolk County are equipped with vent pipes/chimneys and covers to allow access to the systems for inspection, maintenance, and sewage removal. It is through these components, when they are not airtight, that mosquitoes are able to access individual sewerage systems and the systems become prime mosquito habitat. Although there are no data on the prevalence of cracked, uncovered, or unsealed individual sewerage systems in Suffolk County, several Suffolk County vendors do note individual sewerage system repairs include pipe repairs and resealing, tank lid replacement and sealing, and inspection for cracks [158, 159, 160, 161, 162, 163]. No studies have been conducted on Long Island specifically linking septic tanks as breeding habitats for mosquitoes, although a study conducted in Suffolk County following completion of the HIA analysis showed an association between high septic system density and increased WNV infection in mosquitoes [164].

Suffolk County implements an integrated vector control program that utilizes public complaints and formal surveillance of mosquito populations, habitats, and occurrence of vector-borne disease to inform and focus the control measures. The control measures include preventative activities such as public education, water management, larvicide (i.e., insecticide that is specifically targeted against the larval life stage) application, and when other measures have proven infeasible or unsuccessful, adulticide (i.e., insecticide that is specifically targeted against the adult life stage) application. Annual applications of mosquito larvicide are conducted to limit mosquito populations and combat the spread of disease. Adulticide application is only carried out when mosquito infestations are severe and widespread (i.e., a public health nuisance) and/or to respond to the presence of vector-borne disease [146].

Suffolk County uses larvicides and adulticides that are widely agreed upon by toxicologists, medical doctors, and environmental regulators to be safe for humans. However, an internet search for "Long Island pesticide health effects" reveals that **some citizens are opposed to adulticide spraying, arguing that the health risks of chronic exposure outweigh the benefits of mosquito control**, and that larvicide application is a more efficient control strategy [165, 166, 167]. Less than one percent of Suffolk County residences are on the Do Not Spray Registry,[11] indicating that the concern over pesticide application is relatively low overall.

[11] For those residents who wish to exempt themselves from routine spraying, the county maintains a Do Not Spray Registry that lists addresses to avoid. A public health emergency that requires the use of adulticide spraying, however, overrides the Do Not Spray registry.

Nuisance mosquitoes, the threat of vector-borne disease, and pesticide spraying can cause distress and discourage participation in outdoor activities [146, 168, 169]. While research on the effects of mosquitoes on mental well-being in Suffolk County is lacking, examination of local news articles reveals that in warmer months, mosquitoes can be a significant nuisance and quality-of-life issue. In addition, there is the perception by some that insecticides and other control measures are unsafe. The desire to avoid exposure to mosquito control pesticides may also reduce willingness to participate in outdoor activities. **Spending more time in the outdoors or even simply viewing a natural environment has been linked to a wide variety of mental, psychological, and emotional health benefits** [170]**, as well as lowered blood pressure, more positive outlooks on life, and better overall health** [171]. Participating in outdoor recreation also leads to decreases in stress, lowers the chance of obesity and high blood pressure [172], and increases feelings of overall "wellness" [173].

Mosquito-borne disease is a recurring problem on Long Island, owing both to its large amount of surface water and proximity to New York City, which is a hub for international travel and shipping. Mosquito-borne diseases can be transferred from distant locations, such as in the initial 1999 West Nile Virus outbreak when the virus was found to be most similar in serotype to a strain from Israel [174]. **Of the vector-borne diseases found in Suffolk County, the most serious are those caused by WNV and EEEV.** WNV infection most often manifests as West Nile Fever, which causes fever and flu-like symptoms and often goes undiagnosed. However, in the old, very young, or immunocompromised, the disease can become more severe and lead to West Nile Encephalitis, which (like Eastern Equine Encephalitis) can cause swelling of the brain, is difficult to treat, and can lead to death. Many who survive are left with brain damage that lasts for years or is permanent [175]. **While EEEV was detected in mosquitoes on Long Island in 2008, there have been no other reports of EEEV as of 2015** [176]**; WNV, however, continues to be detected in both mosquitoes and humans in Suffolk County annually**.

