Report

Town of Dennis, Massachusetts

Dennis

preserving our water resources

Final Comprehensive Wastewater Management Plan (CWMP)/Single Environmental Impact Review (SEIR) Environmental

November 2021

CDM Smith

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Appendix C Letter to MassDOT regarding Inlet Widening

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Appendix F Evaluation of Additional Effluent Recharge Sites, CCC Grant Letter Report

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Public Archaeology Laboratory, Public Archaeology Laboratory, Technical Memorandum: Dennis CWMP Project Phase 1 Pump Stations Dennis, Massachusetts Cultural Resource Due Diligence Review and Archaeological Sensitivity Assessment, July 2019

Appendix K UMass Donahue Institute, Town of Dennis Wastewater Development Study, April, 2018.

List of Acronyms

AOC	Area of concern
ADF	Average daily flow
AMP	Adaptive Management Plan
APE	Areas of potential effect
BAT	Best Available Technology
BMP	Best Management Practices
BOD	Biochemical Oxygen Demand
BIOS	Biological Intelligent Optimization System
CARB	California Air Resources Board
CCC	Cape Cod Commission
CECs	Contaminants of emerging concern
CLFs	Compact fluorescent lamps
cfu	Colony forming units
CGP	Construction General Permit
CMP	Construction management plan
CMR	Code of Massachusetts Regulations
CPA	Community Preservation Act
CSA	Comprehensive Site Assessment
CWA	Clean Water Act
CWMP	Comprehensive Wastewater Management Plan
CWMTF	Comprehensive Wastewater Management Task Force
CWSRF	Clean Water State Revolving Fund
CZM	Coastal Zone Management
DCPC	District of Critical Planning Concern
DCR	Department of Conservation and Recreation
DHY	Dennis, Harwich, Yarmouth
DO	Dissolved oxygen
DOC	Diesel oxidation catalyst
DOR	Department of Revenue
DPF	Diesel particulate filter
DPW	Department of Public Works
DRI	Development of Regional Impact
EAC	Equivalent annual cost
ECMs	Energy conservation measures
EDUs	Equivalent dwelling units
EEA	Energy and Environmental Affairs
EENF	Expanded Environmental Notification Form
EH	Estimated Habitat

EJ	Environmental Justice
ENR	Engineering New Record
EOEEA	Massachusetts Executive Office of Energy and Environmental Affairs
EOS	Environmental Operating Solutions
ERP	Environmental Results Program
ESPM	Energy Star Portfolio Manager
EUAC	Equivalent uniform annual cost
E. coli	Escherichia coliform
FEMA	Federal Emergency Management Agency
GIS	Geographic Information System
GHG	Greenhouse Gas Policy
GP	General Permit
gpd	Gallons per day
gpm	Gallons per minute
HBPT	Highest and best practical treatment
HVAC	Heating, Ventilating, and Air Conditioning
I/A	Innovative/alternative onsite system
I/I	Infiltation/inflow
ILSF	Isolated Land Subject to Flooding
ISO	International Organization for Standardization
LED	Light-emitting diode
LEED	Leadership in Energy and Environmental Design
LiDAR	Light detection and ranging
LiMWA	Limit of Moderate Wave Action
LSP	Licensed Site Professional
MACRIS	Massachusetts Cultural Resource Information System
MassDEM	Massachusetts Department of Environmental Management
MassDEP	Massachusetts Department of Environmental Protection
MassDOT	Massachusetts Department of Transportation
MassGIS	Massachusetts Geographic Information System
MBR	Membrane Bioreactor
MCL	Maximum Containment Level
MCP	Massachusetts Contingency Plan
MDPH	Massachusetts Department of Public Health
MDRP	Massachusetts Diesel Retrofit Program
MEP	Massachusetts Estuaries Project
MEPA	Massachusetts Environmental Policy Act
MESA	Massachusetts Endangered Species Act
MGD	million gallons per day

MHC	Massachusetts Historical Commission
MMR	Massachusetts Military Reservation
MASSTC	Massachusetts Alternative Septic System Test Center
MSL	Mean sea level
MUTCD	Manual on Uniform Traffic Control Devices
MWPA	Massachusetts Wetlands Protection Act
NEMA	National Electrical Manufacturers Association
NERL	National Renewable Energy Laboratory
NGVD	National Geodetic Vertical Datum
NHESP	Natural Heritage and Endangered Species Program
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NSAs	Nitrogen Sensitive Areas
NWIS	National Water Information System
OC	Order of Conditions
OD	Oxidation ditches
OHM	Or hazardous material
O&M	Operations and maintenance
PAL	Public Archaeology Laboratory, Inc.
PALS	Pond and Lake Stewardship
PCN	Pre-Construction Notification
PCPs	Personal care products
PEM	Premium efficiency motors
PFAS	Polyfluoroalkyl substances
ppb	Parts per billion
ppm	Parts per million
ppt	Parts per trillion
POTWs	Privately Owned Treatment Works
PNFs	Project Notification Forms
PNRs	Passive nitrogen reduction systems
PRB	Permeable reactive barriers
PSAT	Pumping System Assessment Tool
PV	Photovoltaics
RAO	Remedial Action Outcome
ROW	Right-of-way
RVs	Recreational vehicles
SAS	Soil absorption systems
SBR	Sequencing Batch Reactors
SCADA	Supervisory control and data acquisition

SDWA	Safe Drinking Water Act
SEIR	Single Environmental Impact Review
SFHA	Special Flood Hazard Area
SMAST	School of Marine Science and Technology (UMass Dartmouth)
SNEP	Southeast New England Program
SOC	Superseding Order of Conditions
SSURGO	Soil Survey Geographic Database
SRF	State Revolving Fund
STE	STEP/STEG
STEG	Septic Tank Effluent Gravity
STEP	Septic Tank Effluent Pumping
SV	Self Verification
SWPPPs	Stormwater Pollution Prevention Plans
TF	Trickling filters
TKN	Total Kjehldahl Nitrogen
TMDL	Total maximum daily load
TSI	Trophic status index
TN	Total nitrogen
TSS	Total Suspended Solids
ULSD	Ultra-low sulfur diesel
UMass Dartmouth	University of Massachusetts – Dartmouth
US EPA	United States Environmental Protection Agency
USGS	United States Geological Survey
UMass Dartmouth	University of Massachusetts – Dartmouth
US EPA	United States Environmental Protection Agency
USGBC	U.S. Green-Building Council
USGS	United States Geological Survey
UV	Ultraviolet
VFD	Variable frequency drive
VMT	Vehicle miles traveled
VOC	Volatile organic compound
WPADs	Water Pollution Abatement Districts
WIC	Wastewater Implementation Committee
WIIF	Water Infrastructure Investment Fund
WURP	Water Utility Resilience Program
WWTF	Wastewater Treatment Facility
ZOC	Zone of contribution

Glossary

Anthropogenic – Human source of pollution

Brackish – A mixture of fresh and saltwater creating water that has some salinity, but not as much as seawater

Check station – Monitoring station used to check secondary water quality parameters within tributary basins at the point that the threshold level is attained at the sentinel station

Eelgrass – Type of plant that grows within embayments. Eelgrass serves as an indicator of the health of a waterbody.

Effluent – Treated wastewater that discharges from a wastewater treatment facility

Embayment/subembayment – Waterbody formation in the shape of a bay. Embayments are further divided into subembayment areas.

Enterococci – Type of bacteria that is used as an indicator of the health risk from recreational contact of water bodies. Enterococci testing is particularly useful in saltwater applications.

Epiphyte – A type of plant that grows on another plant but obtains its nutrients and moisture from the atmosphere

Estuary – A partially enclosed brackish water body

Eutrophication – Caused by high levels of nutrients in water bodies. Eutrophication leads to oxygen depletion and subsequent negative environmental impacts such as fish kills and increased algal growth.

Hypereutrophy – Classification of a water body which has extremely high levels of nutrients

Infaunal – Aquatic species whose habitat is below a water body's floor

Kettle pond – A shallow body of water that was formed by receding glaciers or draining floodwaters

Marsh – Type of wetland. Plant life in marshes are dominated by herbaceous species as opposed to woody plant species.

Mesotrophy - Classification of a water body which has moderate levels of nutrients.

Natural attenuation – The process by which the concentration of nitrogen in a water body is reduced by conversion to nitrogen gas, sediment absorption, and other biological processes when nitrogen-inundated water passes through natural systems such as streams, rivers and ponds.

Nitrogen – Typically the limiting nutrient for plant growth in estuarine waterbodies. The increased presence of nitrogen in saline and brackish waterbodies can lead to oxygen depletion, eutrophication and overall decline in water quality.

Nutrients – Integral components for plant growth, typically including nitrogen and phosphorus

Oligotrophy – Classification of a water body which has low levels of nutrients.

Phosphorus – Type of nutrient. Phosphorus is a limiting nutrient for plant growth, typically in freshwater bodies.

Phytoremediation – The use of plant species to passively treat contaminated soils and groundwater

Sentinel station – A monitoring station located within an estuary that acts as the indicator location for restored water quality, following established TMDL compliance within that estuary

Watershed/subwatershed - Contributing land area, including all associated surface and groundwater resources, to a water body. Watersheds are further divided into subwatershed areas, or sub-areas of land within a watershed.

Executive Summary

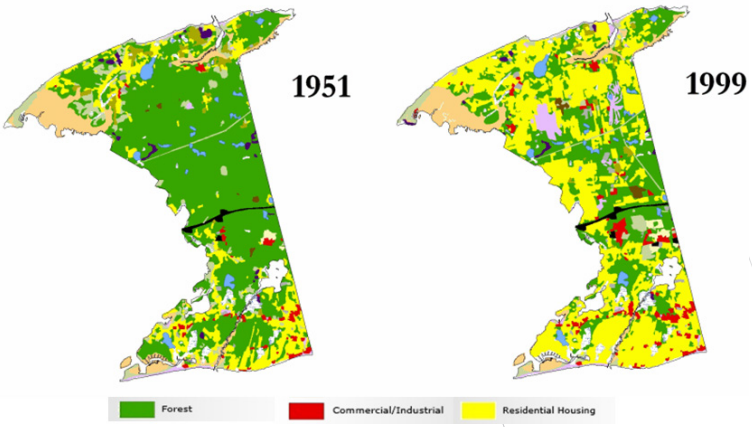
Dennis
preserving our water resources

ES.1 Introduction

The Town of Dennis has developed a Final Comprehensive Wastewater Management Plan (CWMP) with assistance from residents, Town boards and committee members, Town staff, consultants and local, regional and state stakeholders over the past several years. This plan is presented in herein and the Town is ready to begin implementing it realizing some components may be revised over the next 40 years through adaptive management.

Over the last seven years the Town working mainly through its' Wastewater Implementation Committee (WIC), formerly the Comprehensive Wastewater Management Task Force (CWMTF) developed a program to address wastewater management needs, protect drinking water sources, protect freshwater ponds, and restore valuable saltwater estuaries. Protection and restoration of these valuable water resources is extremely important to maintaining the quality of life and economic health of the town. These efforts and the resultant recommendations are intended to guide the community moving forward as it addresses this complex and costly issue.

The Town submitted the Draft CWMP/ Expanded Environmental Notification Form (EENF) in 2017 which was reviewed and approved by Massachusetts Environmental Policy Act (MEPA) in July of 2017. Since 2017, the Town has been working to further develop their Final CWMP while also coordinating with neighboring Harwich and Yarmouth on a potential community partnership for shared wastewater infrastructure including a regional wastewater treatment facility. Dennis wanted to make sure all feasible options were evaluated before finalizing the CWMP for the next submittal to MEPA. As such, the submittal of the Final CWMP was delayed. At this time Dennis has determined that a Dennis only in-town solution is the best path forward.



ES-1 Population Figures for Dennis (1951 & 1999)

ES.1.1 Purpose and Background

In January 2014, the then CWMTF contracted with CDM Smith to work collaboratively on this important project as their water resources consultant and to provide guidance and technical support during the process. This work is mostly driven by the significant population growth and resulting development that has occurred since 1951 as shown in Figure ES-1. The population of Dennis in 1950 was 2,500 which grew to 15,900 in 1999. As of 2020 the number of year round residents is 14,674 with an estimated seasonal increase to 63,000. The Town of Dennis does not have any municipal wastewater collection or treatment facilities.

Over the past few years, nitrogen related issues have become a driving force in influencing several Cape Cod communities to begin considering wastewater programs. The Massachusetts Executive Office of Energy and Environmental Affairs (EOEEA), working through the Massachusetts Department of Environmental Protection (MassDEP) and the University of Massachusetts (UMass) Dartmouth School for Marine Science and Technology (SMAST), has been working with Coastal Zone Management (CZM), the Cape Cod Commission (CCC), and several municipalities to determine the nitrogen sensitivity of southeastern Massachusetts' coastal embayments and estuaries, an effort referred to as the Massachusetts Estuaries Project (MEP). These areas are important ecosystems that provide habitat for shellfish and sea grasses as well as breeding grounds for offshore marine fisheries. Based on the MEP work which includes annual water quality monitoring in Dennis, the town became aware that reductions in nitrogen loading from on-site wastewater disposal systems would likely be instrumental in preserving the health of the Towns local coastal environments. Preserving each of these resources is a high priority for the quality of life that the town's residents, business owners and tourists have come to expect and enjoy. With this knowledge, but without the MEP studies completed, the Town of Dennis initiated planning to identify baseline water and wastewater needs and priorities in preparation for when specific nitrogen loading goals became available through the MEP. The critical MEP reports for Dennis are now available. As nitrogen reduction to estuaries and embayments is the most significant driver in the planning process, these reports provide sufficient information for the town to develop a longterm recommended program.

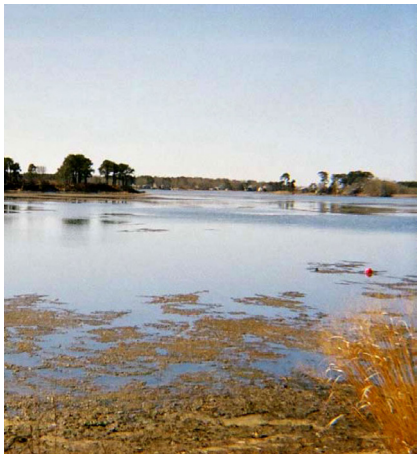
It is important to note that acceptance of the recommended program does not lock the Town into every aspect of the wastewater plan. Instead, it gives the Town a roadmap for wastewater management that can be modified appropriately to meet the needs of the community as various program components and phases are implemented. As long as the program meets the regulatory requirements and the goals of the Town, it can and should be modified as new information, technologies, or town needs become available during implementation.

ES.1.2 Environmental Review Process

This Final CWMP has been prepared and submitted as part of Single Environmental Impact Review (SEIR) to the MEPA Unit of the Massachusetts EOEEA for approval. The Draft CWMP and EENF were submitted and approved by MEPA in July 2017. This document is concurrently undergoing review by the CCC for consistency with the 208 Plan.

The Town of Dennis has implemented a public outreach program throughout the present wastewater planning initiative. According to the Massachusetts Executive Office of Energy and Environmental Affairs (EEA) Environmental Justice (EJ) Map Viewer, there are three

areas of Dennis that are classified as being EJ communities due to income and minority populations, including South Dennis, Dennis Port and West Dennis. The Town and WIC worked to keep all communities within Dennis informed and engaged on this significant future project. Many public meetings have been held at different milestones in the project development. Additionally, educational flyers were created on a regular basis and made available at several locations across Town. The Town welcomes comments on this SEIR/Final CWMP and looks forward to continuing to work collaboratively with the community, the town's WIC, the CCC, the MEP, MassDEP, adjacent communities, residents, and other interested parties as it implements the recommended program over the next 40 years.



Algae Bloom in Swan Pond

ES.2 The Issue Dennis is Facing

The Town of Dennis currently faces threats to the health of its saltwater, freshwater, and groundwater resources. In recent years, excessive levels of nutrients, specifically nitrogen and phosphorus, have resulted in algal blooms in several of the town's surface water bodies. In 2009, an algal bloom occurred in Swan Pond creating aesthetically displeasing waters, fish kills due to depleted oxygen levels in the pond, and an odor that permeated the neighborhood for weeks. This event, as well as similar events at other area water bodies, was predominately caused by nitrogen originating from onsite wastewater systems (fully functioning Title 5 septic systems, cesspool systems, etc.) in the areas that contribute groundwater to the pond, referred to as the pond's watershed. Swan Pond is not alone in these problems. The Bass River and Herring River watersheds have also been identified as areas with high nitrogen sensitivity. Scargo Lake and other freshwater systems in town are facing similar issues, but due to excessive levels of phosphorus from similar sources.

Scargo Lake and Cape Cod Bay

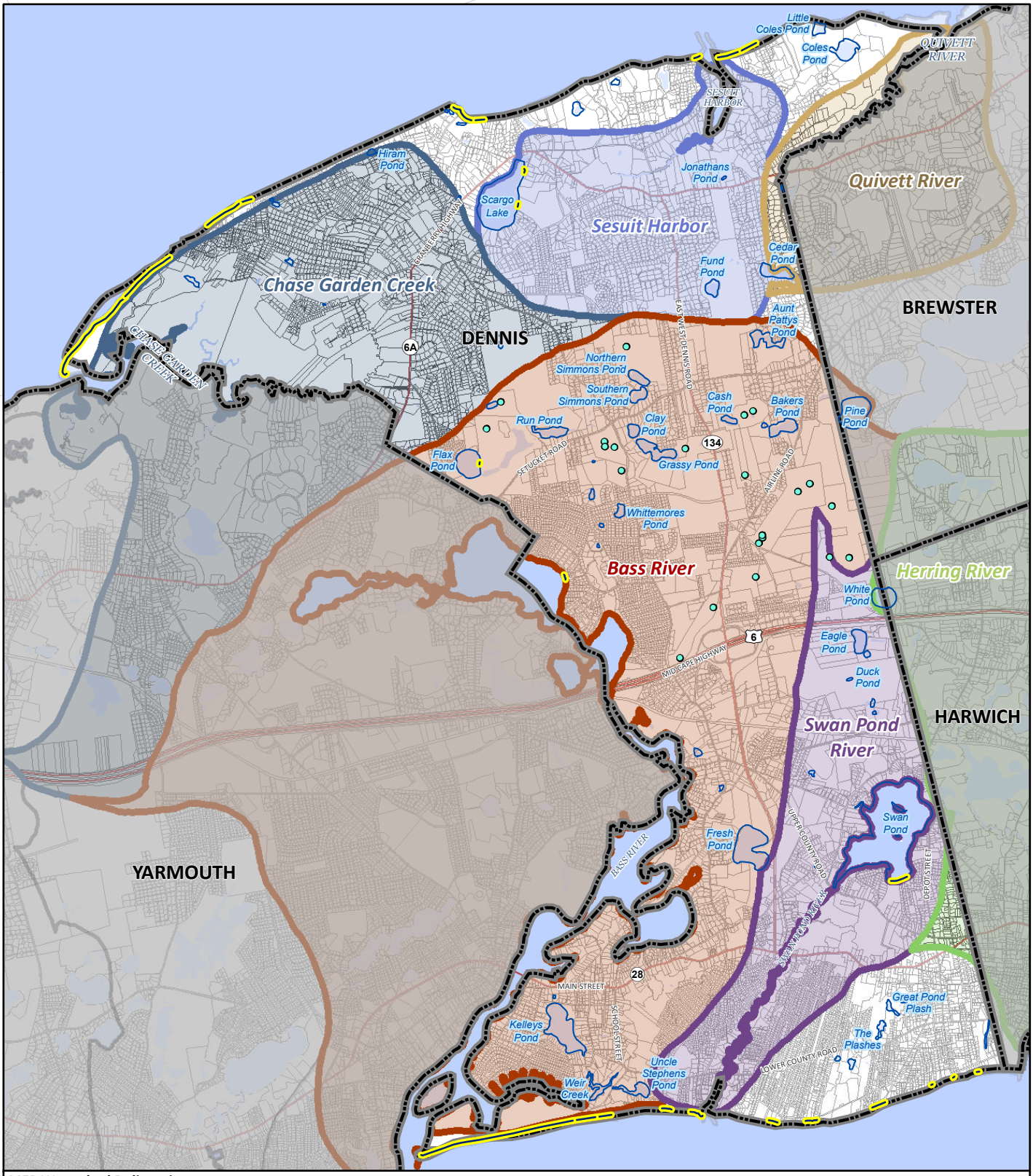
ES.2.1 Key Drivers

Without prompt and targeted actions, the problems identified above will continue to worsen. As water quality declines, the tourist industry will decline as well. Waters that are periodically covered with mats of algae, that smell like decaying fish, and that do not support the ecology associated with the beauty of Cape Cod's waterways, will not draw an audience. Tourists and residents alike will be drawn to other locations. Property values and tax revenues in coastal areas will decline, and the burden of maintaining town services will shift inland, to those who can least afford it. Thus, it is imperative for Cape Cod communities like Dennis to deal with these water quality issues before irreparable economic and quality of life damage is done.

Sesuit Harbor

ES.2.2 Discussion of Water Quality

The Dennis CWMP presents a recommended program that complies with current water quality regulations. However, due to the cost of this overall program some Dennis stakeholders have questioned the cost benefit of full compliance and whether the appropriate standards are being applied to the specific scenarios encountered in the Town. The vast majority believe water quality is extremely important to the quality of life in Town and that a nutrient problem exists that must be addressed in the near future. The critical question is how far the program needs to go in order to adequately address the issue.



MEP Watershed Delineations

- Bass River
- Chase Garden Creek
- Herring River
- Quivett Creek
- Sesuit Harbor
- Swan Pond River
- Direct Discharge

Dennis Water Resources

- Lakes and Ponds
- Beaches
- Water Supply Wells

Town of Dennis, MA

Water Quality Evaluation and Mitigation Alternative Study

November 2021

N

1 in = 4,500 ft

0 0.5 1

Miles

Figure ES-2

Town of Dennis Water Resources

CDM Smith

NEWELLJD F:\Dennis\DATA\MXD\ES-1.mxd 9/17/2014

Table ES-1 Decrease in Present Attenuated Loading to Meet Nitrogen Thresholds

MEP Watershed	Total Controllable Load Decrease to Meet Threshold (% change)	MEP Scenario Septic Load Decrease to Meet Threshold (% change)
Bass River	-47.4%	-59.5%
Swan Pond River	-75.5%	-100.0%
Herring River	-23.6%	-38.5%
Chase Garden Creek	+13.8%	+53.1%
Sesuit Harbor	TBD	TBD

The values in Table ES-1 are for the entirety of each watershed, including those portions in other communities; the exact reduction required by the town of Dennis is calculated based on the percentage of the attenuated nitrogen load in each subwatershed originating in Dennis.

Estuaries and Embayments

Figure ES-2 shows the locations of the saltwater estuaries and embayments in Dennis. Five of the town's six embayments are included in the MEP study areas above.

The MEP results determine the acceptable levels of nitrogen that can be discharged to each watershed while maintaining a healthy water environment. These results are presented in two parts: 1) the amount of total controllable nitrogen requiring reduction in order to meet water quality goals, and 2) the amount of septic system nitrogen reduction required to meet those same goals. Controllable nitrogen includes sources such as stormwater runoff, fertilizer use, and leachate from landfills, in addition to wastewater. While addressing septic system nitrogen may be the most straight-forward means of quantifiable nitrogen reduction, it is not the only option. Therefore, by presenting these two values for each watershed, a range of options to deal with nitrogen reduction can be considered.

The results for each watershed with a completed MEP study are presented in Table ES-1. Note that within each watershed shown, reduction percentages vary widely from one subwatershed to another. Breakdowns by subwatershed can be found in Section 2 of the report and must be considered in the development of options to achieve required nitrogen reduction goals. Typically, watershed areas farther upstream require higher nitrogen reduction, while the areas closer to the ocean and those that experience a greater degree of tidal flushing require less intervention.

Beaches

The Massachusetts Department of Public Health (MDPH) administers the "Beach Program" for all beaches in the Commonwealth. Beaches are sampled regularly for bacteria during the swimming season, at a frequency based on historic beach water quality. Dennis has a mix of saltwater beaches at the shorelines and freshwater beaches at ponds. The sampling frequency in season for all beaches in Dennis is weekly. This sampling is solely for the purpose of evaluating the public health risks of contact recreation and therefore focuses on bacteria levels only. Similar to the drinking water standards noted above, meeting recreational (bacterial) water quality standards does not equate to meeting the nutrient levels necessary for a healthy ecosystem.

Dennis has 23 marine beaches and three freshwater beaches that are tested as part of this program. Five years of beach sampling results were examined for this study, from 2009 through 2013, with between 13 and 18 sampling events per year. Each beach was thus subject

Sesuit Harbor

to roughly 70 sampling events over the five-year period. Of the three freshwater beaches tested, all tests met the required bacterial standards. At the saltwater beaches, only one beach met the required levels in all samples (West Dennis Beach), while 21 beaches had between one and four measurements above the regulatory thresholds. The remaining two beaches, Bayview and Clipper Lane, had five and 11 measurements above the regulatory thresholds, respectively.

Therefore, recreational water quality has largely been in compliance with regulatory standards. Isolated instances have occurred where the bacterial limits have been exceeded, usually in response to a stormwater discharge after a rainfall event. However, these have not typically resulted in beach closures, since the present regulations allow many beaches to remain open if a sample the following day is tested and found to be in compliance with regulatory thresholds.

Past Enforcement Actions

The Town has seen past enforcement actions on properties due to groundwater problems arising from wastewater management problems from septic systems and cesspools. In 2012, Grindell's Ocean View campground closed because of MassDEPs consent order requiring the facility to address it's wastewater discharge. A luxury condominium complex has since opened on the property, including an on-site treatment system to address their wastewater discharge. Similarly, Campers Haven in Dennis Port was under a consent order to address their wastewater discharge, and installed a package system and pressure sewer to address the issue. Other cottage colonies including, Chase's Ocean Grove, Salt Air Village and Curtis Pine Grove have also faced regulatory pressure to address their wastewater discharge. MassDEP is closely watching the progress of all Cape Cod Communities in addressing their impacted embayments and estuaries.

In February 2017, MassDEP issued a response letter to the Town of Harwich, copying the Town Administrator for the Town of Dennis and Department of Public Works Director for Yarmouth regarding regulatory action that the Department may take if the Cape Cod communities slow or fail to make progress towards addressing impaired estuarine systems on Cape Cod. MassDEP identified the following as potential actions that could be taken:

- Designation of Nitrogen Sensitive Areas (NSAs). MassDEP could designate watersheds or embayments that exceed their critical load to be nitrogen sensitive if needed to meet water quality goals as identified in the total maximum daily loads (TMDLs) and Surface Water Quality Regulations (314 CMR 4.00).
- Changes to groundwater discharge permit and regulations. MassDEP could tighten current permit limits, requiring additional treatment of septic system effluent (i.e. innovative and alternative solutions) and also remove the Title 5 Exemption, which exempts on-site septic systems that discharge less than 10,000 gallons per day.
- Formation of Water Pollution Abatement Districts (WPADs). WPADs can be formed by the Department for the prompt and efficient abatement of water pollution within cities or towns. The WPAD would be responsible for developing

watershed plans, applying for requisite permits and construction and operating the treatment works necessary to meeting permitting requirements.

The application of nitrogen removal on-site systems for addressing the TMDLs in Dennis was evaluated as part of this CWMP and it was found that this alternative is more costly to the homeowner than the recommended plan presented herein.

Scargo Lake and Cape Cod Bay

ES.2.3 Drinking Water Supplies

Dennis Water District's drinking water supplies were evaluated in terms of both overall water quality and nitrogen levels. The overall quality of Dennis' groundwater supplies was found to be very good, with no measurements exceeding federal Safe Drinking Water Act standards over the last five years.

Nitrate (nitrogen) levels were examined both in relation to public health impacts and as an indicator of wastewater and stormwater influence on town drinking water supplies. Regulatory thresholds for nitrate in drinking water include a 10 mg/L limit according to the Safe Drinking Water Act and a 5 mg/L goal established by the CCC. None of Dennis Water District's 22 wells have exceeded either of these nitrate levels in any single sample in the 28-year period examined (1993 through 2020). Furthermore, none of the town's wells have exhibited a trend of steadily increasing nitrate over time. Some wells have shown a decrease in nitrogen over time as the Water District continues to purchase land to protect the wells. Average nitrate levels over the period examined were between 0.14 and 2.36 mg/L in the town's wells. Background levels with no impact from development are typically considered to be less than 1.0 mg/l nitrate.

It is worth noting that these public health-related nitrate thresholds (5 and 10 mg/L) are much higher than the thresholds established for healthy estuarine ecosystems (typically 0.5 mg/L or less); therefore, it is common to meet drinking water standards while still greatly exceeding the nitrogen levels in groundwater required to protect the saltwater environment.

ES.2.4 Freshwater Ponds

As noted above, freshwater ponds are typically threatened by excessive levels of phosphorus, which is typically the limiting nutrient in freshwater systems. This means that small increases in phosphorus above typical background levels can spur unwanted growth of algae, which in turn can decrease oxygen levels in the bottom layers of a pond, especially during the warmer months.

Eleven of Dennis' freshwater ponds were sampled routinely as part of the Cape Cod Pond and Lake Stewardship (P.A.L.S.) program. Ten years of historic data from these sampling events were examined as part of this evaluation, along with more detailed data from site-specific studies at particular ponds. From this information, six ponds were identified as having impaired water quality: Cedar Pond, Coles Pond, Fresh Pond, Hiram Pond, Run Pond, and Scargo Lake. Of these six ponds, all except for Run Pond have medium to high density shoreline development which contributes to water quality impairment. Therefore, nutrient reduction methods will be considered for the watersheds to these ponds in the development of a recommended program for water quality improvements moving forward.

Table ES-2
Dennis Ponds Health Assessment Summary and Recommendations

Name	Pond Trophic Status	Monitor	Investigate Road Runoff Contribution	Investigate Potential Contaminant Sources	Shoreline Development
Aunt Pattys Pond	*	X	X		Low-Medium
Bakers Pond	Oligotrophic	X	X		Low
Cash Pond	*	X			Low
Cedar Pond	Eutrophic	X	X	X	Medium-High
Clay Pond		X		X	Low-Medium
Coles Pond	Eutrophic	X			Low-Medium
Duck Pond	*	X	X	X	Medium-High
Eagle Pond	Mesotrophic	X	X	X	Low
Flax Pond	Mesotrophic	X	X	X	Low-Medium
Follins Pond	*	X	X	X	High
Fresh Pond	Eutrophic	X		X	Low
Funn Pond**	*	X		X	Medium
Grassy Pond	*	X			Low
Great Pond Plash	*	X			Low
Hiram Pond	Eutrophic	X	X	X	Medium
Jonathans Pond	*	X		X	Low-Medium
Kelleys Pond	*	X		X	Medium-High
Little Coles Pond	*	X			Low
Northern Simmons Pond	Oligo-mesotrophic	X			Low
Pine Pond	*	X	X	X	Medium
Run Pond	Meso-eutrophic	X		X	Low
Scargo Lake	Meso-eutrophic	X	X	X	Medium
Southern Simmons Pond	*	X		X	Low
Swan Pond	*	X	X	X	High
The Plashes	*	X			Low
Uncle Stephens Pond	*	X		X	Medium
Weir Creek	*	X	X	X	Low-Medium
White Pond	Oligo-mesotrophic	X		X	Low
Whittemores Pond	*	X	X	X	Medium-High

Notes: Eutrophic - Excess levels of nutrients are present and the water body is exhibiting signs of impairment.

ES.2.5 Title 5

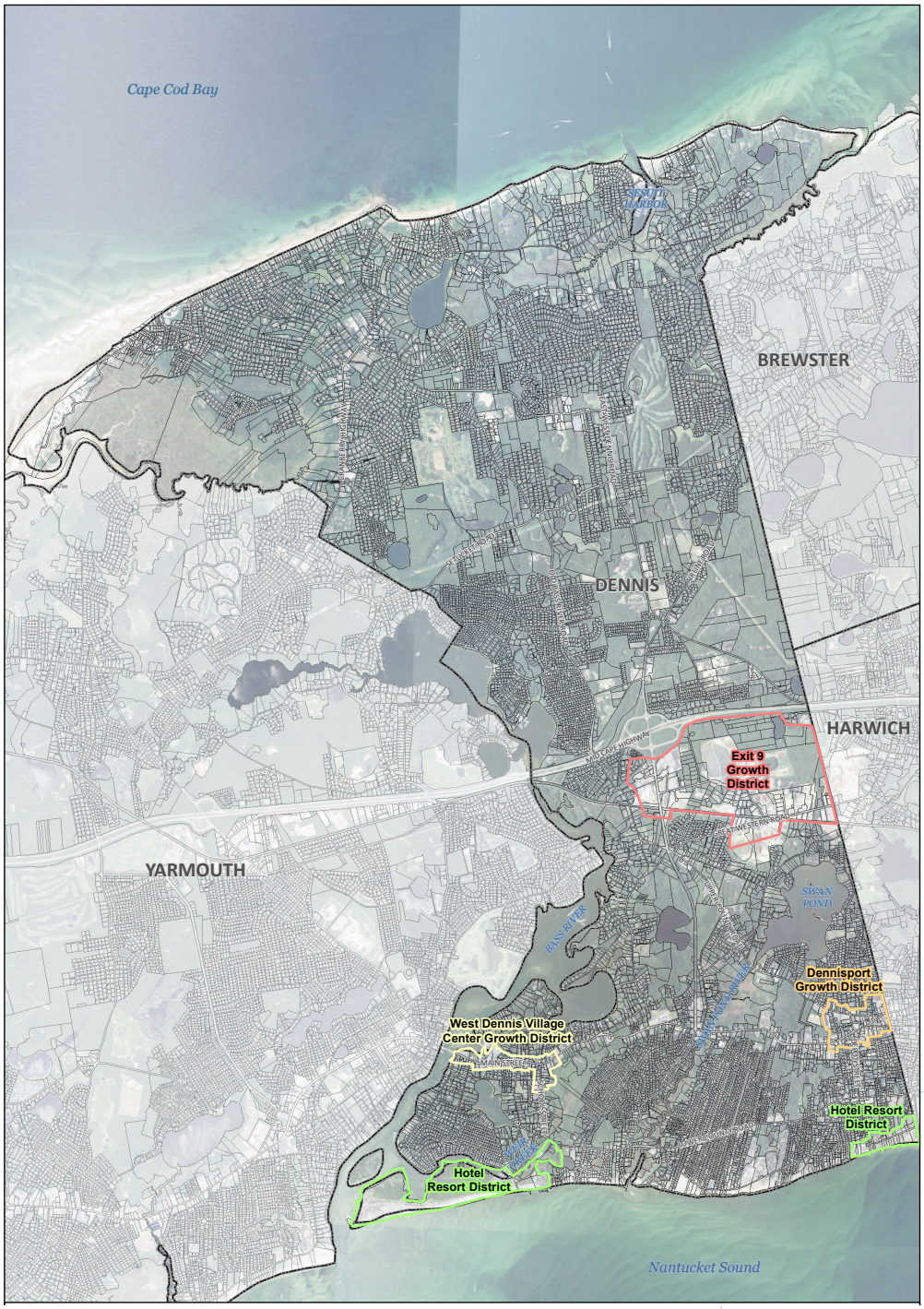
Multiple areas throughout town have been identified as having historic septic system failures but the primary locations are south of Route 28, with the exception of the area just north of Route 28, surrounding Swan Pond, the area just north of Route 6 and a cluster within the Chase Garden Creek watershed, adjacent to Cape Cod Bay. The problems with Title 5 septic systems are generally encountered in areas with low permeability soils, small lots and high groundwater.

ES.2.6 Economic Development

The town of Dennis has created several areas where growth and economic development or redevelopment are desired. These areas have been identified by the Dennis Planning Department and Planning Board and factor into the town's long-term goals for economic viability.

In the 10-year period between 1999 and 2009, Dennis' residential tax payers changed from paying 89 percent of the tax burden to 93 percent, with commercial entities only comprising 7 percent of the tax base in 2009. While in 1999, the average home paid $7 in taxes for every dollar paid by commercial entities, in 2009, the average residence paid $12 for every commercial dollar paid. Since the town prioritizes maintaining its existing open spaces and residential neighborhoods, the logical location for economic growth is within the existing commercial areas. The existing village center areas of Dennis Port and West Dennis, the older hotel areas in Dennis Port, the Route 28 commercial strip, and the area around Exit 78 (formerly Exit 9) present opportunities to balance the town's tax base and enhance economic stability via smart growth.

Figure ES-3 shows the locations of the planning districts. All of these areas are proposed for inclusion in the wastewater management program developed as part of this CWMP since higher density development is being proposed in each location.



ES-3 Dennis Planning Districts

ES.2.7 Regional Opportunities

The Town of Dennis has been in discussions with the neighboring towns of Harwich and Yarmouth to potentially form a regional wastewater partnership. Dennis and Yarmouth share a portion of Bass River watershed, while Dennis and Harwich share a portion of both Swan Pond and Herring River watersheds. The three communities explored a joint approach and developed plans for the DHY Clean Waters Community Partnership between 2017 and 2021. Special Legislation that would allow this partnership to form was passed in 2019 (Chapter 88 of the Acts of 2019). However, at this time, the Towns have each elected to pursue Town only solutions but are leaving the opportunity for future partnerships open.

ES.3 The Proposed Dennis Solution

The recommended wastewater program for the Town of Dennis includes a collection system utilizing one centralized treatment facility. Components would be phased in over 40 years. The implementation of such a program will allow Dennis to meet its water resource management needs as defined throughout this report, including consistency with the MEP and subsequent Total Maximum Daily Load (TMDL) nitrogen reduction goals as well as the protection of freshwater resources including ponds and drinking water resources. This section describes the recommended program components for the collection systems, wastewater treatment, effluent recharge with potential use of a permeable reactive barrier (PRB), and Aquaculture. The recommended non-infrastructure program components include fertilizer and stormwater management programs, potential land use changes, open space acquisition, and several community involved conservation and pollution reduction programs.

ES.3.1 Cape Cod Commission 208 Plan

The CCC's Area-wide Water Quality Management Plan Update ("the 208 Plan") has been developed to address these same federal regulatory requirements.

The 208 Plan discusses the nitrogen problem Cape-wide and presents a suite of options towns can consider in solving their nitrogen loading issues. The 208 Plan's recommendations are based on meeting the goals outlined in each MEP report. The CCC has designated each Cape Cod town as the Waste Management Agency (WMA) responsible for meeting the Clean Water Act requirements for water resource protection.

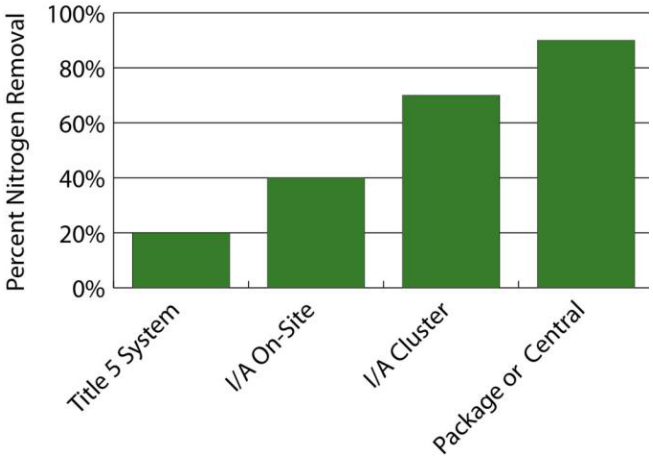
The Town of Dennis has reviewed the work performed by the CCC since the final 208 Plan was approved in 2015. Dennis's plan is in line with the 208 Plan since Dennis's approach is based on the MEP nitrogen loading models with the goal of achieving the most efficient sewershed footprint while keeping costs to a minimum. The town of Dennis's wastewater scenarios utilized a hybrid approach similar to that suggested in the 208 Plan, combining both traditional and non-traditional technologies with an iterative process involving many stakeholders, including the WIC, Select Board, the public and other town committees. to develop the most cost effective and implementable recommended program. This Final CWMP/SEIR also incorporates an adaptive management strategy, whereby ongoing monitoring and analysis will result in continually revisiting and updating the plan accordingly. Regional solutions are also

highly recommended in the 208 Plan and are being considered by the Town as a collaborative approach to addressing shared watersheds and as a potential cost savings, as described above.

The proposed solution presented in the Final CWMP addresses the controllable nitrogen within the watersheds in the Town, as detailed in the MEP reports. The plan meets the nitrogen reduction targets presented in the MEP reports and accepted by MassDEP for each of the watersheds. As identified above, the plan is a hybrid approach using traditional sewering, aquaculture and PRBs to comprehensively address nitrogen reduction targets. The proposed plan was designed such that the buildout wastewater flows were accounted for, to allow for new and smart growth within the Town. The Town of Dennis will work with the CCC throughout the acceptance and implementation of their Final CWMP, as required to align with the 208 Plan.

ES.3.2 Alternatives: Title 5 Systems, I/A Systems, and Treatment Plants

Over the course of the Final CWMP development, the Town considered many alternatives to the system layouts and locations, to the selection of appropriate technologies for wastewater conveyance and treatment, to effluent recharge sites and uses, and to cost recovery approaches. Figure ES-4 shows the typical percent nitrogen removal of several treatment technologies that were considered in development of the Final CWMP.



ES-4 Percent Nitrogen Removal for Several Treatment Technologies

Over the course of the Final CWMP process, the Town explored many alternatives to the wastewater treatment plant program ultimately recommended. Smaller, decentralized service areas with smaller treatment facilities were explored. The Town looked at the scenario of having three different wastewater treatment plants with three different effluent recharge sites. The cost for this and similar decentralized approaches to wastewater management were much higher and therefore rejected by the Town.

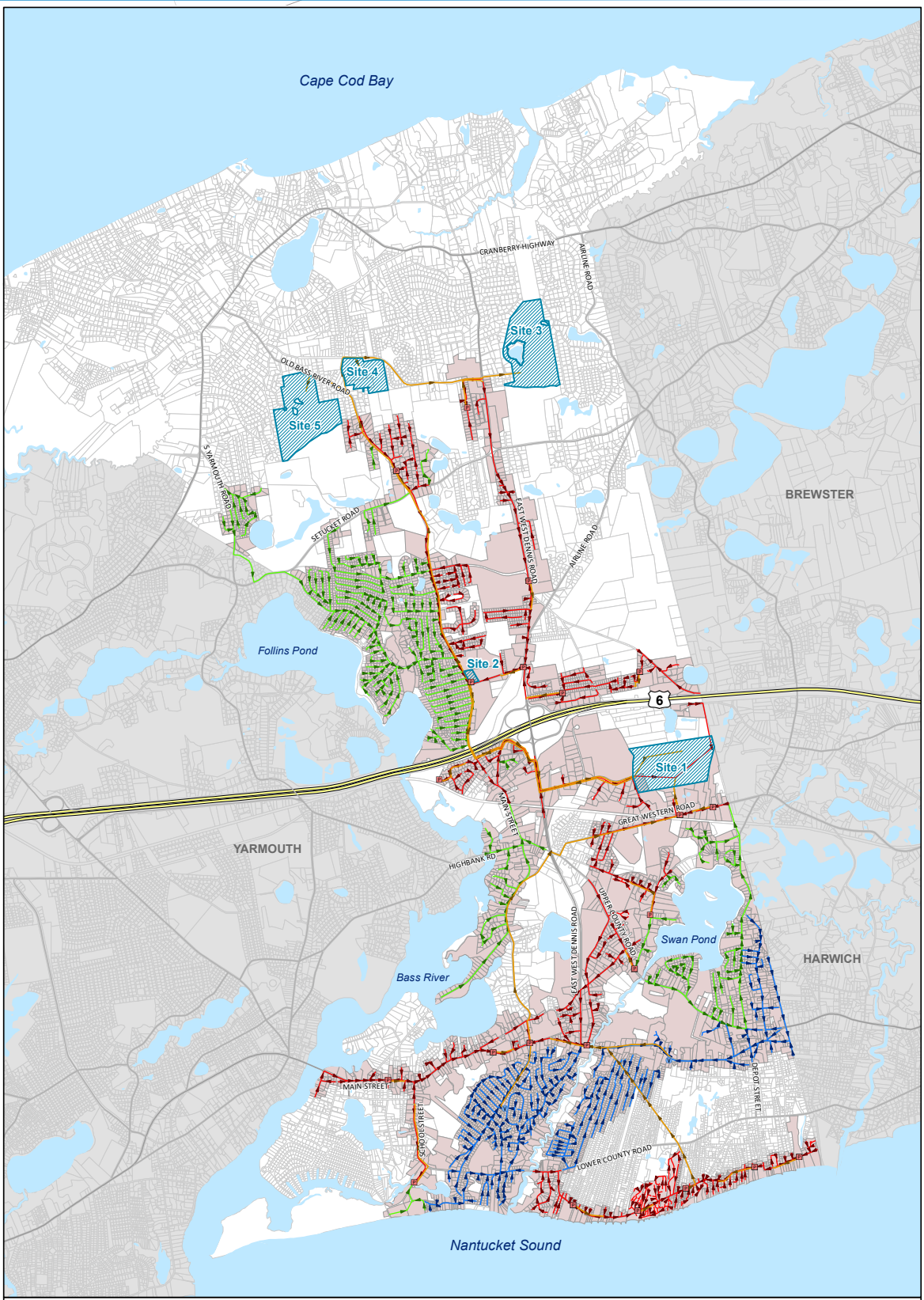
ES.4 Recommended Wastewater Program

ES.4.1 Infrastructure Components

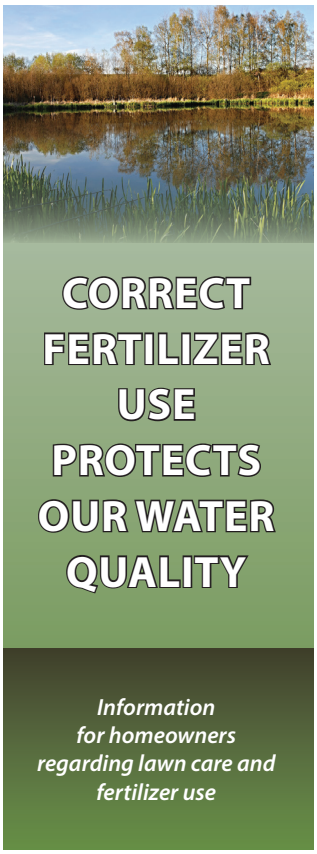
The recommended plan provides collection and conveyance, treatment, and effluent recharge for about 2.07 mgd of annual average daily wastewater flow from the MEP watersheds and other selected portions of Dennis. Figure ES-5 shows the components of the recommended program. This is a future flow projection developed from the buildout analysis in the MEP models with assistance and updates from the Dennis Planning Department as well as CCC.

source: capecod.com

Conceptual sewer service areas shown were selected based on the amount of nitrogen required to be removed in a specific watershed, addressing the Town's needs and selecting higher density ares to keep sewering costs lower. The sewer area includes sewering as many existing developed parcels as necessary in the Bass River, Swan Pond River and Herring River watersheds in order to meet the nitrogen removal requirements. The sewered area includes multiple planning district areas. Aquaculture is included in both the Bass River and Swan Pond River watersheds.


Cape Cod Bay
CRANBERRY HIGHWAY
AIRLINE ROAD
Site 3
Site 4
Site 5
OLD BASS RIVER ROAD
S YARMOUTH ROAD
SETUCKET ROAD
EAST WEST DENNIS ROAD
AIRLINE ROAD
BREWSTER
Follins Pond
Site 2
6
Site 1
GREAT WESTERN ROAD
MAIN STREET
YARMOUTH
HIGHBANK RD
UPPER COUNTY ROAD
EAST WEST DENNIS ROAD
Swan Pond
HARWICH
Bass River
MAIN STREET
SCHOOL STREET
LOWER COUNTY ROAD
DEPOT STREET
Nantucket Sound
Legend
Vacuum Main
Pressure Main
Force Main
Gravity Main
Vacuum Station
Pump Station
Treatment Sites
Sewered Parcels
Town of Dennis, MA
Comprehensive Wastewater Management Plan
November 2021
N
1 in = 3,000 ft
0
0.5
1
Miles
Recommended Areas to be Sewered
Figure ES-5
CDM Smith
NEWELLJD F:\Dennis\DATA\MXD\Dennis_Figure_14-1_Recommended_Sewered_Areas_20210927.mxd 9/27/2021

The recommended treatment technology for the central Dennis treatment facility to be built at Site 1 is a sequencing batch reactor (SBR) process. The SBR option is cost-effective, easily expandable, able to treat to stringent permit limits, and can handle seasonal fluctuations in flows and loads. In accordance with MEPA regarding their Greenhouse Gas Policy, the CWMP presents best practices for energy conservation measures of the future wastewater treatment facility. Additionally, resilient design of the wastewater collection and treatment systems will be an integral component of the next phase of work. Resilient design features will be considered in the final design stage, which will aim to address impacts from future sea level rise conditions.



ES.4.2 Non-Infrastructure Components

Non-infrastructure components of the recommended program include a public participation and outreach program, fertilizer education, stormwater best management practices (BMPs), freshwater ponds evaluation, sampling and restoration, continued saltwater sampling, low impact landscaping, water conservation programs, inflow prevention programs, on-site system support, school education programs, land use and open space changes, innovative and alternative technologies committee, boat pump outs in Dennis marinas, and the shellfish program. Highlights of the non-infrastructure components are described below.

Public Outreach

Public participation and outreach has been a priority during the Final CWMP/SEIR process, starting in 2005 when informational public outreach efforts under the Phase I Needs Assessment were initiated to gain participation and feedback from residents and business owners. Developing positive public relations – defined as an ongoing, informative conversation between the Town and various stakeholders – during the planning phase translates to enhanced public acceptance during the implementation of any project. Ultimately, buy-in from involved citizens, stakeholders like business and community groups, and the public at large will be required to gain acceptance of proposals to fund this water quality effort.

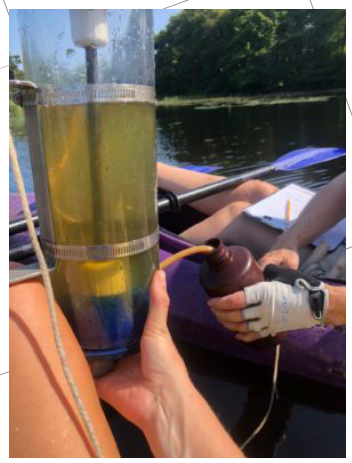
Avenues of public outreach that the WIC has used and will continue throughout the CWMP development and implementation are listed below. More detail is provided for each:

- Branding
- Website
- Publications
- Mailings
- Information Displays and Booths
- Social Media
- Committee Meetings
- Community Meetings

Fertilizer Education

The fertilizer education program will focus on ideal application types and rates of fertilizer use and on resident awareness of the negative effects of over-fertilization or inappropriate use. The program will also target portions of Dennis located upstream from the most sensitive water sources and may include website resources, handout materials, collaboration with local landscaping companies, and other regional and County initiatives for the benefit of the Town. The WIC developed a fertilizer use brochure for Dennis residents and it is available at several locations in town.

Stormwater Retention Basin



source: Barnstable Clean Water Coalition

Stormwater BMPs

The stormwater BMP program will focus on ideal application of BMPs at the drain features throughout Dennis. The program will target those portions of town located upstream from the most sensitive water sources in subwatersheds with the highest nitrogen loads as well as phosphorous in freshwater ponds from stormwater and will include several stormwater controls and/or practices on all new work. As the program is developed, the town will decide which types of controls are most appropriate.

Freshwater Ponds Evaluation, Sampling and Restoration

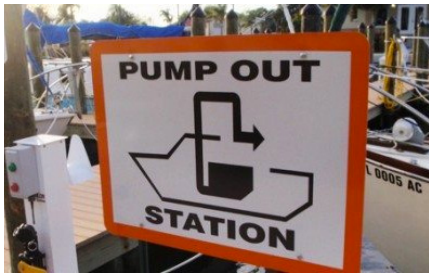
New 1st paragraph: The Town of Dennis has approximately 29 ponds with a total area of 749 acres, including three ponds shared with neighboring towns. The Dennis Local Comprehensive Plan stresses the importance of maintaining the health and quality of the Town's freshwater resources. The Plan states that the freshwater shorelines are classified as "coastal plain pondshores," which provide habitat to rare and endangered plants and animals. The Cape Cod Pond and Lake Stewardship (PALS) program has historically sampled up to seventeen locations annually in eleven of Dennis' ponds, typically in August and/or September.

The growing number of pond restoration actions on Cape Cod suggests that many ponds are reaching their tipping points, where further alterations to the environment will result in sometimes dramatic changes in water quality. Cedar Pond was observed as having macrophytes, aquatic plants, along the northern shoreline; current orthophotos show this growth in the southeastern area of the pond as well. Generally, historical orthophotos show multiple instances of algal growth. Below are some preliminary steps that should be taken to protect or restore Dennis's ponds.

1. Continue sampling
2. Perform an inventory of all stormwater pipes draining to ponds
3. Investigate other potential contaminant sources
4. Determine uses and ponds to support

Innovative and Alternative Technologies Committee

Because of the high costs today of providing proven nitrogen removal treatment technology to the very stringent standards required to meet the proposed TMDLs, there are several innovative and alternative (I/A) technologies being tested. As described earlier, the currently available I/A technologies do not meet the nitrogen removal requirements or their use was not cost effective. However, development of new technologies should always be monitored and evaluated for incorporation into this recommended wastewater program. The Dennis program has been designed with significant flexibility such that it would allow potential technology improvements to be incorporated in the future as appropriate. Dennis will create a committee that will monitor alternative systems going forward.



Boat Pump Out Sign

Boat Pump Out in Dennis Marinas

Currently the Sesuit Harbor, Bass River Marina, Swan River along with the entire Nantucket Sound and Cape Cod Bay, are federally designated no-discharge areas. This designation prohibits the dumping of boat wastewater into the harbors and their tributaries. The Dennis Harbormaster and the Marine Water Quality Committee have worked extensively with Massachusetts CZM and EPA officials to enhance a holding

tank discharge system that is already available to boaters in Dennis. The Town provides this service and it is considered to be valuable and proactive program that protects the town's valuable coastal resources. To continue its effectiveness, the Town should regularly review its ability to effectively provide this service in the marinas throughout Dennis.

Dennis Shellfish Program

The Town of Dennis Wastewater Implementation Committee and Shellfsh Advisory Committee agreed to conduct a small scale program of oyster aquaculture as a nitrogen remediation strategy for the Town's wastewater mitigation planning in the Swan Pond Watershed.The two year project started in July of 2018 in the northwest section of Swan Pond. A total of 150 floating oyster bags with approximately 950 oysters in each comprised the original floating array. In July 2019, an additional 140,000 seed which were stocked at approximately 1,000 per floating oyster bag were added to the floating array.

Swan Pond Aquaculture Pilot

While the scale of the project was not sufficient to demonstrate that it could make a significant difference in the water quality of the pond, it did demonstrate the nitrogen removal potential of a given area of oyster culture in the pond, and a measurable way of removing nitrogen to partially meet watershed TMDL limits. The project scale showed the feasibility of culturing up to 1 million oysters per acre and removing about 150 kg of N per acre at costs less than or equivalent to conventional means of treatment. Given the data collected in the pilot study, aquaculture may be a viable technology for additional nitrogen reduction in the Swan pond watershed or other impacted waterbodies in Town. The Town currently considers this to be a potential nitrogen removal polishing step should a given watershed need additional nitrogen removal in the future.

ES4.3 Governance

The Select Board have been reviewing and discussing several models to help oversee the implementation of the recommended wastewater program. While no formal governance structure has been adopted by the Town to date, the plan is for the Select Board to oversee the planning, design and construction of each program phase. The operation of oversight will be determined over the next year, prior to design of Phase 1 of the Recommended Plan. In the fall of 2021, the Town engaged the support of a contracted Wastewater Program Coordinator (GHD). This role was created to help the Town navigate and advise the Town in the implementation of the wastewater program.

ES4.4 No Build Alternative

The No-Build alternative involves the continued use of onsite Title 5 septic systems and innovative and alternative (I/A) systems where needed to meet the wastewater needs of the community. MassDEP indicates that the baseline, or No-Build, alternative, which focuses on optimization of existing facilities, should be evaluated "with respect to potential effects on surface water quality; groundwater quality (if applicable); land use limitations; and socio-economic factors (e.g., residential, industrial, and health hazards)." None of these factors can reach an acceptable level of service under the No-Build alternative.

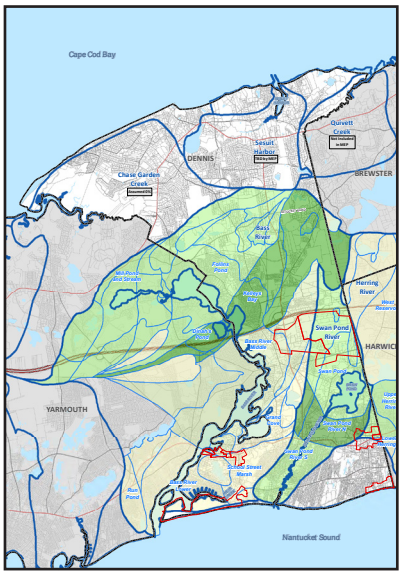
As such, continued use of on-site systems town-wide would not be cost effective to achieve the nitrogen levels required to restore the local embayments to the water quality goals described in the MEP documents. Based on this data, surface water quality cannot be adequately maintained using the No-Build alternative. The drinking water in Dennis demonstrates excellent quality and as such it is important to note that the need to protect drinking water quality is not a significant driver for sewering at this time, although a few wells do show nitrogen levels above expected background concentrations for nitrogen.

The No-Build alternative also presents land use limitations, specifically in the South Dennis and other areas of desired growth throughout town. Without off-site wastewater management options, desired land uses are expected to be severely restricted by Title 5.

The Town relies on tourism for jobs and revenue which is the direct result of the high quality natural resources on Cape Cod. Furthermore, many residents choose to reside in Dennis due to its natural beauty and the recreational opportunities afforded by its beaches, ponds, and scenic waterways. Protection of these resources is critical to the health and well-being of the Town. While the No-Build Alternative is obviously the least expensive option when only considering capital costs, the long-term impact on the economic viability of the Town must also be considered, along with the many qualitative factors related to aesthetics, quality-of-life, and environmental preservation. The No-Build Alternative would not adequately preserve these valuable resources, would be in violation of the TMDL requirements for the Town's embayment's that have TMDLs, and is not considered a viable option by state, county, and local officials.

ES.5 Phasing Plan and Costs

ES5.1 Phasing Plan



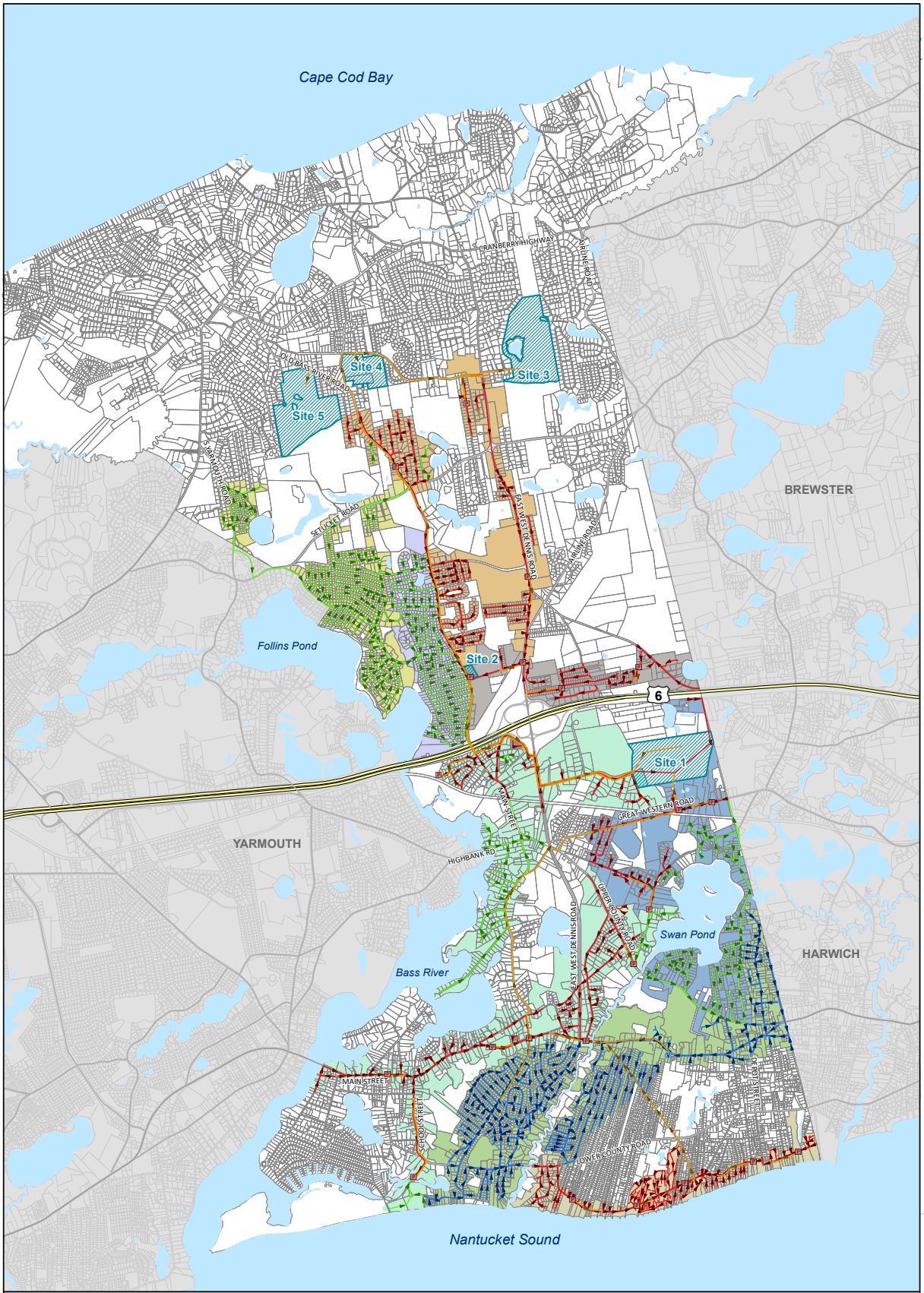
Watershed Total Nitrogen Load Reductions

There are several issues that need to be considered in developing the phasing plan for implementing the recommended wastewater program in the Town. The CWMP addresses many of these issues but conditions and priorities will change over the next 40 years that will impact current day decisions. Thus, the phasing plan will need to be constantly monitored and periodically modified as it is implemented via a process known as adaptive management.

The following bullets outline the important factors that went into developing the recommended phasing plan. The plan was developed through consultation with the Town's WIC, the Select Board and regulatory drivers. Issues that were considered in developing the phasing plan include:

- Title 5 septic system issues;
- Freshwater ponds water quality;
- Future growth and economic development potential;
- Regionalization opportunities;
- TMDL (MEP) issues; and
- Program Costs.

Figure ES-6 shows the phasing plan. Details of the proposed phasing program are described below.



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Town of Dennis, MA
Comprehensive Wastewater Management Plan

November 2021

Recommended Phasing Plan
Figure ES-6

Dennis' proposed wastewater management program includes a mix of fertilizer and stormwater credits, aquaculture, sewering, wastewater treatment, effluent recharge, and PRBs. The sewer footprint includes sewering as many existing developed parcels as necessary in the Bass River and Swan Pond River watersheds in order to meet the nitrogen removal requirements. The sewering plan includes a portion of existing developed parcels, plus all of the economic planning districts development along the southern coast of town.

Dennis evaluated various collection system technology options and chose a hybrid system of gravity, pressure, and vacuum sewers. Each sewer type will be applied in the appropriate location, allowing each technology to take advantage of the natural geography and topography in Dennis. There would also be one wastewater treatment facility and several recharge sites in town. During the initial development of the CWMP, Sites 1 and 2 were identified and are discussed in more detail below and in the Final CWMP. Following more refined hydraulic modeling, it was determined that additional effluent recharge sites will be required to accept the full buildout flow of the wastewater treatment facility. The Town completed a second effluent recharge desktop investigation in 2016 where it identified potential effluent recharge Sites 3, 4, and 5, shown in Figure ES-5. The Town is now conducting a a third investigation to locate effluent recharge sites that meet the current and future needs of the Town, through discussions with the Dennis Water District and other Town departments. Sites 1 and 2 may both be used in Phase 1 when the initial phase of the wastewater treatment facility is constructed, depending on the final design flow of the initial construction of the wastewater treatment facility. One or more sites will be identified and included in Phase 4 when the wastewater treatment facility is expanded. While the plan exceeds the nitrogen removal requirements of the MEP, it has been laid out to meet the infrastructure needs of other town goals such as economic growth and Title 5 issues.

source: Cape Cod Chronicle

Dennis proposes a 40-year, 8-phase approach to implement its recommended wastewater management plan. The preliminary 5-year phases are described in more detail below. In addition, each phase includes stormwater BMPs, and fertilizer education.

- **Phase 1**: Construction of its WWTF and a recharge facility at the same location and potentially other site(s) with a PRB at the recharge facility or another location in Town; construction of a sewer "spine" from the WWTF to the commercial planning district along Route 28; sewering in residential areas adjacent to Bass River and East-West Dennis (Route 134);
- **Phase 2**: Sewering in WWTF-adjacent developed areas and commercial planning districts, and sewering in areas north and west of Swan Pond;
- **Phase 3**: Sewering in commercial planning districts on the southeast coast (i.e. hotel area) and in Dennis Port; construction of aquaculture and other non-traditional treatment technologies;
- **Phase 4**: Expansion of the Town's WWTF and construction of an additional recharge facility at Site 2 and/or other site(s) with a PRB at the recharge facilities or other locations in Town; sewering in areas adjacent to Route 6;

Table ES-3 – Existing and Buildout Wastewater Flows by Phase

Phase	Existing Average Daily Flow (gpd)	Build-out Average Daily Flow (gpd)
1	232,000	514,000
2	123,000	517,000
3	114,000	211,000
4	39,000	74,000
Subtotal	507,000	1,317,000
5	252,000	353,000
6	93,000	101,000
7	112,000	130,000
8	110,000	168,000
Total	**1,074,000**	**2,069,000**

- **Phase 5**: Sewering the areas south of Swan Pond;
- **Phase 6**: Sewering the area north of Route 6 and west of Old Bass River Road;
- **Phase 7**: Sewering the area northwest of Route 6 adjacent to Follins Pond; and
- **Phase 8**: Sewering the area north of Site 2.

Dennis has discussed modifying its recommended plan to address additional Areas of Concern (AOC) that are characterized by high groundwater and very small lots even though groundwater flow from those areas discharges directly to Nantucket Sound. So while current cost projections discussed below only reflect Scenario 6A (i.e. the town's recommended plan), future costs should account for allowances in future flow increases (larger pipe sizes, increased capacity in a pumping station, etc.) to accommodate the Scenario 7A areas and additional effluent recharge areas should also be identified to account for the increased flow.

Sewer service areas in Phases 5, 6, 7, and 8 can be adjusted as needed to meet local needs and based on feedback from water quality monitoring. The order in which these phases are implemented is also flexible and can be adjusted to meet those same needs.

ES5.2 Recommended Cost Recovery Plan

The Town of Dennis's recommended program for nitrogen management is a costly town-wide program which includes sewer installation, wastewater treatment and effluent recharge, as well as a number of non-infrastructure solutions such as public education and aquaculture. The total cost by phase for the different components of the plan is shown in Table ES-4 and the timeline for funding requests with a summary of the activities to take place during those years is shown in Table ES-5.

Table ES-4
Details of Phasing Plan Costs by Phases 1-8

Phase	Collection and Conveyance System	Treatment Facility	Owners Project Manager (OPM)	Effluent Recharge with Conveyance and PRB	Non-Traditional Technologies	Total
1	$49. Mil	$52.7 Mil	$.9 Mil	$20.7 Mil	$1.3 Mil	$124.4 Mil
2	$30.9 Mil				$1.3 Mil	$32.3 Mil
3	$21.0 Mil				$1.3 Mil	$22.3 Mil
4	$15.3 Mil	$16.9 Mil	$.3 Mil	$18. Mil	$1.3 Mil	$51.7 Mil
5	$34.7 Mil				$1.3 Mil	$36.0 Mil
6	$21.3 Mil				$1.3 Mil	$22.6 Mil
7	$26.9 Mil				$1.3 Mil	$28.2 Mil
8	$25.6 Mil				$1.3 Mil	$26.9 Mil
Total (Rounded)	$224.6 Mil	$69.5 Mil	$1.1 Mil	$38.7 Mil	$10.4 Mil	$344.3 Mil

Notes:
1. Costs include 25% construction contingency and 15% for planning, permitting, and engineering.
2. Connection costs not included.
3. Costs are projected to mid-point of construction at the end of 2024, enr: 13,060.
4. Town collection and conveyance systems include additional 10% contingency.
5. Phase 1 - There is a potential to decrease costs for sewer implementation by combining with MassDOT project.
6. Phase 5 - There is a potential to decrease costs for sewer implementation by combining with MassDOT project.
7. Assume OPM services will be 3% of WWTF cost (excluding 25% construction contingency and 15% for engineering, permitting and planning)

Table ES-5
Timeline of Phasing Plan Costs by Phases 1-8

Funding Request Year	Fiscal Year	Annual	Cummulative	Funding For	Total Annual Funding Request
				Phase 1	
2022	2023	$3.6 Mil	$3.6 Mil	Phase 1 Collection System - Design	$10.93 Mil
		$5.3 Mil	$8.9 Mil	WWTF - Design	
		$2.1 Mil	$10.9 Mil	Effluent Recharge - Design	
2024	2023	$45.4 Mil	$56.3 Mil	Phase 1 Collection System - Construction	$113.51 Mil
		$48.2 Mil	$104.5 Mil	WWTF - Construction (Including OPM)	
		$18.6 Mil	$123.1 Mil	Effluent Recharge - Construction	
		$1.3 Mil	$124.4 Mil	Non-Traditional Technologies	
				Phase 2	
2027	2028	$3.1 Mil	$127.5 Mil	Phase 2 Collection System - Design	$3.09 Mil
2029	2030	$27.9 Mil	$155.4 Mil	Phase 2 Collection System - Construction	$29.16 Mil
		$1.3 Mil	$156.7 Mil	Non-Traditional Technologies	
				Phase 3	
2032	2033	$2.1 Mil	$158.8 Mil	Phase 3 Collection System - Design	$2.1 Mil
2034	2035	$18.9 Mil	$177.7 Mil	Phase 3 Collection System - Construction	$20.2 Mil
		$1.3 Mil	$179. Mil	Non-Traditional Technologies	
				Phase 4	
2037	2038	$1.5 Mil	$180.5 Mil	Phase 4 Collection System - Design	$3.2 Mil
		$1.7 Mil	$182.2 Mil	WWTF Upgrade - Design	
2039	2040	$13.7 Mil	$195.9 Mil	Phase 4 Collection System - Construction	$48.5 Mil
		$15.5 Mil	$211.4 Mil	WWTF Upgrade - Construction (Including OPM)	
		$18. Mil	$229.4 Mil	Effluent Recharge - Design & Construction	
		$1.3 Mil	$230.7 Mil	Non-Traditional Technologies	
				Phase 5	
2042	2043	$3.5 Mil	$234.2 Mil	Phase 5 Collection System - Design	$3.5 Mil
2044	2045	$31.2 Mil	$265.4 Mil	Phase 5 Collection System - Construction	$32.5 Mil
		$1.3 Mil	$266.7 Mil	Non-Traditional Technologies	
				Phase 6	
2047	2048	$2.1 Mil	$268.8 Mil	Phase 6 Collection System - Design	$2.1 Mil
2049	2050	$19.1 Mil	$288. Mil	Phase 6 Collection System - Construction	$20.4 Mil
		$1.3 Mil	$289.3 Mil	Non-Traditional Technologies	
				Phase 7	
2052	2053	$2.7 Mil	$292. Mil	Phase 7 Collection System - Design	$2.7 Mil
2054	2055	$24.2 Mil	$316.1 Mil	Phase 7 Collection System - Construction	$25.5 Mil
		$1.3 Mil	$317.4 Mil	Non-Traditional Technologies	
				Phase 8	
2057	2058	$2.6 Mil	$320. Mil	Phase 8 Collection System - Design	$2.6 Mil
2059	2060	$23.0 Mil	$343. Mil	Phase 8 Collection System - Construction	$24.3 Mil
		$1.3 Mil	$344.3 Mil	Non-Traditional Technologies	

Note:
1. Costs are projected to mid-point of construction at then end of 2024, ENR: 13,060

To present the range of cost recovery options to the Town, a number of approaches have been discussed during the development of this CWMP. The WIC, in discussions with Town staff and representatives, decided to create a Cost Recovery Subcommittee to further delve into cost recovery model components for use in funding the implementation of the wastewater plan.

The WIC established the three tenets of wastewater recovery cost sharing, and put that philosophy into a revenue-generating mechanism that the town will use to fund the wastewater program. The net costs (total costs less grants or other subsidies) of building Dennis's wastewater program should be paid for by the Town.

The following cost recovery options are preferred by the WIC and listed below based on the tenets mentioned above and the methods available to the town. These methods would be used to repay capital funds borrowed to implement the recommended program, which are typically borrowed via the Clean Water State Revolving Fund (SRF) loans for a 20 or 30 year period at up to 2 percent interest.

- Town-wide Property Tax Fund – Costs can be recovered from all property owners within the town through the general tax fund;
- Water Infrastructure Investment Fund - A real estate tax surcharge of up to 3 percent can be set aside into a Municipal Water Infrastructure Investment Fund, outside of Proposition 2½, as allowed through recent state legislation. (2014 legislation M.G.L. Chapter 40, Section 39M). The Town has elected to implement a 1 percent tax surcharge at this time.
- Increase Local Rooms Tax Fund – Legislation was passed through Fall 2019 Town Meeting to increase rooms tax from 4 percent to 6 percent with the additional 2 percent to be appropriated in future fiscal years to the Wastewater Stabilization fund. This rooms tax includes local home rentals and AirBnB type rentals.
- Landfill Solar Fund Revenues – The Town installed a large solar field on their capped landfill with the intent to utilize about half of the revenues received for a dedicated wastewater account. Special Legislation was approved to allow this to occur. The account was established in May 2017.
- The Town is also planning to use American Rescue Plan Act (ARPA) State Fiscal Recovery Funds (SRF) to supplement the above programs.

The net cost of the program will be recovered using all of these methods.

Based on the initial cost projections and the above cost recovery program, the average cost to a property owner of a $350,000 home is about $224 over the implementation period as further discussed in Section 15.

Town of Dennis Solar Farm

ES.6 WIC and Other Stakeholders

The Town's water quality and wastewater planning effort is being overseen by the Dennis WIC, who historically has been supported by CDM Smith and more recently through the Wastewater Program Coordinator (GHD). The committee consists of 10 members; eight community volunteers appointed by the Select Board, and two members of the Select Board. Staff support was assigned by the Town Administrator in consultation with the Select Board. There are four permanent staff assigned to support the Committee. There is a representative from the Town Administrators Office, the Town Engineer, the Director of the Office of the Board of Health, and a member of the DPW senior management team. The Dennis Health Director serves as the liaison between town staff and the Committee. The Town Administrator also provides organizational support and coordination.

The Committee was created in 2016 by the Select Board following completion of the Water Quality Evaluation and Mitigation Alternative Study which was led by the CWMTF. Previous efforts led by the CWMTF were being funded and coordinated through the Dennis Water District but has since shifted to the Health Department, and the WIC remains the overseeing town committee for this initiative.

The work of this committee is also being coordinated with other Town committees and departments, including the Select Board, the Planning Department, the Natural Resources Department, the Engineering Department, Finance Committee, and the Dennis Water District. Meetings have been conducted with each of these stakeholders, and coordination will continue throughout the project to achieve consistency between the WIC's recommendations and other town initiatives such as the Local Comprehensive Plan.

ES. 7 Organization of This Final CWMP

This report is divided into nineteen sections. The sections are as follows:

- Executive Summary presents an overview of the report and the findings.
- Section 1 introduces the CWMP project and details the purpose, the scope, existing conditions, and the organization of the report.
- Section 2 describes the findings of the MEP for the four applicable watersheds in Dennis.
- Section 3 discusses the health of the Town's freshwater ponds and associated wastewater needs identified to help protect these resources.
- Section 4 provides a summary of existing groundwater quality and water supply well data in Dennis.
- Section 5 discusses the health of the Town's freshwater and saltwater beaches.

- Section 6 discusses the applicable water quality regulations.
- Section 7 provides details of the wastewater needs assessment, including the original assessment performed in 2005, as well as provides an update.
- Section 8 summarizes the estimated water usage and subsequent wastewater flows to be used in scenario planning.
- Section 9 describes the town-wide evaluation of potential wastewater treatment and effluent recharge sites and recommends specific sites to be carried forward for further analysis.
- Section 10 presents the various water quality management scenarios and includes a recommendation on scenarios to carry forward for further analysis.
- Section 11 summarizes the hydrogeologic evaluations of the preferred effluent recharge sites.
- Section 12 provides a summary and recommendation on the various collection, treatment, and effluent recharge systems that could be implemented as part of the recommended plan.
- Section 13 presents the cost results of the final scenarios and ultimately recommends one scenario to be the recommended wastewater program.
- Section 14 details the components of the recommended program including, capital and O&M costs, phasing, and non-infrastructure components.
- Section 15 outlines the potential cost recovery approach.
- Section 16 includes the Environmental Impact Analysis and Mitigation plans.
- Section 17 presents the Construction Management Plan.
- Section 18 presents the Draft Section 61 Findings.
- Section 19 includes the response to comments received on the Draft CWMP/EENF.

Section 1
Introduction

1.1 Project Identification

The water resources of Cape Cod define the region's aesthetics, tourism industry, and economy. Cape Cod's fifteen towns rely on their oceans, embayments, rivers and lakes to draw in residents, businesses, and visitors alike, resulting in communities that are both viable and sustainable, creating a desirable quality of life. Any threat to the health of the Cape's water resources is thus a threat to the health of the communities at large.

In recognition of the importance of preserving, restoring, and maintaining high quality water resources, the Town of Dennis has undertaken the development of their Comprehensive Wastewater Management Plan (CWMP). This project builds on prior work completed under the Water Quality Evaluation and Mitigation Alternative Study.

The wastewater planning performed during the course of this process has been completed with guidance and oversight from the Town's Wastewater Implementation Committee (WIC) and former Comprehensive Wastewater Management Task Force (CWMTF), working with the Town's consultant, CDM Smith. The information contained in this Final Comprehensive Wastewater Management Plan (CWMP)/Single Environmental Impact Report (SEIR) represents the results of this multi-year planning effort and the associated recommendations for long-term wastewater management in Dennis.

The planning to date has been performed with several town-wide goals in mind. These include:

- Achieving the levels of wastewater nitrogen removal required to restore local aquatic ecosystems, according to the goals established through the Massachusetts Estuaries Project (MEP),
- Reducing nitrogen inputs to the Town's drinking water supplies where necessary,
- Achieving phosphorus removal where needed to restore or stabilize the ecological health of the Town's freshwater ponds,
- Providing alternative wastewater management strategies to areas of town where Title 5 standards have historically been difficult to meet, and
- Providing infrastructure to support the planned growth outlined in the Town's Local Comprehensive Plan.

At the present time, Dennis has no large scale town-owned wastewater treatment facilities, and residents and businesses rely on on-site wastewater management systems regulated by the Massachusetts State Environmental Code, or Title 5. While Title 5 systems provide an adequate level of treatment for pathogens originating from wastewater, minimal nutrient (nitrogen) removal is achieved with a traditional Title 5 system.

This report describes existing conditions and wastewater needs in Dennis and concludes with the identification of a recommended wastewater management program, in conjunction with associated environmental impacts, mitigation measures, implementation phasing, and cost recovery.

1.2 Wastewater Implementation Committee

The Town's water quality and wastewater planning effort is being overseen by the Dennis Wastewater Implementation Committee. The committee consists of 10 members; five community volunteers appointed by the Select Board, two members of the Select Board, two members of the Board of Health and one member of the economic development committee. Staff support was assigned by the Town Administrator in consultation with the Select Board. There are six permanent staff assigned to support the Committee. There is a representative from the Town Administrators Office, the Town Engineer, the Director of the Office of the Board of Health, a member of the DPW senior management team, and the Conservation Agent. The Dennis Health Director serves as the liaison between town staff and the Committee. The Town Administrator also provides organizational support and coordination.

The Committee was created in 2016 by the Select Board following completion of the Water Quality Evaluation and Mitigation Alternative Study which was led by the CWMTF. Previous efforts led by the CWMTF were being funded and coordinated through the Dennis Water District but has since shifted to the Health Department, and the WIC remains the overseeing town committee for this initiative.

The present members of the WIC are as follows:

- Diane Chamberlain, Chair
- James Bonofiglio
- Suzanne Brock
- Joseph Bunce
- David Langan
- Joe Martins
- Paul McCormick
- Paul Moulton
- Gregory Stone
- John Terrio, Select Board

Other key Dennis staff members include:

- Elizabeth Sullivan, Town Administrator

- Kristen Keller, Dennis Health Director, Staff Liaison
- Tom Andrade, Town Engineer
- Karen Johnson, Director of Natural Resources
- David Johansen, Director of Public Works

The work of this committee is also being coordinated with other Town committees and departments, including the Select Board, the Water Quality Advisory Committee, the Planning Department, the Natural Resources Department, the Engineering Department, Finance Committee and the Dennis Water District. Meetings have been conducted with each of these stakeholders, and coordination will continue throughout the project to achieve consistency between the WIC's recommendations and other town initiatives such as the Local Comprehensive Plan.

In January 2014, the CWMTF contracted with CDM Smith to work collaboratively on this important project as their water resources consultant and to provide guidance and technical support during the process.

1.3 Scope of Work

The goal of the water quality evaluation phase of work was to assess the town's saltwater, freshwater, and groundwater resources to identify needs and issues related to water quality. The main focus was on excessive nutrients in these water resources, which can lead to over-enrichment and public health concerns. Specifically, excessive nitrogen in saltwater and excessive phosphorus in freshwater can lead to eutrophication, causing harmful algal blooms and ultimately depleting oxygen from the water column, resulting in degraded habitats and fish kills. **Figure 1-1** illustrates the adverse impacts of excessive nutrient loading to a water body. In addition, high nitrate levels in drinking water can pose human health risks, especially to infants and the elderly. Other potential water quality concerns, such as bacterial pollution resulting in beach and shellfishing area closures, are also discussed where pertinent information is available.

The mitigation alternative study evaluates options for water quality management in Dennis and screens those options down to the four most favorable alternatives for further, more detailed consideration. This effort began with a reevaluation of the water quality needs identified in the Needs Assessment report completed in 2005, to refine the needs areas to match present conditions. Using the updated needs areas, along with the needs identified in the water quality evaluations described above, fourteen alternatives to meet water quality goals were developed and compared to arrive at four alternatives deemed most favorable for further analysis.

The identification and evaluation of alternatives was performed consistent with the methodologies recommended by the Cape Cod Commission (CCC) in the Section 208 Areawide Water Quality Management Plan Update (208 Plan), published in 2014 in draft form and in 2015 as a final draft to the United States Environmental Protection Agency (US EPA). (The complete 208 Plan report can be found at http://cape2o.org/.) The 208 Plan is a requirement under the federal Clean Water Act and the CCC has been tasked with updating the former, 1978 version. According to the CCC, the 208 Plan is "a watershed-based approach to restore embayment water quality on Cape Cod" that recommends "strategies, regulatory reforms, and a process for

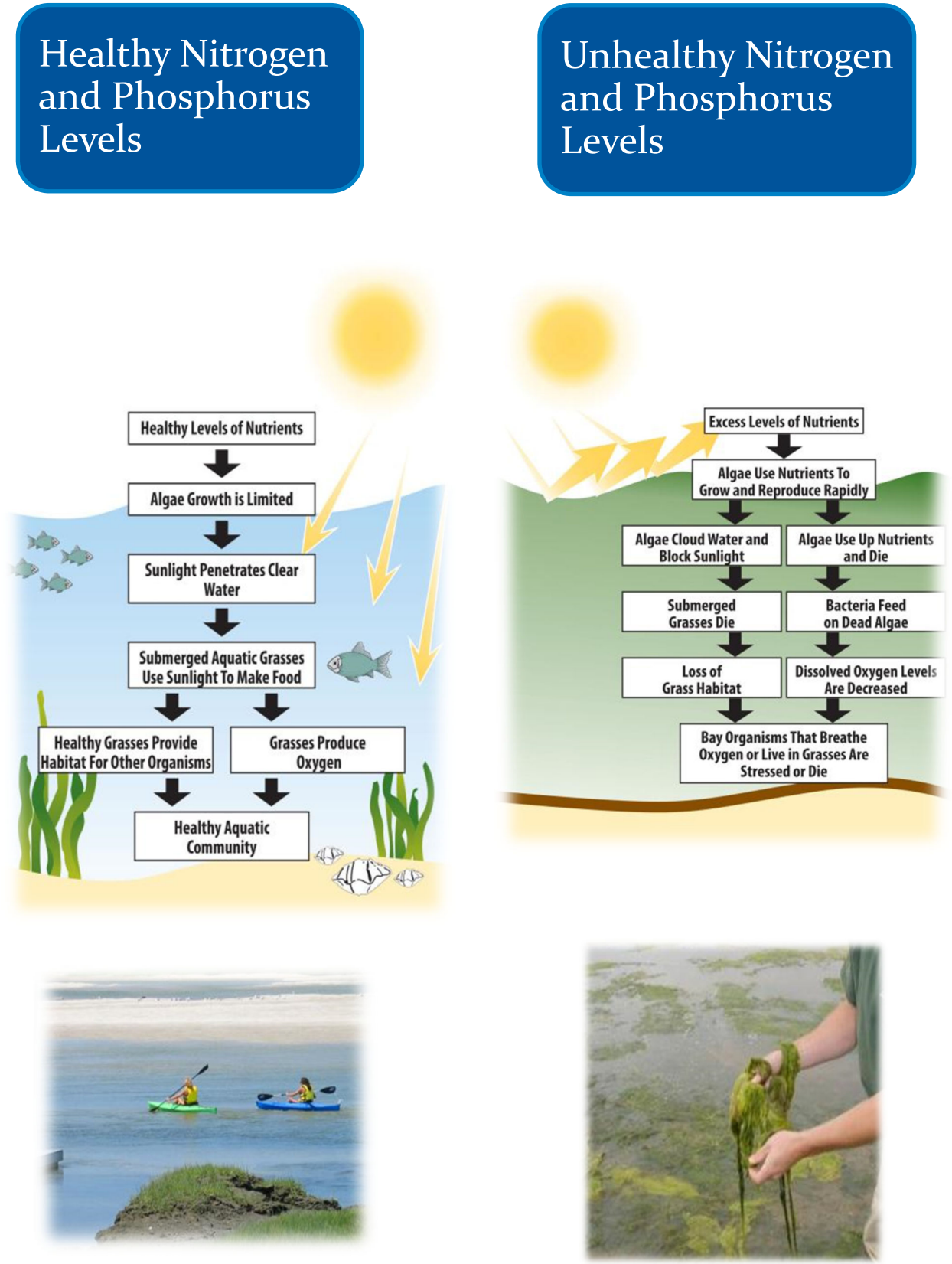


Figure 1-1: Comparison of Healthy and Unhealthy Nutrient Levels in a Water Body

communities to reduce or eliminate excess nitrogen." Coordination of the town of Dennis' Water Quality Evaluation and Mitigation Alternative Study as well as the CWMP with the 208 Plan has included direct consultation with the Commission throughout the planning process, as well as application of the plan's "hybrid approach," whereby a combination of both traditional and non-traditional nitrogen removal technologies have been considered. The Dennis WIC (formerly CWMTF) began the development of nitrogen reduction alternative by examining the full range of technologies presented in the Commission's 208 Plan technologies matrix and ultimately included the technologies deemed most feasible and appropriate for Dennis.

The analysis of mitigation alternatives also encompassed the identification of parcels to be examined in more detail to support water quality improvement goals. The focus of this evaluation was on town-owned parcels, although other parcels were also considered. Possible uses of the parcels identified include wastewater treatment, treated wastewater recharge, water reuse (either irrigation or process water), program administration, and resource area protection. A screening process was undertaken to identify the most viable parcels on which to site the necessary infrastructure to implement the fourteen alternative scenarios evaluated.

Finally, planning-level comparative costs were estimated for the water quality management alternatives being considered. These costs were used to allow for cost comparisons of capital expenditures, operations and maintenance expenses, and equivalent annualized costs.

The prior work completed as part of the Water Quality Evaluation and Mitigation Alternative Study has prepared the town of Dennis for development of this CWMP, submitted to the following organizations for review and approval: Massachusetts Department of Environmental Protection (MassDEP), the Executive Office of Energy and Environmental Affairs (EOEEA), and the CCC.

This CWMP includes a recommended program for water quality improvements that will both address and benefit all parcels in town, including those proposed to maintain their on-site septic systems for long-term wastewater handling. As noted above, the program includes both hard infrastructure and soft solutions (e.g., public education, water conservation, etc.), to arrive at a holistic water quality improvement approach town-wide.

This report has been developed as a CWMP along with an SEIR to the regulations of the Massachusetts Executive Office of Energy and Environmental Affairs (EOEEA), Massachusetts Environmental Policy Act (MEPA) unit. Furthermore, it has been submitted for joint review by the Cape Cod Commission (CCC, or "Commission") under their 208 Plan Consistency review process. Thus, it will undergo reviews by the EOEEA, MassDEP, the CCC, and other stakeholder groups and interested parties, via the public review and comment period associated with the MEPA process and subsequent 208 Plan Consistency Review process.

Once the MEPA review process is complete the Town will formally begin the 208 Plan Consistency Review process with the Cape Cod Commission. The Commission's early involvement in this planning process is beneficial for the Town to help ensure that issues raised by the CCC are addressed during the MEPA approval process to the extent feasible.

The steps completed and presently anticipated during the regulatory review process are listed below:

1. Filed the Draft CWMP/Expanded Environmental Notification Form (SEIR), (June 2017)
2. Initiated Joint Review by the CCC, the EOEEA MEPA unit, and MassDEP (MEPA #15022)
3. Received certificate from the MEPA unit on the Draft CWMP/EENF (July 2017)
4. Submit Final CWMP/SEIR (October to November 2021)
5. Receive final Secretary's Certificate from the MEPA unit on the CWMP/SEIR (December 2021)
6. Begin formal 208 Plan Consistency Review process with the CCC (December 2021)

As noted above, the Town submitted the Draft CWMP/EENF in 2017. Between 2017 and 2021, Dennis collaborated with neighbors Harwich and Yarmouth on the DHY Clean Waters Community Partnership, to develop a regional wastewater solution. Although significant effort from all towns was put into forming the partnership, it was determined in June, 2021 that the Town's would each be pursuing individual Town only solutions. As such, Dennis elected to wait until this determination was made to move forward with finalizing their CWMP. Each of the three Towns is open to discussing wastewater partnerships in the future, as their programs progress.

This Final CWMP/SEIR summarizes relevant data and previous projects relating to wastewater management, explains public participation programs and coordination with other projects, summarizes the wastewater needs assessment, estimates wastewater flows, evaluates effluent recharge sites, proposes possible wastewater management alternatives, and selects a recommended alternative based on a preliminary comparison of costs as well as technical, institutional and environmental criteria. The recommended alternative is then rolled into a complete recommended program for wastewater management in Dennis. The recommended program is then analyzed in detail with regards to hydrogeologic considerations, construction and environmental impacts, and program financing.

The recommended wastewater management program put forth in this Final CWMP/SEIR is a guide for the Town to follow based on current conditions and regulations. Should the Town desire to make changes to the program in the future based on water quality monitoring feedback, changing community interests, new pertinent options that may arise with adjacent communities, or other appropriate factors, it may do so utilizing the appropriate regulatory review procedures.

1.4 Report Outline

This report is divided into nineteen sections as follows:

Section 1 introduces the project and provides background on the project objectives.

Section 2 summarizes water quality data pertaining to saltwater estuaries and embayments, including the work of the Massachusetts Estuaries Project (MEP).

Section 3 provides an analysis of available data on Dennis' freshwater ponds.

Section 4 discusses groundwater and drinking water quality data obtained through the Dennis Water District and the United States Geological Survey.

Section 5 summarizes information pertaining to beach and shellfish closures in Dennis.

Section 6 discusses Massachusetts Water Quality Standards and their applicability to Dennis water bodies and watersheds.

Section 7 presents an update of the Needs Assessment performed in 2005, including an updated list of Areas of Concern within Dennis.

Section 8 summarizes water usage data under both existing and buildout conditions by watershed.

Section 9 presents the site screening analysis used to narrow all parcels in town down to the most feasible sites for water quality management infrastructure.

Section 10 discusses the development and analysis of the fourteen alternative scenarios analyzed to arrive at the four most favorable options for further consideration.

Section 11 presents results of hydrogeologic evaluations of the proposed wastewater effluent recharge locations.

Section 12 discusses the various collection, treatment, and effluent recharge systems that were evaluated as part these efforts.

Section 13 presents the results of the cost analysis and compares costs for the final selected scenarios

Section 14 presents the recommended program, including how the plan meets MEP requirements, TMDL requirements, resource management needs, and the 208 Plan as well as presents capital and O&M costs and shows the proposed phasing plan.

Section 15 addresses the current cost recovery plan for implementation of the CWMP and outlines possible approaches that the Town may implement.

Section 16 includes discussion of the Environmental Impact Analysis and Mitigation measures.

Section 17 presents the Construction Management Plan.

Section 18 includes the Section 61 Findings.

Section 19 presents the response to comments from both MEPA as well as other state agencies from the submittal of the Draft CWMP.

Appendix A provides descriptions of the technologies included in the scenarios and recommendations arising from this analysis, excerpted from the CCC's 208 Plan.

Appendix B presents an in-depth description of New England aquaculture projects and the potential application of similar approaches in Dennis, prepared by Scott Lindell, an aquaculture

specialist and subconsultant to CDM Smith. This appendix also includes results from the 2019-2020 Aquaculture pilot performed in Swan Pond.

Appendix C is a letter to the Massachusetts Department of Transportation (MassDOT) from the town, requesting consideration of a bridge widening project where Route 6 crosses the Bass River.

Appendix D provides the back-up information and assumptions for the planning-level cost estimates used in the comparative analysis in Section 10.

Appendix E includes A Site Visit memorandum, Site Screening memorandum, Soil Boring Data and Steady-State and Transient Model Development and Calibration information all in support of the effluent recharge modeling efforts.

Appendix F includes the CCC Grant Letter Report Evaluation of Additional Effluent Recharge Sites.

Appendix G includes presentations and minutes from public and community meetings as well as a compilation of Frequently Asked Questions.

Appendix H includes the Draft CWMP MEPA certificate dated July 14, 2017, with comments from MEPA as well as other state agencies.

Appendix I includes the nitrogen balance files from the MEPA data disk spreadsheets.

Appendix J includes the two Massachusetts Cultural Resource Due Diligence Review and Archaeological Sensitivity Assessments performed on the proposed wastewater treatment facility site as well as potential pumping station sites.

Finally, Appendix K includes the Economic Development Study for wastewater infrastructure in Dennis, performed by the UMass Donahue Institute.

Section 2
Evaluation of Estuaries and Embayments

2.1 Introduction

This section describes water quality evaluations and analyses related to the town's saltwater estuaries and embayments. **Figure 2-1** shows a map of the town of Dennis, calling out the saltwater resource areas of interest and their associated watersheds. These include five watersheds being modeled as part of the Massachusetts Estuaries Project (MEP) as follows:

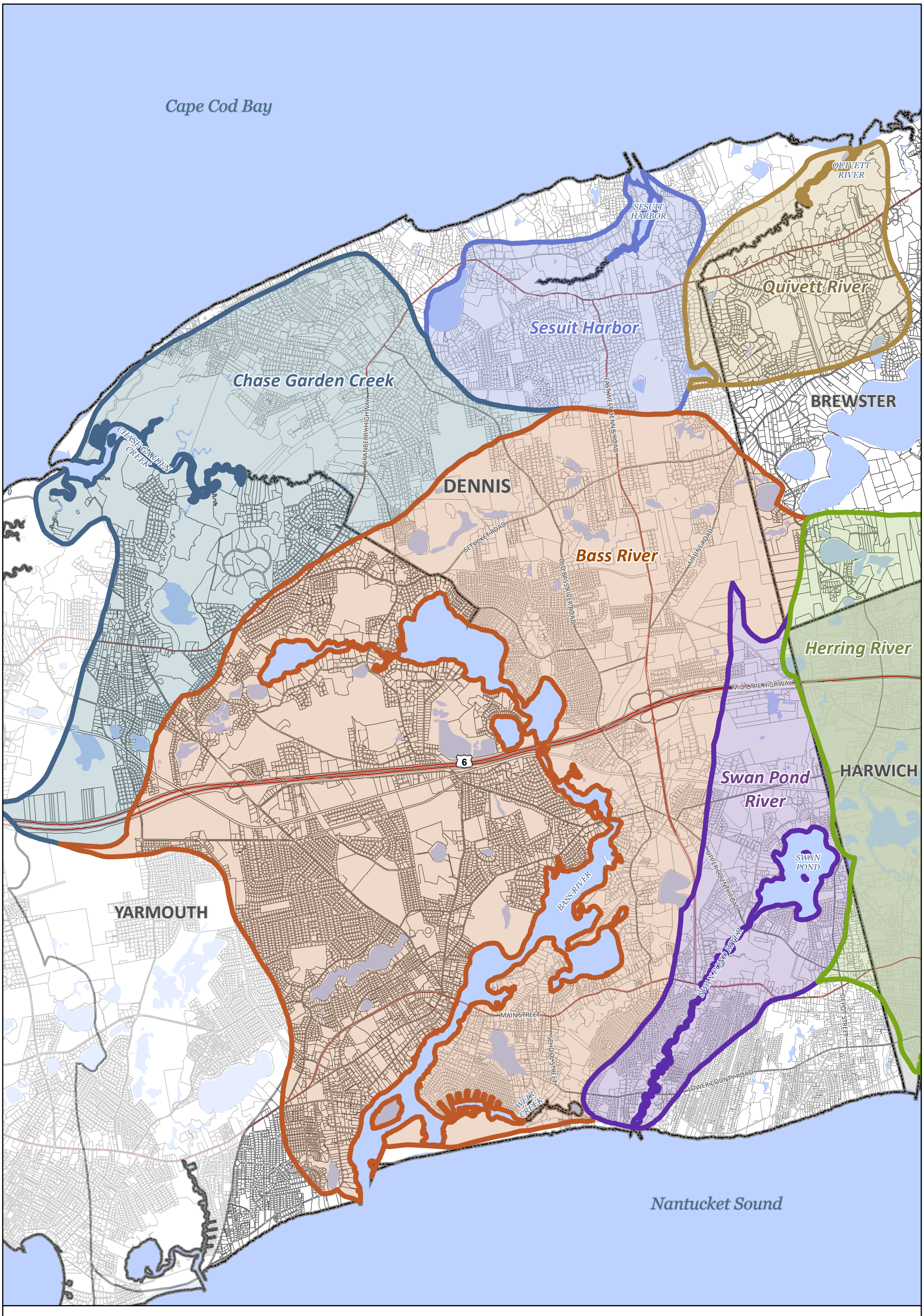
- Bass River (Dennis, Yarmouth, and Brewster)
- Swan Pond River (predominately Dennis)
- Herring River (Harwich, Brewster, and Dennis)
- Chase Garden Creek (Dennis and Yarmouth)
- Sesuit Harbor (Dennis only)

There is one additional watershed in Dennis, Quivett Creek, which is not included in the MEP modeling effort. This watershed is predominately in Brewster but crosses into Dennis along the town's northeast border. Finally, several areas along both Nantucket Sound to the south and Cape Cod Bay to the north have direct discharge from both groundwater and surface watersheds to those adjacent water bodies, as shown on Figure 2-1.