Predicted impacts to vector control

In all three decision alternatives, it is anticipated that mosquito habitat will be reduced by eliminating cracked, uncovered, and/or failing individual sewerage systems. Adoption of **I/A OWTS in Alternative III will also reduce nitrogen pollution, which can lead to a further reduction in mosquito habitat and infestation** by improving the quality of surface waters and supporting predator species that consume mosquito larvae. Reduced mosquito populations would likely lead to fewer applications of pesticides to combat the spread of both nuisance and disease-spreading mosquitoes, as the County uses a surveillance-based approach for pesticide use. **Reduced mosquito populations and fewer insecticide applications may lead to improved perception of the environment (e.g., as safer from infectious disease and nuisance mosquitoes,** although no direct link has been shown between mosquito population size and disease incidence for WNV); as a result, residents may be more likely to engage in outdoor activities and enjoy the many health benefits they provide. Additionally, by reducing insecticide application, a significant source of stress to some residents who find mosquito spraying controversial, will likewise be reduced. Mosquitoes alone likely account for a relatively minor part of discouraging outdoor activities, and studies linking decreased pesticide application and improved perceptions of the environment are lacking.

Predicted health impacts

- It is possible that decreases in mosquito populations, as a result of the reduction in and/or elimination of old and/or failing individual sewerage systems and in Alternative III, the added reduction in nutrient pollution in Suffolk County waters, **could lead to a decrease in illness from vector-borne pathogens**, although there is no direct link between mosquito population size and disease incidence for WNV. **Decreased mosquito populations and subsequently reduced pesticide applications may also benefit health** by increasing the willingness of residents to engage in outdoor activities and reducing stress related to mosquitoes, vector-borne disease, and pesticides. However, mosquitoes alone likely account for a relatively minor part of discouraging outdoor activities, and studies linking decreased pesticide application and improved perceptions of the environment are lacking.
- These potential benefits may have a lesser effect on those who live in sewered areas, but would **disproportionately benefit** the young, the elderly, the immunocompromised, and those who live in proximity to mosquito breeding areas and insecticide application areas.
- The benefits to decreased mosquito populations and pesticide applications include a reduced risk of stress, mosquito bites, and mosquito-borne diseases such as WNV and EEEV.

Recommendations

The analysis in this pathway showed that mosquito habitat is expected to be reduced by eliminating cracked, uncovered, and/or failing individual sewerage systems in all three decision alternatives. Adoption of I/A OWTS in Alternative III will also reduce nitrogen pollution, which can lead to a further reduction in mosquito habitat and infestation. What follows are recommendations focused on I/A OWTS evaluation, system maintenance, and wetland protection/restoration to help maximize improvements in vector control:

- I/A OWTS under consideration by the County could be evaluated to ensure that they do not provide breeding habitat for mosquitoes.
- Unused or abandoned systems should be filled completely with soil or gravel, both to eliminate a source of standing water and to avoid potential collapse and injury.
- Ensure that owners of onsite wastewater treatment systems inspect their systems for cracks, leaks, and loose manhole covers. Use cement to patch any cracks or gaps between the blocks; cover vent pipes with screen mesh; repair broken pipes; and seal joints to deny mosquitoes access to the water within.
- Conduct public outreach to emphasize the role individual homeowners can take to help prevent mosquito infestation, including mosquito production in individual sewerage systems.
- Measures to rehabilitate and restore wetland structure and function and to reduce mosquito production under the Integrated Marsh Management (IMM) framework could continue.

Community and Household Economics

How are community and household economics related to health?

Conditions in the environments where people live, work, learn, and play can impact their health [177, 178, 179, 180, 181, 182]. As such, **community and household economics both contribute to the overall health and well-being of an individual and a community.** Many health determinants are directly related to the economic vitality of the community and the availability of community services, such as neighborhood safety, mobility and access to goods and services, physical activity and social engagement, and many others. On an individual level, household income, combined with housing costs (generally the largest expense for a household), often determine an individual's ability to afford essential health-related goods and services, such as food, clothing, utilities, healthcare, and childcare. Community and household economics are interrelated as a result of the exchange of taxes, social services, and spending by both the individual household and the government in the economy. Regulations can boost the economy or deter economic growth, and when considering new regulations, such as the proposed changes to the Suffolk County sanitary code, the impacts to both community and household economics should be considered.

Key findings

Government policies on infrastructure, energy, sanitation, and water resources all impact the health outcomes of the families and communities they address. Changes in regulation, such as the proposed changes to the sanitary code, often require funding for implementation and oversight. Depending on the sources of this funding, these additional costs can potentially impact the services the community is able to provide. Changes in regulation can also impact household economics directly, if there are costs or fees associated with the changes, or indirectly, through potential impacts to property values.

Household economics

The proposed changes to the sanitary code will result in costs to individual households for County fees and costs associated with installation, operation, and maintenance of individual sewerage systems.[12] These costs depend on a number of factors including the type of upgrade required, the amount of labor required to install the upgrade, and the operating and maintenance costs of the new system. Maintenance for an existing OSDS or C-OWTS is the pumping out of the unit, and the operational costs are minimal, as these systems typically do not require any monthly expenditures, such as electricity, to run the system.

[12] Since the completion of the HIA analysis, funding (grants and loans) has been secured by the County for homeowners upgrading to I/A OWTS – the individual sewerage system called for in Alternative III. For more information on these funding opportunities, see the full HIA Report. Suffolk County has established that there is no plan to move forward with wastewater upgrades unless a stable, recurring revenue source is established to help reduce financial impacts to individual households and ensure that County services are not jeopardized by the costs of wastewater upgrade implementation.

Households upgrading to a C-OWTS would require an investment of approximately $5,225 [183]**. Households upgrading to I/A-OWTS would require a much greater investment, estimated at approximately $17,825, plus operation and maintenance costs.**[13] **I/A OWTS require routine management and monitoring, due to their specialized biological, mechanical, and electrical components, in order to remain operational and effective** [29].[14]

I/A OWTS Cost Information

Updated I/A OWTS cost information was made available through the County following completion of the HIA analysis. The **average** total cost for approved systems, including engineering and design services, purchase, and installation, is approximately $19,200, although costs vary on a case-by-case basis. In addition to the initial costs of having an I/A OWTS installed, there are costs associated with operating and maintaining an I/A OWTS. This updated cost information can be found in Appendix K of the full HIA Report.

The proportion of a household's income remaining after housing costs can determine the ability to afford essential health-related goods and services such as food, clothing, healthcare, and childcare. Households facing high housing costs are often forced to cut back on these essentials [184]. Analysis of the U.S. Bureau of Labor Statistics' 2011 consumer expenditure survey suggests, in general, that some cost-burdened households spend one-fifth the amount that non-burdened households spend on healthcare [184]. In addition, research indicates that as overall housing costs (including heating and cooling) increase, food insecurity increases [185, 186, 187, 188]. Food insecurity is a state in which a household reports reduced quality of diet and/or disrupted eating patterns and reduced food intake [189]. In Suffolk County's Community Health Assessment [25], food insecurity and hunger were identified as a health concern for financially challenged residents. **Reductions in available income for health-related goods and services are strongly linked to poor health outcomes.**

Generally, a household is considered cost-burdened when total housing costs (i.e., mortgage, rent, insurance, utilities, taxes, etc.) exceed 30% of the household income [189]. In Suffolk County, roughly 44.5% of owner-occupied households have housing costs that exceed 30% of their income, while roughly 54.1% of renting single-family households have housing costs that exceed 30% of their income.[15] This alone does not give the most accurate representation of the cost-burdened population in Suffolk County, however. With the high property values and relatively high median income in Suffolk County, it is likely that many higher income households with additional financial assets and capital may elect to live in a house that costs more than 30% of their household income without having to make the types of tradeoffs that result in poor health outcomes. **Looking at regionally specific income limits for assistance programs yields a more accurate image of the cost-burdened population in Suffolk County.** To qualify for the state's Home Energy Assistance Program, a household of three must have an annual income of less than $43,500 [190]. These figures suggest that households in Suffolk County with

[13] The I/A OWTS values represent the costs associated with a number of I/A OWTS alternatives at the time of the HIA analysis. Updated cost information for I/A OWTS was made available through the County, following completion of the HIA analysis. This updated information can be found in the full HIA Report.