2.2 Massachusetts Estuaries Project (MEP)

The MEP is a joint initiative of the Massachusetts Executive Office of Energy and Environmental Affairs (EOEEA), the Massachusetts Department of Environmental Protection (MassDEP), the United States Geological Survey (USGS), and the University of Massachusetts – Dartmouth (UMass Dartmouth) School of Marine Science and Technology (SMAST), along with Coastal Zone Management, the Cape Cod Commission (CCC), and numerous Massachusetts coastal communities. Funding support is shared between municipalities and the Commonwealth of Massachusetts.

The MEP seeks to assess the degradation of several priority estuaries along the southeastern coast of Massachusetts, including all of Cape Cod and the Islands, which has resulted from rapid population growth throughout the region. Excessive nutrient loading in surface and groundwater, largely from man-made sources, has migrated to the region's estuaries, particularly those downstream of highly developed or populated areas. Over time, nutrients build up within an estuary as a result of limited flushing. In saltwater bodies, nitrogen is typically the "limiting nutrient," meaning that increases in nitrogen drive increased productivity. When this productivity exceeds threshold levels, the result is excessive algal growth, oxygen depletion, fish kills, disruption of benthic communities, and an overabundance of invasive weeds. In addition, bacterial contamination can also be of concern in these water bodies. As a result of both excessive



MEP Watershed Delineations

- Bass River
- Chase Garden Creek
- Herring River
- Quivett Creek
- Sesuit Harbor
- Swan Pond River
- Direct Discharge

Town of Dennis, MA

N

1 in = 3,500 ft

0 0.5 1

Miles

Figure 2-1
Estuary Watersheds

CDM Smith

GUNNARSSONLI \\dacgis02\Projects\Dennis\DATA\MXD\Fig2_1_EstuaryWatersheds.mxd 7/14/2014

nutrients and bacterial contamination, beaches are periodically closed, productive shellfish areas have been damaged or destroyed, and the tourist industry and property values are at risk due to aesthetically displeasing waters and high bacteria levels.

Since 2002, the MEP has developed and published a series of reports which assess the nature and extent of nutrient influence within the program area. Comprehensive water quality sampling for these assessments has been conducted in partnership with community groups; in Dennis, local volunteers and town staff have conducted water quality sampling since 2003 as part of this program. These data, along with additional data collected by SMAST as part of the MEP program, have been used to develop quantitative total maximum daily load (TMDL) modeling for each estuary.

The intent of a TMDL is to determine the threshold concentration of a substance that can be assimilated into the natural environment to maintain a water body's designated uses. For the highest quality waters, these uses include both human (recreational) and ecological (habitat) considerations. The MEP studies seek to establish TMDL thresholds for nitrogen in each studied estuary to maintain or restore high quality water. Conclusions from the MEP reports include present-day total nitrogen loadings to each watershed and reductions required to meet water quality goals. Upon review by MassDEP, the thresholds identified through the MEP work are expected to be incorporated into enforceable nitrogen TMDL permits. Therefore, the results of these assessments will require municipalities to remediate excessive nutrient inputs to restore water quality in the subject estuaries.

2.2.1 MEP Approach to Estuary Studies

The MEP team, starting in 2002, selected estuaries across Cape Cod and the Islands based on the level of degradation, need for improvement, community engagement in addressing estuary degradation, and available funds for the assessment. Once the estuaries were selected, each location was prioritized according to state and local planning needs, environmental concerns, and other local issues.

The MEP approach to estuary studies integrates estuarine process and nitrogen loading models to develop a TMDL for each estuary under Section 303(d) of the federal Clean Water Act. The TMDL is based on the link between nitrogen sources in the watershed and relative nitrogen concentrations in receiving embayments. In order to establish a TMDL value, MEP collaborators use sophisticated modeling and quantitative analysis to provide municipalities and regulatory agencies with guidance and technical expertise. Modeling tools support the development of alternative scenarios for nutrient controls. Municipalities use this information to make decisions on estuary management, protection, and restoration practices that will reduce total nitrogen loads.

The MEP assesses the health of each selected estuary ecosystem, determines which nitrogen sources contribute to ecosystem conditions, and presents alternative reductions in total nitrogen load necessary to restore ecosystem health and meet water quality standards. The flow chart shown in Figure 2-2 was developed by the MEP to demonstrate their analytical approach to nutrient assessment. The information below summarizes the MEP process.

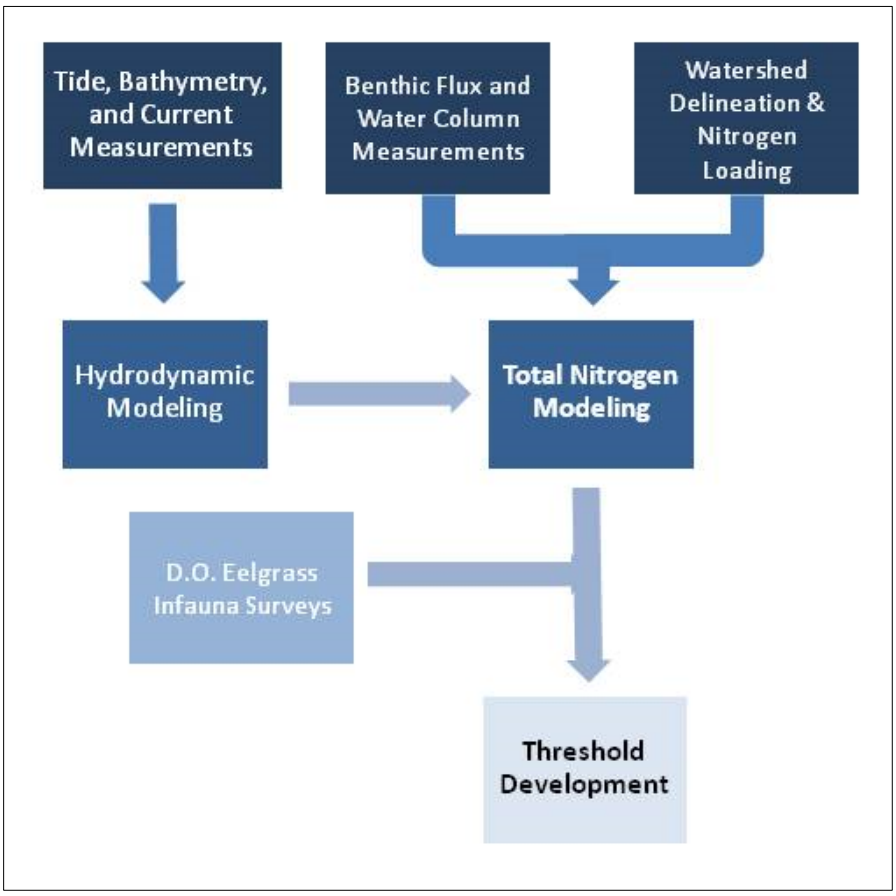


Figure 2-2: Flow Chart of MEP Study Assessment

Environmental Study

The first step in the MEP process is to conduct an environmental study of current land use and aquatic life conditions. Watershed and sub-watershed boundaries were developed by the USGS for each estuary in the program. A watershed is the contributing land area, including all associated surface and groundwater resources, to a water body. This includes contributing areas to ponds, water supply wells, tidal rivers, and bays within the embayment system. In Dennis, not all land area in the town is located within a watershed contributing to an MEP study area, as shown in Figure 2-1.

Watersheds are further divided into subwatershed areas, or sub-areas of land within a watershed. These areas are defined based on varying features within the watershed (e.g., ponds, streams, etc.). The subwatersheds are then even further divided based on groundwater velocity and the resulting time it takes for groundwater to reach a bay or river. A time of travel of 10 years is used to define these latter subdivisions.

Once watershed and subwatershed boundaries are delineated, land use is assessed to spatially evaluate the incidence and concentration of nitrogen sources. Typical anthropogenic (man-made) nitrogen sources include septic systems, stormwater runoff, lawns, and other fertilized landscaped areas. Identifying these areas requires a parcel by parcel assessment linked to a geographic information system (GIS) database which contains data sets that estimate the nature and extent of nutrient sources. When displayed geographically, data patterns highlight targeted areas which require further analysis. In addition, surface water resources are noted for depth, extent, and stream flow. This information can be used to assess natural nitrogen attenuation in freshwater ponds and predict estuary loading by subwatershed. For ponds where insufficient data exists to calculate site-specific attenuation percentages, standard attenuation factors are instead utilized. These factors are based on past MEP data review, including water quality monitoring data from the Cape Cod Pond and Lake Stewardship program.

Ecosystem health is assessed through three indicators which reflect long-term habitat conditions - eelgrass, macroalgae, and benthic animals - in conjunction with water quality measurements. To assess these indicators, each estuary is subject to a minimum of three years of regular sampling. Eelgrass and benthic animals inhabit stationary, long-term communities which react to local environmental changes. Changes in their presence, population, or distribution are an indication of an impaired local environment. Benthic activity, specifically benthic nitrogen flux, is also assessed to gain an understanding of denitrification processes occurring in embayment sediments, which suggests the estuary's ability to process nitrogen and supports determination of healthy nitrogen loading levels.

The aquatic habitat study includes data collection related to benthic community health, dissolved oxygen levels, eelgrass populations, and infaunal animal surveys. This portion of the study may require data spanning several years, based on the extent and complexity of the estuary. Water column monitoring, for example, requires years of nutrient sampling at designated locations to determine natural fluctuations and seasonal variability. Infaunal animal surveys also require sampling, monitoring, and collection over an extended period of time. Once animals are collected, they are counted, preserved, and categorized. The incidence, variety, and health of these animals are indications of the overall health of the benthic environment within an estuary. These same indicators of eelgrass, macroalgae, and benthic animals will also be used in the future to assess whether a water body has been returned to an acceptable level of ecological health following nutrient reduction.

Monitoring Stations

There are typically two types of monitoring stations within each estuary: sentinel stations and check stations. Sentinel stations are designated within each estuary as a discrete point where nitrogen testing will be conducted and where TMDL compliance will be monitored. Sentinel stations are situated such that achieving the nitrogen threshold target at each sentinel station should correspond with restored water quality throughout the estuarine system, as well as restored ecological health and habitats.

In addition to the sentinel station for each estuary, check stations are selected to assist with the goals of restoring healthy eelgrass beds and benthic infaunal habitats and to assess system-wide water quality. The target concentrations at these check stations, referred to as secondary criteria,

are not used for setting nitrogen thresholds, but rather to provide a check on the acceptability of conditions within the tributary basins at the point that the threshold level is attained at the sentinel station.

Estuary Hydrodynamics

The next part of the MEP process is a hydrodynamic assessment of the estuary, which involves gathering field data to develop a three-dimensional circulation model. In order to produce the model, embayment bathymetry (bottom contours) is measured using sonar or remote sensing systems. Site specific tidal records are used to assess the variability of tidal flushing over time. Once all data is gathered, the three-dimensional hydrodynamic model is developed. This model physically demonstrates tidal flushing within the estuary and assesses embayment basin structure, measurement of basin depth relative to water level, tidal variations, and nutrient dispersion within the water column.

Total Watershed Nitrogen Loading

Nitrogen sources within each subwatershed are determined based on land type, parcel data, water use, and fertilization rates and presented in terms of total and controllable loading. Total loading includes all loads which enter the estuary from groundwater, sediment, and direct atmospheric deposition to the estuary surface. These include all sources of nitrogen within the watershed, such as: septic system discharge, treated wastewater effluent from larger treatment systems, stormwater runoff, lawn care fertilizers, agricultural fertilizers, and atmospheric deposition to waterbodies and other natural surfaces. Controllable loading is the portion of total loading that could potentially be reduced and includes all elements of total loading with the exception of atmospheric deposition.

The initial nitrogen loading contributions from wastewater are calculated using water usage data from the public water suppliers in each community. This is the preferred approach over population-based estimates for communities with large seasonal population fluctuations, as it accurately accounts for actual usage. In the case of Dennis, parcel-by-parcel water usage was supplied by the Dennis Water District for a period of at least three years. This usage was then reduced by ten percent to account for water usage that does not end up in the wastewater system (e.g., consumption, lawn watering). With this approach, average per capita or per household residential wastewater generation and average per square foot commercial generation are calculated.

Other nitrogen inputs, such as fertilizers used on golf courses, cranberry bogs, or landscaping and stormwater runoff were quantified using information from past estuary input studies or from site-specific data.

Once nitrogen sources are determined, groundwater flow, subwatershed loading, flushing and hydrodynamic modeling, and natural attenuation are used to estimate total and controllable loading values for a receiving estuary. The nitrogen concentration in ground and surface water is reduced as it passes through natural systems in streams, ponds, and rivers. This process is known as natural attenuation. To accurately calculate total load for a receiving water body, nitrogen load must be evaluated for the percent of natural attenuation per subwatershed. This occurs through conversion to nitrogen gas, sediment absorption, and other biological processes. Thus, in some

cases, a nitrogen load could theoretically be high in one subwatershed but the actual effect on receiving waters could be much lower due to natural attenuation. Additionally, some overall watersheds may be identified as "nitrogen sinks," meaning that they have the capacity to take on more nitrogen than is presently being input. These watersheds are thus candidates for taking additional nitrogen from stressed watersheds.

Total Maximum Daily Load (TMDL) Threshold Development

Once the nitrogen cycle is better understood throughout the watershed and its associated estuary, a TMDL is then developed. Criteria for establishing a TMDL are developed through the hydrodynamic models to achieve the desired level of ecosystem health. Modeling allows for optimization of loading reductions based on subwatershed area while gaining a better understanding of hydraulic interactions of flushing within estuaries. TMDLs are developed based on the target concentrations at the sentinel water quality monitoring stations described above. These standards are designed to allow for concentrations of nitrogen to be at a natural level which provides water quality that supports a healthy estuary.

Buildout Scenarios

Following the development of existing nitrogen loading estimates and load reduction percentages to meet water quality goals, the analysis is repeated based on projected buildout conditions within each watershed. Additional lot subdivision, development of undeveloped lots, and expansion of existing commercial and industrial uses are all considered in the estimation of buildout wastewater generation. An analysis is performed determining where each of these changes is feasible under existing zoning, and the associated wastewater generation is estimated using the per capita and per square foot factors calculated above. Each of these changes is then vetted through the local planning department staff to make adjustments where estimates are thought to not reflect actual conditions or where potential zoning changes are foreseen. Dennis buildout results were reviewed with the Town Planner, Dan Fortier, and appropriate adjustments were made.

In addition to buildout wastewater assumptions, nitrogen loads are added for impervious surfaces such as pavement and roofs associated with all types of projected new development and lawn fertilizer for new residential units only.

2.2.2 Dennis MEP Water Resources

The population of Dennis saw significant growth from 1950 to 2010. There is currently no centralized wastewater treatment system located in town. Thus, as development has increased, so has nutrient loading, largely as a result of septic system discharge.

MEP studies have been conducted to evaluate the effects of development and identify the areas of greatest nutrient contribution within Dennis in five estuaries and the associated contributing watershed land areas. As part of the Dennis estuary studies, the MEP operated under certain assumptions to assess habitat and quality. Eelgrass distribution was based on state surveys conducted in 1951, 1995, 2001, 2006, 2010, and 2012. Watershed delineation was based on long-term steady-state conditions; however boundaries may be affected by water supply pumping rates, particularly during high-volume months.

2.3 Results of Published MEP Studies

The degrading conditions of estuaries in Dennis are a primary driver for reevaluating the town's approach to water resource management and wastewater treatment. Findings presented in the MEP studies are critical to developing a long-term, sustainable water resources plan for the community.

As noted previously, Dennis has five estuaries located in the MEP study area: Bass River, Swan Pond River, Sesuit Harbor, Chase Garden Creek, and Herring River (see Figure 2-1), and one non-MEP watershed, Quivett Creek. The Bass River watershed is shared with the town of Yarmouth and the MEP report was completed in 2011. The Swan Pond River MEP report was completed in 2012. The Herring River watershed is shared with the towns of Brewster and Dennis, and the report was completed in 2012. The Sesuit Harbor study is in progress and Quivett Creek was evaluated outside of the MEP program. A Draft MEP report was developed for the Chase Garden Creek watershed in 2017. The conclusions of each MEP report are described below.

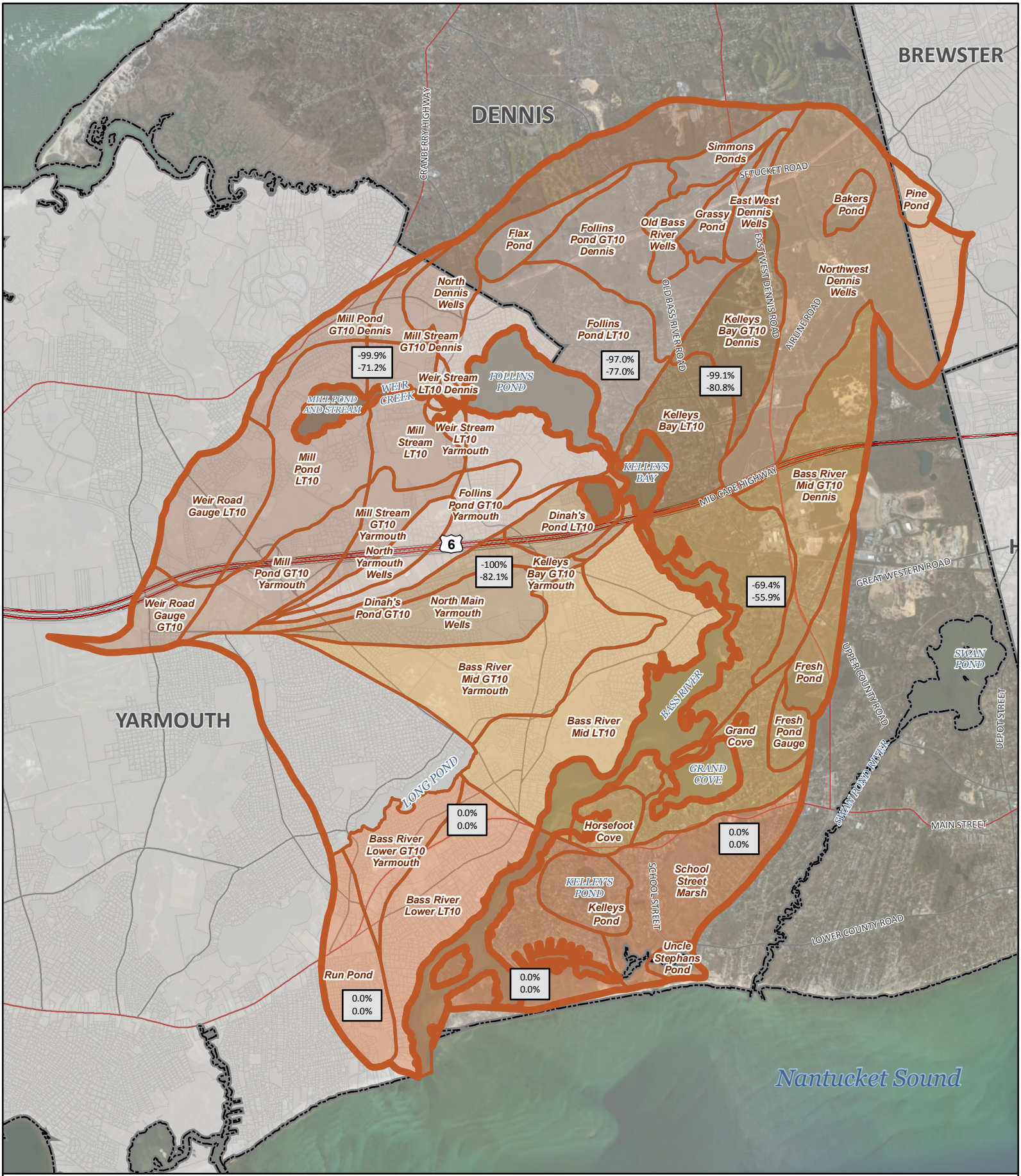
2.3.1 Bass River Results

The final report entitled "Linked Watershed-Embayment Approach to Determine Critical Nitrogen Loading Thresholds for the Bass River Embayment System for the Towns of Yarmouth and Dennis, Massachusetts" was published by the Massachusetts Estuaries Project in April 2011. The Bass River Embayment System is one of the largest estuaries on Cape Cod. It is a complex estuary which connects a series of kettle ponds and exchanges tidal waters with the high quality waters of Nantucket Sound along Cape Cod's southern coast. The Bass River and its associated ponds form the boundary between the towns of Dennis to the east and Yarmouth to the west. The system's watershed is split approximately evenly between Yarmouth and Dennis, with a very small portion extending into the town of Brewster.

Physical Description

Figure 2-3 shows the major components of the Bass River system. Closest to Nantucket Sound is the river's inlet, which is a single inlet with a location fixed by jetties. The barrier spit forming the inlet is used for recreation, with Riviera/Smugglers Beach to the west and Davis Beach to the east. The Davis Beach (West Dennis) area is comprised of salt marsh, some of which has been filled and developed. The tidal inlet channel has been dredged to form an open water lagoon, bordered to the north by sea walls and riprap that bounds a highly developed residential neighborhood. Dredging of the inlet channel has occurred periodically to maintain tidal flows and navigability for recreational boating.

Immediately to the north of the inlet and Davis Beach is the connection with Weir Creek. The remainder of the lower reach of the Bass River system is a tidal river, including restriction through a culvert at Route 28 (*Hydrodynamic Tidal Study of Bass River Final Report*, August 2013).



Watershed

Bass River

Bass River Subwatersheds

-100.0% -74.0% Septic Nitrogen Removal to Meet Threshold/ Total Controllable Nitrogen Removal to Meet Threshold

Town of Dennis, MA

N

1 in = 4,000 ft

0 0.5 1

Miles

Figure 2-3

Bass River System

CDM Smith

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The middle section of the system, north of the Route 28 bridge, consists of a broad stretch of tidal river with a large tributary sub-basin called Grand Cove. The upper portion of the system, north of Grand Cove, contains three basins: Kelleys Bay/Dinah's Pond, Follins Pond, and Mill Pond. Mill Pond is at the northernmost extent of the watershed and is the shallowest basin in the system, with a depth of only about one meter. Historic mapping shows that Mill Pond has been connected to the Bass River system since at least the mid-1800s.

At the southernmost end of the watershed, tidal exchange with Nantucket Sound is high, with few restrictions, while the upper reaches of the watershed exhibit less flushing, resulting in brackish waters in the furthest upstream reaches. Salinity within the system ranges from 31 parts per thousand (ppt) in the inlet area closest to Nantucket Sound, to 25 ppt in Follins Pond, to 15 ppt in Mill Pond. Direct freshwater inputs to the system are Hamblin Brook, which is a tributary to the furthest up-gradient region of Mill Pond, and Fresh Pond, which is connected via a small brook to Grand Cove. In addition, Long Pond, which is a freshwater pond shared with the Parker's River watershed in Yarmouth, contributes a small quantity of freshwater flow via Pine Pond and via wells located along the northeastern boundary of the Bass River watershed.

Due to the system's many ponds and resulting extensive shorelines, travel time of groundwater from the adjacent developed areas is minimized, and the impacts from nitrogen inputs are thus heightened. In addition, as is typical of these enclosed basins, their protected nature makes them ideal for boating, recreation, and land development, and it also limits their tidal flushing. These features compound to increase nutrient over-enrichment (eutrophication) within the upper reaches of the Bass River watershed.

The tidal range of Nantucket Sound is low to moderate, with a mean range of 2.5 to 3.5 feet. This is lower than many other areas on Cape Cod, which also serves to limit tidal exchange. Tidal damping, which is a decrease in the elevation range between low and high tides, is seen in the area north of the North Dennis Road culvert into Mill Pond, where there is a present tidal range of only 0.9 feet.

The system's groundwater watershed (area of contributing groundwater) contains sand and gravel deposits in the lower portions and boulder glacial drift overlying outwash sand and gravel in the upper regions. Freshwater inputs to the Bass River system from both surface and groundwater are estimated to total 79,024 cubic meters per day.

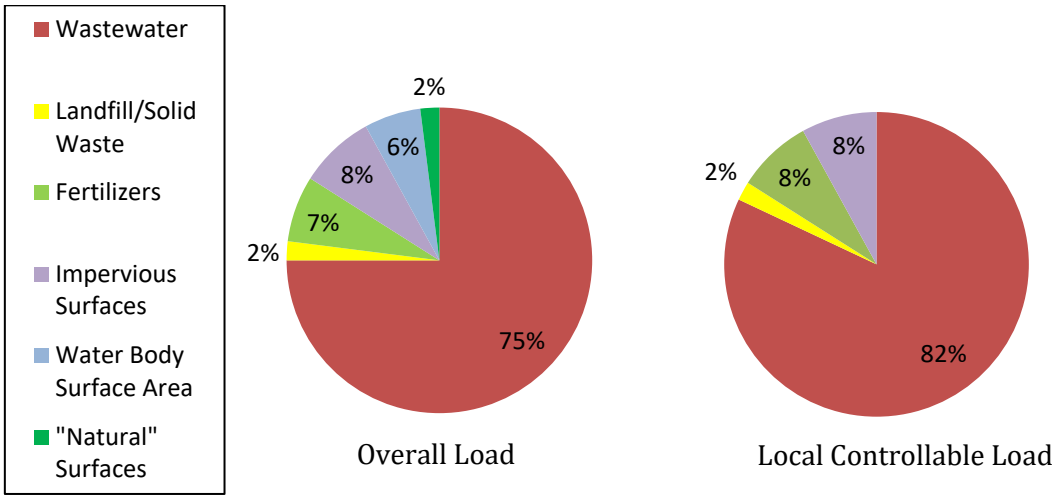
Land Use and Nitrogen Loading

The Bass River Embayment System and watershed have been significantly altered over the last 100 years, and the resulting nutrient over-enrichment has been caused by both development and by geomorphological and ecological changes. Therefore, the restoration of the Bass River system will require attention to both reducing nitrogen inputs and to restoring processes which serve to lessen the amount or impact of nitrogen entering the estuary.

The Bass River system was divided into 42 subwatersheds, including delineation of those within and outside of a 10-year travel time from the estuary (see Figure 2-3). Fifty-seven percent of the unattenuated nitrogen load originates within the 10-year travel time; however, properties in the outer watersheds have largely been developed for over 10 years, and, therefore, their nitrogen inputs are reaching the estuary as well.

Land uses for individual parcels within the watershed were divided into nine land use categories: residential, commercial, industrial, agricultural, mixed use, undeveloped, public service/government (including roadway rights-of-way), freshwater ponds, and unclassified properties. Public service lands comprise 44 percent of the watershed's land area, while residential properties comprise 38 percent. However, residential parcels are the dominant parcel type, accounting for 82 percent of all parcels in the watershed, the majority of which contain single-family residences. Residential nitrogen loading is calculated using estimated wastewater generation from public water usage, as described above, along with a nitrogen loading factor.

In addition, nitrogen loading from wastewater was also accounted for from alternative septic systems and the one Groundwater Discharge Permit on record within the watershed. This permit is issued to the Yarmouth-Dennis Septage Treatment Facility, for its treated effluent discharge. This discharge is either used for spray irrigation at the Links at Bayberry Hills golf course or is discharged to infiltration beds at the Buck Island Road discharge site, within the Parker's River watershed. Additional loads are accounted for based on monitoring well data from capped municipal landfills within the watershed in both Yarmouth and Dennis. Finally, fertilizer use, impervious surfaces, and atmospheric deposition of nitrogen were all factored in to arrive at the total nitrogen loads to the watershed. Figure 2-4 shows the load contributions from the various input sources within the overall Bass River watershed. The total controllable load is also shown in Figure 2-4. The total controllable load includes all sources that could potentially be controlled, and thus only eliminates atmospheric deposition. As is typical of most MEP watershed findings, over 80% of the controllable nitrogen entering the estuaries is coming from septic systems.



Source: Figure IV-7 of the Bass River MEP report

Figure 2-4: Land Use Specific Total and Controllable Unattenuated Nitrogen Loads to the Bass River Watershed

Total unattenuated nitrogen loads to the Bass River system are 95,939 kg/yr, while attenuated loads are 84,068 kg/yr. Buildout adds 9 percent to the unattenuated loads, resulting in 104,186 kg/yr, corresponding to 91,047 kg/yr of attenuated loading.

Bacterial Contamination

In addition to contamination from excessive nitrogen in the incoming groundwater, some bacterial contamination issues exist within the Bass River system, especially in the vicinity of Mill Pond. Sources of bacteria include stormwater runoff from the watershed and animal sources, primarily in wetlands or undeveloped areas along the shorelines of Mill Pond. These bacterial inputs do not appear to be having system-wide impacts. Such bacterial contamination has resulted in permanent closure of two shellfish harvesting areas – Mill Pond and a small tributary cove. In addition, closures of areas in other locations throughout the Bass River system have occurred periodically.

Water Quality Indicators

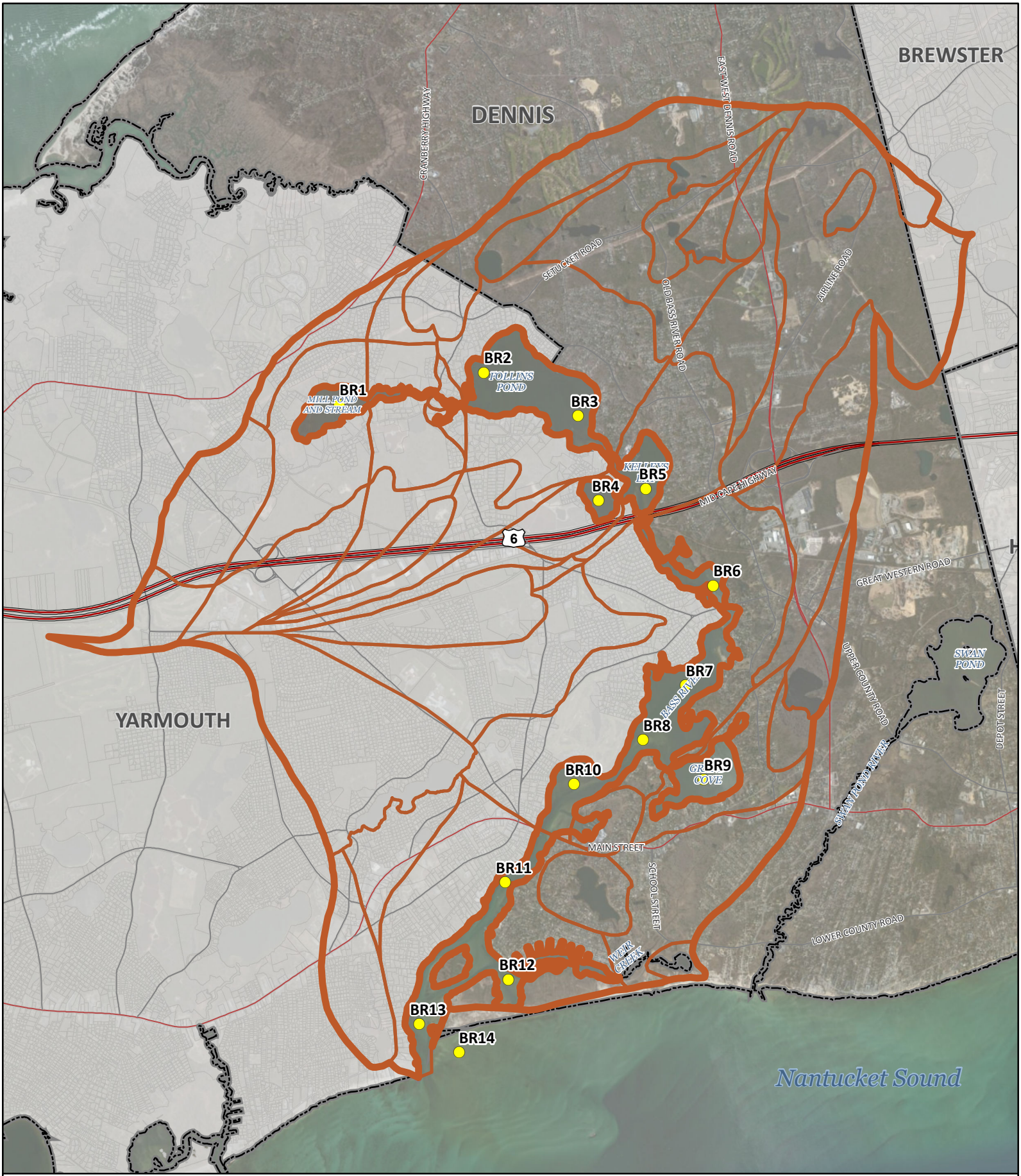
The impacts of nitrogen enrichment to the Bass River system vary among the various component basins. There is a strong habitat quality gradient when moving upgradeint through the estuary, with the highest quality closest to the inlet at Nantucket Sound and the poorest quality in Mill Pond. Grand Cove, Kelleys Bay, Dinah's Pond, Follins Pond, and Mill Pond are all exhibiting significantly impaired infaunal habitat. The mid to lower reaches of the Bass River still support high quality benthic habitat, but they have shown significant impairment relative to eelgrass habitat. Weir Pond is also exhibiting some modest impairment of benthic habitat.

The Bass River reaches from the tidal inlet to Route 6 support some of the highest quality benthic animal habitat in the areas of Cape Cod assessed by the MEP. This portion of the system supported eelgrass beds in 1951 under lower nitrogen loading conditions, but eelgrass is now absent. Some eelgrass was observed in Dinah's Pond during the MEP study, but it had heavy epiphyte growth over each of the plants.

Furthermore, dissolved oxygen concentration and chlorophyll-a data is indicative of high nutrient levels and impaired water quality. Each of these parameters becomes progressively worse farther upgradient within the estuarine system. Overall, more than 90 percent of the estuarine area of the Bass River Embayment System is showing significant to moderate habitat impairment with regards to either eelgrass or benthic infaunal habitats.

Monitoring Stations and Thresholds

The goal of the Bass River sentinel station (BR-7) is to identify a location where meeting a target nitrogen concentration will result in water quality throughout the water body sufficient to restore acceptable ecological health. The sentinel station selected is the furthest upstream extent of historic eelgrass observation and is therefore located in the mid-reaches of the Bass River. In addition, thirteen check stations were selected to assist with the goal of restoring healthy benthic infaunal habitats. These check stations are not used for setting nitrogen threshold values; they merely provide a check on the acceptability of conditions within the tributary basins at the point when the threshold level is attained at the sentinel station. The location of each of station is shown in Figure 2-5.



Watershed

- Monitoring Station
- Bass River
- Bass River Subwatersheds

Town of Dennis, MA

N

1 in = 4,000 ft

0 0.5 1

Miles

Figure 2-5
Bass River
Monitoring Stations

CDM Smith

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The threshold nitrogen concentration was determined based on the average concentration of nitrogen in the water column that will support eelgrass habitat to the extent historically observed. At this concentration, high quality benthic habitat is also anticipated to be achieved in the upstream basins of the system. Table 2-1 shows present average modeled total nitrogen concentrations at each monitoring station, along with the recommended threshold concentrations for the Bass River and the percent change necessary to meet those threshold concentrations for each monitoring station. The present concentration data indicates that a total nitrogen level of 0.523 mg/L at the sentinel station cannot support eelgrass. The MEP concluded that an upper limit of 0.419 mg/L of nitrogen (tidally averaged) would support eelgrass in the Bass River. Since eelgrass has not been present in the system for more than a decade, this was based on other MEP data for similar local embayments.

Table 2-1 Sentinel and Check Monitoring Stations with Associated Nitrogen Limits for the Bass River System

Sub-embayment	Monitoring Station	Present Total N Concentration* (mg/l)	Threshold Average Total N Concentration* (mg/l)	% Change
Mill Pond	BR-1	0.949	0.609	-35.8%
Follins Pond-Up	BR-2	0.751	0.519	-30.9%
Follins Pond-Lo	BR-3	0.747	0.517	-30.7%
Dinahs Pond	BR-4	0.696	0.493	-29.1%
Kelleys Pond	BR-5	0.695	0.496	-28.6%
Uppermost River	BR-6	0.607	0.458	-24.5%
Upper River	**BR-7**	**0.523**	**0.419**	**-19.9%**
Upper River	BR-8	0.493	0.404	-18.1%
Grand Cove	BR-9	0.520	0.424	-18.5%
Upper River	BR-10	0.438	0.377	-13.9%
Lower River	BR-11	0.389	0.352	-9.5%
Marsh-Lower	BR-12	0.372	0.346	-7.0%
Lower River	BR-13	0.340	0.325	-4.3%
Nearshore	BR-14	0.306	0.306	-0.2%

*Present and threshold average total N values according to Table VIII-5 of the April 2011 MEP Final Report for the Bass River Embayment System
Values in RED indicate that the value is above the standard and must be reduced.

Determining the threshold nitrogen loading in a watershed to meet a target concentration is more complex than determining the threshold concentration itself. Calculation of thresholds within an embayment requires integration of key habitat parameters (infauna and eelgrass), sediment characteristics, and nutrient-related water quality information. Watershed nitrogen loading threshold development then builds on these data and links habitat quality to summer water column nitrogen loading levels. To determine the total loading, several factors must be considered including nitrogen flow into the watershed (from septic systems, fertilizers, stormwater, atmospheric deposition, etc.), natural attenuation throughout the watershed, estuary flushing, and finally the threshold concentrations presented in the table above. Table 2-2 below

presents the current attenuated nitrogen loads reaching the Bass River estuarine system, the threshold load that would be allowable to meet the threshold concentrations listed above, and the percent change required to meet this goal. Attenuated loads, as noted previously, refer to the loads that ultimately reach the estuarine waterways, once all natural attenuation processes have been taken into account. These values are provided for each of the nine main subembayments within the system. Note that these nine subembayments collectively include the forty-two subwatersheds shown in Figure 2-2.

Table 2-2 Comparison of Sub-embayment Total Attenuated Watershed Loads and Threshold Loads

Sub-embayment	Present Total Load (kg/day)	Threshold Total Load (kg/day)	Threshold % Change
Run Pond	8.384	8.384	0.0%
Bass River - Lower	36.764	36.764	0.0%
School Street Marsh	11.882	11.882	0.0%
Bass River – Middle	67.674	29.833	-55.9%
Grand Cove	7.293	7.293	0.0%
Dinah's Pond	4.337	0.778	-82.1%
Kelleys Bay	20.126	3.860	-80.8%
Follins Pond	34.121	7.858	-77.0%
Mill Pond and Stream	27.238	7.847	-71.2%
Total	**217.8**	**114.5**	**-47.4%**

Source: Table VIII-3 of the Bass River MEP Report
Values in RED indicate that the value is above the standard and must be reduced.

Because septic system loading accounts for over 80 percent of the controllable nitrogen in the system, septic system nitrogen is the primary source which is typically targeted for total reduction within the contributing watersheds. Overall, 173.5 kg/day, or roughly 63,330 kg/yr, total attenuated nitrogen was estimated to originate from wastewater within the watershed. In order to meet threshold total nitrogen loads, it is estimated that the present total septic load in the Bass River watershed would need to be reduced by 59.5 percent, as summarized in **Table 2-3**, to meet the targeted thresholds under existing development conditions, as compared to a 47.4 percent reduction in total nitrogen loading shown in Table 2-2.

The threshold septic loading for the Bass River system is the sum of threshold loads developed in the MEP report for the nine major Bass River sub-embayments. To meet the requirements of both the check and sentinel stations by removing wastewater loads alone, the Bass River–Middle sub-embayment would require 69.4 percent removal, and Dinah's Pond, Kelleys Bay, Follins Pond, and Mill Pond/Stream all require between 97 and 100 percent wastewater nitrogen removal. All other subwatersheds do not require any septic system nitrogen removal to achieve the target thresholds based on the restoration scenario presented in the MEP report.

Note that these values represent just one way of meeting the target thresholds, as modeled by the MEP. Other scenarios can also be considered, using different removal percentages in different sub-embayments, as long as follow-up modeling shows that the target concentrations will be met.

Table 2-3 Decrease in Present Bass River System Attenuated Septic Loading to Meet Nitrogen Thresholds

MEP Watershed	Present Septic Load (kg/day)	Threshold Septic Load (kg/day)	Septic Load Decrease to Meet Threshold (% change)
Run Pond	7.014	7.014	0.0%
Bass River - Lower	29.858	29.858	0.0%
School Street Marsh	9.496	9.496	0.0%
Bass River – Middle	54.512	16.671	-69.4%
Grand Cove	6.159	6.159	0.0%
Dinah's Pond	3.559	0.000	-100.0%
Kelleys Bay	16.408	0.142	-99.1%
Follins Pond	27.085	0.822	-97.0%
Mill Pond and Stream	19.416	0.025	-99.9%
Total	**173.507**	**70.187**	**-59.5%**

Source: Table VIII-2 page 177 of Bass River MEP Report
Values in RED indicate that the value is above the standard and must be reduced.

As described previously, the MEP watershed nitrogen loading modeling includes a buildout assessment of potential development within the watersheds studied. **Table 2-4** shows buildout average total nitrogen concentrations modeled at monitoring stations, along with the recommended threshold concentration for the Bass River subsystem and the percent change necessary to meet the threshold concentrations.

Table 2-4 Sentinel and Check Stations with Associated Buildout Nitrogen Limits for the Bass River System

Embayment	Monitoring Station	Buildout total N Concentration (mg/l)	Threshold average total N Concentration (mg/l)	% Change
Mill Pond	BR-1	1.21	0.609	-49.7%
Follins Pond-Up	BR-2	0.809	0.519	-35.8%
Follins Pond-Lo	BR-3	0.804	0.517	-35.7%
Dinahs Pond	BR-4	0.743	0.493	-33.6%
Kelleys Pond	BR-5	0.743	0.496	-33.2%
Uppermost River	BR-6	0.642	0.458	-28.7%
Upper River	**BR-7**	0.548	0.419	-23.5%
Upper River	BR-8	0.514	0.404	-21.4%
Grand Cove	BR-9	0.543	0.424	-21.9%
Upper River	BR-10	0.453	0.377	-16.8%
Lower River	BR-11	0.398	0.352	-11.6%
Marsh-Lower	BR-12	0.378	0.346	-8.5%
Lower River	BR-13	0.344	0.325	-5.5%
Nearshore	BR-14	0.307	0.306	-0.3%

Source: Tables VI-6 and VIII-5 of the Bass River MEP Report
Values in RED indicate that the value is above the standard and must be reduced.

Table 2-5, which follows, shows the total attenuated nitrogen loads from each of the nine sub-embayments at buildout, along with the same threshold loads listed previously, and the percent change required under buildout conditions to meet the threshold loads. The total attenuated load under buildout is approximately 9.4 percent higher than the present total load, and the total nitrogen loading reduction percentage is 51.9 percent, as compared to 47.4 percent calculated for present day total loads.

Table 2-5 Comparison of Sub-embayment Total Buildout Attenuated Watershed Loads and Threshold Loads

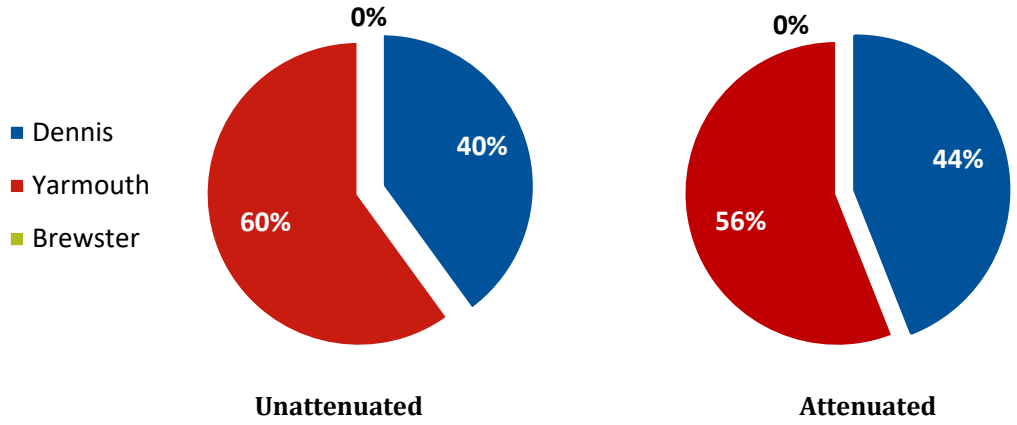
Sub-embayment	Buildout Total Nitrogen Load (kg/day)	Threshold Total Nitrogen Load (kg/day)	Threshold Total Nitrogen Load Decrease (% change)
Run Pond	8.732	8.384	-4.0%
Bass River - Lower	37.545	36.764	-2.1%
School Street Marsh	13.255	11.882	-10.4%
Bass River – Middle	75.403	29.833	-60.4%
Grand Cove	7.833	7.293	-6.9%
Dinah's Pond	4.532	0.778	-82.8%
Kelleys Bay	22.918	3.860	-83.2%
Follins Pond	37.959	7.858	-79.3%
Mill Pond and Stream	30.104	7.847	-73.9%
Total	**238.3**	**114.5**	**-52.0%**

Source: Tables VI-4 and VIII-3 of the Bass River MEP Report
Values in RED indicate that the value is above the standard and must be reduced.

Load Distribution between Dennis, Yarmouth, and Brewster

In a follow-up technical memorandum to the Bass River MEP report, dated October 26, 2011, SMAST provided a division of the unattenuated and attenuated nitrogen loads from each of the 42 subwatersheds of the Bass River watershed between the towns of Dennis, Yarmouth, and Brewster. This information has since been updated to correct the location of the Run Pond watershed, which was listed in the 2011 memorandum as entirely within Dennis, while it is actually located entirely within Yarmouth. **Figure 2-6** shows this division as a percentage from each community for both unattenuated and attenuated nitrogen loads. As shown, the attenuated load is divided predominately between Dennis and Yarmouth, with a contribution from Brewster of less than 1 percent.

Table 2-6 which follows shows the attenuated loads divided by subwatershed and by community. The locations of the corresponding subwatersheds are shown on Figure 2-1. This more detailed information will help guide decisions as to where in Dennis the most efficient and cost-effective solutions may be targeted. Additionally, removal of nitrogen that is not attenuated prior to reaching the estuarine system can provide more benefit than removal of the same quantity of nitrogen from an area that will experience some level of natural attenuation. This is considered later in this study as areas are specifically targeted for water quality improvements.



Source: October 26, 2011 SMAST Technical Memorandum (corrected with updated information)

Figure 2-6: Division of Unattenuated and Attenuated Bass River System Nitrogen Loads Between Communities

Table 2-6 Attenuated Bass River Nitrogen Loads in each Subwatershed by Community

		Attenuated Subwatershed Nitrogen Loading (kg/yr)			
Subwatershed	#	Dennis	Yarmouth	Brewster	TOTAL
N Dennis Wells	1	1,937	539	-	2,476
Flax Pond	2	127	-	-	127
Simmons Ponds	3	216	-	-	216
Old Bass river Wells	4	331	-	-	331
Grassy Pond	5	257	-	-	257
East West Dennis Wells	6	504	-	-	504
NW Dennis Wells	7	1,756	-	208	1,964
Bakers Pond	8	151	-	-	151
Pine Pond	9	0	-	61	61
Hamblin Brooke Gauge LT10	10	-	644	-	644
Hamblin Brook Gauge GT10	11	-	663	-	663
Mill Pond GT10N	12	0	1,513	-	1,513
Mill Pond LT10	13	-	1,947	-	1,947
Mill Pong GT10 S	14	-	1,774	-	1,774
Mill Stream GT10 N	15	15	446	-	460
Mill Stream LT10	16	-	847	-	847
Mill Stream GT10 S	17	-	235	-	235
Weir Stream	18	-	266	-	266
Muddy Creek	19	-	139	-	139
N Yarmouth Wells	20	-	715	-	715
Follins Pond GT10 D	21	1,961	-	-	1,961

		Attenuated Subwatershed Nitrogen Loading (kg/yr)			
Subwatershed	#	Dennis	Yarmouth	Brewster	TOTAL
Follins Pond LT10	22	4,187	2,211	-	6,398
Follins Pond GT10 Y	23	-	1,065	-	1,065
Kelleys Bay GT10 D	24	1,901	-	-	1,901
Kelleys Bay LT10	25	3,235	188	-	3,422
Kelleys Bay GT10 Y	26	-	243	-	243
Dinah's Pond LT10	27	-	560	-	560
Dinah's Pond GT10	28	-	1,030	-	1,030
N Main Yarmouth Wells	29	-	2,243	-	2,243
Bass R Mid GT10 D	30	3,144	-	-	3,144
Bass R Mid LT10	31	3,035	7,114	-	10,149
Bass R Mid GT10 Y	32	-	7.709	-	7.709
Bass R Lower GT10 Y	33	-	2,598	-	2,598
Bass R Lower LT10	34	4,217	5,792	-	10,009
Fresh Pond	35	186	-	-	186
Fresh Pond Gauge	36	151	-	-	151
Grand Cove	37	2,269	-	-	2,269
Horsefoot Cove	38	601	-	-	601
School Street Marsh	39	3,450	-	-	3,450
Kelleys Pond	40	715	-	-	715
Uncle Stephans Pond	41	172	-	-	172
Run Pond	42	-	3,055	-	3,055
Long Pond	43	-	990	-	990
Total		34,518 (43.5%)	44,526 (56.1%)	269 (0.3%)	79,311

Flushing Improvements at Bridge Crossings

There are three major bridge crossings over the Bass River system: Route 28, Route 6, and a railroad bridge. The Route 6 bridge is comprised of a parallel set of bridge structures, while the railroad bridge has had the deck removed, but the abutments remain in place. In addition, Highbank Road crosses the river about midway between the Route 28 and railroad bridges, and North Dennis Road crosses the narrow tidal channel between Follins Pond and Mill Pond in the upper reaches of the watershed.

The railroad bridge over the Bass River was analyzed by the MEP to determine if this structure was a significant tidal restriction, as presented in the April 2011 final Bass River MEP report. Several model runs were performed to determine if widening of the culvert under the railroad bridge would have an appreciable change in flushing to the upper portions of the river. Specifically, the scenarios evaluated included either one additional 20-foot-wide culvert placed 30-feet west of the bridge span, or that culvert combined with a second 20-foot-wide culvert placed 20-feet east of the bridge span.

The results of this modeling effort indicated that the railroad bridge does not appear to create a significant flow restriction. The largest modeled culvert option only increased the tidal range north of the railroad bridge crossing by 0.2 feet, or 11 percent of the present tidal range. As a result, enhanced flushing at this location alone would not provide a significant change in the amount of nitrogen that requires reduction within the watershed.