[14] The intensive monitoring and management of I/A OWTS would require a culture shift, as maintenance of existing individual sewerage systems varies widely but is often performed as part of a fix rather than as routine maintenance [48]. There could be some challenges and barriers to making a culture shift like this.

[15] County-level data are used in the economics analysis because the geographic location of specific types of individual sewerage systems was unknown at the time of the HIA analysis; therefore, geographic-specific income statistics could not be determined for each alternative. This was a limitation of the analysis.

incomes near or below $45,000, while earning more than twice the federal poverty level, are still in a precarious financial situation and are at the greatest risk of a negative impact, should their housing costs increase. County wide, this group is roughly 23% of the total number of households. The University of Wisconsin Population Health Institute's [191] County Health Rankings also estimate that 23% of Suffolk County households are at risk of adverse health effects due to high housing costs [192]. For Section 8 housing,[16] a household of three in Suffolk County is considered low income if their household income is $76,480 or less, and very low income if it is $47,800 or less [193]. The number of households earning under $50,000 a year is estimated to be around 26.7%, according to the 2012 American Community Survey (ACS). **Based on these metrics, 23-26.7% of households in Suffolk County are likely be cost-burdened;** it should be noted that a portion of the cost-burdened population does reside in sewered areas and therefore would not be impacted by the proposed sanitary code changes.

Sanitary code changes that would require the installation of a C-OWTS or I/A OWTS may fit into a wealthier homeowner's budget, but **it is highly unlikely lower income homeowners would be able to budget for the installation without financial assistance**. The cost burden to families for upgrading an individual sewerage system under the proposed code changes ranges from 5% of their annual income for Alternatives I and II to 18% for Alternative III. For non-families, who occupy 19.8% of owner-occupied households, the cost burden is higher, ranging from 11% for Alternatives I and II to as high as 38% for Alternative III, based on median annual household income in the County.[25] **For households that are already experiencing difficulty, the increase in household expenditures to upgrade to a C-OWTS or I/A-OWTS, including any additional operating and maintenance costs, may put them at increased risk for cost burdens, food insecurity, and the associated health outcomes.** This is a high cost burden to place on these residents, and all efforts should be taken to assist cost-burdened households in the replacement of their individual sewerage systems.

I/A OWTS Funding

Since completion of the HIA analysis, Suffolk County has implemented a Septic Improvement Program to provide grants and low-interest financing to make system upgrades more affordable for homeowners, and several state and individual town-septic upgrade assistance programs are now in place in Suffolk County as well. For more information on these funding opportunities and their criteria, see the full HIA Report, Appendix K.

In addition to costs, employment and wages are also key factors in household economics. **The increase in demand for individual sewerage system upgrades may lead to more job opportunities in the OSDS/OWTS industry in all sectors** (i.e., inspection, service, construction, manufacturing, and shipping); although, the locations of these opportunities may not be limited to Suffolk County. While there are currently approximately 70 septic system businesses on Long Island, it is likely that given the high rate of demand created by the proposed code changes, companies from other parts of New York and the surrounding areas may extend service to Suffolk County to meet the demand. Even with these industries based outside of the County itself, the increased economic activity brought into Suffolk County will positively impact the local service economy. In addition, **there may also be employment opportunities at SCDHS and the Suffolk County Office of Wastewater**

[16] Section 8 is the common name for the Housing Choice Voucher Program, funded by the U.S. Department of Housing and Urban Development, which allows private landlords to rent apartments and homes at fair market rates to qualified low income tenants, with a rental subsidy.

Management to meet the increased demand for inspectors, permit evaluation, and loan management associated with the proposed code changes.

The proposed code changes also have the potential to impact property values. While installing a new individual sewerage system to replace an aging but functioning system would not be expected to increase the value of the property, there is one exception – if the home is located in an area that is required by law to upgrade their individual sewerage system; in this case, a house that has already upgraded their system would likely be more valuable than had they left that expense for the new homeowner. Property values could also be impacted with any improvements in water quality. **Research shows that increased good water quality does have a positive impact on real estate value,** and Dvarskas and Smith [194] demonstrated the potential for that impact in Suffolk County. Suffolk County has nearly 1,000 miles of coastline, so beach and water quality can have dramatic impacts on the overall economy through their effect on residential property values. Waterbodies near properties provide a number of benefits to property owners, such as aesthetics, recreational opportunities, economic impacts through property prices, and other ecosystem services [195, 196]. Although their data was limited to four towns – Riverhead, Smithtown, Southampton, and Southold – Dvarskas and Smith [194] found that **water quality, measured as water clarity, affects housing values at a rate of 2% for every 1-foot increase in water transparency. Further, they found that having waterfront access has a dominant effect on price, suggesting that increases in water clarity can significantly impact the value of residential property in Suffolk County** [194]**.** Improvements to water quality and its associated economic benefits would not be experienced with Alternatives I and II, but could be expected with Alternative III. However, the question remains to what extent Alternative III will help reverse the deterioration in Suffolk County water quality and lead to increased property values and improvements in the local economy.

Community economics

At the community level, Suffolk County can expect to generate more revenue through the permits, licenses, and fees associated with new individual sewerage system installations and maintenance. However, there will also be extra costs to the County for implementing and maintaining the program, including an increased workload and the need for more staff. There is also the potential for the proposed code changes to benefit the local economy through increased property values, tourism, recreation, fishing and shellfishing, should improvements in water quality be realized.

If Suffolk County mandates that between 125,751 (Alternative II) and 251,502 (Alternative III) households have to update their septic systems, SCDHS will have an enormous growth in its responsibility and workload and the County's costs will increase. If Alternative I is adopted, 192,558 households, served by cesspool only, would be required to install new septic tank-leaching pool systems. This would equate to nearly 200,000 construction applications. Depending on the strategy for implementation of the proposed code changes (i.e., failure of existing OSDS, property transfer, or fixed schedule), the number of applications each year would vary, with the total number spread across multiple years. For example, if replacement of a home's sewerage system is triggered by property transfer, based on an average countywide sale rate of 5%, there would be an increase of 9,628 applications per year under Alternative I; this would be equivalent to increasing the amount of applications and the effort to process each one by nearly 9 fold over 2015 efforts (i.e., 1,094 applications in 2015) [197]. Alternative II requires fewer households to take action (125,751). Given the same assumptions, this would increase the amount of construction applications by 6,288, an almost 6-fold increase over the 2015 totals.

Alternative III would require the most construction applications, with 251,502 households subjected to the upgrades. If all households subject to Alternative III had to replace their systems at time of property transfer, based on a 5% annual sale rate, the annual number of construction applications would increase by 12,575, well over a 10-fold increase.

Issuing OWTS construction permits is just a fraction of the role the County would play in implementing these new regulations. Other actions include enforcement, record keeping, inspection, and financial management of any loan programs. **Oversight of the C-OWTS and I/A OWTS companies may also be needed to ensure they are not taking advantage of the demand created by the code changes by charging much higher rates for inspections, repairs, and installations.** The SCDHS 2015 end-of-year deficit will make it difficult for the County to enforce these new regulations without increasing revenues, either through charges for fees and services or through operating grants and contributions.[17]

In addition to the costs associated with the proposed code changes, **Suffolk County can also expect to generate more revenue through the issuance of permits, licenses, and fees associated with C-OWTS and I/A OWTS installation and maintenance. In the near term, it is not expected that the anticipated code changes will result in a net financial gain for the County, however, since many households will require assistance to comply with the regulations.** Enforcement will also be a challenge, with up to 251,502 households needing to update their individual sewerage systems.

Increasing beach closures, algal blooms, and perceived degradation of waters, which are used for aquatic recreation, have placed revenue streams from tourism and recreation at risk for decline. In addition, Suffolk County Executive Steve Bellone reported thousands of job losses in the shellfishing industry due to declining shellfish populations [198]. Impairment in the quality of water resources places revenue streams for other Suffolk County services at risk for decline.

The County may see some benefits to the local economy depending on the code's ability to address nitrogen and pathogen loading to Suffolk County waters. If Alternatives I or II is selected, the County may have to consider other actions to reduce nitrogen load to the groundwater, freshwater, and marine waters surrounding Long Island (since these alternatives do not address nitrogen loading); these efforts may increase costs to the County. However, **benefits to the local economy would be expected with the reduction in nutrient and pathogen loading associated with implementation of Alternative III**. These benefits could include increases in real property values and revenues from recreation, tourism, and commercial and recreational fishing and shellfishing due to improved water quality and other environmental conditions; the degree to which these benefits will be experienced is unknown.