A follow-up study was then performed in August 2013 by Applied Coastal Research and Engineering, Inc., and presented in a report entitled, "Hydrodynamic Tidal Study of the Bass River." This study analyzed two restoration scenarios to examine the associated ecosystem restoration benefits within the Bass River system. The first scenario modeled was the "best case" scenario, which entailed maximizing tidal exchange by modeling natural channels representing historically unrestricted tidal flow at both the railroad bridge and the Route 6 bridge over the Bass River. The second scenario examined increased the cross-sectional width of the railroad bridge abutments to match the channel widths at the Route 6 bridge. Increasing the opening under the railroad bridge would be removing the largest obstruction to flow within the system and would thereby increase flushing.

Scenario 1, as predicted, results in the largest reductions of tidal residence times and nitrogen concentrations, both of which would contribute significantly to the restoration of salt marsh and benthic habitat in the upper reaches of the Bass River system. This scenario results in approximately a 6 percent reduction in nitrogen concentrations in the upper reaches of the watershed. However, this scenario entails infrastructure improvements which would require considerable time and funds to complete. Scenario 2 results in more modest improvements to tidal attenuation, residence times, and nitrogen concentrations when compared to Scenario 1. Specifically, nitrogen concentrations in the upper reaches of the Bass River would be reduced by approximately 2 percent, and residence times would be reduced by 12 hours. Both scenarios offer opportunities to restore more natural tidal flow through the system and contribute to restoration of salt marsh and benthic habitat, which otherwise could only be achieved through nitrogen removal via sewering or other means of significantly improved wastewater treatment. At this time, only scenario 2 has been implemented.

2.3.2 Swan Pond River Embayment System Results

The final report entitled "Linked Watershed-Embayment Approach to Determine Critical Nitrogen Loading Thresholds for the Swan Pond River Embayment System for the Town of Dennis, Massachusetts" was published by the Massachusetts Estuaries Project in October 2012. The Swan Pond River Embayment system is a complex estuary composed of two functional types of component basins: an open water embayment (Swan Pond) and a tidal river (Swan Pond River), with the upper reaches supporting significant salt marsh area.

The Swan Pond River embayment is located within the sand and gravel outwash of the Harwich Outwash Plain Deposits overlying Pleistocene deposits. The soils of the entire watershed are such that direct rainwater runoff is typically rather low, and most freshwater inflow to the estuary is via groundwater direct inputs or groundwater fed surface water flow.

Physical Description

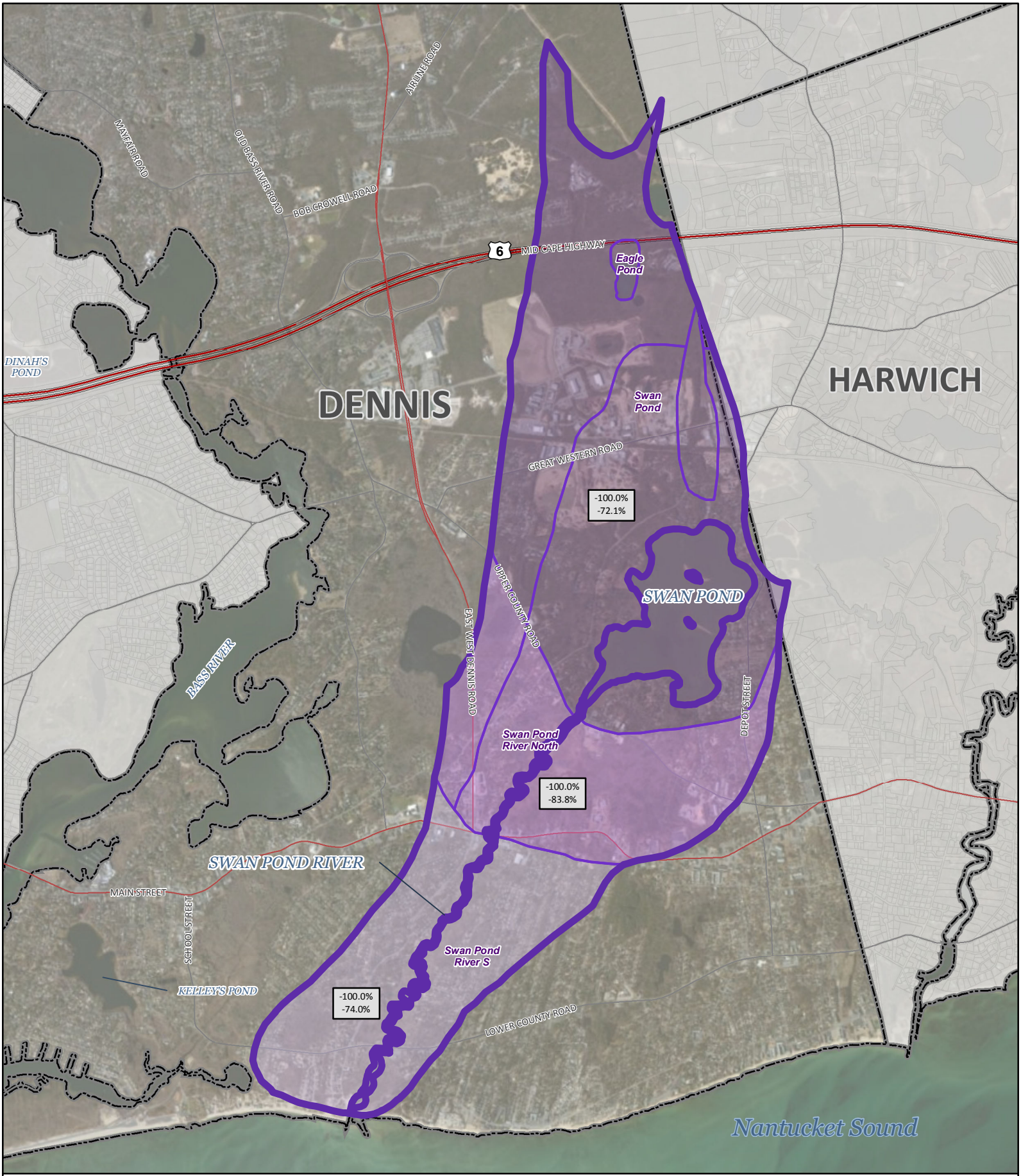
The Swan Pond River Embayment System is a located predominately within the town of Dennis, with some small watershed areas extending into Harwich and Brewster. The embayment system consists of a long meandering river (the Swan Pond River, sometimes referred to as the Swan River) which connects to Nantucket sound, and a 154 acre upstream pond (Swan Pond), as shown on **Figure 2-7**. The estuary exchanges tidal waters with the high quality waters of Nantucket Sound through a single inlet that is partially armored with a single jetty on its western shore. The Swan Pond River Estuary contains high salinity water throughout its tidal reaches, generally 30 ppt near the inlet and 23 ppt in Swan Pond. These high salinities reflect the dominance of tidal flows, rather than freshwater inflows, in the system.

Swan Pond is generally the same depth as the Swan River, both being only 1.0 – 1.5 m deep. Almost all of the watershed recharge enters the Swan Pond River system through direct groundwater seepage via its shoreline. A small surface water input flows from a creek along Hydaway Lane (Hydaway Creek) that discharges into the upper portion of Swan Pond. The shoreline of nearly all of Swan Pond is bordered by 50 to 100 feet of salt marsh. There are three subembayments composed of eight sub-watersheds that contribute to the daily groundwater inputs to the overall Swan Pond River system, totaling 16,972 cubic meters per day. The Swan Pond River system is at high risk for nitrogen over-enrichment due to its morphology. Specifically, the long, meandering Swan River produces significant friction for the tidal flows that would otherwise better flush the upgradient portions of the system. Due to this friction, the tide range at the inlet is approximately three feet, while the tide range in Swan Pond decreases to only about one foot.

Land Use and Nitrogen Loading

Public service land uses are the dominant land use type in the overall Swan Pond River watershed and occupy 38% of the watershed area. Residential land uses occupy the second largest area comprising 34% of the watershed area. Land classified by the town assessor as undeveloped is 14% of the overall watershed area. In all the sub-watershed groupings, residential parcels are the dominant parcel type, with 39% to 90% of all parcels in the sub-watersheds, and 79% of all parcels in the overall Swan Pond River system watershed. Single-family residences are the dominant type of residential parcel, which represent 91% of the residential parcels throughout the system.

Within the Swan Pond River study area, the major types of nitrogen loads are: wastewater (e.g., septic systems), fertilizers, impervious surfaces, direct atmospheric deposition to water surfaces, solid waste sites, and sediment recharge within attenuation areas. **Figure 2-8** shows land use-specific unattenuated nitrogen load (by percent) from the whole Swan Pond River watershed. Although natural attenuation occurs in a portion of freshwater flow transporting nitrogen via an un-named creek discharging into the head of Swan Pond, this natural attenuation is not uniformly distributed within the watershed. Because nitrogen attenuation is significant in one portion of a watershed and insignificant in another, the result is that nitrogen management would likely be more effective in achieving water quality improvements if focused on the watershed region having unattenuated nitrogen transport.



Watershed

Swan Pond River

Swan Pond River Subwatershed

-100.0%
-74.0%
Septic Nitrogen Removal to Meet Threshold/
Total Controllable Nitrogen Removal
to Meet Threshold

Town of Dennis, MA

N

1 in = 2,500 ft

0 0.25 0.5

Miles

Figure 2-7
Swan Pond River System

CDM Smith

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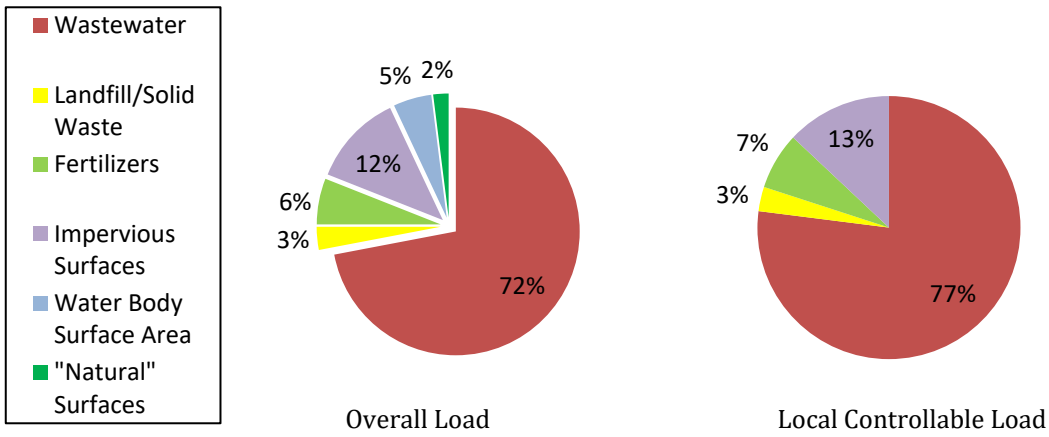


Source: Figure IV-5 of the Swan Pond River MEP report

Figure 2-8: Land Use Specific Total and Controllable Unattenudated Nitrogen Loads to the Swan Pond River System

Bacterial Contamination

While the primary threat to the Swan Pond River system is nutrient enrichment, it has also had periodic bacterial contamination issues. These have been attributed predominately to stormwater runoff from the watershed and animal sources primarily associated with waterfowl and the extensive tidal wetlands. As a result of this historic contamination, seasonal closure of shellfish harvesting areas has been imposed, restricting shellfishing in both Swan Pond and the Swan Pond River to December 1st through April 30th.

Water Quality Indicators

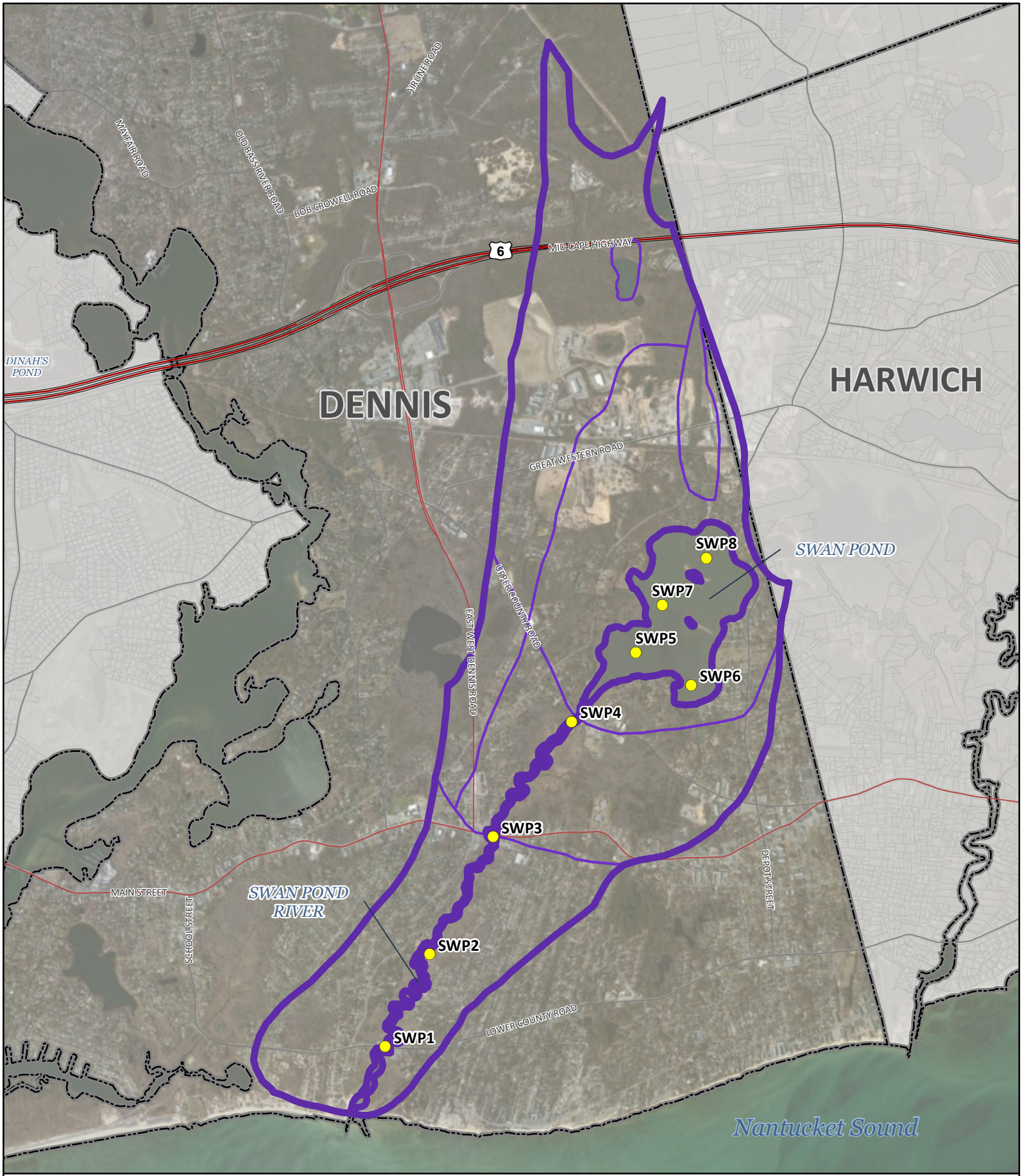
Presently the Swan Pond River system is showing differences in nitrogen enrichment and habitat quality among its various component basins, with regions of clearly impaired habitat. Swan Pond is a significantly impaired basin relative to benthic animal habitat, and it historically has not supported eelgrass based on information dating back over 60 years. Eelgrass beds have not been observed within the overall Swan Pond River system as far back as 1995. Since Swan Pond is the terminal basin of this estuary, it has the most enriched conditions within the estuary, with the Swan River being intermediate in nutrient related water quality between Swan Pond and the high quality waters of Nantucket Sound. Nitrogen enrichment through direct inputs and naturally low tidal exchange has resulted in frequent large phytoplankton blooms, periodic hypoxia/anoxia, large macroalgal accumulations, and a benthic community comprised of stress indicator species. Large macroalgae blooms in Swan Pond in 2006 and 2009 have provided dramatic evidence of habitat impairment and pushed nitrogen management into public forums (see Figure 2-9).

Figure 2-9: View of upper (northern) Swan Pond during an algal bloom. Drift algae is seen floating at the surface in dense patches.

The Swan River is also nitrogen enriched but has less nitrogen enrichment based primarily on its structure and higher relative water turnover. While the lower reach currently supports only high quality to moderately impaired benthic habitat, its loss of historic eelgrass beds indicates that it has become significantly impaired relative to eelgrass habitat. The upper tidal reach of the Swan River, between Swan Pond and the lower River, is intermediate in habitat quality. This upper tidal reach, north of Route 28, is moderately to significantly impaired based upon its benthic animal habitat, due primarily to organic and nitrogen rich waters leaving Swan Pond on the ebb tides and natural enrichment processes associated with its extensive wetlands.

Monitoring Stations and Thresholds

Nitrogen concentrations in the embayment were measured in order to understand water quality throughout the Swan Pond River system. Monitoring station locations are shown on **Figure 2-10.** Multi-year averages present the best comparison to true water quality, since factors of tide, temperature and rainfall may exert short-term influences on individual sampling dates and even cause inter-annual differences. Three years of field data is the minimum required to provide a baseline for MEP analysis. The data for each monitoring station used in the water quality modeling effort are presented in Table 2-7. As shown, nitrogen concentrations generally form a gradient from high to low starting in Swan Pond and traveling towards the Sound.



Watershed

- Monitoring Station
- Swan Pond River
- Swan Pond River Subwatershed

Town of Dennis, MA

N

1 in = 2,500 ft

0 0.25 0.5

Miles

Figure 10
Swan Pond
Monitoring Stations

CDM Smith

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Table 2-7 Water Quality Monitoring Nitrogen Concentrations (mg/L) for the Swan Pond River System

Sub-embayment	Monitoring Station	2005 – 2010 Mean
Lower River	SWP-1	0.556
Lower River1	SWP-21	0.673
Upper Swan River	SWP-3	0.862
Swan Pond	SWP-5	1.036
Swan Pond	SWP-6	1.123
Swan Pond	SWP-7	1.197
Swan Pond	SWP-8	1.159

(1) Indicates sentinel station
Source: Table VI-1 of the Swan Pond River MEP Report

Station SWP-2 was selected as the sentinel station for the Swan Pond River system. As described previously, the goal of the sentinel station is to identify a location where meeting a target nitrogen concentration would result in water quality throughout the estuary sufficient to restore acceptable ecological health. This site was selected based on its location at the uppermost extent of the documented historic eelgrass coverage in the estuary, in the middle of the lower reach of the River.

Observed loss of eelgrass, moderate oxygen and chlorophyll levels, and benthic community structure within the lower reach of the system indicate nitrogen concentrations beyond the threshold level that would be supportive of eelgrass, but relatively closer to the level for supporting high quality infaunal habitat. The tidally averaged modeled nitrogen levels for the lower reach were 0.651 mg/L over the entire reach and 0.564 mg/L in the region that historically supported eelgrass. These levels are slightly above the level typically supportive of infaunal communities (0.5-0.55 mg/L TN), but well above levels supportive of eelgrass beds as found in a variety of other Cape Cod MEP assessments. Similarly, average nitrogen levels within Swan Pond (1.056-1.207 mg/L TN) are well above levels found in basins supportive of high quality benthic animal habitat. The target tidally averaged nitrogen concentration for restoration of eelgrass at the sentinel location is 0.398 mg/L, as shown in Table 2-8.

Table 2-8 Sentinel and Check Stations with Associated Nitrogen Limits for the Swan Pond River System

Embayment	Monitoring Station	Present Total N Concentration (mg/l)	Threshold Average Total N Concentration (mg/l)	% Change
Lower River	SWP-1	0.465	0.346	-25.6%
Lower River	**SWP-2**	**0.661**	**0.398**	**-39.8%**
Upper Swan River	SWP-3	0.826	0.445	-46.1%
Swan Pond	SWP-5	1.055	0.515	-51.2%
Swan Pond	SWP-6	1.143	0.544	-52.4%
Swan Pond	SWP-7	1.168	0.553	-52.6%
Swan Pond	SWP-8	1.210	0.569	-53.0%

Source: Table VIII-5 of the Swan Pond River MEP Report
Values in RED indicate that the value is above the standard and must be reduced.

The nitrogen threshold developed based upon the SWP-2 sentinel location was then used to determine the amount of total nitrogen mass loading reduction required to meet this goal. Nitrogen reduction requirements were assessed based on both total controllable loads and septic-only loads. **Table 2-9** shows the present nitrogen loading, the threshold concentrations, and the required percent removal of total controllable loads.

Table 2-9 Decrease in Present Swan Pond River System Attenuated Total Loading to Meet Nitrogen Thresholds

Sub – Embayment	Present Total Load (kg/day)	Threshold Total Load (kg/day)	Total Load Decrease (% change)
Swan Pond	18.123	5.063	-72.1%
Swan Pond River- North	10.036	1.625	-83.8%
Swan Pond River- South	15.556	4.038	-74.0%
Total	**43.715**	**10.726**	**-75.5%**

Source: Table VIII-3 of the Swan Pond River MEP Report
Values in RED indicate that the value is above the standard and must be reduced.

As shown in **Table 2-10**, if only septic system nitrogen load reductions are accomplished within the watershed, 100% removal of the septic system nitrogen is required in all subwatersheds.

Table 2-10 Decrease in Present Swan Pond River System Attenuated Septic Loading to Meet Nitrogen Thresholds

Sub – Embayment	Present Septic Load (kg/day)	Threshold Septic Load (kg/day)	Septic Load Decrease (% change)
Swan Pond	13.057	0.00	-100.0%
Swan Pond River- North	8.411	0.00	-100.0%
Swan Pond River- South	11.518	0.00	-100.0%
Total	32.986	0.00	-100.0%

Source: Table VIII-2 of the Swan Pond River MEP Report
Values in RED indicate that the value is above the standard and must be reduced.

The buildout analysis for the Swan Pond River watershed focuses on shifts in land use from forest or grasslands to residential and commercial development and does not necessarily account for other changes that can occur within existing uses, such as changes from seasonal to year-round use. As seen above, restoration of the Swan Pond River system necessitates the equivalent of removal of all existing septic system nitrogen from the watershed. Therefore, further growth impacts would have to also be completely negated in order to meet the nitrogen thresholds established.

In the buildout scenario for this watershed, certain sub-embayments would be impacted more than others. Swan Pond would experience a large load increase, specifically 25% from the present day loading levels. **Table 2-11** shows the concentrations at the sentinel and check stations under buildout conditions and the required reductions to meet threshold concentrations. **Table 2-12** which follows shows the total attenuated nitrogen loads from each of the three sub-embayments at buildout, along with the same threshold loads listed previously, and the percent change required under buildout conditions to meet the threshold loads. The total attenuated load under

buildout is approximately 14 percent higher than the present total load, and the total nitrogen loading reduction percentage is 78.5 percent, as compared to 75.5 percent calculated for present day total loads. As mentioned, though, septic system buildout loading would have to be completely eliminated from the watershed to meet thresholds if other controllable loads were not also reduced.

Table 2-11 Sentinel and Check Stations with Associated Buildout Nitrogen Limits for the Swan Pond River System

Embayment	Monitoring Station	Buildout Total N Concentration (mg/l)	Threshold Average Total N Concentration (mg/l)	% Change
Lower River	SWP-1	0.484	0.346	-28.5%
Lower River	**SWP-2**	**0.712**	**0.398**	**-44.1%**
Upper Swan River	SWP-3	0.907	0.445	-50.9%
Swan Pond	SWP-5	1.182	0.515	-56.4%
Swan Pond	SWP-6	1.291	0.544	-57.9%
Swan Pond	SWP-7	1.324	0.553	-58.2%
Swan Pond	SWP-8	1.378	0.569	-58.7%

Source: Tables VI-6 and VIII-5 of the Swan Pond River MEP Report
Values in RED indicate that the value is above the standard and must be reduced.

Table 2-12 Comparison of Sub-embayment Total Buildout Attenuated Watershed Loads and Threshold Loads for the Swan Pond River System

Sub-embayment	Buildout Total Nitrogen Load (kg/day)	Threshold Total Nitrogen Load (kg/day)	Threshold Total Nitrogen Load Decrease (% change)
Swan Pond	22.600	5.063	-77.6%
Swan Pond River- North	11.419	1.625	-85.8%
Swan Pond River- South	15.822	4.038	-74.5%
Total	**49.841**	**10.726**	**-78.5%**

Source: Tables VI-4 and VIII-3 of the Swan Pond River MEP Report
Values in RED indicate that the value is above the standard and must be reduced.

2.3.3 Herring River Results

The MEP report for the Herring River embayment, "Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Thresholds for the Herring River Embayment System, Harwich, Massachusetts," was published in March of 2013.

Physical Description

The Herring River Marsh/Embayment System is located within the town of Harwich, however the watershed to the overall system extends into the towns of Brewster and Dennis. Only a very small area of the Herring River watershed extends into the town of Dennis. Subwatershed boundaries established by the MEP divided the watershed into 27 subsystems. Of these, the watersheds to White Pond (#1), West Reservoir LT10 (#24), Upper Herring River GT10 (#26), and Lower Herring River-Main GT10 (#18) cross the boundary from Harwich into Dennis. (Note that GT10 refers to a travel time to the estuary of greater than 10 years.)

The Herring River System is comprised of a main tidal channel and includes a west branch that extends up to a man-made freshwater reservoir and an east branch that extends up into a small brackish marsh. This embayment system is one of the largest functional wetlands on Cape Cod. This wetland is predominantly a freshwater marsh in the upper reaches and a salt marsh system in the lower reaches. Although most of the Herring River system is a tidal wetland system, the lower reaches closer to the inlet are considered to be a tidal river with limited wetland vegetation. Below the Route 28 bridge, the tidal channel is relatively wide and functions more like an open water basin than a marsh. Above Route 28, the channel narrows and then intersects with smaller tributary marsh creeks.

The differences in structure above and below the Route 28 bridge are notable. Historic eelgrass habitat and benthic animal communities of more open water basins exist in the lower tidal reach. However, minimal eelgrass is currently present in this area. Wetland dominated habitats exist in the upper system of salt marsh and tidal channels. This ecological difference results in a greater sensitivity to nitrogen in the lower tidal river portion than in the upper wetland dominated portions.

The Herring River System receives water from Nantucket Sound through a single tidal inlet. The inlet is relatively wide and navigable and functions more like an embayment rather than a marsh. Above Route 28, the channel narrows and quickly changes to a system that is dominated by salt marsh.

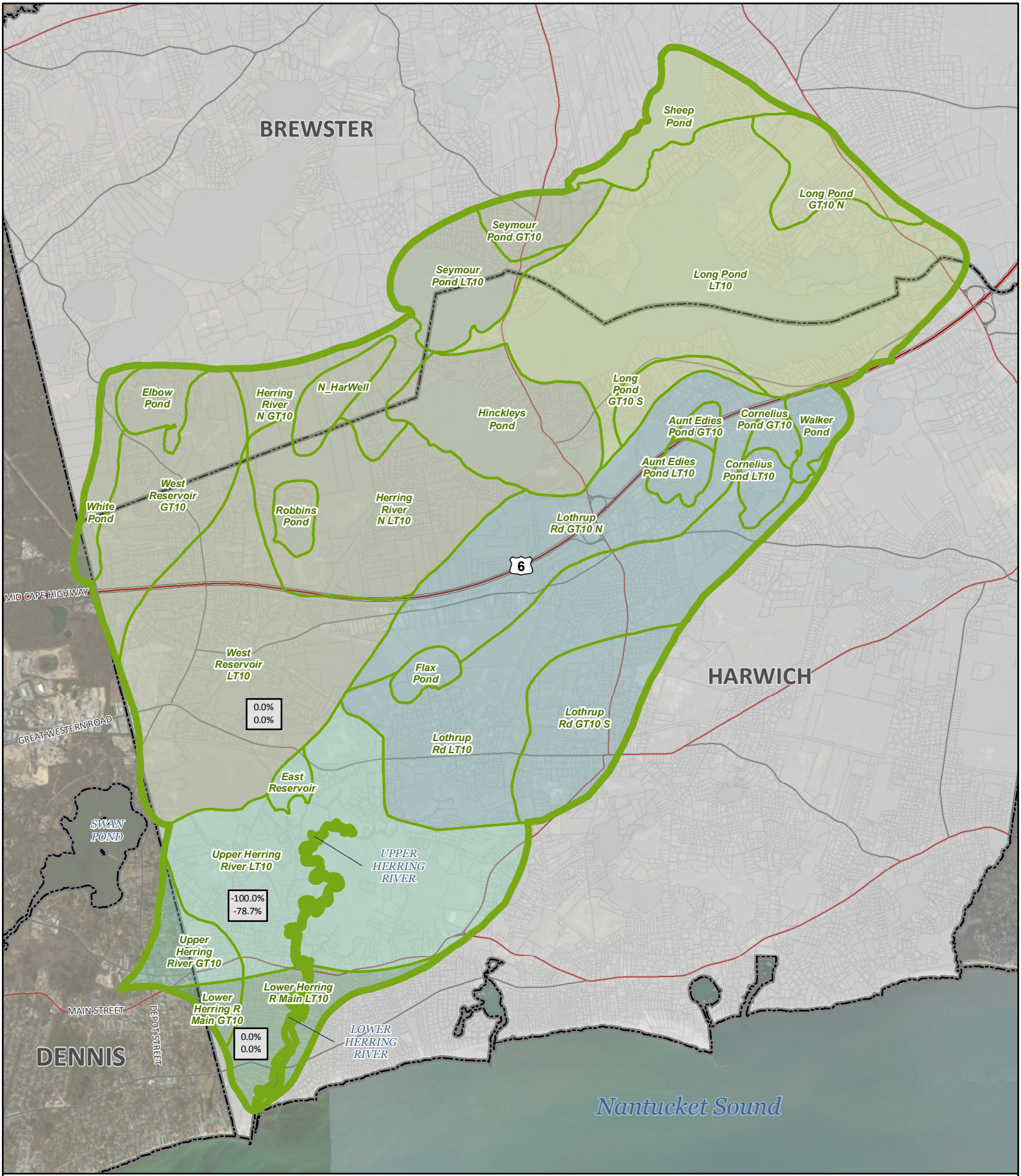
Overall, the Herring River Marsh/Embayment system is typical of a large New England tidal marsh system, with the lower regions composed of predominantly salt marsh dominated by a central tidal creek. The upper regions, furthest from the tidal inlet show the influence of the freshwater inflows from the surrounding watershed. Tidal exchange with Nantucket Sound is high with near complete drainage of tidal creeks in the upper most portions of the system at low tide. Observations by the USGS and the MEP indicate that the Herring River is a healthy functioning New England tidal wetland system north of the Route 28 bridge. The Herring River Marsh provides both wildlife habitat and a nursery to offshore fisheries, as well as serving as a storm buffer and nutrient sink for watershed derived nitrogen.

The primary ecological threat to the Herring River system is degradation from nutrient enrichment. This is particularly true within the lower tidal river reach. Nitrogen loading is primarily from on-site disposal of wastewater. Most areas of the Herring River watershed rely almost entirely on privately maintained on-site septic treatment and disposal of wastewater. As existing and likely increasing levels of nutrients impact the coastal embayments on Cape Cod, water quality degradation is expected to increase. **Figure 2-11** shows the Herring River system.

Land Use and Nitrogen Loading

Land use in the Herring River watershed overall is 56% residential, of which 66% are single family homes. High residential use, coupled with the fact that the watershed has experienced significant population growth since 1950, has resulted in moderate nitrogen loading in the watershed, primarily due to nitrogen from septic system discharge.

Natural deposition of atmospheric nitrogen on water bodies and natural land surfaces accounts for 18% of the total loading within the Herring River system. Controllable sources, such as



Watershed

Herring River

Herring River Subwatershed

-100.0% -74.0% Septic Nitrogen Removal to Meet Threshold/ Total Controllable Nitrogen Removal to Meet Threshold

Town of Dennis, MA

N

1 in = 3,700 ft

0 0.5 1

Miles

Figure 2-11
Herring River System

CDM Smith

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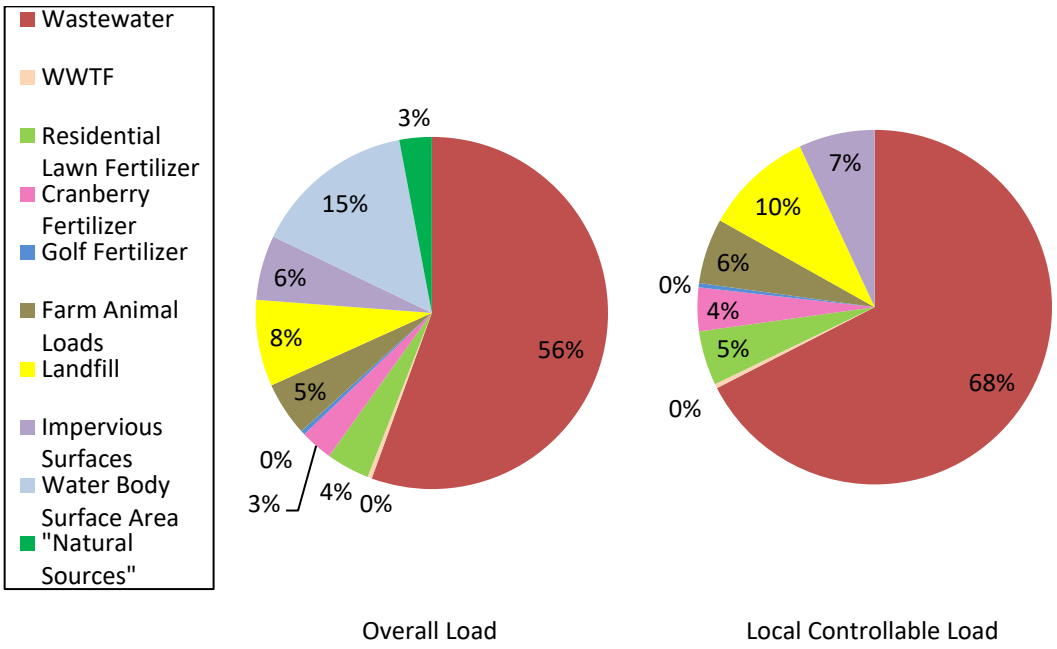
wastewater from septic systems and residential and commercial fertilizer applications, account for approximately 63% of the total nitrogen loading. Because septic system effluent accounts for such a large percent of nitrogen inputs, 68% of controllable nitrogen sources, reducing this source is a priority for improving overall estuary habitat. **Figure 2-12** shows total nitrogen loading for the Herring River watershed, including natural deposition and also the percent of controllable nitrogen loading sources within the watershed.



Source: Figure IV-6 of the Herring River MEP report

Figure 2-12: Land Use Specific Total and Controllable Unattenuated Nitrogen Loads to the Herring River Watershed

Water Quality Indicators

High quality habitat in open water basins supports different communities than high quality habitat in tidal wetlands. These important differences are described in the MEP assessment of the wetland dominated upper region and open water dominated tidal river comprising the lower region of the Herring River system. This difference in structure above and below the Route 28 bridge created historic eelgrass habitat and benthic animal communities of more open water basins in the lower tidal reach and wetland dominated habitats in the upper wetland basin. Based upon the available information, tidal creeks of the upper reach do not appear to be able to support eelgrass habitat. The lower estuarine reach below Route 28 is structured to support eelgrass habitat.

The MEP report identified the Herring River system as one that can support high quality habitat. It is not presently impaired by its naturally high levels of nitrogen and organic matter enrichment. The open water basin of the tidal river is presently supporting high quality benthic animals which is consistent with its level of dissolved oxygen, organic matter, nutrient enrichment and flushing. This open water basin does, however, appear to be at or slightly below its threshold level of

enrichment relative to benthic animal habitat in its upper most reaches. Any additional nutrient inputs are expected to further degrade ecological health.

Since the results of the infaunal survey do not indicate clear impairment of benthic habitat within the Herring River system, the MEP recommends a nitrogen management analysis that focuses primarily on the recent losses of eelgrass habitat from the lower estuary's tidal river basin. The loss of eelgrass is the result of its sensitivity to nutrient loads. The upper wetland basin appears to be well below its nitrogen loading threshold level. Since infaunal habitat is less sensitive to the effects of nitrogen enrichment than eelgrass, protecting the more sensitive eelgrass habitat will, by default, enhance infaunal habitat within the tidal river portion of the estuary. Determining the nitrogen target to restore eelgrass habitat is therefore the focus of the nitrogen management threshold standards presented herein.

Monitoring Stations and Thresholds

In Herring River, one sentinel station identified as HAR-7 is located at the Route 28 Bridge in Harwich (the upper most limit of the historic eelgrass within the system) as shown in **Figure 2-13**. This location is positioned such that meeting the target criterion in this location will signify improved water quality throughout the tidal area sufficient to restore eelgrass within the tidal portion of the estuary.

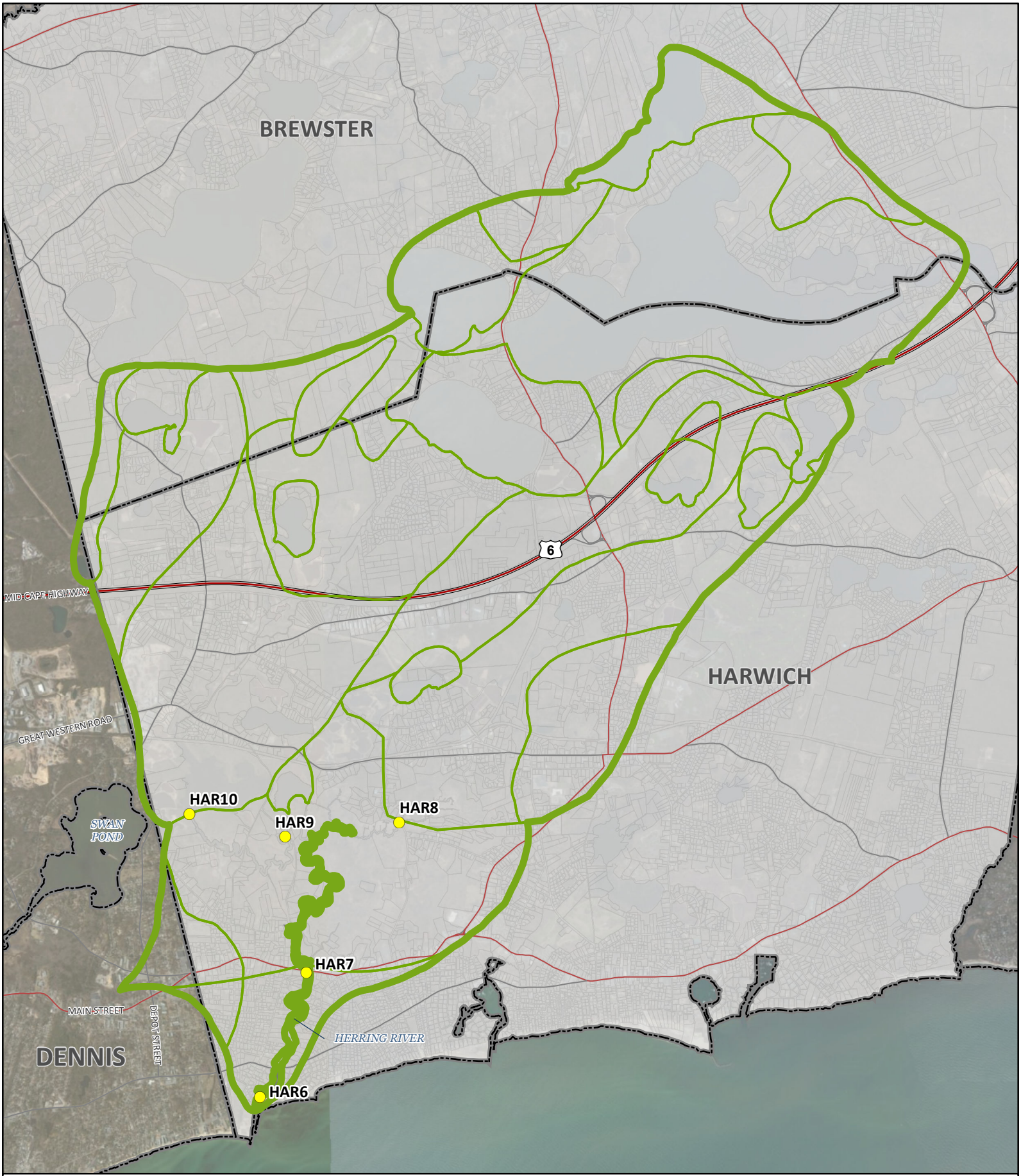
The threshold nitrogen concentration for the Herring River sentinel station HAR-7 is 0.479 mg/L. The MEP concluded that an upper limit of 0.479 mg/l of nitrogen would support both eelgrass and healthy infaunal habitat in the Herring River system. The concentrations at the monitoring stations may be slightly different than the upper limit, but they are chosen so that the upper limit of 0.479 mg/l of nitrogen (tidally averaged) is achieved throughout the system. This is summarized in **Table 2-13** below.

Table 2-13 Sentinel Monitoring Station with Associated Nitrogen Limit for the Herring River System

Embayment	Monitoring Station	Present total N Concentration* (mg/l)	Threshold average total N Concentration* (mg/l)	% Change
Wixen Dock	HAR-6	0.425	0.384	-9.6%
Rt. 28 Bridge	HAR-7	0.567	0.479	-15.5%
Lothrop Road	HAR-8	0.840	0.583	-30.6%
North Road	HAR-9	0.776	0.648	-16.6%
West Reservoir	HAR-10	0.710	0.709	-0.1%

Source: Table VIII-5 of the March 2013 Herring River MEP Report
Values in RED indicate that the value is above the standard and must be reduced.

Determination of site-specific nitrogen thresholds for an embayment requires integration of key habitat parameters (infauna and eelgrass), sediment characteristics, and nutrient related water quality information. Nitrogen threshold development builds on these data and links habitat quality to summer water column nitrogen levels. To determine the total loading several factors must be considered including septic system effluent flow into the watershed, natural attenuation throughout the watershed, estuary flushing, stormwater sources, fertilizers applied throughout the watershed, and finally the threshold concentrations presented in the table above. The MEP evaluation of habitat quality supported by the Herring River system considers the natural



Watershed

- Monitoring Station
- Herring River
- Herring River Subwatershed

Town of Dennis, MA

N

1 in = 3,700 ft

0 0.5 1

Miles

Figure 2-13
Herring River
Monitoring Stations

CDM Smith

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structure of each system and its ability to support that habitat before determining the threshold septic load.

In looking at the total attenuated controllable load, a reduction of 23.6 percent nitrogen is required, as shown in **Table 2-14**.

Table 2-14 Decrease in Present Herring River System Attenuated Total Loading to Meet Nitrogen Thresholds

Sub – Embayment	Present Total Load (kg/day)	Threshold Total Load (kg/day)	Threshold Septic Load Decrease (% change)
Lower Herring River*	9.036	9.036	0.0%
East Reservoir	0.293	0.293	0.0%
Upper Herring River*	13.296	2.827	-78.7%
West Reservoir*	27.564	27.564	0.0%
Lothrop Road	12.627	8.255	-34.6%
Total	**62.816**	**47.975**	**-23.6%**

*Includes land area in Dennis
Source: Table VIII-3 of the March 2013 Herring River MEP Report
Values in RED indicate that the value is above the standard and must be reduced.

The primary source of nitrogen in the Herring River watershed is septic system effluent, which accounts for a majority of total and controllable nitrogen loading. For this reason, this source is the primary focus of nitrogen reduction to meet the threshold values. Overall, 38.592 kg/day, or roughly 14,086 kg/year, of attenuated nitrogen is estimated to originate from septic systems within the watershed. In order to meet threshold nitrogen loads, it is estimated that the current total septic load in the Herring River watershed would need to be reduced by 38 percent, as shown in **Table 2-15**.

Table 2-15 Decrease in Present Herring River System Attenuated Septic Loading to Meet Nitrogen Thresholds

Sub – Embayment	Present Septic Load (kg/day)	Threshold Septic Load (kg/day)	Threshold Septic Load Decrease (% change)
Lower Herring River*	7.063	7.063	0.00%
East Reservoir	0.047	0.047	0.00%
Upper Herring River*	10.468	0.000	-100%
West Reservoir*	12.137	12.137	0.00%
Lothrop Road	8.877	4.504	-49.3%
Total	**38.592**	**23.751**	**-38.5%**

*Includes land area in Dennis
Source: Table VIII-2 of the March 2013 Herring River MEP Report
Values in RED indicate that the value is above the standard and must be reduced.

The threshold septic loading for the Herring River system is the sum of five threshold loads developed in the MEP report for the Lower Herring River, East Reservoir, Upper Herring River, West Reservoir and Lothrop Road sub-embayments. Together these five thresholds combine to give a total threshold septic load for the watershed. To meet the requirements of check and

sentinel stations, the system will require at least 38.5 percent of the attenuated present septic load to be reduced.

Note again that the portions of the Herring River watershed in Dennis are located in the Lower Herring River, Upper Herring River, and West Reservoir subwatersheds. The latter includes both the West Reservoir and the White Pond subsystems noted above. Of these, only the Upper Herring River system is shown to require septic nitrogen reduction under present conditions. This area is called out on Figure 2-11.

Table 2-16 shows the concentrations at the sentinel and check stations under buildout conditions and the required reductions to meet threshold concentrations. The total controllable buildout load reductions for each sub-embayment are shown in **Table 2-17**. In order to meet the MEP established threshold total nitrogen loads, it is estimated that the total buildout load in the Herring River watershed would need to be reduced by 39.6%.

Table 2-16 Sentinel and Check Stations with Associated Buildout Nitrogen Limits for the Herring River System

Embayment	Monitoring Station	Buildout Total N Concentration (mg/l)	Threshold Average Total N Concentration (mg/l)	% Change
Wixen Dock	HAR-6	0.471	0.384	-18.5%
Rt. 28 Bridge	HAR-7	0.671	0.479	-28.6%
Lothrop Road	HAR-8	1.019	0.583	-42.8%
North Road	HAR-9	0.991	0.648	-34.6%
West Reservoir	HAR-10	0.953	0.709	-25.6%

Source: Tables VI-6 and VIII-5 of the Herring River MEP Report
Values in RED indicate that the value is above the standard and must be reduced.

Table 2-17 Comparison of Sub-embayment Total Buildout Attenuated Watershed Loads and Threshold Loads for the Herring River System

Sub-embayment	Buildout Total Nitrogen Load (kg/day)	Threshold Total Nitrogen Load (kg/day)	Threshold Total Nitrogen Load Decrease (% change)
Lower Herring River	9.836	9.036	-8.1%
East Reservoir	0.293	0.293	0.0%
Upper Herring River	17.173	2.827	-83.5%
West Reservoir	37.011	27.564	-25.5%
Lothrop Road	15.071	8.255	-45.2%
Total	**79.384**	**47.975**	**-39.6%**

Source: Tables VI-4 and VIII-3 of the Swan Pond River MEP Report
Values in RED indicate that the value is above the standard and must be reduced.

In the buildout projection, septic system loading also accounts for most of the controllable nitrogen in the watershed. Overall, 56.59 kg/day, or roughly 20,655 kg/yr, total attenuated nitrogen was estimated to originate from septic systems within the watershed. This is about a 46.6% *increase* over present loads. In order to meet threshold nitrogen loads, it is estimated that the buildout septic load in the Herring River system watershed would need to be reduced by 58.0 %, as summarized in **Table 2-18** below, to meet the MEP established threshold.

Table 2-18 Buildout Attenuated Septic Loading in the Herring River System

Sub – Embayment	Buildout Septic Load (kg/day)	Threshold Septic Load (kg/day)	Threshold Septic Load Decrease (% change)
Lower Herring River	7.781	7.063	9.23%
East Reservoir	0.0048	0.0047	2.08%
Upper Herring River	13.945	0.000	100%
West Reservoir	23.592	12.137	48.55%
Lothrop Road	11.229	4.504	59.89%
Total	56.59	23.751	58.03%

Source: Table VIII-2 of the March 2013 Herring River MEP Report and associated loading spreadsheets (a.k.a. Rainbow Tables)
Values in RED indicate that the value is above the standard and must be reduced.

Under buildout conditions, additional septic nitrogen removal is required in all three of the subwatersheds that extend into Dennis. However, the land area within Dennis of the Lower Herring River and West Reservoir watersheds is minimal and is unlikely to have accounted for any additional buildout loads. There are 156 parcels within the town of Dennis fall into the Upper Herring River subembayment. Each community's contribution to the Herring River system is summarized below in **Table 2-19**. This table presents the *unattenuated* buildout nitrogen contribution from each community and the percentage of the total unattenuated load to the system.

Table 2-19 Unattenuated Buildout Septic Loading in the Herring River System by Community

Town	Unattenuated Present Septic Load (kg/day)	Unattenuated Buildout Septic Load (kg/day)	Buildout % of Total Nitrogen Load
Harwich	58.5	77.5	82.8%
Dennis	1.8	2.4	2.5%
Brewster	9.1	13.7	14.7%

Source: Herring River MEP Report loading spreadsheets (a.k.a. Rainbow Tables)

The Harwich Draft Comprehensive Wastewater Management Plan, dated February 2013, indicates that the town of Dennis is expected to manage its own septic system load within its portion of the Herring River system. Discussions between the two communities should occur to determine the most cost-effective solution.

2.3.4 Chase Garden Creek

The Chase Garden Creek Embayment System is included in the larger Barnstable Great Marshes-Bass Hole embayment. The draft report titled, "Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Threshold for the Barnstable Great Marshes-Bass Hole Estuarine System" was issued in June 2017. **Figure 2-14** shows the Chase Garden Creek system. Results from the report indicate that nitrogen removal from this watershed will not be required.