Recreational and commercial fishing make up a large share of the jobs and economy in some towns in Suffolk County. **To have a healthy fishing economy, there must be healthy, intact fish habitat for mating, egg laying, and rearing and good water quality to support the industry** [199]. A study conducted in Chesapeake Bay found that the effect of deteriorating water quality (e.g., eutrophication) on striped bass would have significant adverse economic impacts on the fishing industry [200]. The same has been reported in the media for Long

[17] Since completion of the HIA analysis, some grants and other funding sources have been secured for implementation of I/A OWTS upgrades. This is detailed in the full HIA Report.

Island, and this remains a primary environmental concern for the public, according to responses gained during the community engagement and outreach portion of this HIA. As with recreational fishing, water quality can also affect commercial fisheries with conditions like increased nitrogen loading affecting the timing of commercial fishing seasons as well as the size of catches [201]. **Unless nitrogen and pathogen pollution is addressed, towns with a higher reliance on commercial and recreational fishing and tourism industries may continue to be impacted.**

The tourism industry relies on tourists coming to Long Island to enjoy its beaches, recreational fishing opportunities, and fresh seafood. Without a healthy environment, the decreased fishing potential and closed beaches will reduce the number of tourists, thereby reducing the employment opportunities in the tourist and services industries. **As the population in the east end of Suffolk County nearly doubles in the summer months** [202, 203]**, any reduction in tourism may lead to a significant decrease in summer employment opportunities and revenues for the County.**

In addition to these impacts to the local economy, it is important to acknowledge that the proposed code changes and any resulting improvements in water quality are not likely to have an impact on resiliency to storm and/or tidal surges and coastal flooding due to other contributing factors. As a result, the risk of storms and/or tidal surges and coastal flooding and its associated costs to the Suffolk County are expected to continue. Direct physical damages can have severe consequences for a community's revenue stream. Harder to measure are the economic costs associated with indirect losses such as loss of power, disruption of transportation services, and washed out roadways. In addition, local resources can become taxed, as money is diverted to aid in recovery and reconstruction.

Predicted impacts to household and community economics

Regardless of the alternative chosen, households with fixed or low income and/or high housing costs will be at greatest risk for adverse health outcomes. In addition, if County costs to implement the program are not offset by other sources of revenue, there is a possible risk that health-related services provided by the County will be reduced or unavailable. Households that rely on health-related services from the County, irrespective of whether the home is targeted for an upgraded system, may experience adverse health outcomes if funding for health services does not increase to meet the potential increased demand from households facing a greater cost burden from their housing. There are Federally Qualified Health Centers in the County, but it should not be assumed that they will be able to absorb the potential increased demand of services, given the number of households impacted by the sanitary code changes. However, the potential increase in opportunities for employment in the OSDS/OWTS industry (and the recreation, tourism, fishing and shellfishing industries, if water quality improves) will provide a positive health benefit for those who gain employment.

Stable Recurring Revenue Source Required for Wastewater Upgrades

Since completion of the HIA analysis, Suffolk County has established that there is no plan to move forward with wastewater upgrades unless a stable and recurring revenue source is established. A stable recurring revenue source will reduce financial impacts to individual households and ensure that County services are not jeopardized by the cost of wastewater upgrade implementation.

There would be no reduction in the amount of total nitrogen leaving the individual sewerage system in Alternatives I and II, so these alternatives would have a limited impact on water quality. **Unless Alternative III is**

implemented and/or other actions are taken to decrease nitrogen loading, the County is projected to experience declining water quality, which puts water-related revenue streams at risk. From the community economics perspective, Suffolk County could weigh the costs and benefits of implementing Alternative III as a means to address nitrogen and pathogen loading to Suffolk County waterbodies. Although the upgrade to I/A OWTS adds additional costs to individual households, it would positively impact the recreation, tourism, fishing and shellfishing industries and possibly property values, by improving water quality. There are creative ways to cover the necessary investment to implement Alternative III, such as Maryland's Bay Restoration (Septic) Fund Program; see the full HIA Report, Appendix J for more information.