Watershed

Chase Garden Creek

Subwatershed deliniations for Chase Garden Creek are not included in the MEP

Town of Dennis, MA

N

1 in = 3,200 ft

0 0.5 1

Miles

Figure 2-14
Chase Garden Creek System

CDM Smith

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Physical Description

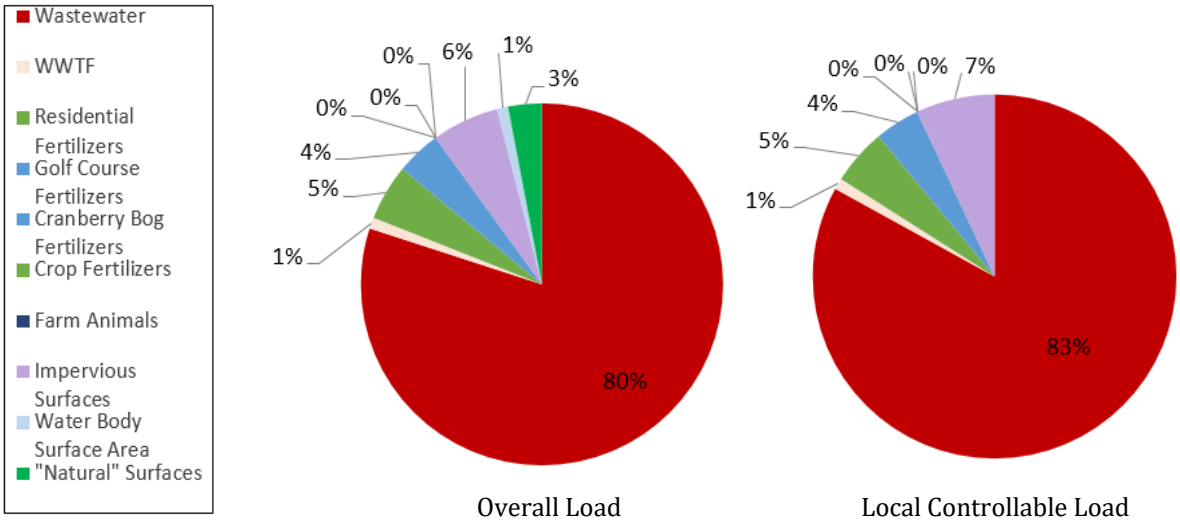
The Chase Garden Creek watershed is located on the northwest side of Dennis and is shared by both the towns of Dennis and Yarmouth. Subwatershed boundaries established by the MEP divided the watershed into 14 subsystems. Of these, the watersheds, Bass Hole (LT10), Chase Garden Creek Salt W (LT10), Chase Garden Creek Salt E (LT10), and Chase Garden Creek Salt W (GT10) cross the boundary between Dennis and Yarmouth. (Note that LT10 refers to a travel time to the estuary of less than 10 years and GT10 refers to a travel time of greater than 10 years.)

The Chase Garden Creek embayment system, often termed as both the Bass Hole or Chase Garden Creek, is primarily comprised of tributary salt marshes that discharge to Cape Cod Bay. Chase Garden Creek is the main stream that contributes flow to the main basin.

Land Use and Nitrogen Loading

Land use in the Chase Garden Creek watershed is dominated by public or undeveloped space, which accounts for 56% of the land. The next highest land use is occupied by residential use at 35%.

Natural deposition of atmospheric nitrogen on water bodies and natural land surfaces accounts for 4% of the total loading within the Chase Garden Creek system. Controllable sources, such as wastewater from septic systems and residential and commercial fertilizer applications, account for approximately 96% of the total nitrogen loading.



Source: Figure IV-5 e. of the Barnstable Marshes-Bass Hole MEP report

Figure 2-15: Land Use Specific Total and Controllable Unattenuated Nitrogen Loads to the Chase Garden Creek Watershed

Water Quality Indicators

Key habitat indicators including infaunal animals, eelgrass, dissolved oxygen/chlorophyll-a were used to assess the overall habitat quality of the subembayment. Overall, the system was given a healthy habitat rating. All indictors were rated as healthy with the exception of macro-algae and eelgrass as algae was absent during the survey and it was determined that the basin is not supportive of eelgrass. Based on the data collected during the study, it appears that the estuary system has not supported eelgrass for many decades. Therefore, the threshold development for protection/restoration of this system focused on infaunal animal habitat quality. The Great Marsh system is typical of other New England salt marsh dominated estuaries, which are naturally organic and nutrient rich and generally contain little water in the creeks at low tide as well as having open water areas with strong tidal currents and actively shifting sand bottoms near their tidal inlets.

Overall, the infauna survey indicated that all areas within the Barnstable Great Marsh estuary system are supporting healthy infauna habitat typical of open salt marsh dominated basins as well as organic rich New England salt marsh tidal creeks.

Monitoring Stations and Thresholds

In Chase Garden Creek, one sentinel station identified as Chase Garden Creek /Bass Hole station BSH-4 is at the upper boundary of the main tidal creek as shown in **Figure 2-16**. This location is positioned such that meeting the target criterion in this location will signify improved water quality throughout the tidal area.

The MEP report concludes that the Great Marshes and Bass Hole basins are presently supporting high quality infaunal habitat and have not exceeded their threshold nitrogen levels for assimilating additional nitrogen without impairment.

The threshold nitrogen concentration for the Chase Garden Creek /Bass Hole sentinel station BSH-4 is 0.158 mg/L. The MEP concluded that an upper limit of 0.158 mg/l of nitrogen would continue to support healthy infaunal habitat in the Chase Garden Creek system. The concentrations at the monitoring stations may be slightly different than the upper limit, but they are chosen so that the upper limit of 0.158 mg/l of nitrogen (tidally averaged) is achieved throughout the system. This is summarized in **Table 2-20**.

Watershed

- Monitoring Stations
- Chase Garden Creek

Town of Dennis, MA

N

1 in = 1,500 ft

0 0.25 0.5

Miles

Figure 2-16
Monitoring Stations in Chase Garden Creek Watershed

CDM Smith

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Table 2-20 Sentinel Monitoring Station with Associated Nitrogen Limit for the Great Marshes-Bass Hole System

Embayment	Monitoring Station	Present total N Concentration (mg/l)	Threshold average total N Concentration* (mg/l)	% Change
Scorton Creek	BM-13	0.121	0.156	+60.0%
Spring Creek	BM-11	0.127	0.161	+55.0%
Great Marshes -Upper	BM-12	0.111	0.139	+57.4%
Great Marshes -Upper	BM-1	0.097	0.116	+56.9%
Great Marshes – Mid	BM-2	0.085	0.096	+48.0%
Great Marshes – Lower	BM-3	0.072	0.077	+51.1%
Broad Sound	BM-10	0.105	0.126	+47.4
Bass Hole - Inlet	BSH-1	0.093	0.104	+36.8%
Bass Hole – Lower	BSH-2	0.111	0.128	+35.8%
Bass Hole - Mid	BSH-3	0.122	0.144	+37.2%
Bass Hole - Mid	BSH-4	0.132	0.158	+37.2%
Bass Hole - Upper	BSH-5	0.271	0.366	+45.5%
Bass Hole - Upper	BSH-6	0.571	0.695	+24.4%
Whites Brook	BSH-7	0.321	0.361	+15.3%

Source: Table VIII-5 of the June 2017 Barnstable Great Marshes-Bass Hole MEP Report
Values in RED indicate that the value is above the standard and must be reduced.

The MEP evaluation of habitat quality supported by the Chase Garden Creek system considers the natural structure of each system and its ability to support that habitat before determining the threshold septic load.

In looking at the total attenuated controllable load, the system can handle an increase of 39.6 percent nitrogen without seeing deleterious impacts, as shown in **Table 2-21**.

Table 2-21 Decrease in Present Great Marshes-Bass Hole System Attenuated Total Loading to Meet Nitrogen Thresholds

Sub – Embayment	Present Total Load (kg/day)	Threshold Total Load (kg/day)	Threshold Total Load Decrease (% change)
Barnstable Great Marshes - West	38.586	62.959	+63.2%
Barnstable Great Marshes - Mid	27.562	56.793	+106.1%
Barnstable Great Marshes – East	42.600	42.600	+0.0%
Millway	10.575	5.892	-44.3%
Bass Hole – West	29.666	36.944	+24.5%
Bass Hole - East	25.030	40.647	+62.4%
Bass Hole	7.408	7.408	+0.0%
Total	**181.427**	**253.242**	**+39.6%**

Source: Table VIII-3 of the June 2017 Barnstable Great Marshes-Bass Hole MEP Report
Values in RED indicate that the value is above the standard and must be reduced.

The primary source of nitrogen in the Chase Garden Creek watershed is septic system effluent, which accounts for a majority of total and controllable nitrogen loading. However, as mentioned above, the system is not currently experiencing negative impacts due to this presence of nitrogen and as such is able to accept additional nitrogen with deleterious impacts. It is estimated that the current total septic load in the Great Marshes/Bass Hole watershed would need to increase by 53.1 percent, as shown in **Table 2-22**, to exceed the threshold load.

Table 2-22 Decrease in Present Great Marshes-Bass Hole System Attenuated Septic Loading to Meet Nitrogen Thresholds

Sub – Embayment	Present Septic Load (kg/day)	Threshold Septic Load (kg/day)	Threshold Septic Load Decrease (% change)
Barnstable Great Marshes – West	26.364	50.737	+92.4%
Barnstable Great Marshes – Mid	19.488	48.719	+150.0%
Barnstable Great Marshes – East	32.397	32.397	0.0%
Millway	7.205	2.522	-65.0%
Bass Hole - West	23.107	30.385	+31.5%
Bass Hole – East	20.822	36.438	+75.0%
Bass Hole	5.847	5.847	0.0%
Total	**135.230**	**207.045**	**+53.1%**

Source: Table VIII-2 of the June 2017 Barnstable Great Marshes-Bass Hole MEP Report
Values in RED indicate that the value is above the standard and must be reduced.

The threshold septic loading for the Great Marshes/Bass Hole system is the sum of seven threshold loads developed in the MEP report for Barnstable Great Marshes-west, Barnstable Great Marshes-mid, Barnstable Great Marshes-east, Millway, Bass Hole-west, Bass Hole-east, Bass Hole sub-embayments. Together these seven thresholds combine to give a total threshold septic load for the watershed. To exceed the requirements of check and sentinel stations, attenuated septic loading to the system would need to increase by 53.1 percent.

Table 2-23 shows the concentrations at the sentinel and check stations under buildout conditions and the percent change to meet threshold concentrations. The total controllable buildout load reductions for each sub-embayment are shown in **Table 2-23**. In order to exceed the MEP established threshold total nitrogen loads, it is estimated that the total buildout load in the Great Marshes-Bass Hole watershed would need to increase by 10.1%.

Table 2-23 Sentinel and Check Stations with Associated Buildout Nitrogen Limits for the Great Marshes-Bass Hole System

Embayment	Monitoring Station	Buildout Total N Concentration (mg/l)	Threshold Average Total N Concentration (mg/l)	% Change
Scorton Creek	BM-13	0.136	0.156	+14.7%
Spring Creek	BM-11	0.141	0.161	+14.1%
Great Marshes – Upper	BM-12	0.123	0.139	+13.0%
Great Marshes – Upper	BM-1	0.105	0.166	+58.0%
Great Marshes – Mid	BM-2	0.090	0.096	+6.6%
Great Marshes – Lower	BM-3	0.075	0.077	+2.6%
Broad Sound	BM-10	0.166	0.126	-24.0%
Bass Hole – Inlet	BSH-1	0.095	0.104	+9.4%
Bass Hole - Lower	BSH-2	0.155	0.128	-17.4%
Bass Hole - Mid	BSH-3	0.127	0.144	+13.3%
Bass Hole – Mid	BSH-4	0.139	0.158	+13.6%
Bass Hole -Upper	BSH-5	0.292	0.366	+25.3%
Bass Hole – Upper	BSH-6	0.626	0.695	+11.0%
Whites Brook	BSH-7	0.344	0.361	+4.9%
Total		**2.614**	**2.877**	**+10.1%**

Source: Tables VI-7 and VIII-5 of the June 2017 Barnstable Great Marshes-Bass Hole MEP Report
Values in RED indicate that the value is above the standard and must be reduced.

Table 2-24 Comparison of Sub-embayment Total Buildout Attenuated Watershed Loads and Threshold Loads for the Great Marshes-Bass Hole System

Sub-embayment	Buildout Total Nitrogen Load (kg/day)	Threshold Total Nitrogen Load (kg/day)	Threshold Total Nitrogen Load Change (% change)
Barnstable Great Marshes – West	48.452	62.959	+29.9%
Barnstable Great Marshes - Mid	33.964	56.793	+67.2%
Barnstable Great Marshes – East	60.115	42.600	-29.1%
Millway	12.679	5.892	-53.5%
Bass Hole – West	31.896	36.944	+15.8%
Bass Hole – East	27.581	40.647	+47.3%
Bass Hole	7.770	7.408	-4.6%
Total	**222.457**	253.243	**+13.8%**

Source: Tables VI-6 and VIII-3 of the June 2017 Barnstable Great Marshes-Bass Hole Report
Values in RED indicate that the value is above the standard and must be reduced.

Under buildout conditions, a small amount of nitrogen removal is required in the Bass Hole subwatershed which is partially located within the Town of Dennis; however, as a whole watershed, the total buildout nitrogen load is less than the threshold total load.

2.3.5 Sesuit Harbor Preliminary Results

The Sesuit Harbor Embayment System is also in the process of being evaluated by the MEP. An initial analysis had been completed for this system; however, in 2007, following the completion of sampling, the 24-inch culvert at Bridge Street was replaced with two twin 10 by 12 box culverts. In addition, culvert work was performed under Route 6A and Dr. Lord's Road South (near Scargo Lake), in an effort to restore the herring run all the way to Scargo Lake from the inlet at Sesuit Harbor. Post-construction conditions within the estuarine system were notably different than before, so the MEP analysis required re-sampling and new modeling runs. This work is still in progress, and a completion date has not been set, due to funding uncertainties.

Figure 2-17 shows the Sesuit Harbor system, which includes Scargo Lake. Scargo Lake is the largest lake in Dennis and is described in more detail in Section 3, as it is a freshwater lake.

2.4 Water Quality Concerns in Non-MEP Watersheds

2.4.1 Quivett Creek (non-MEP watershed)

The Quivett Creek watershed is located in the northeast area of Dennis and in the adjacent town of Brewster (see **Figure 2-18).** This watershed has four freshwater ponds and encompasses 1,177 acres of land area. The watershed has 623 buildings greater than 200 square feet with a density of 0.52 buildings per acre. It has estimated open space acreage of 298 acres. The watershed has 243 acres estimated to be less than 5 feet to groundwater, mostly located along Quivett Creek itself. This watershed also has poorly drained soils. However, the poor soils and high groundwater in the Quivett Creek watershed are located primarily in the marshlands to the north. The MEP program has no current plans to study the Quivett Creek watershed.

The Quivett Creek saltmarsh lies along the shoreline of Cape Cod Bay. Salt marshes are coastal wetlands that are rich in marine life and are sometimes called tidal marshes. These tidal marshes occur in the zone between the high and the low tides. Salt marshes are typically dominated by stands of rushes, sedges, and grasses. Salt marshes provide nursery areas for fish, shellfish and crustaceans and help to stabilize the shoreline from storm surges. They also act as pollutant filters since they can absorb and trap some of the pollutant loads entering estuaries. Lastly, salt marshes can help in slowing coastal erosion by preventing sediments from washing offshore.

In general Cape Cod Bay waters have high quality. However, there are occasional exceedances of MassDEP water quality standards for fecal coliform bacteria and enterococci at the public beaches. Due to occasional high bacteria levels, MassDEP issued a pathogen TMDL for Quivett Creek. The source of the pathogens was not identified in the TMDL report but could be related to birds and other animals or increased stormwater from the significant growth that Cape Cod has experienced through the years.

2.4.2 Direct Discharge Areas

As shown in Figure 2-1, substantial areas along both the northern and southern coastlines of Dennis have direct discharge of groundwater to Cape Cod Bay and Nantucket Sound, respectively.

Watershed

MEP Watershed Delineations

Subwatershed deliniations for Sesuit Harbor are to be decided by the MEP

Town of Dennis, MA

N

1 in = 1,550 ft

0 0.25 0.5

Miles

Figure 2-17
Sesuit Harbor System
Preliminary Results

CDM Smith

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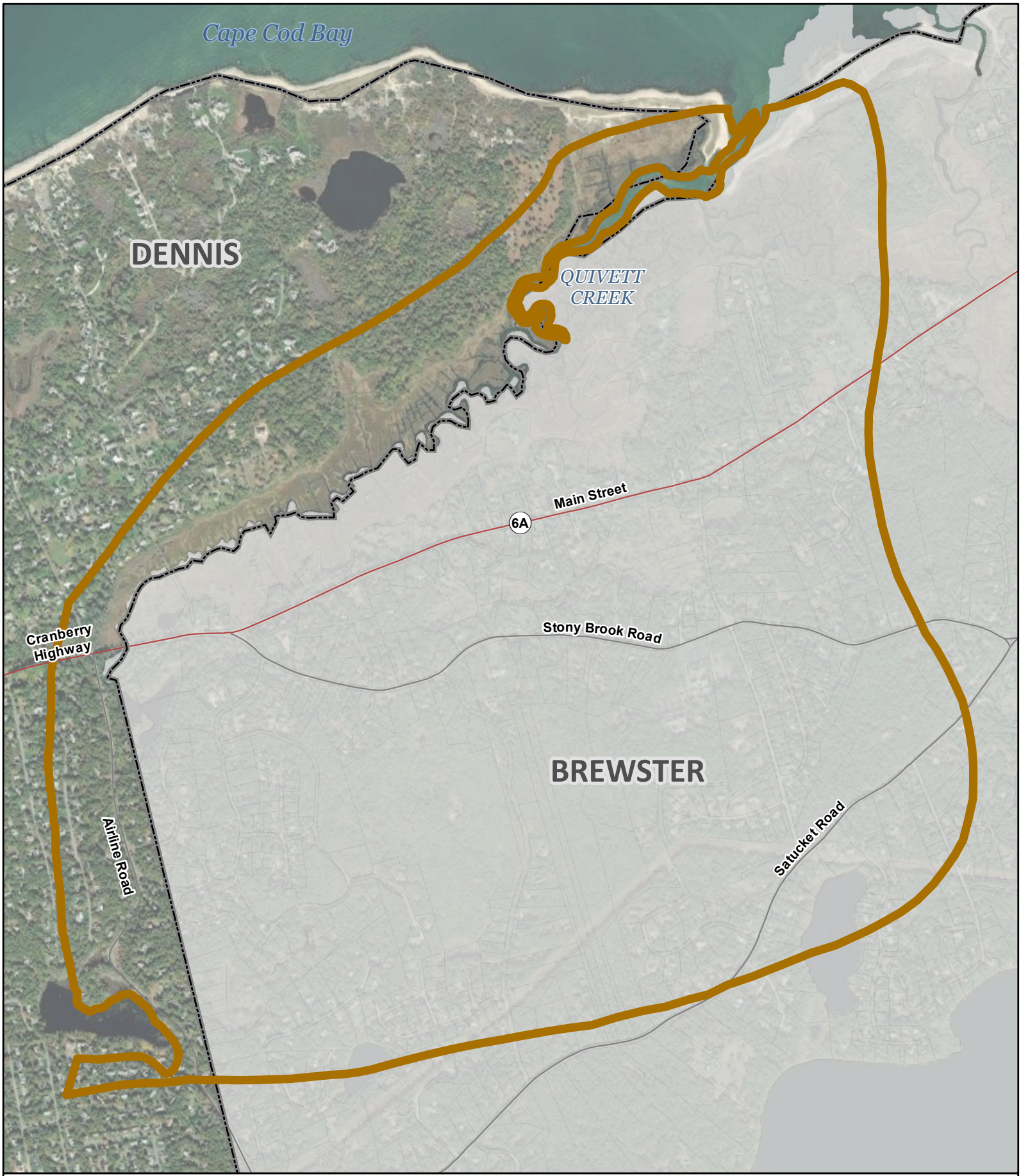

Watershed

MEP Watershed Delineations

Subwatershed deliniations for Quivett Creek are not included in the MEP

Town of Dennis, MA

N

1 in = 1,200 ft

0 0.15 0.3

Miles

Figure 2-18
Quivett Creek System

CDM Smith

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Since tidal flushing is not restricted in these direct discharge areas, nitrogen inputs from the adjacent watersheds are not held within the system for any substantial period of time, and thus impacts to the coastal marine ecological environments have not been seen. For this reason, nitrogen standards have not been set for these direct discharge areas. Nitrogen loads removed from MEP watersheds and treated to low levels could be discharged within direct discharge watershed areas provided that other environmental impacts are not identified. Further discussion of beach water quality along these coastlines is provided in Section 5.

2.5 MassDEP Eelgrass Mapping Program

Eelgrass is used as a biological health indicator to assess the impacts of nutrients on overall ecosystem health. Impacts to eelgrass beds were used to assess the health of Dennis' bays, estuaries, and rivers early in the MEP process. Much of this information was based on the MassDEP Eelgrass Mapping Program data described herein. Eelgrass beds in Dennis' estuaries were delineated as part of the MassDEP program in 1995 and 2001. Mapping of this information is available through MassGIS (http://maps.massgis.state.ma.us/images/dep/eelgrass/eelgrass_map.htm). Aerial photographs from 1951 were compared to the MassDEP maps to estimate the distribution of eelgrass prior to watershed development. Continued mapping of eelgrass beds in future years by MassDEP is anticipated.

There has been no eelgrass within the Dennis portion of the Herring River watershed. Eelgrass was present in the Herring River in 1995 up to the limits of the mapping project at the Route 28 Bridge in Harwich. The eelgrass coverage in the Herring River declined in 2001 and had declined to a negligible amount in 2010.

The eelgrass coverage in Cape Cod Bay was limited outside of the Chase Garden Creek watershed in 1995 and saw a decline until 2012 where a significant amount of eelgrass was present. The eelgrass coverage in Nantucket Sound at the Dennis beaches has declined significantly since 1995. There has been no eelgrass present in the Swan Pond watershed since 2001. The Bass River watershed has seen a fluctuation of eelgrass presence since 1995, but currently has very little. Additional details regarding the historic extent of eelgrass are provided above with regards to the individual MEP watersheds.

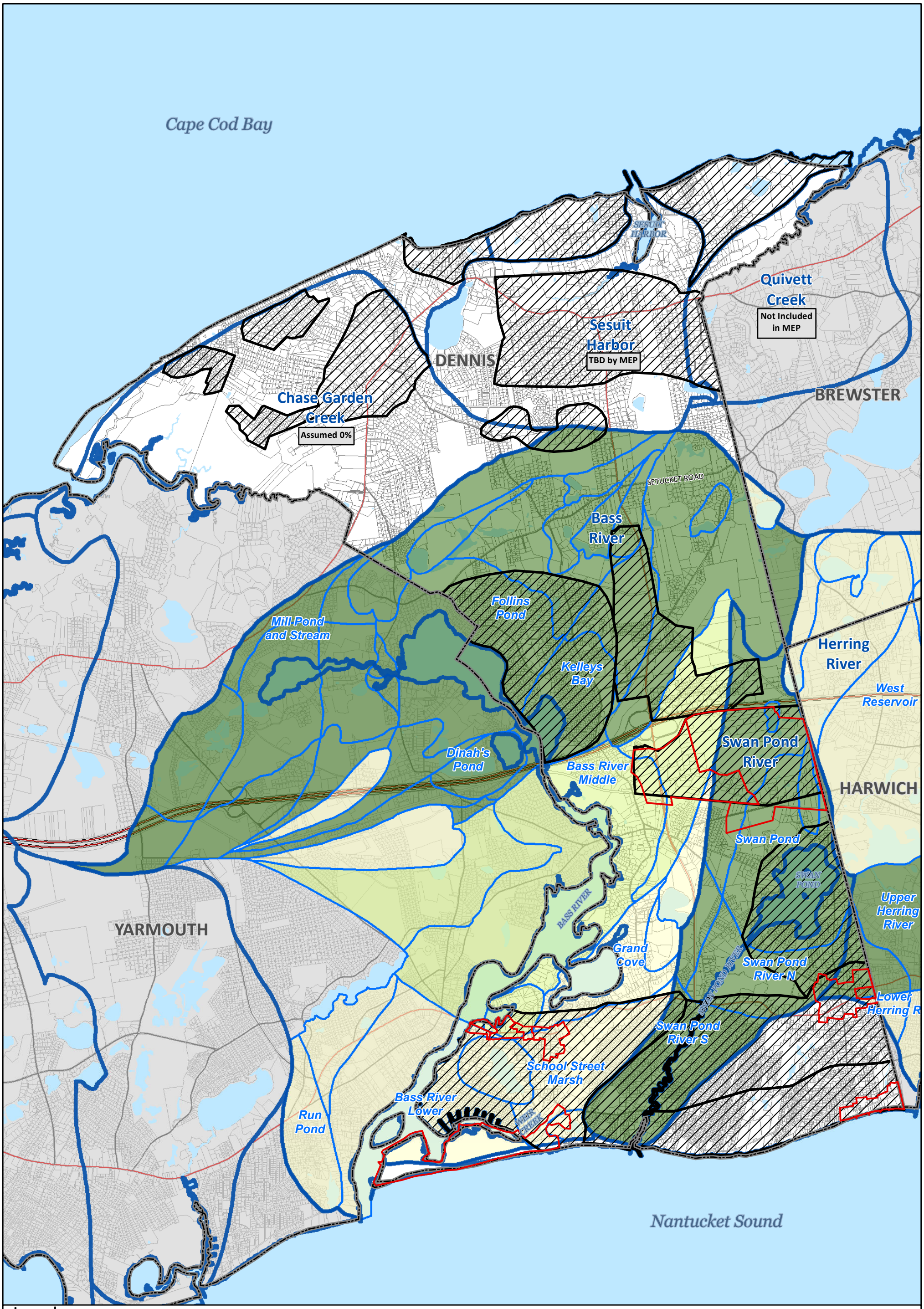
2.6 Summary

This section summarizes the findings of the MEP investigation of the five embayments within the Town of Dennis, as well as the one non-MEP watershed, Quivett Creek. Conclusions from these investigations will be used to develop strategies to mitigate the water quality impacts of excessive nitrogen loading via this Water Quality Evaluation and Mitigation Alternative Study, as described further in Section 10 of this report.

Since embayment systems are shared by several towns, each individual community will need to develop a mutually beneficial plan aimed at reducing excess nutrients in the subwatersheds that fall within its boundaries. From a management perspective, each community will want to understand its individual contribution to each subwatershed and may develop a plan that will

address their contribution and ultimately meet the established thresholds. Regional solutions are also encouraged.

Figures 2-19 and 2-20 depict the aggregation of the MEP data to date, showing the septic system and total controllable nitrogen load reduction requirements, respectively. This information has been used later in this study to develop mitigation alternatives to meet the thresholds identified herein.



Legend

- MEP Watershed Delineations
- MEP Subwatersheds
- Area of Concern
- Planning Districts

Proposed Septic Nitrogen Removal from MEP to Meet TMDL

- 90-100%
- 60-70%
- 0%

Town of Dennis, MA

N

1 in = 3,500 ft

0 0.5 1

Miles

Watershed Septic Load Reductions

Figure 2-19

CDM Smith

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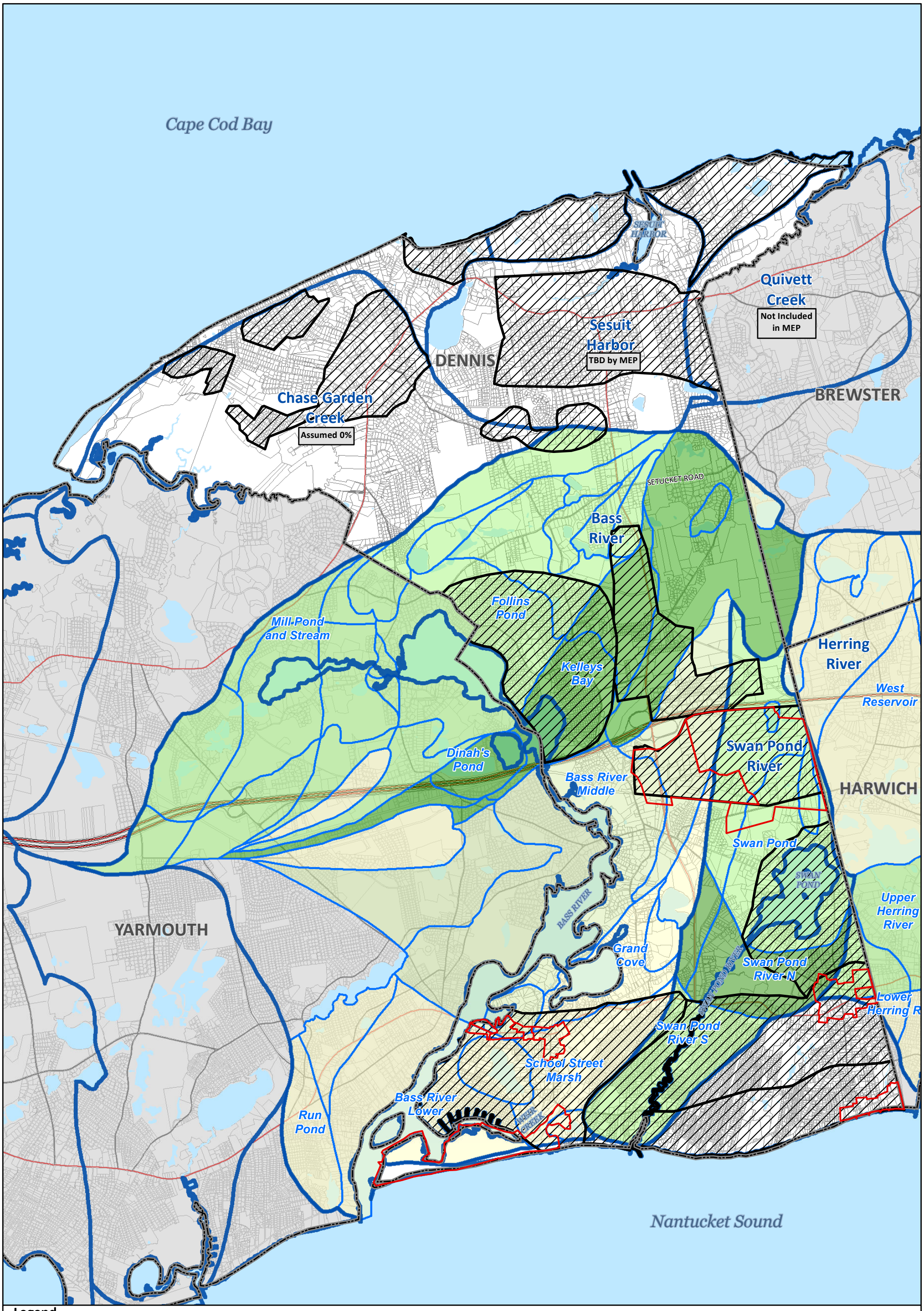

Legend

- MEP Watershed Delineations
- MEP Subwatersheds
- Area of Concern
- Planning Districts

Proposed Controllable Nitrogen Removal from MEP to Meet TMDL

- 80-90%
- 70-80%
- 50-60%
- 0%

Town of Dennis, MA

N

1 in = 3,500 ft

0 0.5 1

Miles

Proposed MEP Controllable Nitrogen Removal

Figure 2-20

CDM Smith

NEWELLJD F:\Dennis\DATA\MXD\Total_Nitrogen_Removals.mxd 10/25/2021

Section 3
Evaluation of Freshwater Ponds

3.1 Introduction

The Town of Dennis has approximately 29 ponds with a total area of 749 acres, including three ponds shared with neighboring towns. The Dennis Local Comprehensive Plan stresses the importance of maintaining the health and quality of the Town's freshwater resources. The Plan states that the freshwater shorelines are classified as "coastal plain pondshores," which provide habitat to rare and endangered plants and animals. Each of these ponds is shown on **Figure 3-1** and listed in **Table 3-1** below. The Cape Cod Pond and Lake Stewardship (PALS) program has consistently sampled up to seventeen locations annually in eleven of Dennis' ponds, typically in August and/or September. Data from the PALS sampling program for 2004 through 2013 were reviewed for this analysis. In addition, PALS summary data from the 2001-2002 Cape Cod Pond and Lake Atlas were considered, herein referred to as the Pond and Lake Atlas. Ponds with detailed PALS sampling data are noted in Table 3-1 and on Figure 3-1.

Table 3-1 List of Dennis Ponds (Table continues page 3-3)

Name	Area (Acres)	Max Depth (feet)	PALS Sampling Years for Data Provided
Aunt Pattys Pond	9.1	-	-
Bakers Pond	9.5	19.0	2004-2013
Cash Pond	2.5	-	-
Cedar Pond	9.4	13.9	2004-2013
Clay Pond	3.9	-	-
Coles Pond	11.2	5.2	2004-2013
Duck Pond	0.4	-	-
Eagle Pond	8.0	24.0	2004-2013
Flax Pond	17.0	29.0	2004-2013
Follins Pond	306.9	-	-
Fresh Pond	31.6	9.2	2004-2013
Funn Pond	5.2	-	-
Grassy Pond	11.8	-	-
Great Pond Plash	1.9	-	-
Hiram Pond	1.2	20.0	2004-2010
Jonathans Pond	0.3	-	-
Kelleys Pond	29.8	-	-
Little Coles Pond	3.8	-	-
Northern Simmons Pond	5.6	21.3	2004-2013
Pine Pond	23.3	-	-
Run Pond	8.1	10.5	2004-2013
Scargo Lake	59.3	45.0	2004-2013
Southern Simmons Pond	5.7	-	-
Swan Pond	153.7	-	-

Legend

- Lakes and Ponds
- Lakes and Ponds with PALS Data

Town of Dennis, MA

Figure 3-1
Ponds with PALS Data

1 in = 4,500 ft

0 0.5 1

Miles

Note: Some ponds under private ownership were unnamed in Cape Cod Pond Data.

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Table 3-1 List of Dennis Ponds (continued from page 3-1)

Name	Area (Acres)	Max Depth (feet)	PALS Sampling Years for Data Provided
The Plashes	2.4	-	-
Uncle Stephens Pond	6.7	-	-
Weir Creek	5.5	-	-
Whites Pond	12.1	26.7	2004-2013
Whittemores Pond	2.9	-	-

In September 2009, the 2001 to 2008 PALS data were analyzed in a report titled, "Dennis Freshwater Ponds: Water Quality Status and Recommendations for Future Activities" (SMAST, 2009), herein referred to as the Dennis Ponds Report. Specifically, this report references PALS data for Bakers Pond, Cedar Pond, Coles Pond, Eagle Pond, Flax Pond, Fresh Pond, Hiram Pond, Northern Simmons Pond, Run Pond, Scargo Lake, and White Pond and presents a graphical analysis of data comparing all ponds. The Dennis Ponds Report also presents individual pond reviews for Bakers Pond, Cedar Pond, Coles Pond, Eagle Pond, Flax Pond, and Scargo Lake. Only ponds with individual reviews include a detailed phosphorus budget for the pond's surrounding area to determine sources and magnitudes of phosphorus loading.

The following additional sources were also considered in the analysis herein:

- Comprehensive Wastewater Management Planning Project Final Needs Assessment Report (Stearns & Wheler, LLC, 2005), herein referred to as the 2005 Needs Assessment Report
- Dennis MA Local Comprehensive Plan: Freshwater Resources (2011), herein referred to as the Freshwater Resources Plan
- Scargo Lake Technical Support Project Memorandum (SMAST, 2012), herein referred to as the Scargo Lake Memo
- Scargo Lake Water Quality Management Report (SMAST, 2012), herein referred to as the Scargo Lake Report
- Eagle Pond and Cedar Pond Technical Support Project Memorandum (SMAST, 2012), herein referred to as the Eagle and Cedar Pond Memo
- Linked Watershed-Embayment Approach to Determine Critical Nitrogen Loading Thresholds for the Swan Pond River Embayment System (SMAST, Applied Coastal, and CCC, 2012), herein referred to as the Swan Pond River MEP Report
- Swan Pond River: Tidal Attenuation Study (Applied Coastal, 2011), herein referred to as the Swan Pond River Tidal Study
- Massachusetts Year 2012 Integrated List of Waters (MassDEP, 2012), herein referred to as MassDEP's Comprehehsive List
- Dennis Comprehensive Planning Documents, Section 2.4 Wildlife and Plant Habitat (Town of Dennis, 2010), herein referred to as the Wildlife and Plant Habitat excerpt

- Dennis Comprehensive Planning Documents, Section 2.3 Wetlands (Town of Dennis, 2010), herein referred to as the Wetlands excerpt
- Town of Dennis Land Map (Dennis Department of Natural Resources, 2012), herein referred to as the Dennis Land Map
- Status of Town of Dennis Freshwater Ponds 2011-2015 Water Quality Database Development Final Report (Town of Dennis, 2016), herein referred to as the Dennis Freshwater Ponds Report

3.1.1 Water Quality in Kettle Ponds

Ponds in Dennis are primarily kettle ponds, formed as depressions left by ice blocks following the retreat of the glaciers. In their original state, the ponds on Cape Cod are naturally clear and acidic due to few sources of nutrients and soils of granitic origin. The pond water surface elevation is often a reflection of the groundwater table.

The typical physical setting of the ponds on Cape Cod aids to both protect and threaten their water quality. The protection is offered by the relatively high permeability soils of the ponds' watersheds. These soils soak up precipitation resulting in limited runoff in an unaltered watershed. The soils also tend to bind phosphorus, making it unavailable for transport through groundwater into the ponds; though with sufficient time (several decades or longer) and/or with a very large source (such as a discharge of effluent from a wastewater treatment plant that does not treat for phosphorus), the binding sites will be occupied and continued addition of phosphorus will move through the soils.

The introduction of phosphorus to ponds is important because an increase in phosphorus will increase plant growth (typically as algae), which can lead to degraded water quality through loss of water transparency, noxious algal blooms, and impairment or death of aquatic life through loss of oxygen.

Kettle ponds are sensitive to anthropogenic phosphorus loadings, and even a small increase in phosphorus can alter the pond's water quality. The physical setting is thus a threat to water quality because most kettle ponds have long residence times (slow flushing rates). This means that additional phosphorus that reaches the ponds will remain in the ponds unless lost through an outlet stream (for those few ponds with outlets) or by deep burial. Thus, many kettle ponds have their principal source of phosphorus generated from within the pond, typically through regeneration of phosphorus at the sediment-water interface under no oxygen (anoxic) conditions. In kettle ponds, historic sources of phosphorus such as fertilizer runoff from agricultural activities or large waterfowl populations can continue to affect pond water quality long after their input.

3.1.2 Indicators of Pond Health

The PALS sampling program involves collecting Secchi depth readings, vertical profiles (multiple readings with depth) of temperature, pH, and dissolved oxygen (DO), and two discrete samples (top and near bottom of the pond) for analysis of phosphorus, total nitrogen (TN), and chlorophyll-a concentrations. The use of these parameters in assessing pond health is discussed below.

- **Secchi depth**: Secchi depth is a measure of water clarity. It is the depth at which a Secchi disk can no longer be seen as it is lowered through the water column. Waters with low Secchi depth readings can occur naturally (e.g., if wind/waves suspend bottom sediment) or be an indicator of degraded pond health (e.g., high concentrations of algae). A Secchi depth of 4 feet or more generally indicates suitability for swimming based on water clarity.

- **Dissolved oxygen:** Adequate concentrations of dissolved oxygen are necessary to sustain fish and other aquatic organisms and prevent offensive odors.

  MassDEP's water quality standards require oxygen levels to be greater than either 5 or 6 mg/L depending on the characteristics of the pond. Some Dennis ponds are considered shallow ponds and thus must meet the 5 mg/L threshold to support warm-water fish.

  Waters are termed anoxic when oxygen levels drop below 1 mg/L. When a shallow pond has little to no oxygen at its bottom, this suggests that the decomposition of organic matter at the pond bottom is sufficient to use all available oxygen in between mixing. When a pond has anoxic bottom waters, phosphorus can be regenerated from the sediments to the overlying waters, which in shallow ponds is typically available to fuel algae or aquatic plant growth.

- **Phosphorus**: Phosphorus is a key nutrient influencing plant growth in ponds. Phosphorus is usually the limiting nutrient to freshwater ponds here in New England, such that increasing its concentration alone will result in greater plant productivity.

  Currently, MassDEP does not have a numerical criterion for phosphorus unless the water body is subject to a TMDL or site-specific criterion; however, discharges that result in excessive aquatic plant or algal growth (eutrophication) need to be controlled.

- **Nitrogen:** Nitrogen is an essential nutrient for plant growth; nitrogen is usually sufficiently abundant in freshwater systems and thus does not limit plant growth. In some highly eutrophic lakes (which have excess phosphorus – more than plants can use to grow), nitrogen can become the limiting nutrient for plant productivity. In these cases, an ecological advantage is afforded to certain blue-green algae that have the ability to obtain nitrogen from the atmosphere (called fixing nitrogen) and use this nitrogen as a nutrient source to fuel algal growth. Thus nitrogen limitation in ponds with excess phosphorus concentrations can be a factor in blue-green algal blooms.

  Currently, MassDEP does not have a numerical criterion for nitrogen unless the water body is subject to a Total Maximum Daily Load (TMDL) or site-specific criterion; however, discharges that result in excessive aquatic plant or algal growth (eutrophication) need to be controlled.

- **Chlorophyll-a**: Chlorophyll-a is a direct measure of a green pigment that transforms light energy into chemical energy in photosynthesis. Chlorophyll-a indicates the presence of phytoplankton (algae) biomass; the trophic status of ponds is often determined from the summer mean chlorophyll-a concentrations.

Currently, MassDEP does not have a numerical criterion for chlorophyll-a unless the water body is subject to a TMDL or site-specific criterion. However, the Commonwealth's water quality standards may be modified in the near future to include a new standard for chlorophyll-a. The standard would allow chlorophyll-a levels to exceed 16 µg/L only once during a growing season.

There are two additional methods for using water quality data to evaluate pond health: trophic status and the guidelines for pond health established by the Cape Cod Commission (CCC).

- **Trophic Status**: This is an integrative measure typically considering at least one of the following parameters: Secchi depth, seasonal average phosphorus concentration, and chlorophyll-a concentration. A common trophic status index (TSI) was derived by Carlson from work on northern temperate lakes. **Table 3-2** (www.Secchidipin.org/tsi.htm) provides values used to evaluate the TSI and gives examples how fisheries and recreation in these lakes can be affected as the trophic status moves from oligotrophic to mesotrophic to eutrophic.

Table 3-2 Carlson Trophic Status Index Metrics

TSI	Chloro-phyll (ug/L)	Secchi Depth (feet)	Total Phosphorus (ug/L)	Attributes	Fisheries & Recreation
<30	<0.95	>26	<6	Oligotrophy: Clear water, oxygen throughout the year in the bottom waters	Salmonid fisheries dominate
30-40	0.95-2.6	26-13	6-12	Bottom waters of shallower lakes may become anoxic	Salmonid fisheries in deep lakes only
40-50	2.6-7.3	13-7	12-24	Mesotrophy: Water moderately clear; increasing probability of no oxygen in bottom waters during summer	Lack of oxygen in bottom waters results in loss of salmonids.
50-60	7.3-20	7-3	24-48	Eutrophy: No oxygen in bottom waters, macrophyte problems possible	Warm-water fisheries only. Bass may dominate.
60-70	20-56	1.5-3	48-96	Blue-green algae dominate, algal scums and macrophyte problems	Nuisance macrophytes, algal scums, and low transparency may discourage swimming and boating
70-80	56-155	0.8-1.5	96-192	Hypereutrophy: (light limited productivity). Dense algae and macrophytes	*
>80	>155	<0.8	192-384	Algal scums, few macrophytes	Rough fish dominate; summer fish kills possible

Note: (*) Data not provided

- **CCC guidelines:** The CCC has established guidelines for pond health for phosphorus, nitrogen, and chlorophyll-a concentrations. The guidelines are based on the statistical analysis of data from 195 ponds in the first PALS snapshot in 2001, and they establish threshold values to "identify ponds minimally impacted by human activities." The threshold values were determined following a USEPA methodology for establishing eco-region

reference values. The two threshold values developed by the CCC represent (1) the lower 25th percentile of all water quality data and (2) the upper 25th percentile of unimpacted ponds. The second reference value is based on 2001 water quality data of eight ponds across the Cape. The reference values are shown in **Table 3-3** below.

Table 3-3 CCC Pond Water Quality Guidelines

Water Quality Indicator	Lower 25th Percentile of All Ponds	Upper 25th Percentile of Unimpacted Pond
Total Phosphorus (µg/L)	10	7.5
Total Nitrogen (mg/L)	0.31	0.16
Chlorophyll-a (µg/L)	1.7	1.0

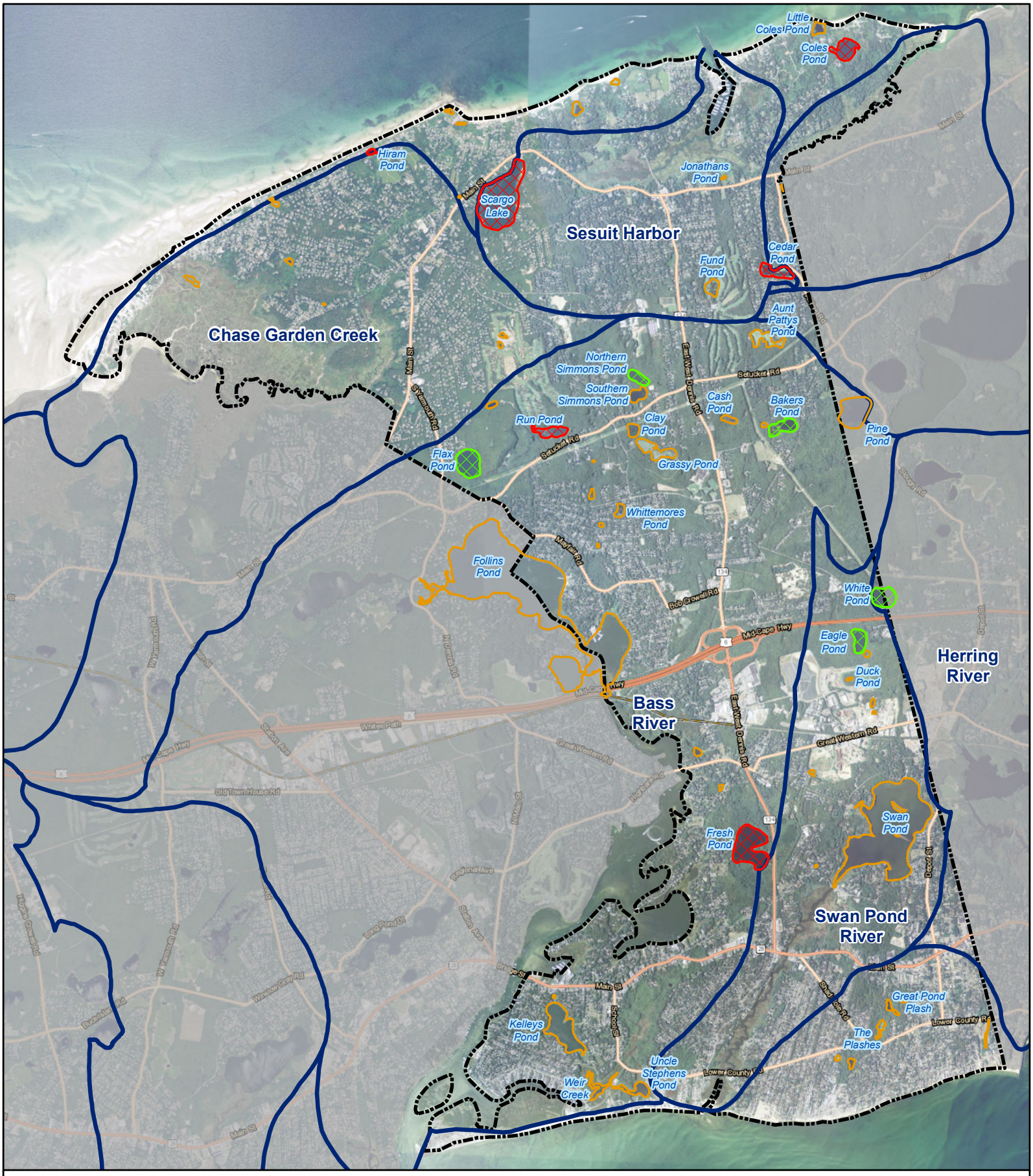
3.2 Assessment of Pond Health in Dennis

The 2004 through 2013 PALS data for Dennis ponds were reviewed and compared to the indicators of pond health described above. These results were then compared to the previous water quality analyses in the reports listed above. This assessment can be used to suggest if development surrounding ponds is contributing to degradation of pond health. Such degradation could be caused by inputs from nearby septic systems or by potentially significant sources of nutrients in stormwater runoff such as impervious surfaces, excess fertilizer application, or discharges from cranberry bogs. Phosphorus may also come from regeneration from bottom sediments in ponds or from birds and other wildlife.

Traditionally studies of Cape Cod's water resources use a 300-ft distance as the zone-of-influence for phosphorus travel in groundwater to ponds and other waterbodies (see, for example, the Massachusetts Estuaries Project studies). While Title 5 (310 CMR 15.00) defines the minimum septic system setback distance as 50 feet for the conditions found in Dennis, the Cape Cod Regional Policy Plan has a 300-ft setback for septic leach fields.

Given the range of potential sources, data on pond water quality alone may not be sufficient to determine if changes in wastewater or stormwater practices near a pond will improve pond health. However, in this section, available water quality data is analyzed along with the degree of development near each pond to suggest if future actions should be considered to improve pond health. In general, actions are either watershed-based measures to address external sources of phosphorus, or in-lake measures to address internal loading (from sediment regeneration). It is important to understand the relative magnitude of internal versus external loads since action taken to address one may not successfully improve pond health if it is not the dominant load to a pond. In some instances, it may be necessary to take both watershed and in-lake actions.

Figure 3-2 presents the results of this pond analysis, showing the ponds which were identified as having high water quality versus those identified as impaired.



Legend

- High Water Quality
- Impaired Water Quality
- No PALS Data
- Watershed Boundaries

Note: Some ponds under private ownership were unnamed in Cape Cod Pond Data.

Town of Dennis, MA

N

1 in = 4,500 ft

0 0.5 1

Miles

Figure 3-2
Pond Water Quality

CDM Smith

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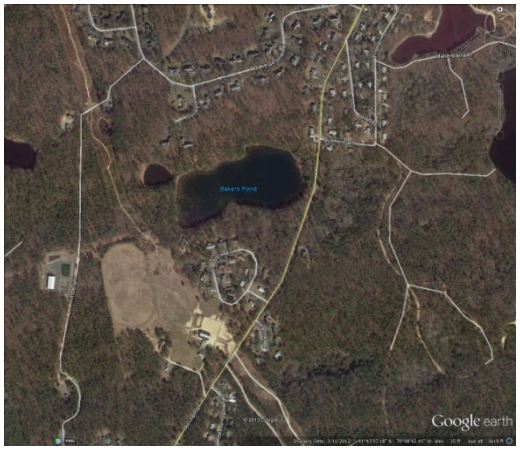
3.2.1 Bakers Pond



Satellite Image of Bakers Pond

Bakers Pond was characterized as an oligotrophic pond according to the Dennis Ponds Report, which aligns with the discrete data analyzed here. The Pond and Lake Atlas lists the maximum depth as 5.79 m (19 ft). The Dennis Ponds Report has classified Bakers Pond as a warm-water fisheries pond, as the average temperature at all depths is above 20°C. As listed by the Dennis Ponds Report, the smaller water body to the northwest of Bakers Pond is a relic cranberry bog with an impoundment separating it from Bakers Pond. To the east, the pond is less than 100 feet from Airline Road. There are 9 developed housing units that are within the 300-ft buffer zone. In past orthophotos, historic algae growth can be found, which may suggest high levels of phosphorus.

Discrete data from 2004-2013 are summarized below:

- None of 58 recorded DO measurements were below the DO threshold of 5 mg/L for shallow, warm-water ponds, excluding the two non-detect measurements.
- The average total phosphorus concentrations were generally in the mesotrophic range, with noticeably high concentrations in 2004, 2005, 2011, and 2012.
- The average Secchi depth reading was 14.6 feet, which makes the pond's clarity exceptional for swimming.
- Concentrations of chlorophyll-a at any depth did not exceed 16 µg/L for any of the 23 readings.

3.2.2 Cedar Pond

Satellite Image of Cedar Pond

The Dennis Ponds Report characterized Cedar Pond as a eutrophic pond, which agreed with the discrete data. The average maximum depth recorded in the Dennis Ponds Report was 3.8 m (12.6 ft), which was also consistent with the PALS data. The average temperature was above 20°C for all but the deepest measurements of the pond. The Dennis Ponds Report classified Cedar Pond as a warm-water fisheries pond.

The shoreline of Cedar Pond has approximately fifteen housing units within a 300-ft buffer from the water's edge. According to the Dennis Ponds Report, there are eighteen properties located within the 300-ft buffer zone, fifteen of which have septic leaching pits within that buffer zone. Located 600 feet to the west of Cedar Pond is a golf course, and the eastern edge of the pond is as close as 50 feet to Airline Road. The area surrounding the pond has medium-to-high density residential units. Golf

course runoff, road runoff, and the leaching septic systems may contribute to pond contamination. Also in the Dennis Ponds Report, Cedar Pond was observed as having macrophytes, aquatic plants, along the northern shoreline; current orthophotos show this growth in the southeastern area of the pond as well. Generally, historical orthophotos show multiple instances of algal growth.

The Dennis Ponds Report identified Cedar Pond as an impaired water body from analysis of PALS data from 2001 to 2008. The Eagle and Cedar Pond Memo described activities such as a bird population survey to determine potential phosphorus loading, a bathymetric survey, an aquatic plant survey, and a freshwater mussel distribution survey that have begun at Cedar Pond.

Discrete data from 2004-2013 are summarized below.

- 17 out of 49 DO measurements were below the state DO threshold of 5 mg/L for shallow, warm-water ponds.
- The average total phosphorus concentrations were between mesotrophic and eutrophic ranges, with concentration increases at the deepest depths, specifically in 2005 and 2006.
- The average Secchi depth reading was 7.0 feet, which makes the pond's clarity suitable for swimming.
- There were 4 of 25 instances where concentrations of chlorophyll-a exceeded 16 µg/L, 3 occurring in 2006 and one occurring in 2005.

3.2.3 Coles Pond

Satellite Image of Coles Pond

The Dennis Ponds Report and the discrete data agreed that Coles Pond was characterized as a eutrophic pond. Similar average maximum depths of 1.4 m (4.6 ft) and 1.35 m (4.43 ft) were recorded by the Dennis Ponds Report and the discrete data. Also, in the Dennis Ponds Report, Coles Pond is classified as a shallow, warm-water fisheries pond with water temperature above 20°C at all depths. Historic orthophotos of Coles Pond show evidence of a wetland with varying levels of growth directly north of the pond. The Wildlife and Plant Habitat excerpt for the pond suggests that the surrounding area is coastal wetlands with the potential for growth of rare species. Coles Pond is bordered by the Plymouth Gentian (Sabatia kennedyana), an endangered plant that is rare on Cape Cod and endangered in the US.

The shoreline of Coles Pond has four units within a 300-ft buffer from the water's edge, where two are residential, one is a condominium complex, and one is town owned. The shoreline also has at least five access paths or docks. South Road is approximately 200 feet from the pond's edge, but the surrounding area is generally undeveloped with the ocean about 700 feet to the north.

Discrete data from 2004 to 2013 are summarized below:

- 12 of 34 recorded DO measurements were below the DO threshold of 5 mg/L for shallow, warm-water ponds, excluding 2 non-detect measurements and 3 outlying measurements from 2006.
- The average total phosphorus concentrations were within the eutrophic range with an increase in concentrations in 2007.
- The average Secchi depth reading was 4.23 feet, which makes the pond's clarity suitable for swimming; however there were 5 out of 13 readings that were unsuitable for swimming.
- Concentrations of chlorophyll-a exceeded 16 µg/L for 6 out of 24 readings, 3 of which were in 2006 and 3 of which were at a depth of 0.5 m (1.64 ft).

3.2.4 Eagle Pond

The Dennis Ponds Report categorized Eagle Pond as a mesotrophic pond, which agrees with the discrete data analysis. The maximum depth of Eagle Pond is 7.32 m (24 ft) according to the Pond and Lake Atlas. The temperature of the pond did not drop below an average 20°C at any depth. This classifies the pond as a shallow, warm-water fishery.

Satellite Image of Eagle Pond

Route 6, the Mid-Cape Highway, is located 300 feet from the northerly edge of Eagle Pond. A cranberry bog, located in the Town of Harwich, is located 1,500 feet to the east of the pond. There is evidence that suggests the bog was, at one time, connected to the pond. South of the pond by approximately 500 feet is a landfill site. There are also four residential units within the 300-ft buffer zone.

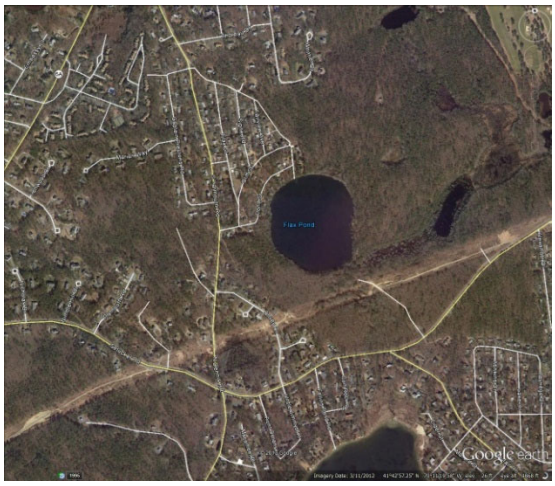
Additionally, the Dennis Ponds Report classified Eagle Pond as having acceptable water quality. This was further confirmed through the Eagle and Cedar Pond Memo when analyzing phosphorus loading and contributing factors. However, all sources agree that the greatest contributor of contamination to Eagle Pond is road runoff.

Discrete data from 2004 to 2013 are summarized below:

- 3 out of 82 recorded DO measurements were below the DO threshold of 5 mg/L for shallow, warm-water ponds, excluding one non-detect measurement.
- The average total phosphorus concentrations were within the mesotrophic range with comparatively higher values in 2004 and 2009.
- The average Secchi depth reading was 12.1 feet, which makes the pond's clarity suitable for swimming.

- Concentrations of chlorophyll-a exceeded 16 µg/L for only 1 out of 24 readings.

3.2.5 Flax Pond



Satellite Image of Flax Pond

The Dennis Ponds Report categorized Flax Pond as an oligotrophic pond. Flax Pond is on MassDEP's Comprehehsive List as a Category 3 water body, meaning there is insufficent information on the pond which results in an inconclusive pond impairment status and recommended pond usage. The maximum depth recorded in the Pond and Lake Atlas is 8.84 m (29 ft). With increasing depths, the temperature drops about 3°C at the deepest depths but does not drop below 20°C according to the discrete data. The PALS samples taken each year in August and September classify the pond as a shallow, warm-water fishery. The Dennis Ponds Report analyzed year round sample data which indicated temperatures of a cold-water fishery during the transition months between winter and summer. These colder temperatures were inconsistent however, and because not maintained year round, Flax Pond can be classified as a warm-water fishery.

Surrounding Flax Pond are 25 properties located on the northerly shore that are within the 300-ft buffer zone. Aside from this higher density area, most of the area surrouding the pond is undeveloped and owned by the Town of Dennis Conservation Commission. Madison Road runoff is visible by discoloration on orthophotos and has been noted in the Dennis Ponds Report by the volunteers sampling. Flax Pond is connected to Run Pond by a creek and wetland areas.

Discrete data from 2004 to 2013 are summarized below:

- 6 out of 107 recorded DO measurements were below the DO threshold of 5 mg/L for shallow, warm-water ponds, excluding one non-detect measurement.
- The average total phosphorus concentrations were within the mesotrophic range with increases in 2008 and 2011.
- The average Secchi depth reading was 14.2 feet, which makes the pond's clarity suitable for swimming.
- Concentrations of chlorophyll-a exceeded 16 µg/L for 2 out of 29 readings.

3.2.6 Fresh Pond

Satellite Image of Fresh Pond

Fresh Pond was catagorized as a eutrophic pond in the Dennis Ponds Report. However the discrete data shows that the majority of Secchi depth readings and total phosporus measurements were greater than the average eutrophic range. This means that generally, Fresh Pond can be classified as a eutrophic pond, but the conditions should be monitored for they have potential to become hypereutrophic. The depth recorded in the Pond and Lake Atlas is 2.4 m (8 ft). The Dennis Ponds Report had a maximum recorded depth of 2.8 m (9.2 ft), which is similar to the depth recorded by the discretee data. The temperature does not drop below 20°C at any depth according to the discrete data. This classifies the pond as a shallow, warm-water fishery.

The area surrounding Fresh Pond is generally undeveloped. There are 11 residential houses within the 300-ft buffer zone of the pond, 10 along the western shore. Route 134, East-West Dennis Road, is 200 feet to the east of Fresh Pond at it's closest point. The eastern shore also includes a Conservation Land parking facility that is dog friendly. According to the Wetlands excerpt, Fresh Pond is surrounded by wetlands known as the Atlantic White Cedar (Chamoecyparis thyoides), which causes acidic tendencies.

Discrete data from 2004-2013 are summarized below:

- 4 out of 53 recorded DO measurements were below the DO threshold of 5 mg/L for shallow, warm-water ponds, excluding one non-detect measurement.
- The average total phosphorus concentrations were higher than the eutrophic range with significant concentration increases approaching the hypereutrophic range in 2012 and 2013.
- The average Secchi depth reading was 1.34 ft, which makes the pond's clarity unsuitable for swimming. All 13 readings were below the 4 ft clarity requirement for swimming.
- Concentrations of chlorophyll-a exceeded 16 µg/L for 5 out of 25 readings.

3.2.7 Hiram Pond

Satellite Image of Hiram Pond

Hiram Pond was catagorized as a eutrophic pond in the Dennis Ponds Report. However, discrete data shows average Secchi depths and phosporus readings to be greater than the eutrophic thresholds, nearing hypereutrophic pond levels. The maximum depth recorded in the Dennis Ponds Report is 5.7 m (18.7 ft). The temperature decreased quickly with depth by as much as 10°C to 14°C. Hiram Pond is classified as a shallow, warm-water fishery.

Surrounding Hiram Pond is 12 houses within the 300-ft buffer zone. The area is generally developed but about 200 feet from the northwestern edge of the pond is Cape Cod Bay. The pond is also surrounded by multiple local streets: Hiram Pond Lane, 50 feet to the northwest; Webfoot Path, 100 feet to the southwest; and Hiram Lane, 100 feet to the south. There are two active cranberry bogs inland of Hiram Pond: one is 600 feet south and the other is about 900 feet southwest of the pond. Hiram Pond is possibly connected to the southeasterly bog and a marsh to the southwest of the pond.

- 31 of 44 recorded DO measurements were below the DO threshold of 5 mg/L for shallow, warm-water ponds, excluding four non-detect measurements.
- The average total phosphorus concentrations were higher than the eutrophic range with significant concentration increases occurring at the pond bottom nearing the hypereutrophic range in 2007. Higher total phosphorus readings near the pond bottom could be indicative of significant phosphorus regeneration from bottom sediments.
- The average Secchi depth reading was 1.18 feet, which makes the pond's clarity unsuitable for swimming. None of the 10 readings met the clarity threshold.
- Concentrations of chlorophyll-a exceeded 16 µg/L for 7 out of 20 readings.

3.2.8 Northern Simmons Pond

Satellite Image of Simmons Ponds

Northern Simmons Pond is categorized as oligotrophic by the Dennis Ponds Report, however the discrete data suggests the pond has shifted towards a mesotrophic status. The maximum depth recorded in the discrete data is 5.73 m (18.8 ft). With temperatures at all depths being above 20°C, Northern Simmons Pond can be classified as a shallow, warm-water fishery.

Surrounding Northern Simmons Pond is a cluster of smaller ponds.This includes Southern Simmons Pond, which is approximately the same size as

Northern Simmons Pond to the south and two smaller ponds to the northwest and southeast. North and South Simmons Ponds are separated by a 50 to 60 foot wide land bridge, but any connection between the ponds' waters is unverified. Southern Simmons Pond seems to be more impaired than Northern Simmons Pond, as evident by orthophotography of historical algea growth during the summer months.

The area around Northern Simmons Pond has three residential units within the 300-foot buffer zone. According to Dennis Land Map and the Freshwater Resources Plan, the land north of the pond is owned and used by the Dennis Water District. As a whole, the area has minimal development.

Discrete data from 2004-2013 are summarized below:

- 5 out of 77 recorded DO measurements were below the DO threshold of 5 mg/L for shallow, warm-water ponds, excluding 2 non-detect measurements.
- The average total phosphorus concentrations were generally between oligotrophic and mesotrophic ranges with concentration increasing into the mesotrophic range in 2009.
- The average Secchi depth reading was 13.83 feet, which makes the pond's clarity suitable for swimming. None of the 13 readings exceeded the clarity threshold.
- Concentrations of chlorophyll-a did not exceed 16 µg/L for any of the 26 readings.

3.2.9 Run Pond

The Dennis Ponds Report classified Run Pond as mesotrophic. However, the discrete data suggests that the pond may be classified as eutrophic. The pond is relatively shallow, with a maximum depth of 2.63 m (8.61 ft), which classfies Run Pond as a shallow, warm-water fishery.

Satellite Image of Run Pond

There are six houses within the 300-ft buffer zone, all to the south of the pond. At its closest point, Setucket Road is about 200 feet south of Run Pond. Flax Pond is connected to Run Pond by a creek and surrounding wetland areas. The northwestern half of Run Pond's shore is 175 to 200 feet south of the Dennis Highlands Golf Course. Historical orthophotos show algae blooms in the area of the pond closest to the golf course.

Discrete data from 2004-2013 are summarized below:

- 9 out of 43 recorded DO measurements were below the DO threshold of 5 mg/L for shallow, warm-water ponds.

- The average total phosphorus concentrations increased with depth, with shallower concentrations falling within the mesotrophic phosphorus range and deeper concentrations falling within the eutrophic range.
- The average Secchi depth reading was 5.50 feet, which makes the pond's clarity suitable for swimming. However, 4 of the 13 readings failed to meet the clarity threshold.
- Concentrations of chlorophyll-a exceeded 16 µg/L for 7 out of 25 readings.

3.2.10 Scargo Lake

Scargo Lake, the largest pond sampled through the PALS program in Dennis, is classified as mesotrophic by the Dennis Ponds Report, which generally agrees with the discrete data. There is, however, some outlier data that would suggest the pond may be becoming eutrophic. Scargo Lake is also the deepest pond in Dennis, with an average maximum depth of 13.72 m (45 ft), according to the Pond and Lake Atlas. Water temperatures drop below 20°C for all measurements deeper than 9 m, allowing the pond to meet classifications as a cold water fishery.

Satellite Image of Scargo Lake

The Scargo Lake Report found that the conditions of Scargo Lake have worsened and the pond is becoming impaired. In addition to the discrete data analysis, this report recommended a bird population survey, stormwater survey, pond sediment survey, and a mussel survey, all performed by SMAST volunteers. These surveys were later performed and the results were summarized in the Scargo Lake Memo, which recommends further phosphorus and stormwater load analyses. The Scargo Lake Memo recommends that the town consider hypolimnetic aeration as a remediation measure for Scargo Lake. This entails providing aeration to the bottom layer of the lake during the period of the year when the lake is stratified (May through September). Specifically, SMAST recommended targeting the area deeper than 9 meters in the large basin of Scargo Lake. This layer comprises a total of 16 acres with an average depth of 2 meters. Also discussed in the report is a potential long-term option to reduce future phosphorus loading to the watershed by improving wastewater treatment for the properties within 300-feet inside the lake's watershed (mainly properties on the eastern and southern shores).

The area surrounding Scargo Lake is developed, with at least 35 residential or town owned units within the 300-ft buffer zone, many of which have docks and waterfront access. Two town-owned units correspond with the lake's two beaches: Scargo Beach and Princess Beach. These beaches have public parking areas that were analyzed in the Scargo Lake Report for stormwater runoff impacts. To the north, Route 6A is approximately 125 feet from the lakeshore, and to the west, Dr. Lord's Road is approximately 10 to 15 feet from the lakeshore, both at their closest points.There is also boat ramp on the westerly shore of the lake.

Discrete data from 2004-2013 are summarized below:

- 38 out of 131 recorded DO measurements were below the DO threshold of 6 mg/L for deep, cold-water ponds, excluding 4 non-detect measurements.
- The average total phosphorus concentrations were between the mesotrophic and eutrophic range with significant concentration increases nearing the hypereutrophic range in 2011.
- The average Secchi depth reading was 13.73 feet, which makes the pond's clarity suitable for swimming, and none of the 13 readings failed to meet the clarity threshold.
- Concentrations of chlorophyll-a exceeded 16 µg/L for 3 out of 39 readings.

3.2.11 White Pond

The Dennis Ponds Report classified White Pond as oligotrophic. However the discrete data suggests from chlorophyll-a, Secchi depths, and total phosporus measurements that it may be on the verge of a meso-oligotrophic pond. With an average maximum depth of 6.74 m (22.11 ft) and temperatures at all depths above 20°C, White Pond is considered a shallow, warm-water fishery.

Satellite Image of White Pond

The shoreline of White Pond has approximately fifteen housing units within a 300-ft buffer from the water's edge. The northern area upgradient of the pond is relatively undeveloped except for a large horse stable approximately 500 feet from the water's edge. Discharge locations are visible around the pond when bottom growth is lacking.

Discrete data from 2004-2013 are summarized below:

- 3 out of 90 recorded DO measurements were below the DO threshold of 5 mg/L for shallow, warm-water ponds, excluding one non-detect measurement.
- The average total phosphorus concentrations increased with depth and exhibited a mesotrophic range, especially at shallower depths. Average concentrations increased in recent years, markedly in 2011 and 2012.
- The average Secchi depth reading was 15.25 feet, which makes the pond's clarity exceptionally suitable for swimming.
- Concentrations of chlorophyll-a did not exceed 16 µg/L for any of the 30 readings.

3.3 Summary

The eleven Dennis ponds in this pond health assessment are quite diverse in both physical and water quality characteristics. Dennis' ponds provide important, sensitive habitats for rare plants and animal species and are important natural resources for the community. The growing number of pond restoration actions on Cape Cod suggests that many ponds are reaching their tipping points, where further alterations to the environment will result in sometimes dramatic changes in water quality. These have included noxious and potentially harmful algal blooms, fish kills, and impacts caused by population growth. Below are some preliminary steps that should be taken to protect or restore Dennis' ponds. Refer to Section 14 of the Final CWMP for an update on the freshwater ponds, sampling and restoration as it relates to the recommended plan.

3.3.1 Continue Monitoring

It is recommended that monitoring of all current ponds continue. It is also recommended to expand the PALS program to collect at least one round of water quality samples annually from other Dennis ponds without historic water quality data to establish a baseline for water quality in all ponds. If possible, this sampling round should be taken in conjunction with the PALS program's sampling round in August/September. Such ponds include:

- Southern Simmons Pond and the Clay Pond/Grassy Pond complex, which may be connected or tributary.
- Smaller water bodies like Aunt Pattys Pond, to obtain a more detailed dataset to determine if these water bodies are experiencing similar trends in water quality.

Additional recommended measures related to continuing monitoring include:

- Support the recommended activities listed in the Dennis Ponds Report such as develop bathymetric information for all ponds.
- Consider further assessment of the potential for birds to contribute significant phosphorus load at Cedar Pond and Scargo Lake. Birds were considered to be a source of phosphorus in the high estimate of loads in the assessment in the Dennis Ponds Report. The phosphorus load regenerated in the bottom sediments should also be quantified through sediment sampling.

This expansion can be done gradually and adaptively. The additional monitoring of a handful of ponds each year would increase the knowledge database of the Town’s ponds.

3.3.2 Perform an Inventory of All Stormwater Inputs to Ponds

Road runoff was identified as a potential source of contamination in at least thirteen ponds. Create an inventory of catch basins and drains that directly discharge to each pond. This can be performed incrementally with focus on ponds with water quality data and those that have a high percentage of impervious cover that may contribute to the pond. This causes a greater potential for runoff to contribute nutrients to the pond. If inputs are found, divert or disconnect stormwater systems such as catch basins that directly discharge to ponds. Examples of such connections can be initially discovered using orthophotography.

3.3.3 Investigate Other Potential Contaminant Sources

Phosphorus loads from the following sources should be considered: abandoned or active cranberry bogs, sediment dumping locations, landfills, farms, private impervious surface runoff, private landscape and fertilizer applications, and waterfowl.

Decreasing phosphorus loads to ponds that are currently affected by high phosphorus concentrations would improve pond health. For ponds that have evidence of phosphorus regeneration, expansion of monitoring points allows for a more accurate understanding of phosphorus regeneration. If phosphorus loads are coming from internal loading, then in-lake measures may be an option. For ponds that are on the border between mesotrophic and eutrophic conditions, it is important to act soon to determine the source(s) of phosphorus contributing to this degradation.

3.3.4 Consider Appropriate Watershed Management Options

Initial suggestions for watershed management options include reduction of phosphorus-containing detergents, elimination of sink garbage disposals to reduce phosphorus loads from food waste, and more rigorous enforcement of the Town Board of Health requirements for septic systems. Consider further public outreach and education or developing guidelines or bylaws to curtail/restrict use of inorganic phosphorus laden fertilizer in lands near the ponds or tributaries to ponds and to encourage maintaining or restoring vegetated buffer strips along pond shorelines.

It is also extremely important to understand the relative magnitude of internal versus external loads. External actions taken to address one source of load may not successfully improve pond health if it is not the dominant load to a pond. In some instances it could be necessary to take both watershed and in-lake actions.

3.3.5 Determine Uses and Ponds to Support

Fostering stakeholder and public participation is a key component in determining which ponds and which uses for each individual pond should be prioritized to keep or meet a high quality designation. Table 3-4 summarizes the analysis and recommendations for each of the eleven ponds examined, as well as other ponds in town. The highlighted ponds in Table 3-4 should be examined more closely to determine if providing sewers within the watersheds and thus removing septic system effluent phosphorus inputs would be appropriate to reduce degradation. Ponds that require additional analysis prior to determining sewering needs within their watersheds can be handled through an adaptive management approach.

3.3.6 Investigate the Feasibility and Applicability of Alternative Wastewater Management Practices

Pond shorelines with medium-to-high levels of residential development could be candidates in determining the feasibility of alternative wastewater management practices. Pond areas with upgradient high level development are more likely candidates for alternative wastewater management than downgradient areas. In general, these actions are watershed-based measures to address external sources of phosphorus to a pond.

3.3.7 Consider Developing Pond Associations

Pond associations can help coordinate and implement pond monitoring and restoration programs. They can also provide a needed advocacy group for pond-related issues. Dennis should consider encouraging residents local to each pond to create an association for their pond, especially for the larger ponds in town.

Table 3-4 Dennis Ponds Health Assessment Summary and Recommendations

Name	Pond Trophic Status	Monitor	Investigate Road Runoff Contribution	Investigate Potential Contaminant Sources	Shoreline Development
Aunt Pattys Pond	*	X	X		Low-Medium
Bakers Pond	Oligotrophic	X	X		Low
Cash Pond	*	X			Low
Cedar Pond	Eutrophic	X	X	X	Medium-High
Clay Pond		X		X	Low-Medium
Coles Pond	Eutrophic	X			Low-Medium
Duck Pond	*	X	X	X	Medium-High
Eagle Pond	Mesotrophic	X	X	X	Low
Flax Pond	Mesotrophic	X	X	X	Low-Medium
Follins Pond	*	X	X	X	High
Fresh Pond	Eutrophic	X		X	Low
Funn Pond**	*	X		X	Medium
Grassy Pond	*	X			Low
Great Pond Plash	*	X			Low
Hiram Pond	Eutrophic	X	X	X	Medium
Jonathans Pond	*	X		X	Low-Medium
Kelleys Pond	*	X		X	Medium-High
Little Coles Pond	*	X			Low
Northern Simmons Pond	Oligo-mesotrophic	X			Low
Pine Pond	*	X	X	X	Medium
Run Pond	Meso-eutrophic	X		X	Low
Scargo Lake	Meso-eutrophic	X	X	X	Medium
Southern Simmons Pond	*	X		X	Low
Swan Pond	*	X	X	X	High
The Plashes	*	X			Low
Uncle Stephens Pond	*	X		X	Medium
Weir Creek	*	X	X	X	Low-Medium
White Pond	Oligo-mesotrophic	X		X	Low
Whittemores Pond	*	X	X	X	Medium-High

Note: (*) PALS data not provided.

(**) Also known as Fund Pond in historical USGS maps and the Pond and Lake Atlas.

Red Fields indicate impaired water quality.

Gray Fields indicate recommendation to explore alternative wastewater management due to shoreline density.

Section 4
Evaluation of Groundwater Resources

4.1 Introduction

This section summarizes existing groundwater quality data in Dennis. The Dennis Water District's public drinking water supply is discussed, including a review of annually-reported water quality data. Specific attention is paid to the presence of nitrogen in the town's drinking water supply and any long-term trends observed in the town's water supply wells with regards to nitrate concentrations. In addition, groundwater elevations and depth to groundwater are presented. Information presented in this section originates from the Dennis Water District, the United States Geological Survey (USGS) National Water Information System Database (waterdata.usgs.gov/nwis), and MassGIS.

4.2 Drinking Water Supply and Groundwater Quality

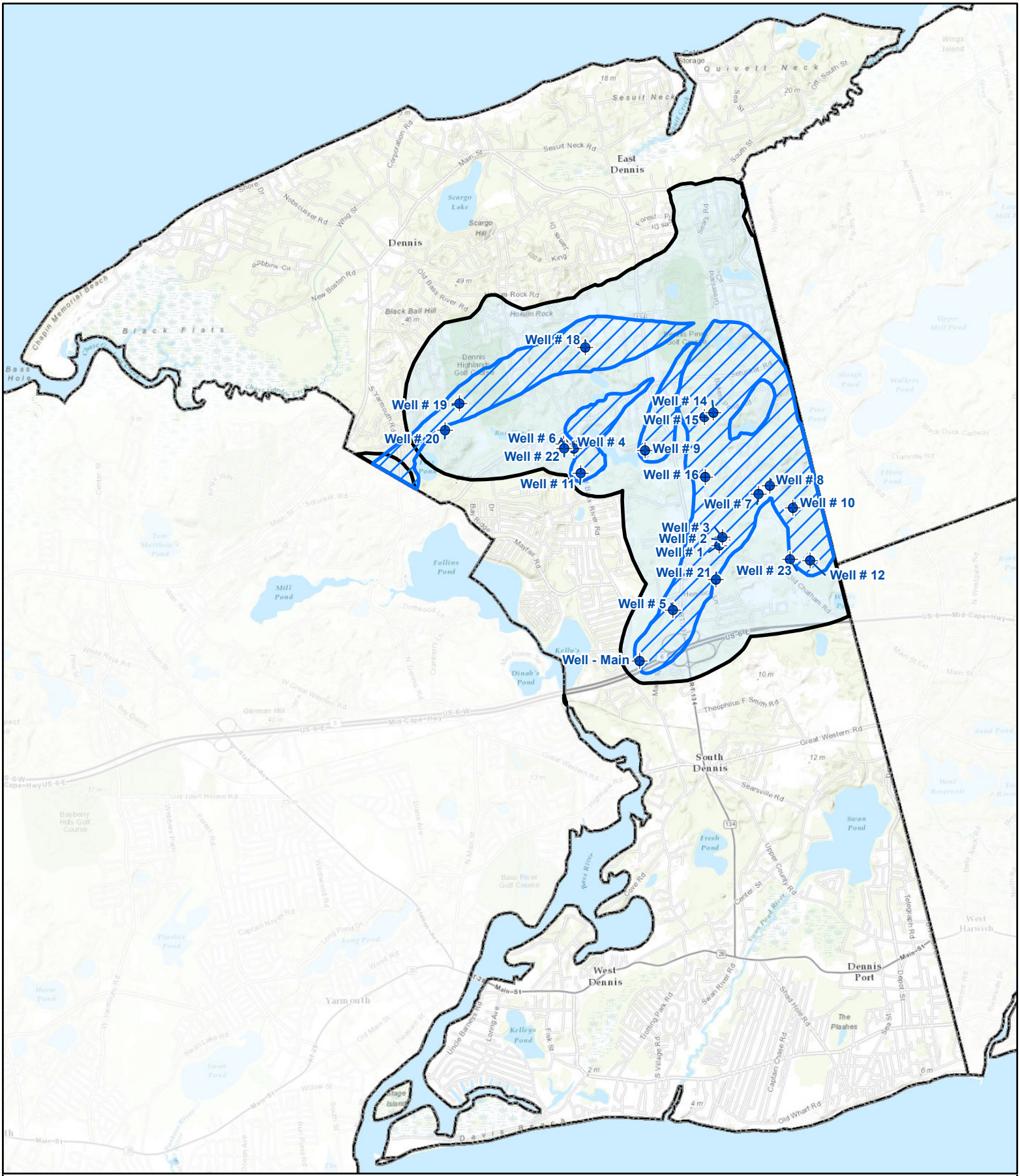
4.2.1 Dennis Water District Supply Wells and Usage

Public water supply for the town of Dennis is provided by the Dennis Water District. The District supplies water via 22 wells, situated on more than 1,067 acres of land either owned or protected by the District. All of these wells are located north of Route 6, as shown on **Figure 4-1**, and draw from the Monomoy lens. This figure also shows the Zone II areas surrounding each well. These areas, approved by MassDEP, represent the maximum extent of land area expected to contribute groundwater to each supply well. They are defined as the area from which water will be drawn with 180 continuous days of pumping at a well's maximum permitted yield (flow rate), assuming drought conditions (no recharge from precipitation). In addition, smaller and less conservative "zones of contribution" to each well were established as part of the MEP process. These areas are also shown on Figure 4-1.

Table 4-1 below lists each well along with its location and calendar year 2020 pumped flow. In 2020, a total of 1,241,277,600 gallons of water was pumped from the town's water supply wells.

Table 4-1 **2013 Public Water Supply Well Data**

Source Name	2013 Flow (GPM)	Location of Source
Wells 1, 2, 3, 12, 23	2,100	Old Chatham Road
Wells 4, 6, 11, 22	1,600	Old Bass River Road
Well 5	500	Route 134
Wells 7, 8, 10	1,300	Airline Road
Well 9	600	Grassy Pond Drive
Well 14, 15	1,150	Bakers Pond Road
Well 16	450	Timber Lane
Well 18	700	Hokum Rock Road
Well 19, 20	1,400	Setucket Road
Well 21	700	Route 134
Main Station	700	80 Old Bass River Road



N

Legend

- Water Supply Wells
- MEP Well Zones of Contribution
- Zone II

Town of Dennis, MA

1 inch = 4,500 feet

0 2,000 4,000 Feet

Dennis Drinking Water Resources

Figure 4-1

CDM Smith

NEWELLJD F:\Dennis\DATA\MXD\Figure_4_1_Drinking_Water_Resources.mxd 9/16/2014

Dennis is surrounded by the towns of Yarmouth, Harwich, and Brewster. In case of a water system emergency, Dennis' water distribution pipeline network is interconnected with each of these neighboring communities. Specifically, there are three interconnections with Yarmouth, three with Harwich, and one with Brewster.

Figure 4-2 shows historic District pumping data by month for the years 2001 to 2004 and 2008 to 2012. The bold red line shows the 2001-04 average monthly gallons pumped, and the bold blue line shows the 2008-12 average monthly gallons pumped. As shown, water usage in the period of 2008 to 2012 was similar to that in 2001 to 2004. This earlier data set was used in previous studies of the Comprehensive Wastewater Management Task Force. Based on the information shown in Figure 4-2, continued usage of the conclusions drawn from the 2001-04 data appears appropriate, as conditions have not changed since that time.

As shown in Figure 4-2, water demand in Dennis is consistent with typical trends in seasonal communities. Water usage in New England tends to be highest in the summer, when outdoor watering is at its peak. This trend is then heightened significantly by the dramatic increase in population in Dennis in the summertime. Total pumping typically varies from one year to the next depending on weather conditions, with little variation in indoor water use in the winter, but greater variation in the summer as a result of wet versus dry years. The data shown in Figure 4-2 are consistent with that typical tendency. The summer (June, July, and August) water usage is approximately four times higher than the winter water usage and twice the average annual usage.

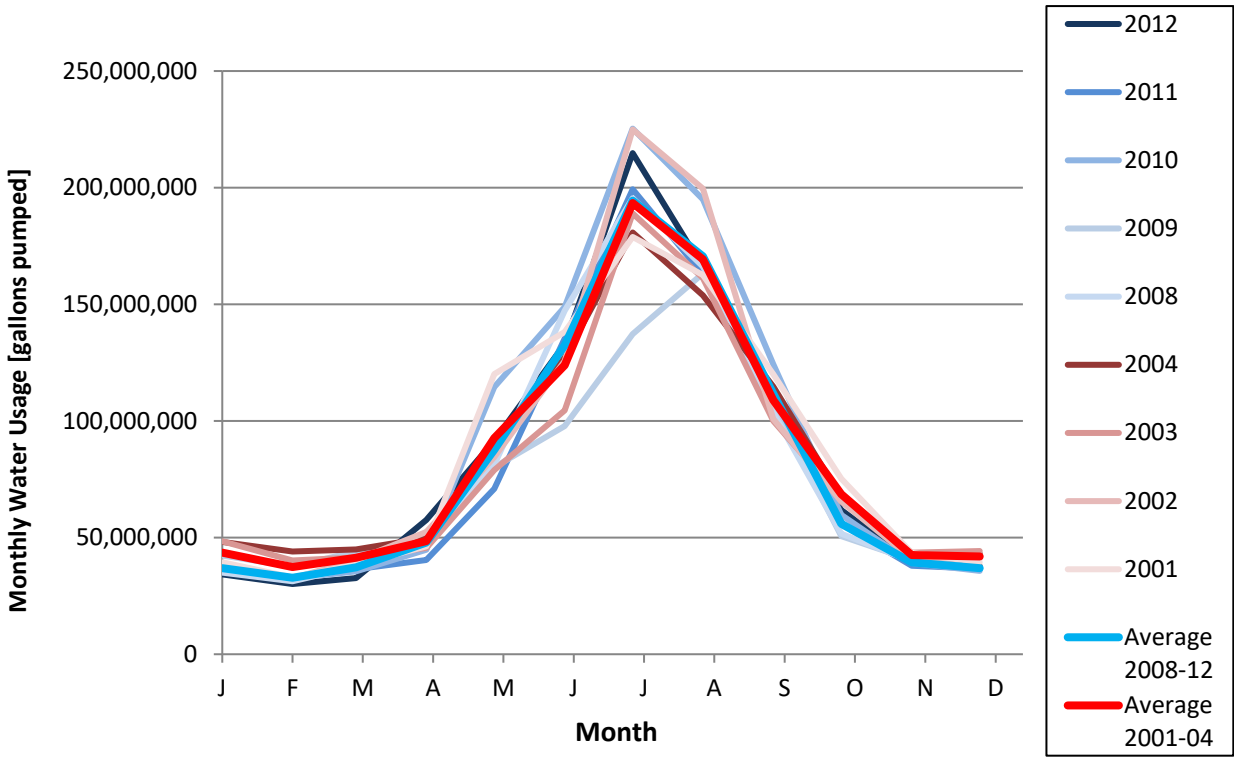


Figure 4-2 Dennis Water Usage – 2001-2004 Compared to 2008-2012

4.2.2 Dennis Water District Water Supply Quality

Quality of drinking water is regulated under the federal Safe Drinking Water Act (SDWA). As detailed below, water quality from Dennis' wells is very high, and the District's drinking water has met or exceeded the requirements of the SDWA during the last five year period available, shown in **Table 4-2**.

The District provides information about water quality testing and results in their Annual Water Quality Report, which is sent annually to all public water supply customers. The District tests for over 150 different compounds in its water supply. The 2016 through 2020 Dennis Water District Annual Water Quality Reports include measurements of 19 different compounds which were detected, usually in trace amounts. Table 4-2 summarizes the levels of the various constituents measured, to create a representative picture of the water quality of Dennis drinking water over a span of five years. Note that some parameters do not need to be tested every year, based on state regulation. Where the results reported on a particular annual water quality report are from a prior year, the year is indicated in parentheses. In earlier years, when tests were not taken for a particular parameter in that year, the data were not reported and are shown as such.

Table 4-2 represents an overall view of the high quality of drinking water in Dennis. Over the five year period shown, none of the parameters were in violation of the SDWA.

Table 4-2 **Dennis Water District Drinking Water Quality 2016 - 2020**

Parameter	Source	MCL/ MCLG	Annual Range – Lowest to Highest Measured Value				
			2020	2019	2018	2017	2016
Inorganic Contaminants							
Nitrate as N (ppm)	Septic systems, fertilizers, erosion	10/10	ND – 2.1	ND – 1.7	0.07 – 2.4	ND – 1.8	ND – 2.1
Perchlorate (ppb)	Fireworks, flares, munitions	2/NA	NA	NA	NA	NA	ND-0.46
Barium (ppm)	Drilling wastes, metal refineries, natural erosion	2/2	0.03-0.0085	0.0067-0.046	0.0067-0.046	ND – 0.037	ND-0.041
Sodium (ppm)	Road salt	NA/NA	8.5 – 71	11 – 130	9.5 – 65	9.3 – 88	8 – 100
Radioactive Contaminants							
Gross Alpha Activity (pCi/L)	Natural erosion	15/0	ND – 2.9	ND – 0.19	ND – 0.19	ND –0.19	ND –0.19
Radium-228 (pCi/L)	Natural erosion	5/0	0.18 – 0.77	ND – 1.8	ND – 1.8	ND –1.8	ND –1.8
Volatile Organic Contaminants							
HAA5 (ppb) Haloacetic Acids	Drinking water chlorination	60/NA	ND-1.1	ND-2.4	3.0-4.1	ND – 3.2	0.52 – 4.1
THHM (ppb) Trihalomethanes	Drinking water chlorination	80/NA	3.0 – 8.6	3.4-11	3.6-14	4.4-13	1.3 - 10
Microbiological Contaminants							
Total Coliform Bacteria (% samples)	Naturally present	5/0	0	0	0	2.8	1.3

Table 4-2 Dennis Water District Drinking Water Quality 2016 – 2020 (continued)

Parameter	Source	SMCL/ ORSG	Annual Range – Lowest to Highest Measured Value				
			2020	2019	2018	2017	2016
Lead and Copper							
Lead (ppb)	Plumbing corrosion and natural erosion	15/0	0* (2020)	0* (2017)	0* (2017)	0* (2017)	1* (2014)
Copper (ppm)	Plumbing corrosion and natural erosion	1.3/1.3	0* (2020)	0* (2017)	0* (2017)	0* (2017)	0* (2014)
Unregulated Contaminants							
Chloroform (ppb)	Drinking water chlorination	NA/NA	ND – 5.5	ND – 7.9	ND – 7.9	ND – 5.2	ND – 5.0
Bromodichloro-methane (ppb)	Drinking water chlorination	NA/NA	ND – 0.66	ND – 3.1	ND – 1.5	ND -0.94	ND – 1.8
Chlorodibromo-methane (ppb)	Drinking water chlorination	NA/NA	ND – 1.1	ND – 2.7	ND – 1.7	ND -0.63	ND – 1.5
MTBE	Fuel additive	20-40/70	NA	ND – 0.51	ND - 0.95	ND – 1.2	ND – 2.0
Parameter	**Source**	**MRDL/ MRDLG**	**Annual Range – Lowest to Highest Measured Value**				
			2020	**2019**	**2018**	**2016**	**2017**
Unregulated Contaminants							
Chlorine (free, ppm)	Drinking water chlorination	4/NA	0.01 – 0.52	0.05 – 0.7	ND – 0.33	ND – 0.35	ND – 0.32
Parameter	**Source**	**SMCL/ Health Advisory**	**Annual Range – Lowest to Highest Measured Value**				
			2020	**2019**	**2018**	**2017**	**2016**
Secondary Contaminants							
Total Iron (ppm)	Naturally present	0.3/NA	ND – 0.7	ND – 0.16	ND – 0.26	ND – 0.36	0.53
Total Manganese (ppm)	Naturally present	0.05/.3	ND – .036	0.004 – 0.04	ND – 0.032	ND – 0.071	0.005 – 0.04

* = Number of tested sites above the EPA action level; these values do not constitute a violation of the standard

MCL = Maximum contaminant level, which is the highest level of a contaminant that is allowed in drinking water. MCLs are set as close to the MCLGs as feasible using the best available treatment technology.

MCLG = Maximum contaminant level goal, which is the level of contaminant in drinking water below which there is no known or expected risk to human health. MCLGs allow for a margin of safety.

MRDL = Maximum residual disinfectant level, which is the highest level of disinfectant (chlorine) allowed in drinking water.

MRDLG = Maximum residual disinfectant level goal, which is the level of drinking water disinfectant below which there is no known expected risk to health.

SMCL = Secondary maximum contaminant level, which is a level of a contaminant developed to protect against adverse aesthetic qualities of drinking water and are not health based.

ORSG = Massachusetts Office of Research and Standards guideline, which is the concentration of a chemical in drinking water at or below which adverse, non-cancer health effects are unlikely to occur after chronic (lifetime) exposure.

ND = Not detected

NA = Not applicable

Results presented in RED indicate a violation of the SWDA standard. (No violations occurred in the period of 2009 to 2013.)

As shown in Table 4-2, levels of iron and manganese often exceed the secondary maximum containment levels for those compounds. These levels are set for protection of aesthetics (discoloration, taste and odor). In 2009, the District constructed two iron and manganese removal facilities (North and South Treatment Plants), each treating 4 million gallons per day. Since these facilities have come online, iron and manganese conditions have improved.

The District also treats its supply with potassium hydroxide to raise the pH from 5.5 to 7.0, as a corrosion control measure. This decreases the likelihood of corrosion of plumbing fixtures which can cause lead and copper to leach into water supply pipes, typically from internal building plumbing.

Lastly, the District disinfects all of its water supply using sodium hypochlorite (liquid chlorine solution) to protect against microbial contamination.

A source water assessment was performed in Dennis, as described in the 2013 Annual Water Quality Report. The conclusions of this assessment were that Dennis' drinking water supply is well protected through a combination of maximizing land ownership and control within the Zone IIs to its wells, maintaining a town Wellhead Protection District, and conducting annual household hazardous waste collection days.

Overall, the District's water demonstrates excellent quality, as evidenced by its recognition by MassDEP in 2013 for outstanding performance and achievement.

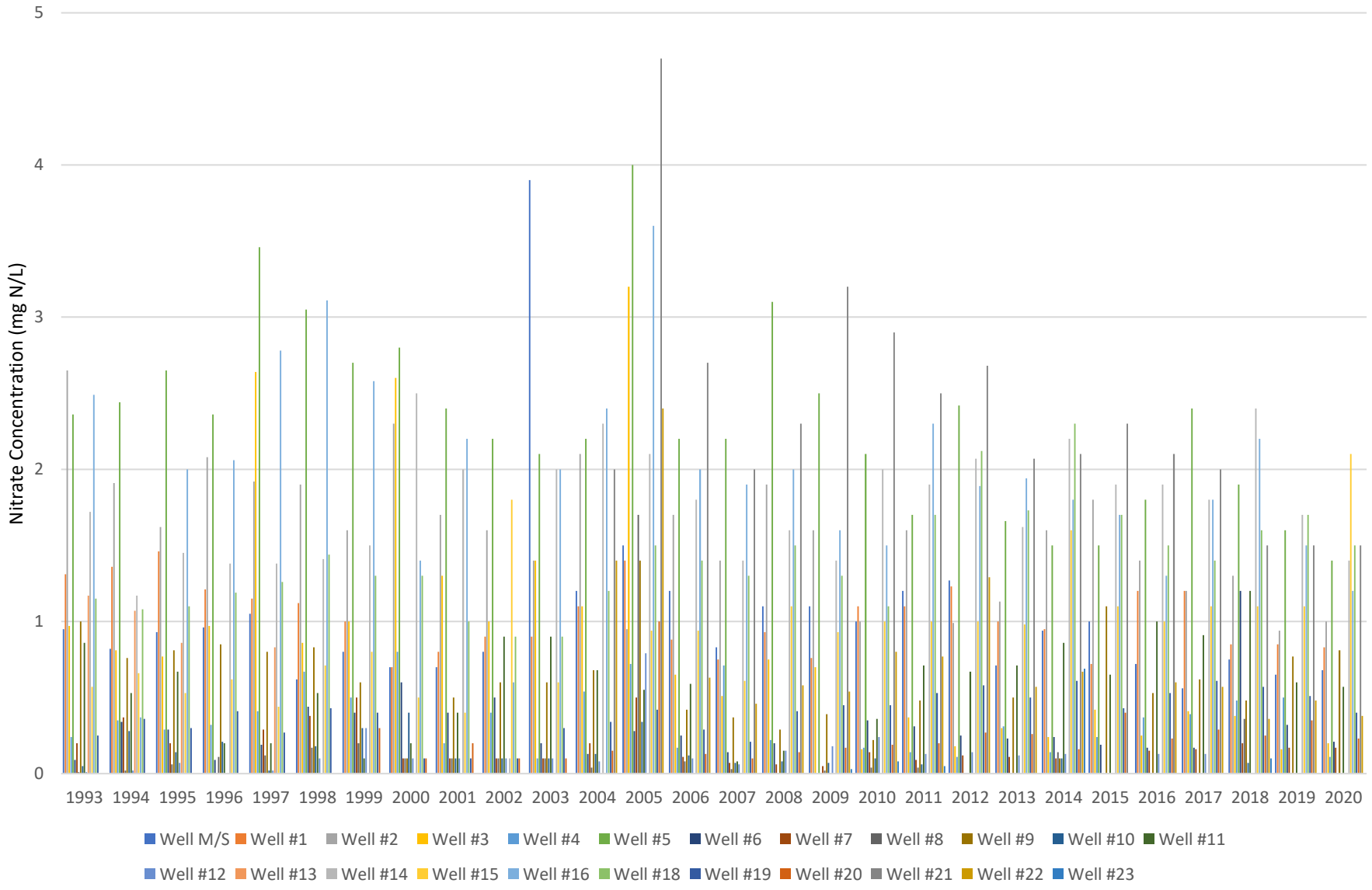
4.2.3 Nitrate in Drinking Water

Of particular interest for wastewater planning are nitrate concentrations. Of the many compounds tested for, detected levels of nitrate are important because they can serve as an indicator of fertilizer runoff, stormwater recharge, and leachate from septic tanks entering the water supply. As shown in Table 4-2, other constituents measured do not typically originate from septic systems and therefore cannot be managed by a change in wastewater handling methodology.

In addition, high nitrate levels in drinking water can cause health concerns, the most well-known of which is methemoglobinemia, also known as blue-baby syndrome, which can affect infants. High levels can also impact the elderly and their prescription medications. Regulatory limits or guidelines for nitrate include a SDWA primary Maximum Containment Level (MCL) of 10 mg/L and a Cape Cod Commission goal of 5 mg/L. It is worth noting that these public health-related nitrate thresholds are much higher than the thresholds established for healthy estuarine ecosystems (typically 0.5 mg/l or lower); therefore, it is common to meet drinking water standards while still greatly exceeding the nitrogen levels in groundwater required to protect the environment.

Figure 4-3 shows the nitrate levels measured by the Dennis Water District at each drinking water well over a 28-year period from 1993 to 2020. Note that Well #23 was added in 2006, and Well #13 is no longer in use. **Figures 4-4 through 4-13** show wells grouped by geographic location and illustrate the long-term trends of nitrate in the wells of each area versus time. Note that the only well exhibiting a seemingly upward trend over time is Well #18 in the Hokum Rock Road

Figure 4-3
Dennis Water District Water Supply Wells - Nitrate Concentrations
(1993 through 2020)



area. Despite this trend, nitrate values in Well #18 remain substantially below both the EPA limit and the CCC goal, with a maximum measurement of 2.3 mg/L. In general, Well #21 showed the highest consistent levels of nitrate. This well is located on Old Bass River Road.