In taking action, the County can prevent the further decline of water quality and the fishing, recreation, and tourism industries in the area. Recreational fishing is based on reputation, and if water quality worsens, visits from tourists may decline and commercial fishing companies may consider moves from the County. Actions taken to improve water quality could increase property values as a result of proximity to the waterfront; improve demand for vacation homes due to recreation and tourism; and grow the County's reputation as a desirable, healthy, and safe place to live.

Predicted health impacts

- The costs associated with upgrading, operating, and maintaining new individual sewerage systems in **all three alternatives could negatively impact health by reducing the amount of household expendable income**, which could lead to cost burdens and food insecurity. The higher costs associated with I/A OWTS (Alternative III) will increase the number of cost-burdened households relative to Alternatives I and II. However, the potential **increases in job opportunities** in the OSDS/OWTS industry (and other industries, should there be improvements in water quality) **would benefit health by increasing access to health-related goods and services.**
- **Alternatives I and II** will not reduce nitrogen loading and, as a result, have the potential to **detract from health through further declines in water quality and the associated risks** to the local economy (property values; employment in the recreation, tourism, fishing and shellfishing industries; and revenue streams for County services). **Alternative III would benefit health based on the potential for water quality improvements** and the associated increases to property values, employment in the recreation, tourism, fishing and shellfishing industries and revenue streams for County services.
- **Individuals with fixed/low income and/or high housing costs would be disproportionately impacted by the costs of system upgrades** and could be forced to cut back on health-related goods and services **if financial assistance is not provided**. This impact would be magnified if publicly provided health-related-services decrease due to the County resources needed to implement the code changes.[18] **Employment and its associated health benefits would be disproportionately experienced** (positively or negatively) by individuals employed in the various sectors (e.g., OSDS/OWTS, recreation, tourism, fishing and shellfishing).
- The **availability of household income and health-related goods and services are strongly linked to overall health and well-being.**

[18] Since completion of the HIA analysis, Suffolk County has established that there is no plan to move forward with wastewater upgrades unless a stable, recurring revenue source is established to help reduce financial impacts to individual households and ensure that County services are not jeopardized by the costs of wastewater upgrade implementation.

Recommendations

The analysis in this pathway showed that, without financial assistance, the increased cost of the proposed upgrades in all three alternatives could increase household costs and potentially food insecurity by reducing the amount of expendable income available for nutrition. Under Alternatives I and II, water quality would also continue to decline, with associated risks to property values, employment in the fishing and recreational industries, and revenue streams for County services. Only Alternative III (I/A OWTS) would result in improvements in water quality, which would benefit the local economy, although the degree of benefit is unknown. What follows are recommendations that focus on planning and implementation of the proposed code changes, system maintenance, cost control and funding measures, employment and hiring, and protection of water resources:

- Select a timeline for implementation that will encourage tempered growth of the OSDS/OWTS industry, minimizing the risk of a spike in the cost of installation and unsustainable industry growth.
- If Alternative III is chosen, towns with a greater reliance on commercial and recreational fishing could be considered in the prioritization of areas for implementation of the code.
- Send maintenance reminders to residents to help provide a stable market for the companies.
- To avoid unintended health impacts, action could be taken to ensure that the increased cost to implement and oversee the proposed changes to the sanitary code does not impact other programs or pull funding away from other social and health services. Operating grants and contributions could be sought from both State and Federal entities to defray costs.
- Outside funding could be sought to reduce the costs of individual sewerage system upgrades for individual households. Assistance for cost-burdened and low-income households and property owners renting to low-income households could be prioritized. Assistance could be made available for all household types including non-family households, which have a much lower median income than households of families.
- Work with communities and OWTS vendors to plan concurrent upgrades to neighboring properties to reduce construction costs and take advantage of block grant opportunities.
- Review of the Rhode Island and Maryland programs may provide Suffolk County with guidance on implementation of individual sewerage system upgrades, including the triggers for replacement of systems and loan and grant programs for households to assist with costs associated with installation and operation of new systems.[19]
- Steps could be taken to encourage OWTS businesses to locate and hire within the County. Possible strategies include tax incentives and decrease of certification fees for OWTS companies that locate in the County and support of a community jobs program to train local residents in OWTS and I/A OWTS technology installation, maintenance, repair and inspection. Consider working with local community colleges to include training courses in this field.
- If Alternative I or II is selected, other measures could be taken to reduce nutrient enrichment and protect water resources to mitigate the impact of declining water quality on employment opportunities associated with the commercial fishing and recreational industries and property values, both of which have the potential to impact both county revenues and household income.

[19] More details on these state programs are provided in Appendix J of the full HIA Report.

Conclusions

The proposed code changes will have health impacts, both positive and negative, although only Alternative III (upgrading all existing individual sewerage systems in high-priority areas to I/A OWTS) could result in a net positive public health impact. Recommendations for promoting the positive health impacts and reducing the negative health impacts of all three decision alternatives are provided in this report. It should be noted that since completion of the HIA analysis and reporting of preliminary findings and recommendations to the decision-makers and stakeholders in the fall of 2016, Suffolk County entered a period of robust activity working to change the local nutrient pollution paradigm:

The County revised the Suffolk County Sanitary Code and the residential and commercial construction standards to define requirements for the design and construction of I/A OWTS and developed standards for management and approval of I/A OWTS. The County has provisionally approved six innovative/alternative OWTS for use in Suffolk County and completed reports summarizing the 2016, 2017, 2018, and 2019 performance of the I/A OWTS installed in Suffolk County and neighboring jurisdictions. The County has implemented a Septic Improvement Program to provide grants and low-interest financing to make system upgrades more affordable for homeowners, and several individual town-septic upgrade assistance programs are now in place in Suffolk County as well. County-specific nitrogen loading models have been completed for several areas, and a countywide modeling effort has recently been completed to delineate subwatersheds, establish travel times, and establish nitrogen load reduction goals for all surface waterbodies and public supply wells in Suffolk County. To learn more about these and other efforts undertaken by the County since the completion of the HIA, visit: https://reclaimourwater.info/.

Development of a Phased Countywide Wastewater Management Strategy in Suffolk County

Since completion of the HIA analysis, Suffolk County undertook countywide nitrogen loading modeling as part of the development of a Subwatersheds Wastewater Plan (SWP). This modeling was used to establish travel times and nitrogen loading estimates for each subwatershed, establish nitrogen load reduction goals based upon specific human health and environmental endpoints, and refine priority areas in which to focus those nitrogen reduction efforts.

The County determined that implementation of the recommendations in the SC SWP may have a significant impact on the environment, so a General Environmental Impact Statement (GEIS) was prepared to accompany the implementation of the SC SWP. The draft SC SWP was issued in July 2019 and the public comment period for the draft GEIS ran August 14, 2019 through October 16, 2019 (https://www.reclaimourwater.info/TheSubwatershedsWastewaterPlan.aspx). A revised SWP and a Final Generic Environmental Impact Statement (FGEIS) incorporating public comments and comments received by the Suffolk County Council on Environmental Quality (CEQ) was posted in February 2020. The SC SWP identified a phased countywide strategy to replace cesspools and C-OWTS in Suffolk County with I/A OWTS, sewering, or clustering. This $4 billion approach would be implemented over 50+ years, with an initial 5-year ramp-up period (Phase I) that includes establishing a countywide wastewater management district and a new, yet to be specified, $50-75 million recurring annual funding stream. With the establishment of a stable and recurring funding source, Phase II would require upgrades to systems in the highest priority areas (i.e., the near shore 0-2 year groundwater contributing zone to surface waters and watersheds with the most impaired or vulnerable waterbodies). Implementation would continue in Phase III upgrading systems in the remaining priority areas, and in Phase IV, upgrades to the remaining systems (primarily in Central Suffolk County) would take place. As of the time of the SWP, a funding source had not yet been secured for the upgrades. However, as documented in the SWP, Suffolk County has made it clear that the implementation of a countywide wastewater upgrade program is contingent on identification of a stable and recurring revenue source to make the program affordable to homeowners.

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