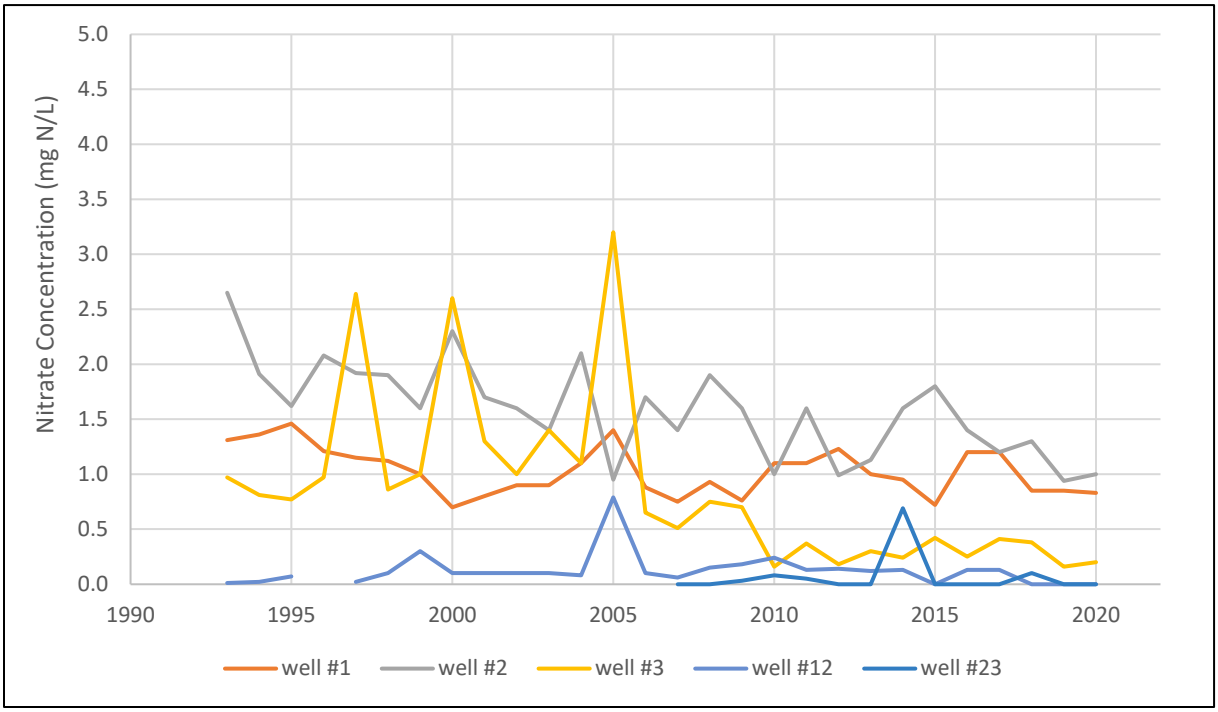


Figure 4-4: Nitrate Levels in Old Chatham Road Area Wells

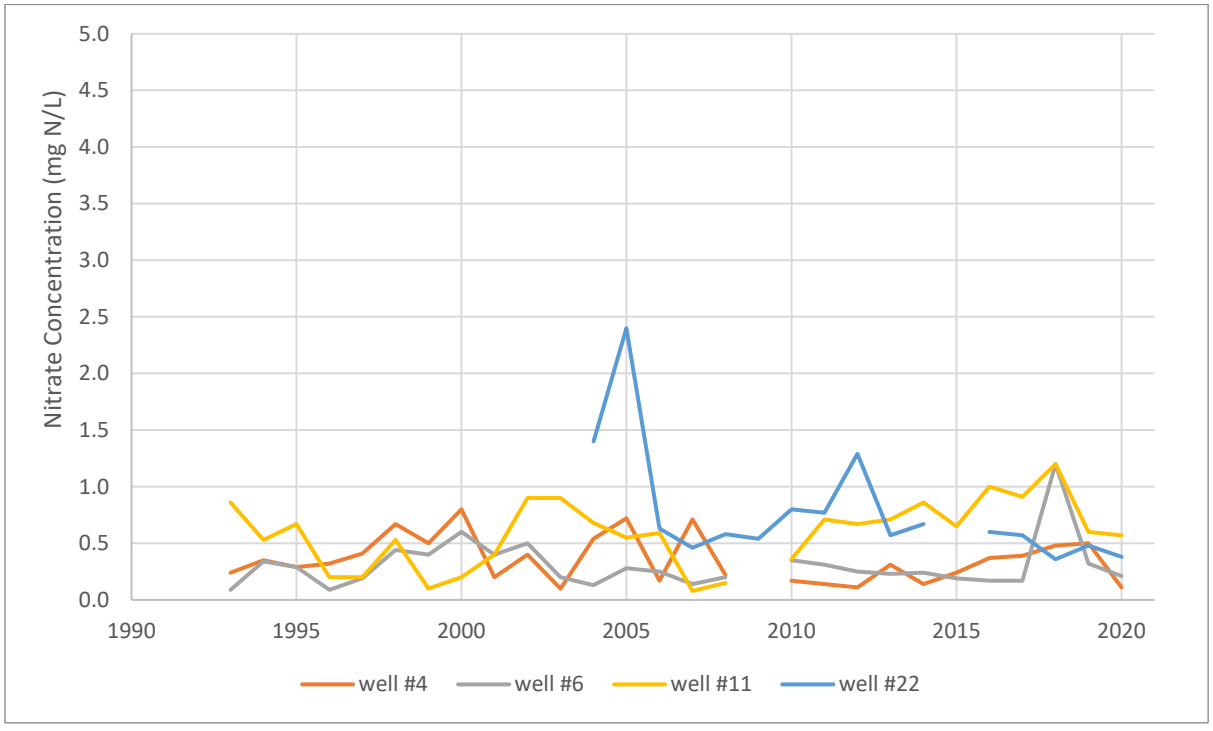


Figure 4-5: Nitrate Levels in Old Bass River Road Area Wells

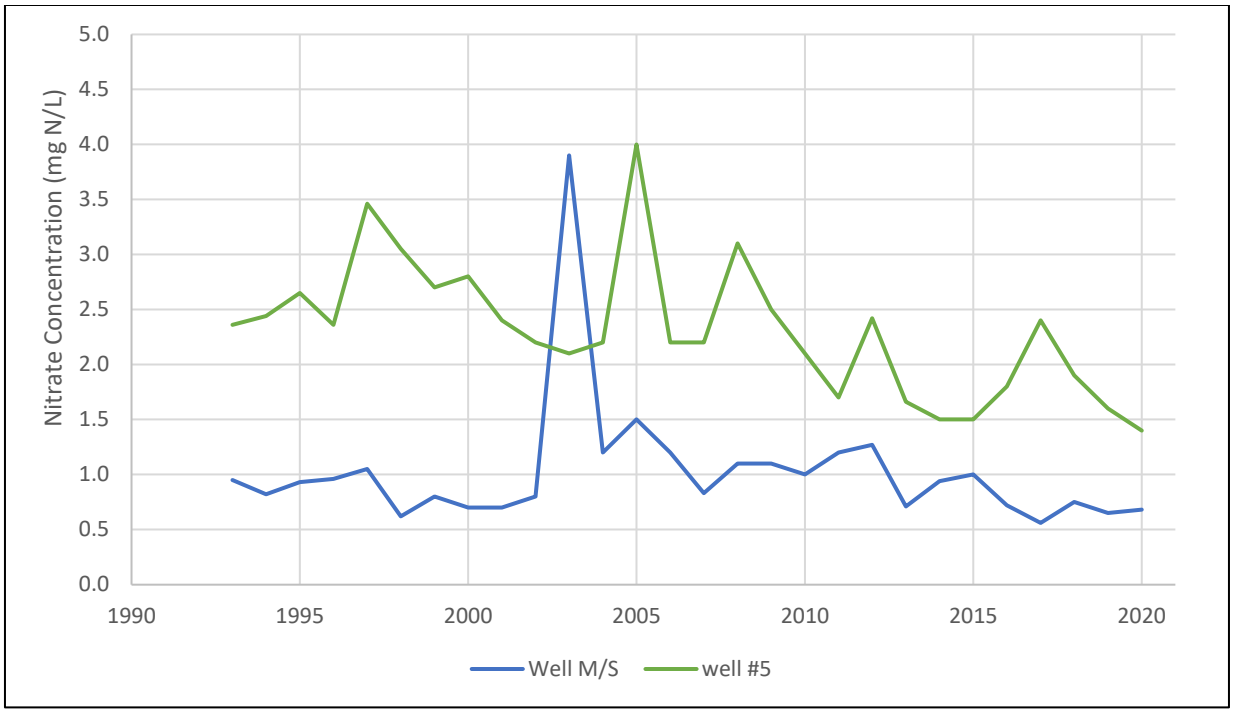


Figure 4-6: Nitrate Levels in Route 134 Area Wells

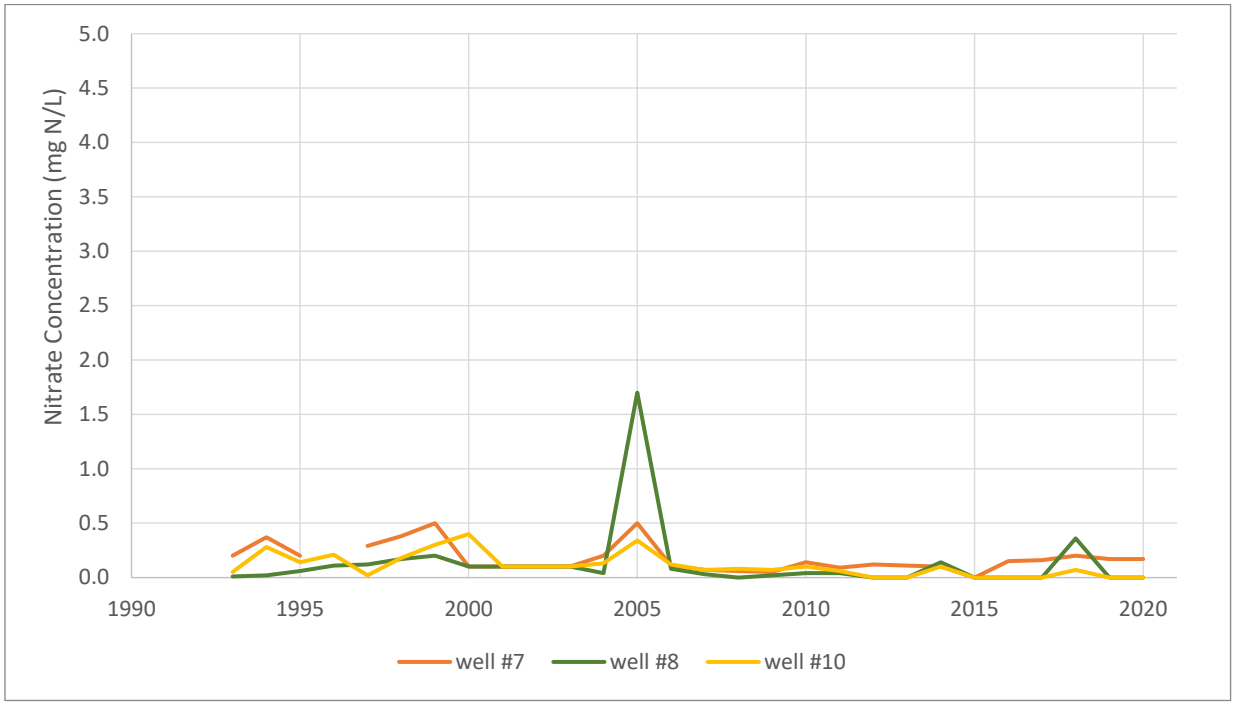


Figure 4-7: Nitrate Levels in Airline Road Area Wells

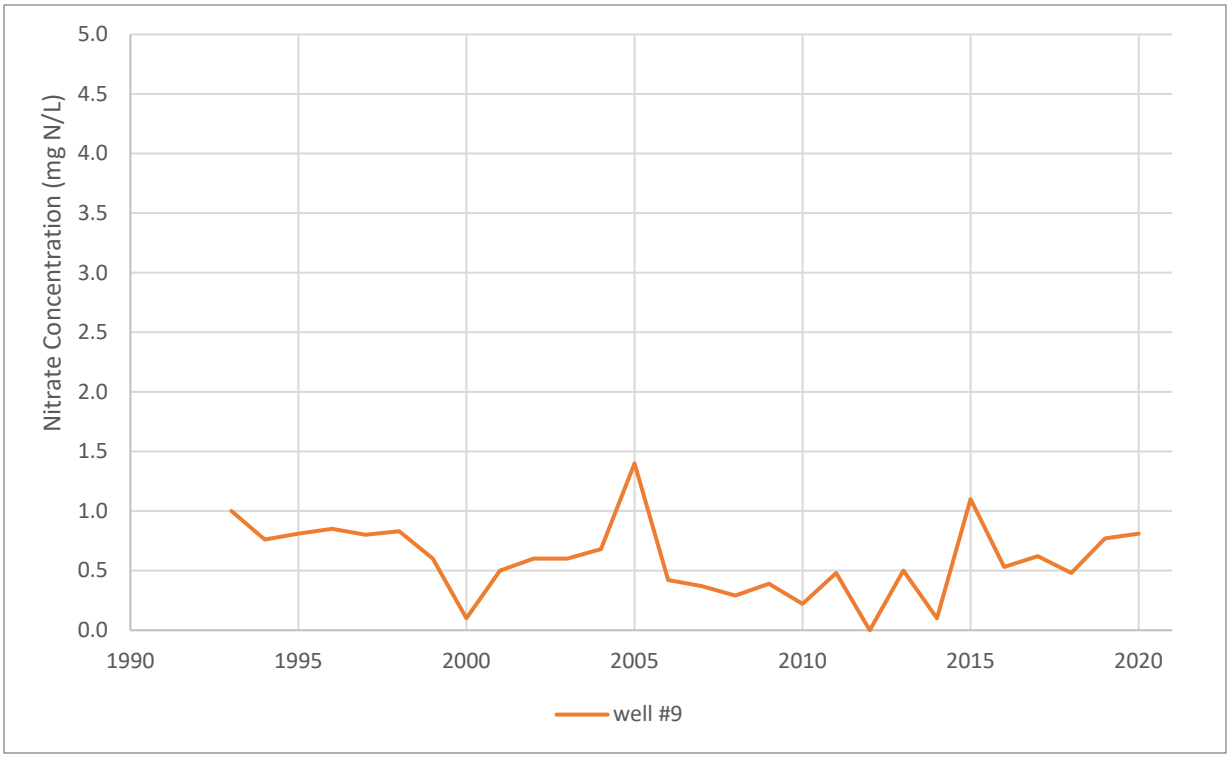


Figure 4-8: Nitrate Levels in Grass Pond Drive Area Wells

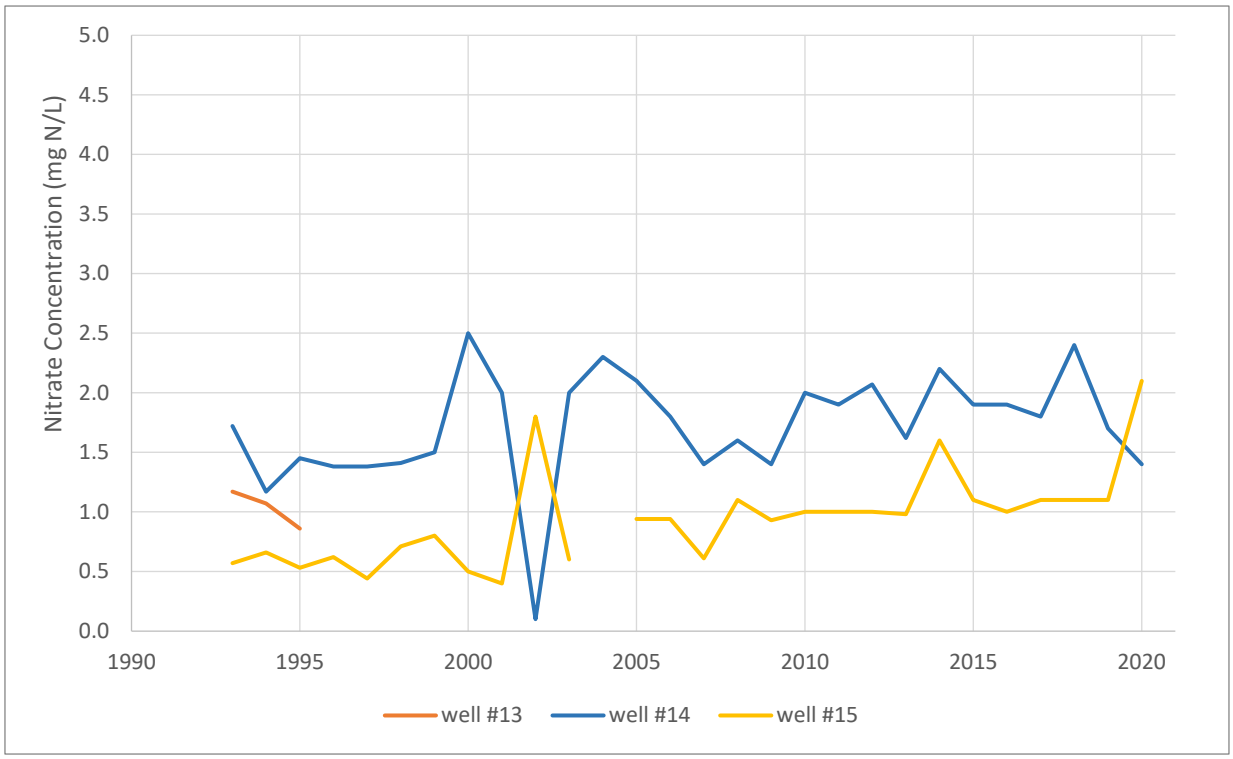


Figure 4-9: Nitrate Levels in Bakers Pond Road Area Wells

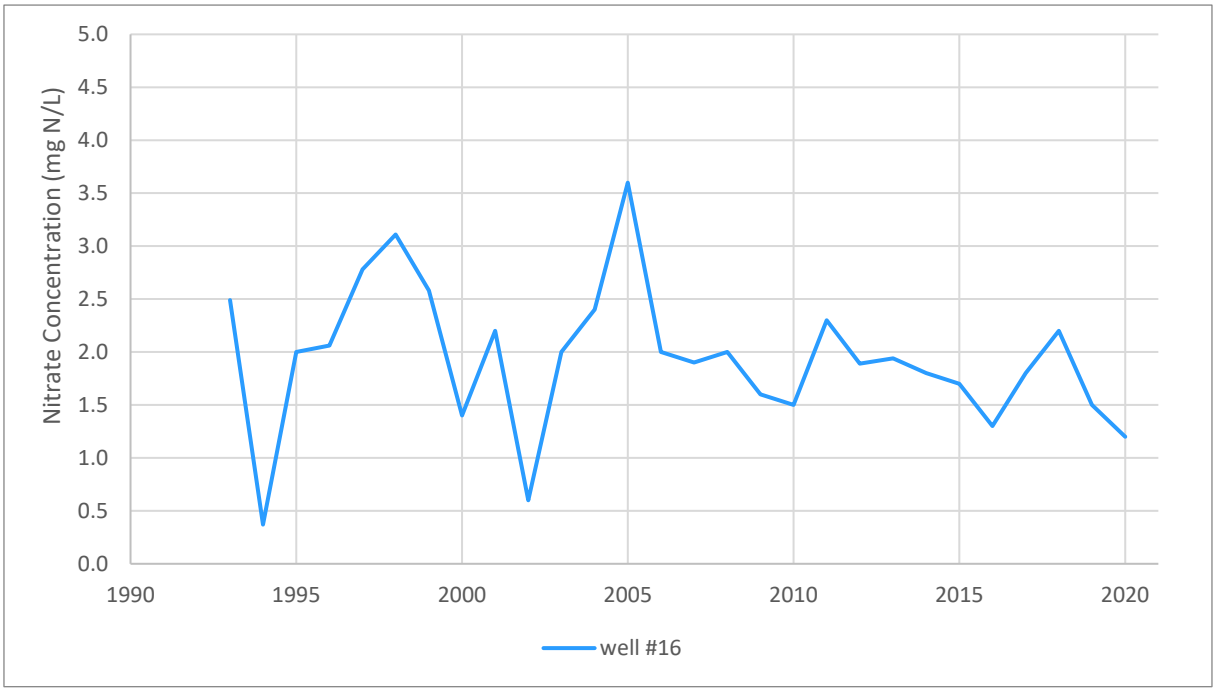


Figure 4-10: Nitrate Levels in Timber Lane Area Wells

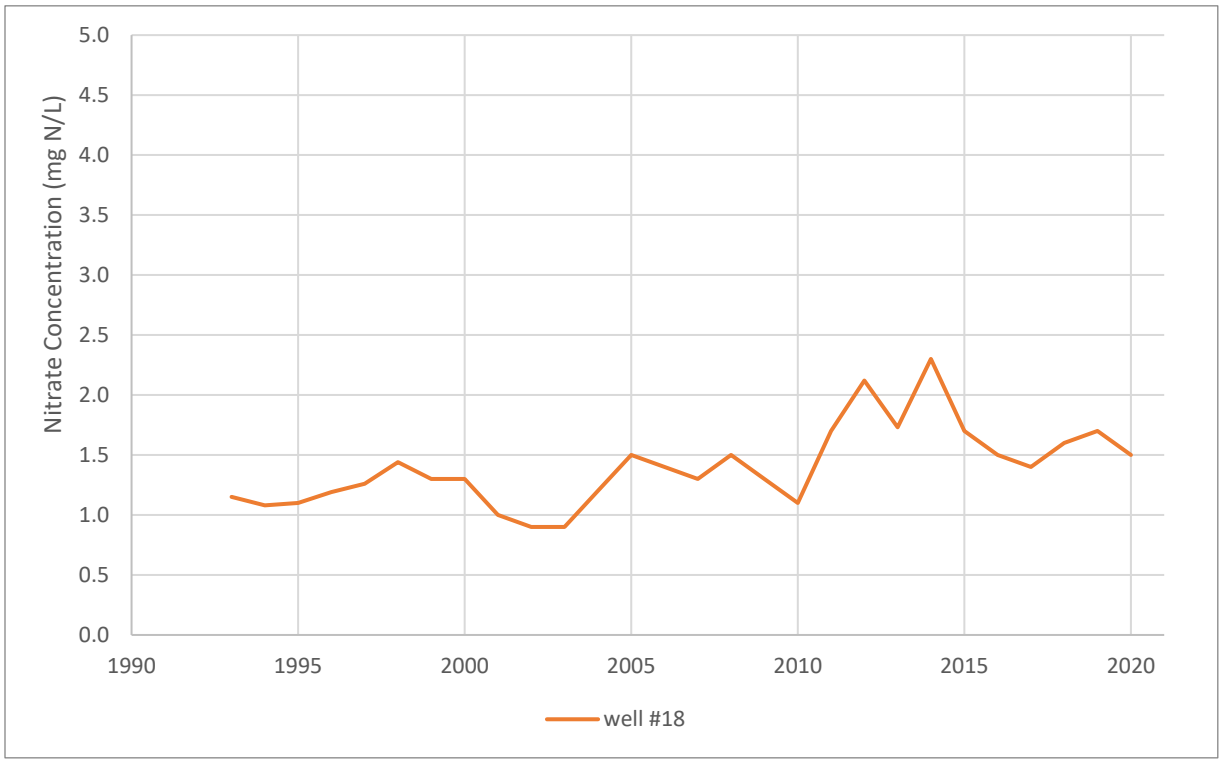


Figure 4-11: Nitrate Levels in Hokum Rock Road Area Wells

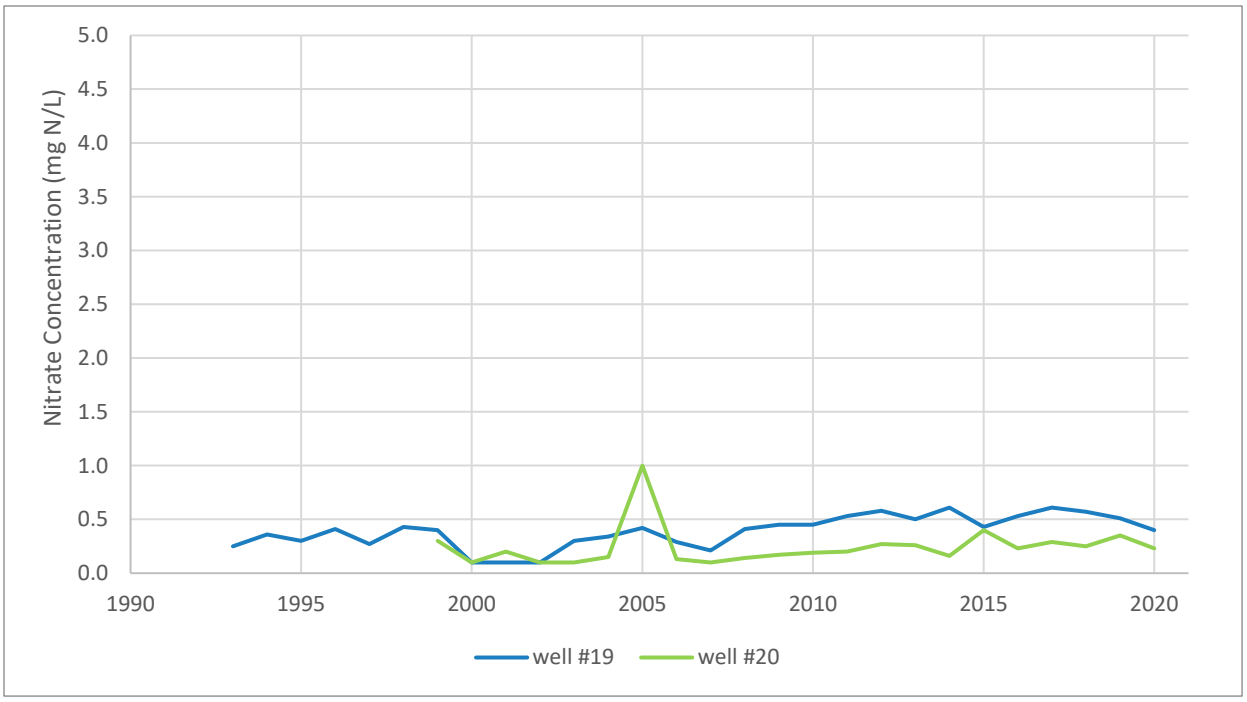


Figure 4-12: Nitrate Levels in Setucket Road Area Wells

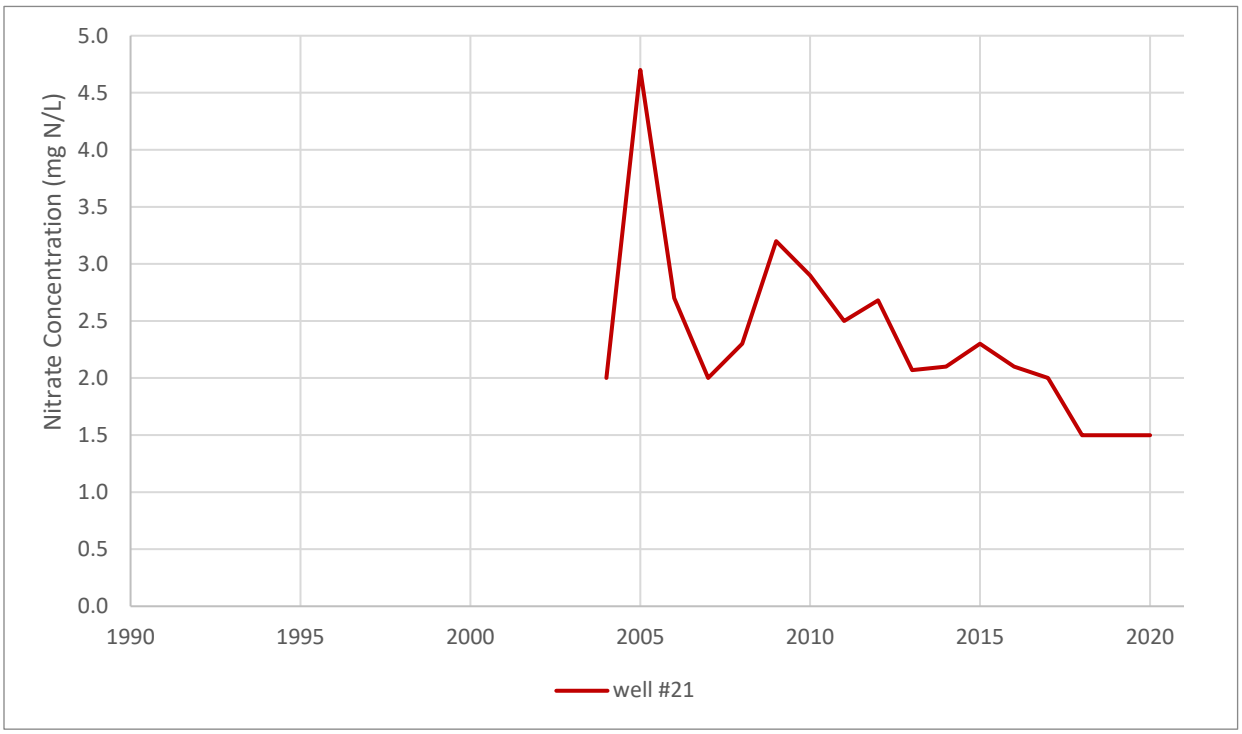


Figure 4-13: Nitrate Levels in 80 Old Bass River Road Area Wells

Many of the wells exhibited a spike in nitrate levels in 2005, for which no explanation has been discovered to date. It is possible that such a spike was due to changes in sampling or laboratory methodologies or the use of a different laboratory for analysis. The Dennis Water District was not aware of any special circumstances that would have caused this spike in so many locations at once.

Finally, **Figures 4-14 through 4-16** portray a summary of the nitrate data town-wide. Figure 4-14 summarizes the well data, showing both the maximum and average measured nitrate levels in each well, with wells grouped by geographic location. Figure 4-15 is a map showing the average measured nitrate concentrations over the 28-year period of record, and Figure 4-16 shows the maximum measured concentrations. The District annually updates nitrate water quality results on their website.

Also of potential concern from septic systems are "emerging contaminants," specifically pharmaceuticals and personal care products. These substances are not well studied at this time in septic system effluent but will be considered as future wastewater management decisions are made within areas of contribution to public water supply wells.

4.3 USGS Groundwater Monitoring Well Data

Historic groundwater data were obtained from the USGS NWIS Database for groundwater monitoring wells in Dennis. Note that these are different from water supply wells and are located both within and outside of Zone II areas.

4.3.1 USGS Nitrate Data

Groundwater samples from 16 of the USGS NWIS wells in Dennis were analyzed for nitrate. Sample frequency varies, but data are available between 1972 and 1986. The historic groundwater data are useful in providing a context and an understanding of past conditions. Nitrate concentrations ranged from non-detect to 6.2 mg/L, with a 95th percentile value of 1.7 mg/L. The highest values measured were at a well near the intersection of Route 134 and Old Chatham Road in the mid-1970s.

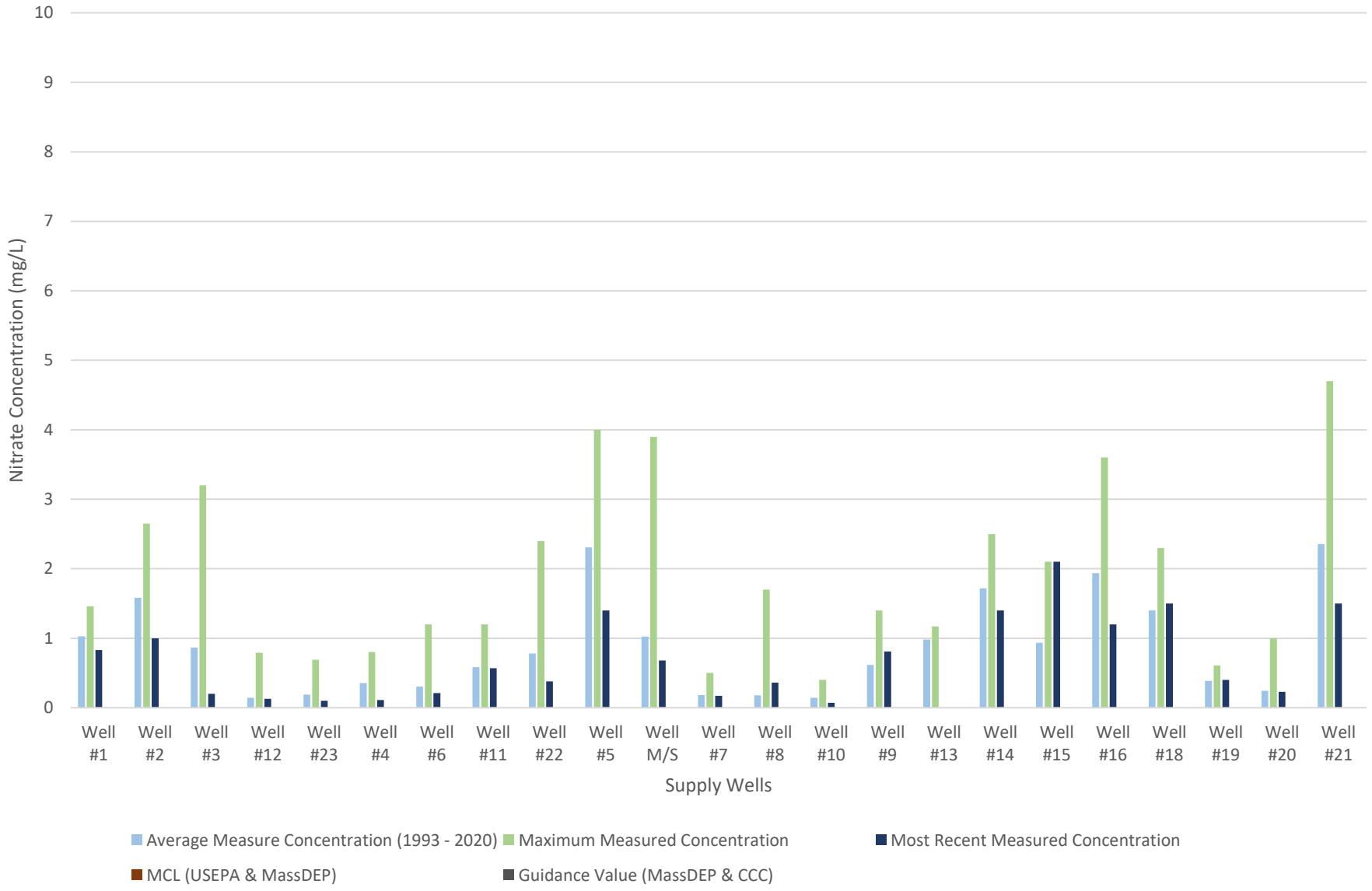
4.3.2 Groundwater Elevations

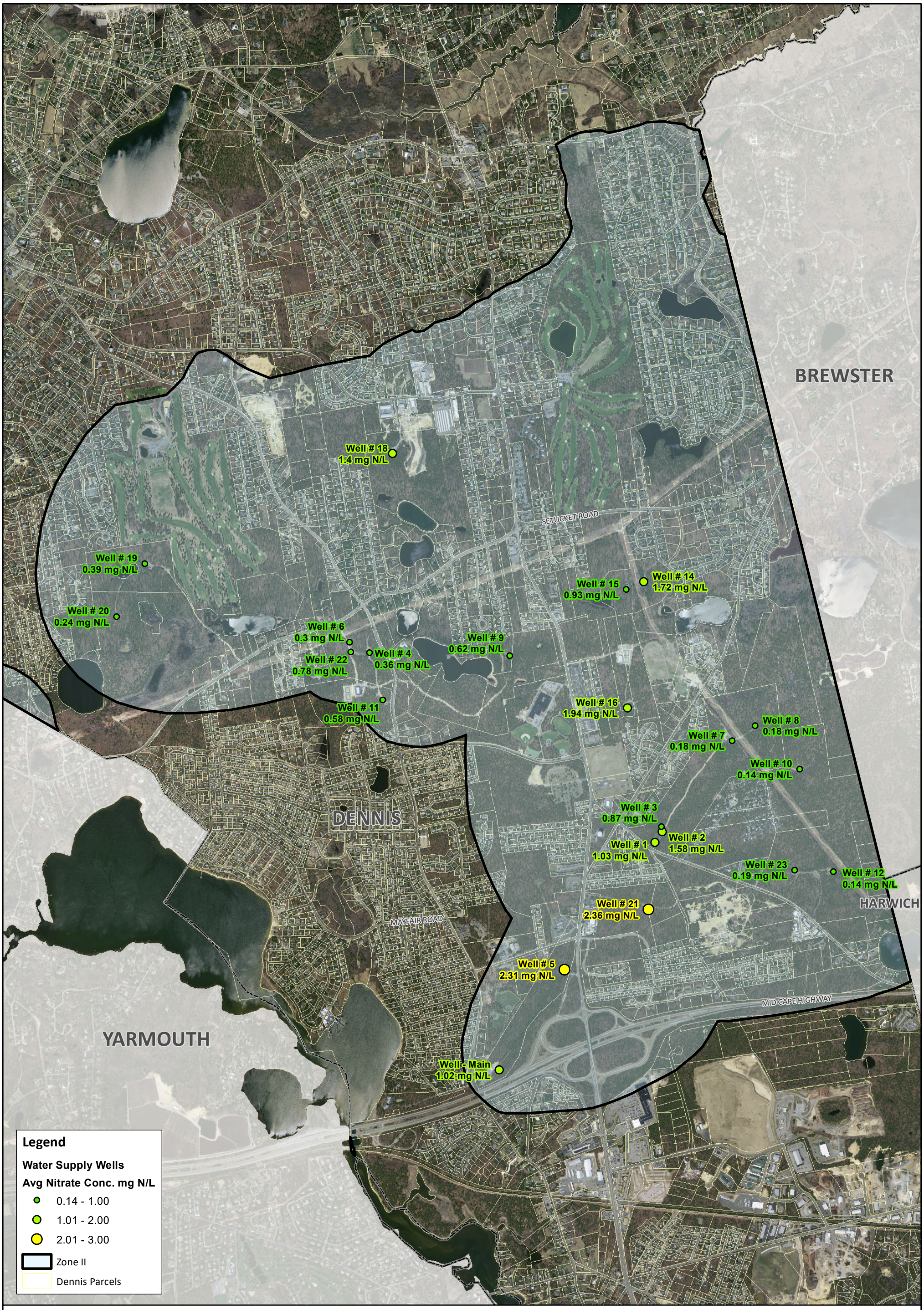
Long-term data from five wells were plotted to examine trends in groundwater elevations and to determine whether overall changes in groundwater conditions have been observed since the 1970s. Three of the wells are located north of Route 6 (Well Nos. MA-DGW 123, 157, and 158), and the other two are located south of Route 6 (Well Nos. MA-DGW 172 and 173). Figure 4-17 shows a plot of the long-term groundwater elevations. No long-term trends of groundwater elevations (either up or down) were observed from 1975 through 2007 aside from normal year-to-year variations.

Figure 4-18 shows the USGS groundwater contours in Dennis. These elevations range from sea level to 26-feet above sea level. **Figure 4-19** shows the depth to groundwater, calculated by determining the difference between the USGS groundwater contours and 2-foot land surface contours developed using town flyover data from the 2011 Northeast LiDAR (light detection and ranging) mission. As shown on Figure 4-19, there are substantial developed areas of Dennis

where the depth to groundwater is in either the 0 to 4 foot or 4 to 10 foot range, which can present challenges for septic systems and stormwater management.

Figure 4-14
Dennis Water District Water Supply Wells - Nitrate Concentrations
(1993 through 2020)





N

1 inch = 1,600 feet

0 1,000 2,000

Feet

Town of Dennis, MA

Average Measured Nitrate Levels 1993 - 2020

Figure 4-15

CDM Smith

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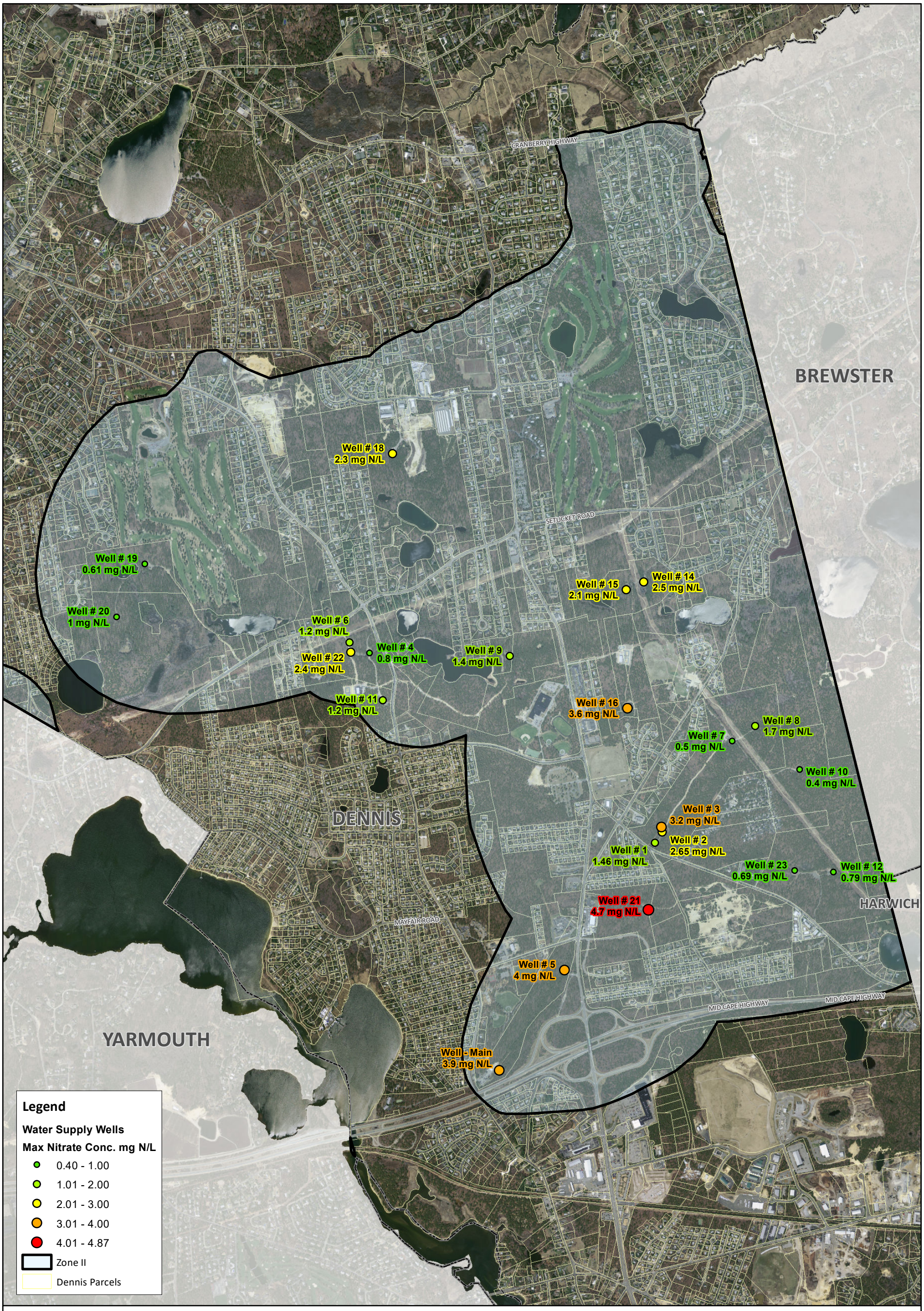

N

1 inch = 1,600 feet

0 1,000 2,000

Feet

Town of Dennis, MA

Maximum Measured Nitrate Levels 1993 - 2020

Figure 4-16

CDM Smith

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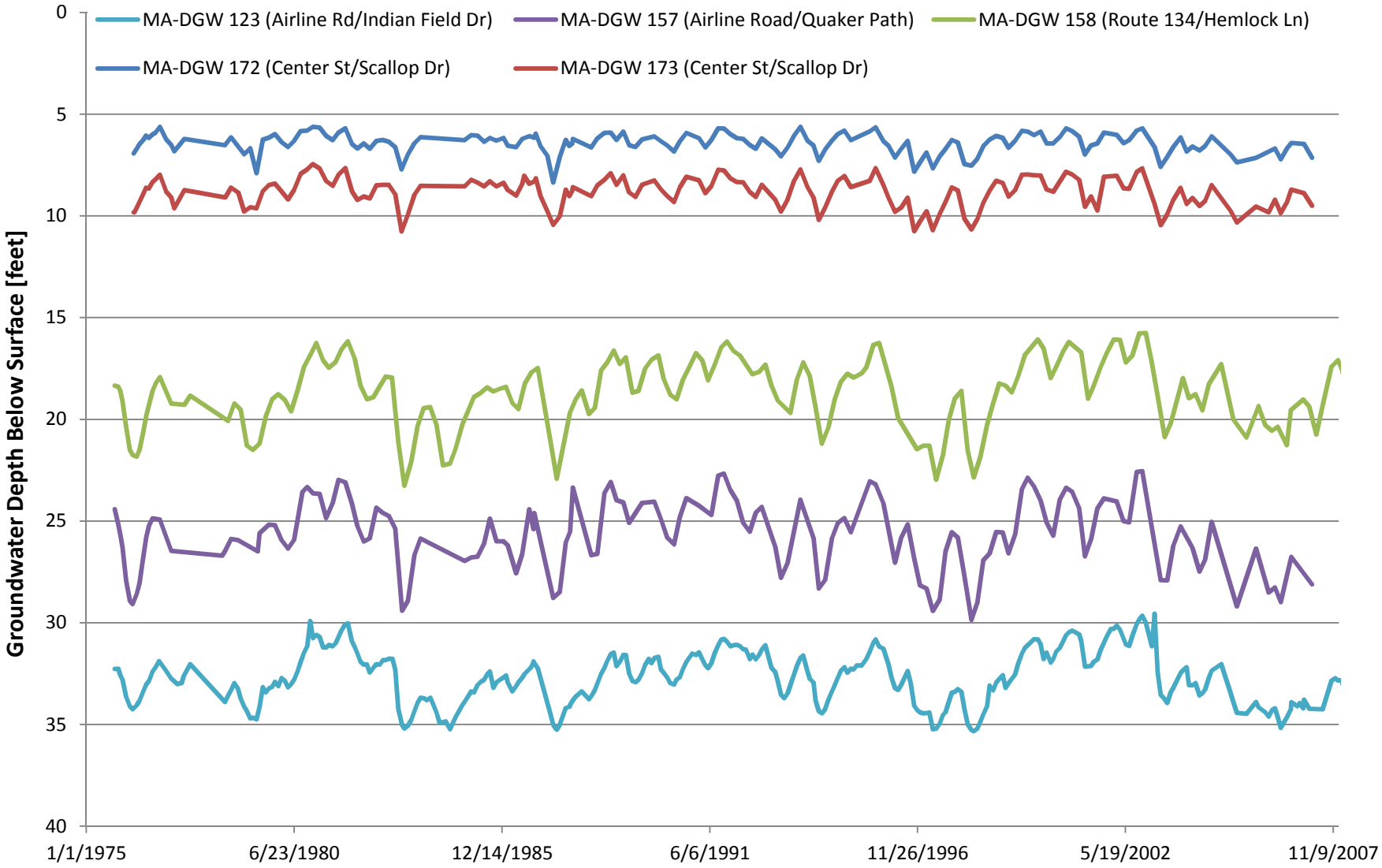
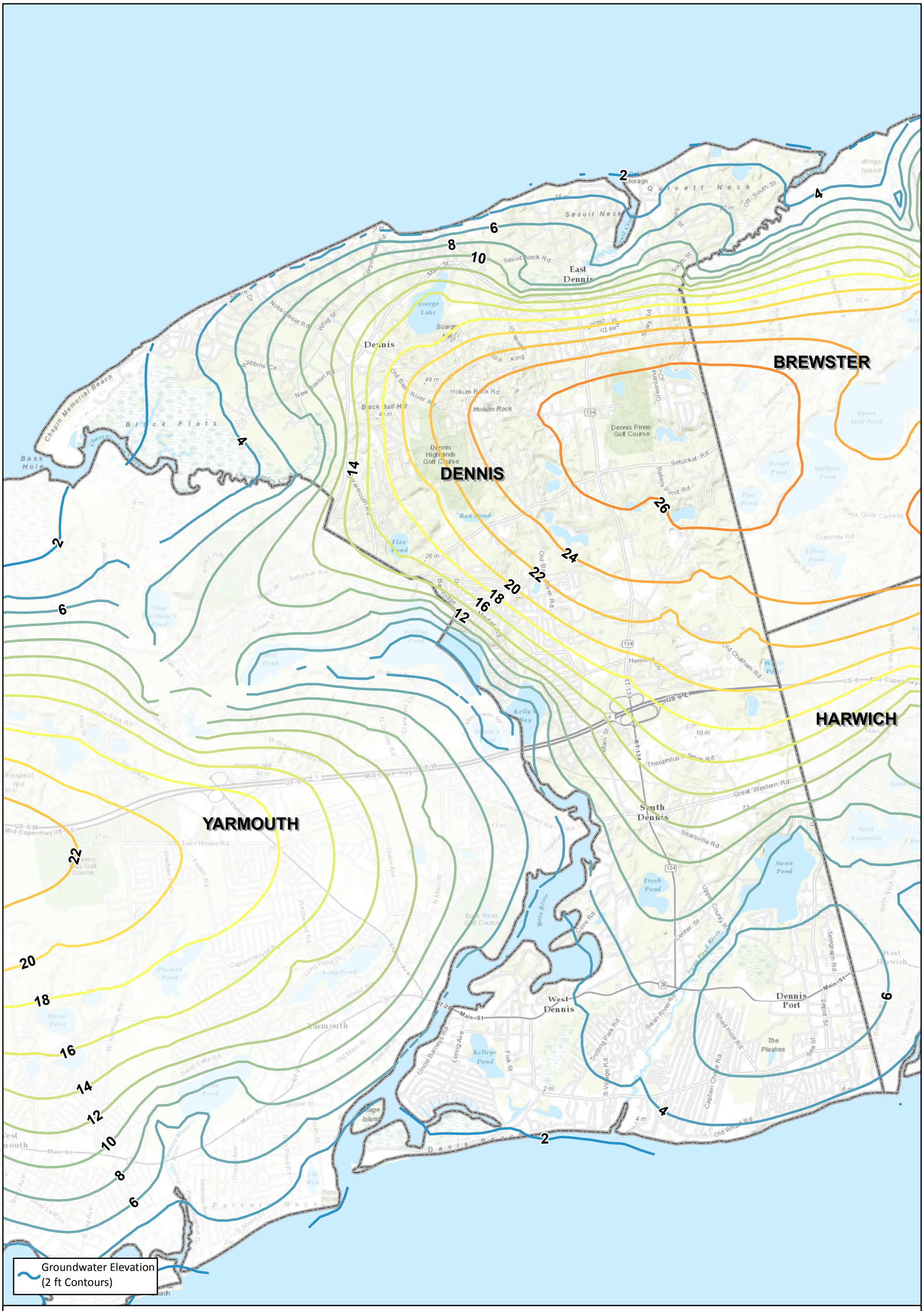
Figure 4-17
USGS Monitoring Well Groundwater Elevation Data





N

1 inch = 3,500 feet

0 5,000

Feet

Town of Dennis, MA

Groundwater Contours

Figure 4-18

CDM Smith

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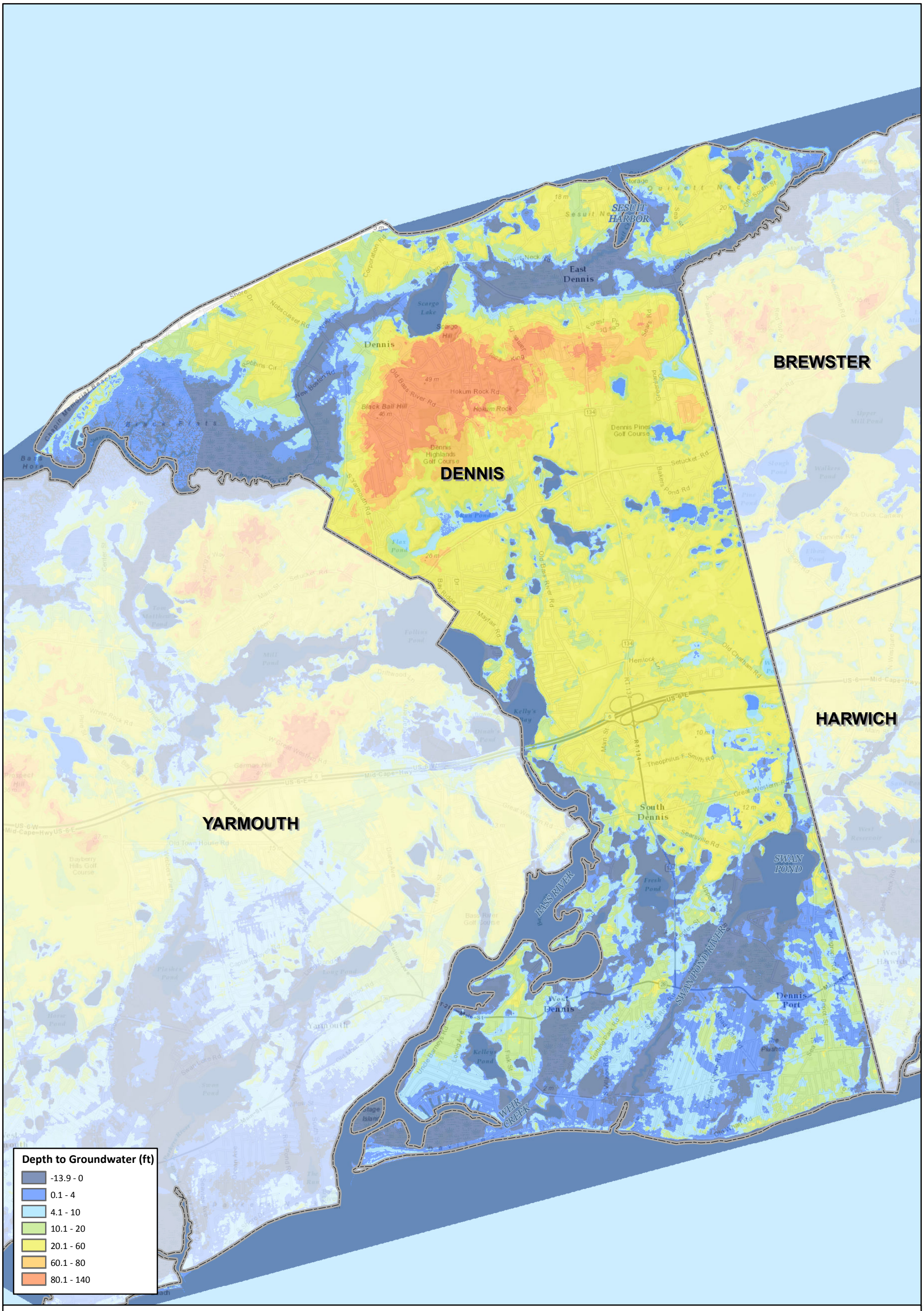

N

1 inch = 3,500 feet

0 5,000

Feet

Town of Dennis, MA

Depth to Groundwater

Figure 4-19

CDM Smith

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Section 5

Water Quality of Dennis Beaches

5.1 Introduction

The source of the information discussed in this section is the Barnstable County Department of Health and Environment, through their beach water quality data collection and reporting program.

The Massachusetts Department of Public Health (MDPH) administers the "Beach Program" for all beaches in the Commonwealth. All beaches are sampled regularly during the bathing season as part of a three-tiered monitoring program. Sampling and monitoring twice weekly is required for beaches classified as Tier 1. Tier 2 beaches require weekly monitoring. A classification of Tier 3 signifies beach waters of "low health concern" and requires less frequent monitoring.

The beach sampling program measures colonies of *Escherichia coliform* ("E. coli") and enterococci as indicator organisms for water quality, per state regulations listed in 314 CMR 4.00. The maximum single-sample standard for marine waters is 104 colony forming units (cfu) of enterococci per 100 milliliters (100 mL), and the geometric mean of the five most recent bathing season samples cannot exceed 35 cfu/100 mL. For fresh water, either enterococci or E. coli bacteria are used as indicators. The E. coli single-sample limit for recreational fresh water is 235 cfu/100 mL, and the enterococci limit is 61 cfu/100 mL. In addition, the geometric mean cannot exceed 126 cfu/100 mL of E. coli or 33 cfu/100 mL of enterococci in the five most recent bathing season samples according to state regulations.

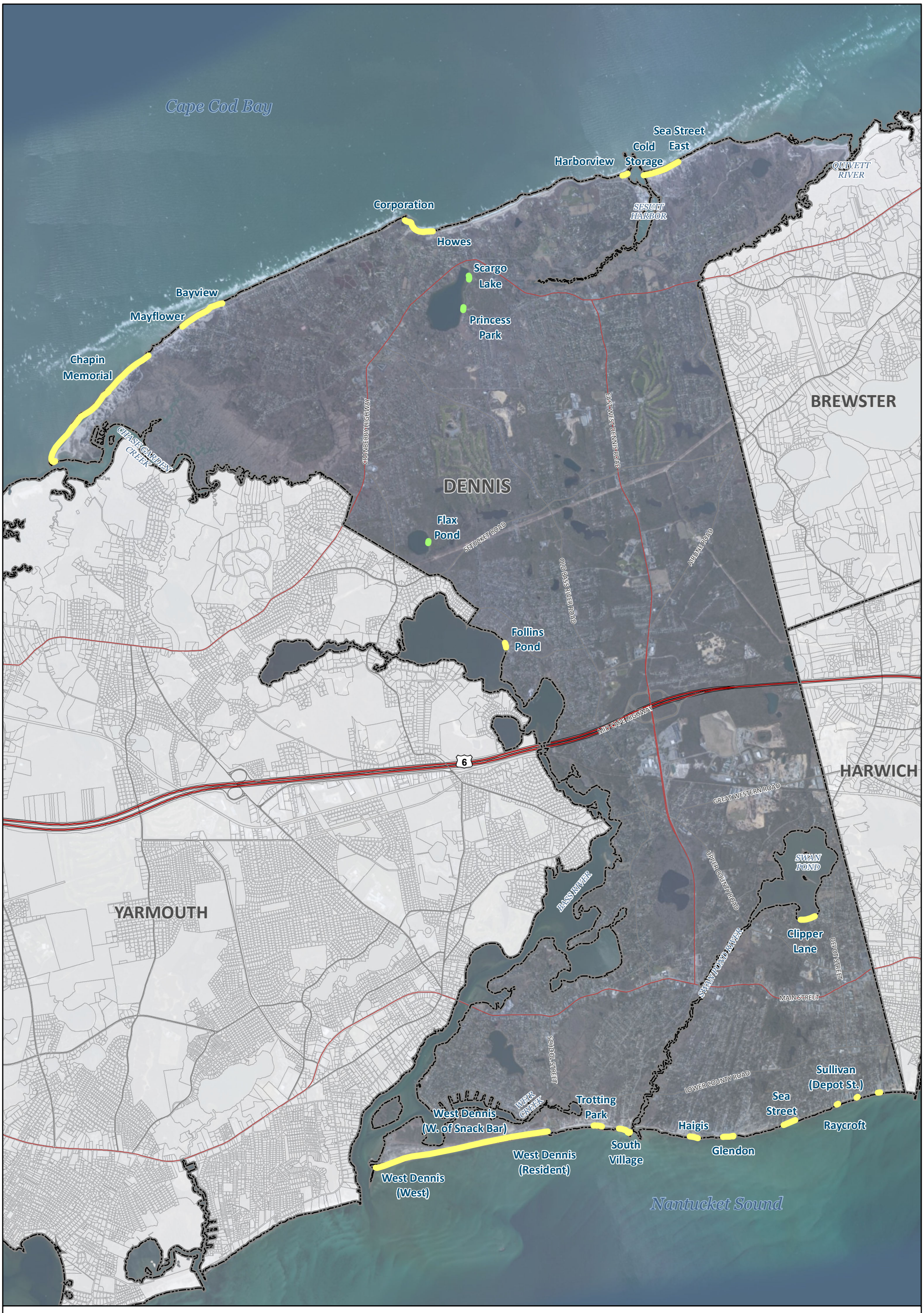
5.2 Dennis Beaches

Dennis has a mix of saltwater beaches at the shoreline and freshwater beaches at ponds. Isolated instances have occurred where the bacterial limits have been exceeded, usually after a rainfall event in response to a stormwater discharge. The sampling frequency of both freshwater and saltwater beaches in Dennis is weekly based on the state regulations described above.

Figure 5-1 shows the locations of all Dennis beaches. Freshwater and saltwater beaches are described in more detail below, along with the sampling results from 2009 to 2013. Longer term data, since 2001, are also shown in this section.

5.2.1 Freshwater Beaches

The freshwater beaches in Dennis include Flax Pond, Scargo Lake, and Princess Park (also along Scargo Lake). The sampling results can be found in **Table 5-1.** All beaches were tested from June through August, during the height of recreational use. All tests performed were sampling for E. coli, with the exception of four weeks in 2011, when enterococci sampling was instead performed.



Dennis Beaches

Freshwater Beach

Saltwater Beach

Town of Dennis, MA

N

1 in = 3,500 ft

0 0.5 1

Miles

Figure 5-1
Dennis Beaches

CDM Smith

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Table 5-1 Dennis Beach Sampling Results, 2009 through 2013

Beach Name	Number of Samples/ Number of Exceedances				
	2013	2012	2011	2010	2009
Fresh Water Beaches					
Flax Pond	13/0	13/0	12/0	13/0	14/0
Princess Park	13/0	13/0	13/0	13/0	14/0
Scargo Lake	13/0	13/0	13/0	13/0	14/0
Total Fresh Water Beaches	**39/0**	**39/0**	**38/0**	**39/0**	**42/0**

Out of the three freshwater beach locations that were tested in Dennis, all of the tests for 2009 to 2013 were acceptable by state regulations. Overall, the water quality at these beaches is exceptional.

5.2.2 Saltwater Beaches

The saltwater beaches in Dennis include Bayview, Chapin Memorial, Clipper Lane, Cold Storage, Corporation, Follins Pond, Glendon Road, Haigis, Harborview, Howes Street, Inman Road, Mayflower, Raycroft, Sea Street (Dennis Port), Sea Street (East Dennis), South Village, Sullivan (Depot Street), Trotting Park, West Dennis (Resident), West Dennis (Snack Bar), and West Dennis (West).

The sampling results are found in **Table 5-2**. All beaches were tested from June through August, during the height of recreational use. The highlighted cells represent at least one exceedance of recreational water quality standards for a particular beach in a particular year.

Table 5-2 Dennis Beach Sampling Results, 2009 through 2013

Beach Name	Number of Samples/ Number of Exceedances				
	2013	2012	2011	2010	2009
Marine Beaches					
Bayview	14/1	13/0	17/4	13/0	14/0
Chapin Memorial	15/2	13/0	13/0	13/0	17/1
Clipper Lane	16/3	14/1	17/6	14/1	11/0
Cold Storage	14/1	13/0	13/0	13/0	14/0
Corporation	16/1	15/0	15/0	14/0	17/1
Follins Pond	14/1	13/0	14/1	15/2	14/0
Glendon Road	N/A	N/A	N/A	N/A	15/1
Glendon Road East	14/1	14/1	13/0	13/0	N/A
Glendon Road West	14/1	13/0	13/0	13/0	N/A
Haigis	14/1	13/0	13/0	13/0	14/0
Harborview	16/3	13/0	13/0	13/0	14/0
Howes St.	14/1	13/0	13/0	13/0	16/2
Inman Rd.	15/2	13/0	13/0	13/0	15/1
Mayflower	17/2	17/2	15/0	14/0	16/0
Raycroft	15/3	13/0	13/0	13/0	14/0

Beach Name	Number of Samples/ Number of Exceedances				
	2013	2012	2011	2010	2009
Sea St. (Dennisport)	14/1	13/0	13/0	13/0	14/0
Sea St. (East Dennis)	14/1	13/0	13/0	13/0	16/2
South Village	13/0	13/0	13/0	13/0	15/1
Sullivan (Depot St.)	15/2	13/0	13/0	13/0	14/0
Trotting Park	15/2	13/0	14/1	13/0	15/1
West Dennis (Resident)	18/3	15/0	16/1	13/0	16/0
West Dennis (Snack Bar)	17/2	15/0	15/0	14/0	16/0
West Dennis (West)	15/0	14/0	14/0	14/0	16/0
Total Marine Beaches	**329/34**	**299/4**	**293/13**	**293/3**	**313/10**

5.3 Summary of 2009 to 2013 Data

Overall, Dennis has seen good beach water quality over the last five years. The fresh water quality has experienced no exceedances in the past five years. Each saltwater beach in Dennis saw at least one exceedance annually, with the exception of West Dennis (West). These exceedances occur during the summer recreational season when there are impacts from boat wastes, adjacent wildlife habitats, and stormwater. There were more saltwater exceedances than usual during 2013, most of which occurred on June 19th and June 26th. These occurred at beaches on both the north and south sides of Dennis. Re-tests on the following days were all in compliance with the exception of Raycroft Beach, which still exceeded the maximum enterococcus level two days later. Per revised (2014) state bathing beach regulations, beaches are permitted to remain open after one individual exceedance, provided that a re-test within 24 hours yields compliant results. There is no obvious explanation for the June 2013 exceedances. One typical source is stormwater runoff; however, there was no rainfall for seven days preceding the June 26th exceedances at thirteen different saltwater beaches. That said, June 2013 was one of the five wettest Junes on record (1931, 1982, 1998, 2006, and 2013), so stormwater may have played a role.

5.4 Long Term Beach Sampling Results

Figures 5-2 through 5-6 provide the weekly long-term bacteria sampling results by MEP watershed area including the Sesuit Harbor watershed, Swan Pond River watershed, Bass River watershed, and northside and southside direct discharge areas. Note that all samples are reported in cfu/100 mL.

5.4.1 Northside Beaches (Direct Discharge)

Figure 5-2 shows the weekly long term enterococci sampling results for the beaches with direct discharge to Cape Cod Bay from 2001 to 2013. These beaches are Chapin Memorial, Mayflower, Bayview, Corporation, Howes Street, Harborview, and Sea Street East. On average, the sampling results at these seven salt water beaches are under the daily maximum 104 cfu/100 mL limit. Occasional peaks of >400 cfu/100 mL were measured in sampling years in the mid-2000s.

5.4.2 Sesuit Harbor Watershed

Figure 5-3 shows the weekly long term bacteria sampling results for the beaches within the Sesuit Harbor watershed from 2001 to 2013. On average, the sampling results in this watershed are very low for the two freshwater beaches, Princess Park and Scargo Lake. Freshwater sampling was predominately for E. coli, as noted above. The saltwater beach at the outlet of Sesuit Harbor, Cold Storage Beach, usually had results below 50 cfu/100 mL enterococci; however there was one spike during the mid-2000s where sampling results were greater than 400 cfu/100 mL.

5.4.3 Swan Pond River Watershed

Figure 5-4 shows the weekly long term bacteria sampling results for the Swan Pond River watershed beaches from 2001 to 2013. South Village Beach normally sees low results, however, there were a few years where results reached 104-150 cfu/100 mL of enterococcus, thus exceeding the 104 cfu/100 mL limit. Sampling at Clipper Lane started in the late 2000s. Results for this beach are higher than those of South Village, with sampling results often reaching above 50 cfu/100 mL. There were seven occasions of results greater than 104 cfu/100 mL.

5.4.5 Bass River Watershed

Figure 5-5 shows the weekly long term bacteria sampling results for the Bass River watershed beaches from 2001 to 2013. Flax Pond, a fresh water beach, has extremely low results, except for one sample with an E. coli measurement of 462 cfu/100 mL in 2002. Follins Pond, a salt water beach, has fairly low results. There were six instances of results exceeding 104 cfu/100 mL since 2001, with a couple of instances of samples exceeding 350 cfu/100 mL in the early 2000s.

5.4.6 Southside Beaches (Direct Discharge)

Figure 5-6 shows the weekly long term enterococci sampling results for the southside beaches from 2001 to 2013. These 11 saltwater beaches have most results under 50 cfu/100 mL. The West Dennis (Resident) and Inman Road Beaches, however, have had individual exceedances of the 104 cfu/100 mL standard in many years since 2001.

5.5 Conclusions

Based on the above information, the water quality at Dennis' freshwater and saltwater beaches appears to be acceptable under normal conditions. Occasional bacterial contamination does occur, which is likely due to stormwater inputs, wildlife, and boat discharges. Regular bacterial contamination from septic systems does not appear to be a concern in any particular location. Mitigation strategies for each of these potential sources of bacterial contamination should be considered moving forward.

Figure 5-2. Long Term Weekly Bacteria Sampling Results
Northside Direct Discharge Beaches

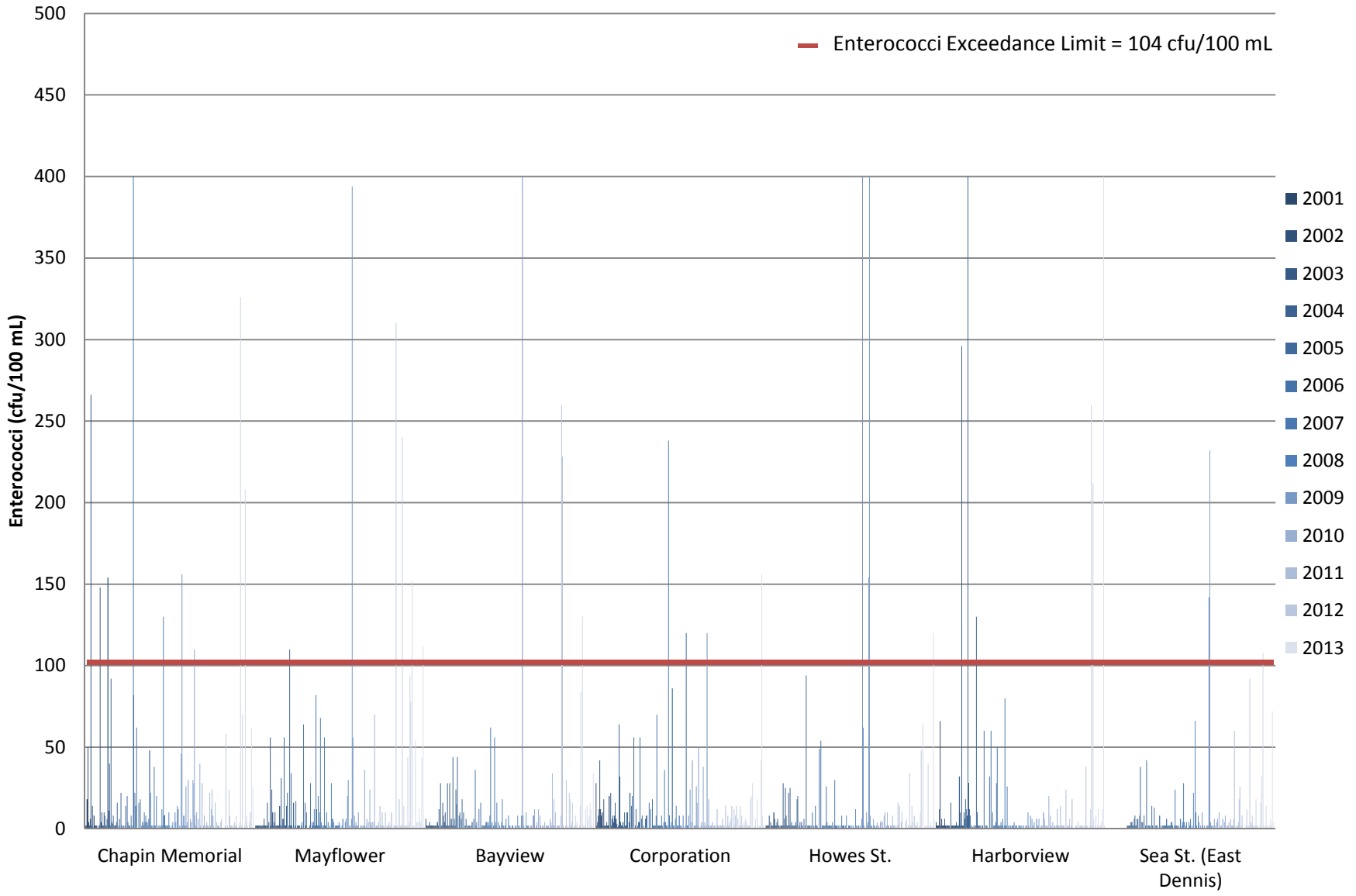


Figure 5-3. Long Term Weekly Bacteria Sampling Results
Sesuit Harbor Watershed

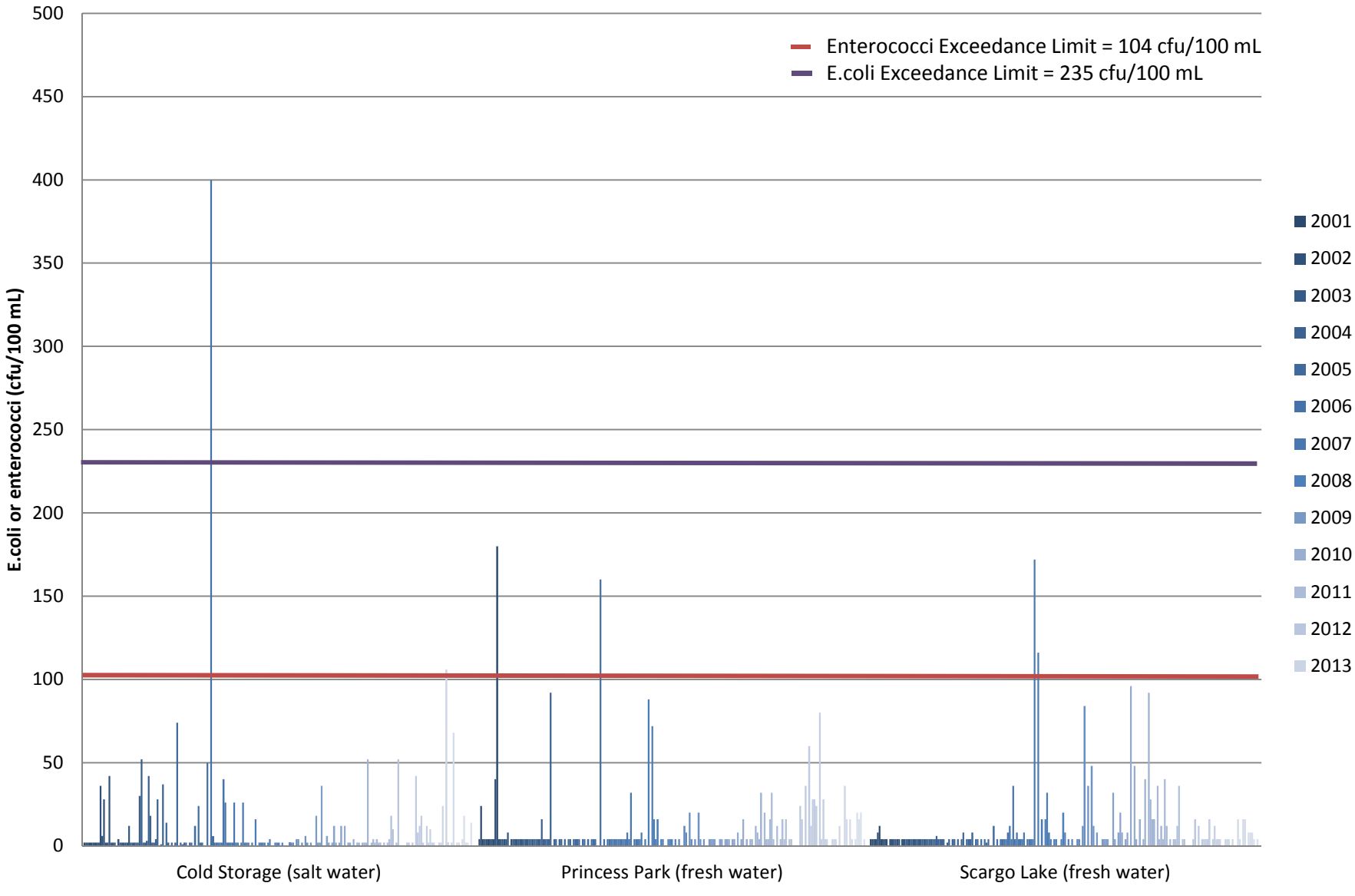


Figure 5-4. Long Term Weekly Bacteria Sampling Results
Swan Pond River Watershed

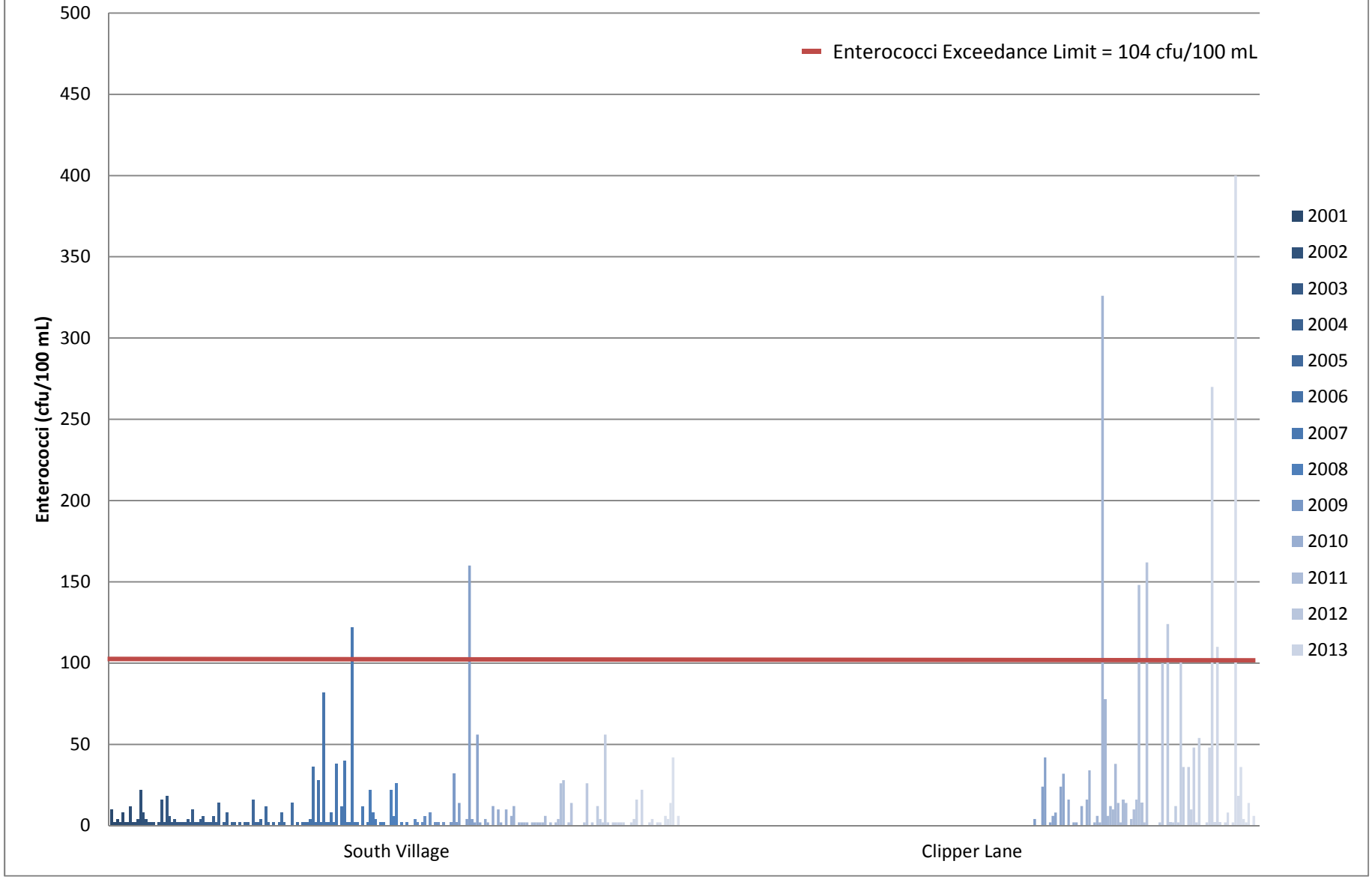


Figure 5-5. Long Term Weekly Bacteria Sampling Results
Bass River Watershed

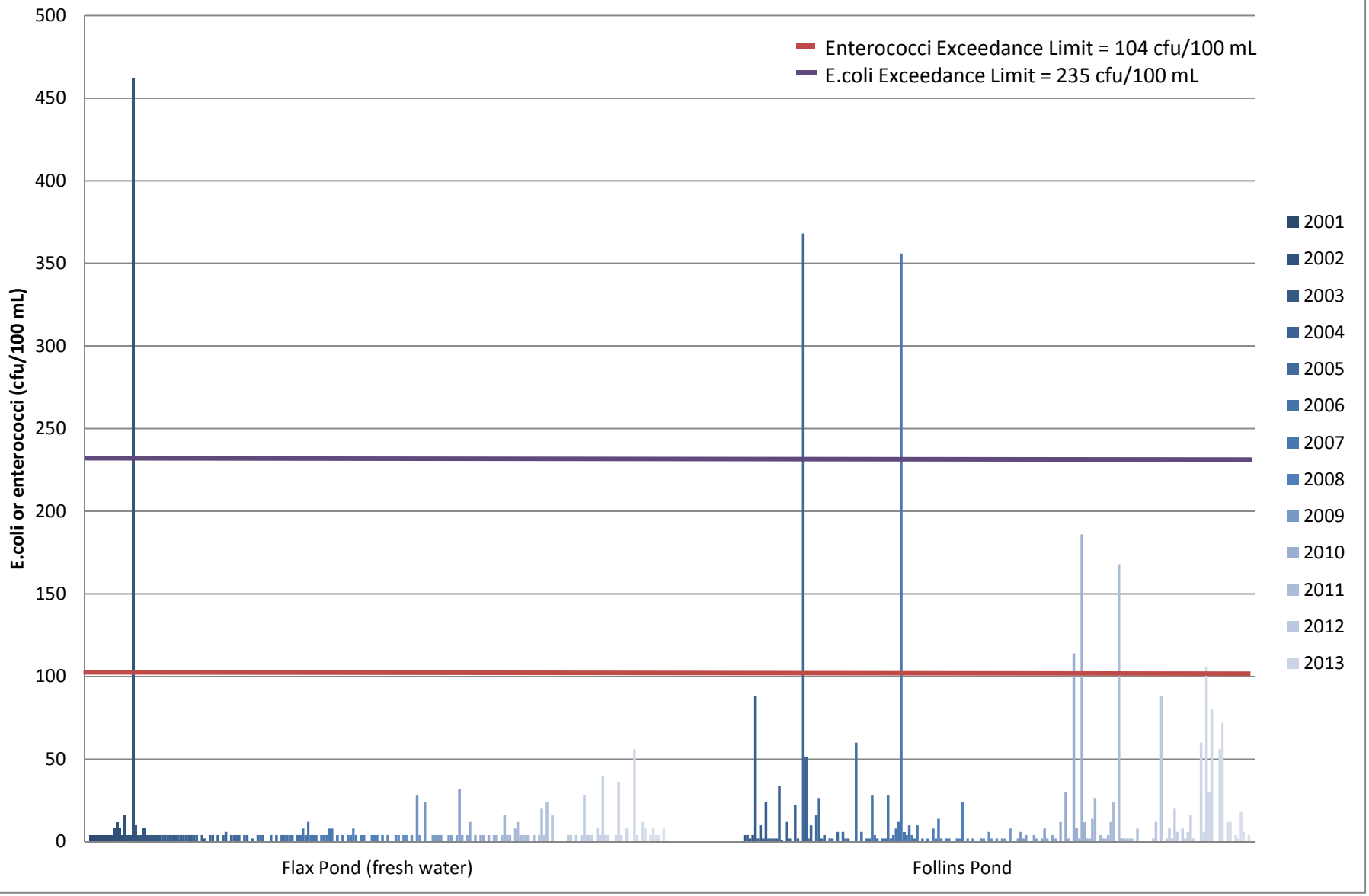
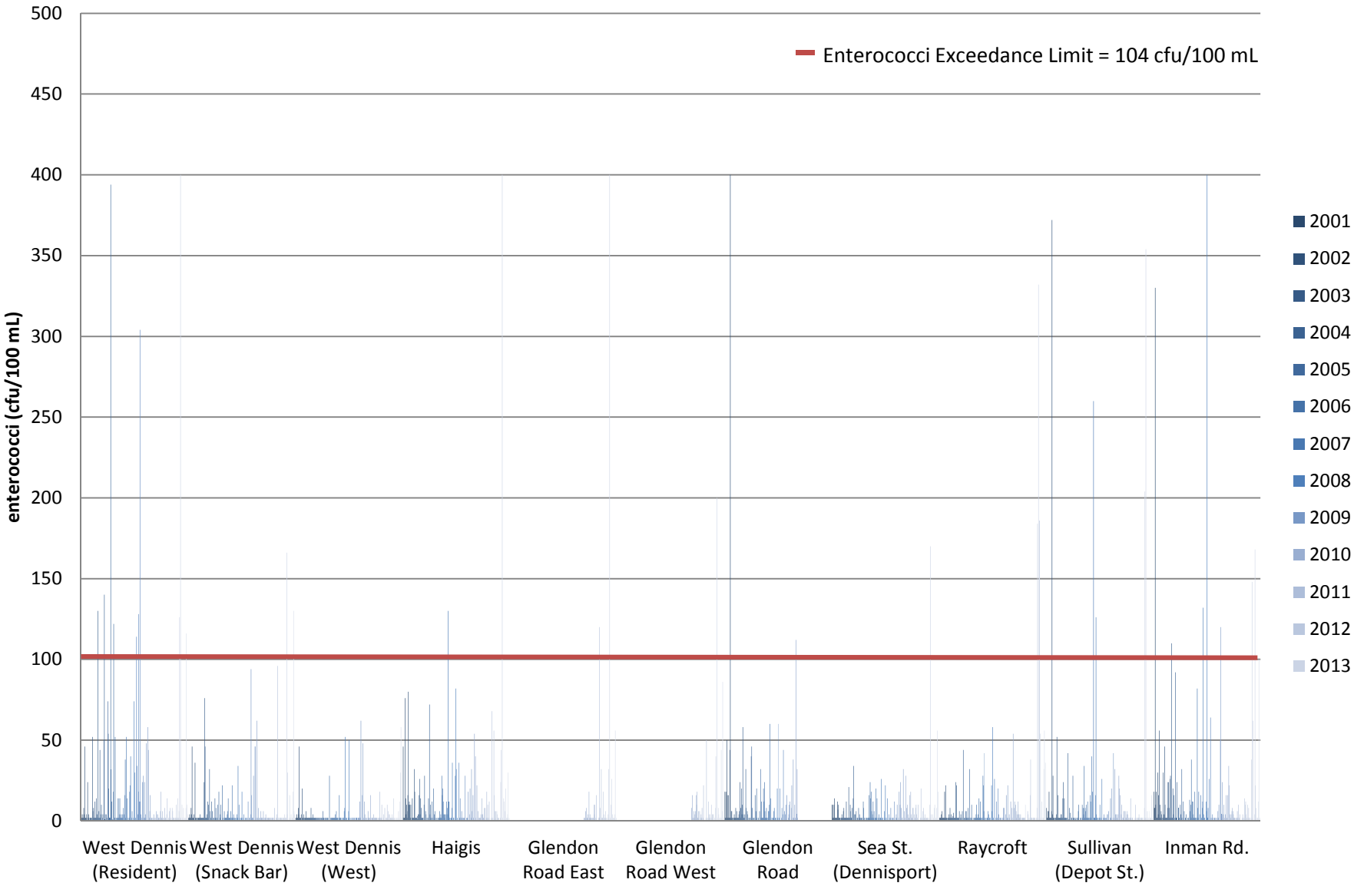


Figure 5-6. Long Term Weekly Bacteria Sampling Results
Southside Direct Discharge Beaches



Section 6
Water Quality Regulations

6.1 Introduction

The federal Clean Water Act (CWA) was enacted over 40 years ago (October 18, 1972), mainly to address the discharge of raw sewage and other pollutants into our nation's waters. Point source pollution has been addressed through the issuance of and compliance with National Pollutant Discharge Elimination System (NPDES) permits. Significant progress in cleaning up our waters has been achieved, and many of the nation's water bodies are once again used for fishing, swimming and more. While progress has been made, about 40 percent of lakes, ponds, rivers, wetlands and coastal waters in the United States remain impaired due to pollution. Thus, further regulations and related programs have been enacted by both the federal government and individual states to bring these waterways back to conditions which support their designated uses.

The Massachusetts Department of Environmental Protection (MassDEP) has adopted several Code of Massachusetts Regulations (CMRs) that address water quality, including sections addressing Surface Water Quality Standards (314 CMR 4.00), the Groundwater Discharge Permits Program (314 CMR 5.00), and Ocean Sanctuaries (302 CMR 5.00). This section describes each of these regulations, along with discussion regarding their applicability to Dennis waterways. In addition, water bodies in Dennis that have been identified as impaired are described below, including a description of specific impairments identified by the regulatory agencies.

In February 2017, MassDEP issued a response letter to the Town of Harwich, copying the Town Administrator for the Town of Dennis and Department of Public Works Director for Yarmouth regarding regulatory action that the Department may take if the Cape Cod communities slow or fail to make progress towards addressing impaired estuarine systems on Cape Cod. MassDEP identified the following as potential actions that could be taken:

- Designation of Nitrogen Sensitive Areas (NSAs). MassDEP could designate watersheds to embayments that exceed their critical load to be nitrogen sensitive if needed to meet water quality goals as identified in the total maximum daily loads (TMDLs) and Surface Water Quality Regulations (314 CMR 4.00).
- Changes to groundwater discharge permit and regulations. MassDEP could tighten current permit limits, requiring additional treatment of septic system effluent (i.e. innovative and alternative solutions) and also remove the Title 5 Exemption, which exempts on-site septic systems that discharge less than 10,000 gallons per day.
- Formation of Water Pollution Abatement Districts (WPADs). WPADs can be formed by the Department for the prompt and efficient abatement of water pollution within cities or towns. The WPAD would be responsible for developing watershed plans, applying for requisite permits and construction and operating the treatment works necessary to meeting permitting requirements.

6.2 Massachusetts Water Quality Regulations

6.2.1 Massachusetts Surface Water Quality Regulations

Massachusetts Surface Water Quality Regulations, found in 310 CMR 4.00, designate the uses for which the various surface waters of the Commonwealth must be enhanced, maintained and protected. Examples of designated uses include drinking water supply, recreation, habitat, and aesthetics. These regulations prescribe the minimum water quality criteria required to sustain or achieve designated uses including, where appropriate, the restriction or prohibition of discharges to waterways. The regulations segment Massachusetts waters into classes that are based upon the most sensitive, and therefore governing, water uses to be achieved and protected.

6.2.1.1 Inland Water Classes

Class A is the highest inland water quality class. Class A waters include waters designated as public water supplies and their tributaries. They are designated as excellent habitat for fish, other aquatic life and wildlife, including for their reproduction, migration, growth and other critical functions, and for primary and secondary contact recreation, even if not allowed. These waters must have excellent aesthetic value. Numeric criteria for Class A waters include minimum dissolved oxygen (DO) and maximum temperature requirements for both cold and warm water fisheries, a specific allowable pH range, and limits on bacterial concentrations for both fecal coliform (for drinking water supplies) and E. coli or enterococci (for recreation). In addition, narrative (non-numeric) criteria are included for solids, color and turbidity, oil and grease, and taste and odor.

Class B waters are designated as habitat for fish, other aquatic life, and wildlife, including for their reproduction, migration, growth and other critical functions, and for primary and secondary contact recreation. They are sometimes suitable as a source of public water supply with appropriate treatment, and they are suitable for irrigation and other agricultural uses and for compatible industrial cooling and process uses. These waters have consistently good aesthetic value. Again, numeric criteria are specified for DO, temperature, pH, and bacteria, while narrative criteria are prescribed for solids, color and turbidity, oil and grease, and taste and odor.

Class C waters are designated as habitat for fish, other aquatic life, and wildlife, including all of the wildlife functions noted for Classes A and B above, and for secondary contact recreation. They are also suitable for irrigation of crops used for consumption after cooking and for compatible industrial cooling and process uses, and they have good aesthetic value. Numeric and narrative criteria are again prescribed for the same parameters listed above for Class A and B waters.

6.2.1.2 Coastal and Marine Classes

Class SA is the highest coastal and marine class. Class SA waters are designated as excellent habitat for fish, other aquatic life, and wildlife, including for reproduction, migration, growth and other critical functions, and for primary and secondary contact recreation. In certain waters, this designation may include excellent habitat for seagrass. These waters may also be designated for shellfishing (as “approved” and “conditionally approved” shellfish areas) and have excellent aesthetic value.

Class SB waters are designated as habitat for fish, other aquatic life, and wildlife, including for their reproduction, migration, growth, and other critical functions, and for primary and secondary contact recreation. When designated suitable for shellfish harvesting, depuration is required (considered "restricted" and "conditionally restricted" shellfish areas). Depuration is the process by which shellfish are placed in high quality water prior to consumption to purge potentially contaminated gut contents. These waters have consistently good aesthetic value.

Class SC waters are designated as habitat for fish, other aquatic life, and wildlife, including for their reproduction, migration, growth and other critical functions, and for secondary contact recreation. They are also considered suitable for certain industrial cooling and process uses and have good aesthetic value.

Similar to inland waters, numeric water quality standards for all three classes of marine waters include DO, temperature, pH, and bacteria, while narrative standards are assigned for solids, color and turbidity, oil and grease, and taste and odor.

The classification of a water body is set based on its highest and best use versus what it currently is used for today. Thus, most coastal and marine waters are designated Class SA, with very few Class SB, and no current Class SC waters in the Commonwealth (B. Dudley, MassDEP, 12-15-10). **Figure 6-1** shows the Cape Cod Drainage Area from 314 CMR 4.06. As shown, all of the marine waters along both Dennis' northern and southern coastlines are classified as Class SA.

The Surface Water Quality Standards also contain additional site-specific numerical limits for particular water bodies. None of the water bodies in Dennis or for which Dennis shares watershed area are listed as having site-specific numerical limits.

6.2.1.3 Antidegradation Provision

MassDEP's "antidegradation provisions" included in the Surface Water Quality regulations stipulate that existing uses must be maintained and protected, waters whose quality is higher than required must have that quality level maintained unless otherwise allowed by the MassDEP, and waters designated as Outstanding Resource Waters receive additional protection. Outstanding resource waters include those used as public drinking water supplies, certain wetlands, and other waters determined based on their outstanding socio-economic, recreational, ecological and/or aesthetic values. In addition, MassDEP designates some waters as Special Resource Waters, which also have additional protection.

Herring River is listed as Class SA and additionally as both a shellfishing area and an Outstanding Resource Water. No other areas in Dennis or water bodies for which Dennis shares a watershed are specifically called out in the tables in 314 CMR 4.06 which list Outstanding and Special Resource Waters (specifically, Table 26, which addresses the Cape Cod Coastal Drainage Area).

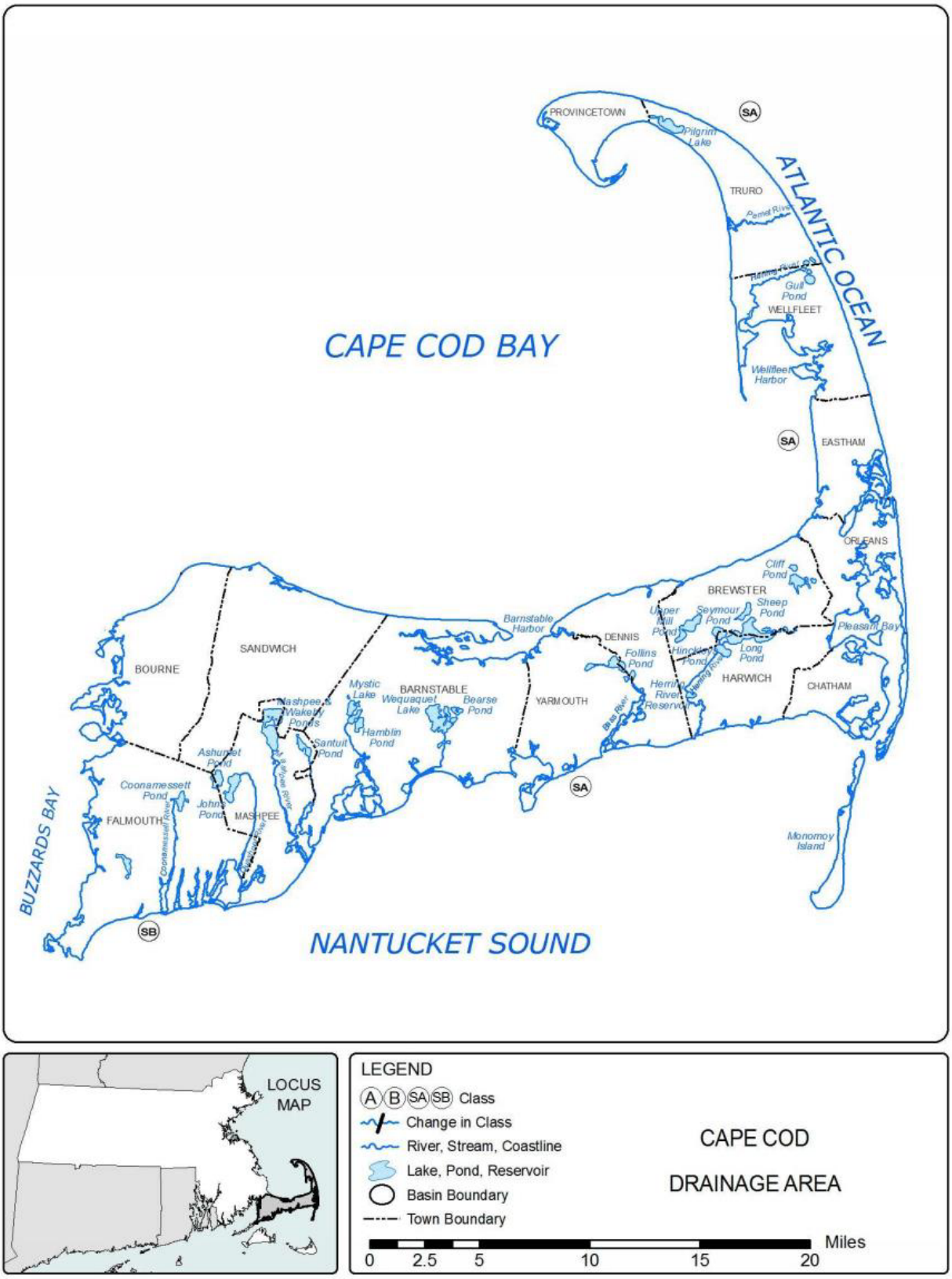


Figure 6-1
Massachusetts Surface Water Classifications for Cape Cod

6.2.1.4 Nutrient Criteria

Narrative (non-numeric) criteria are assigned for all waters for aesthetics, bottom pollutants or alternations, nutrients, radioactivity, and toxic pollutants. Most applicable to the Dennis Water Quality Evaluation and Mitigation Alternative Study is the language pertaining to nutrients, which reads as follows:

> *"Unless naturally occurring, all surface waters shall be free from nutrients in concentrations that would cause or contribute to impairment of existing or designated uses and shall not exceed the site specific criteria developed in a TMDL [Total Maximum Daily Load] or as otherwise established by the Department pursuant to 314 CMR 4.00. Any existing point source discharge containing nutrients in concentrations that would cause or contribute to cultural eutrophication, including excessive growth of aquatic plants or algae, in any surface water shall be provided with the most appropriate treatment as determined by the Department, including, where necessary, highest and best practical treatment (HBPT) for POTWs and BAT [best available technology economically achievable] for non-POTWs, to remove such nutrients to ensure protection of existing and designated uses. Human activities that result in the nonpoint source discharge of nutrients to any surface water may be required to be provided with cost effective and reasonable best management practices for nonpoint source control."*

The Surface Water Quality Standards also allow MassDEP to develop and enforce compliance with TMDLs and TMDL implementation plans for impaired waters. The Standards define a TMDL as:

> *"The sum of a receiving water's individual waste load allocations and load allocations and natural background, which, together with a margin of safety that takes into account any lack of knowledge concerning the relationship between the effluent limitations and water quality, represents the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards in all seasons."*

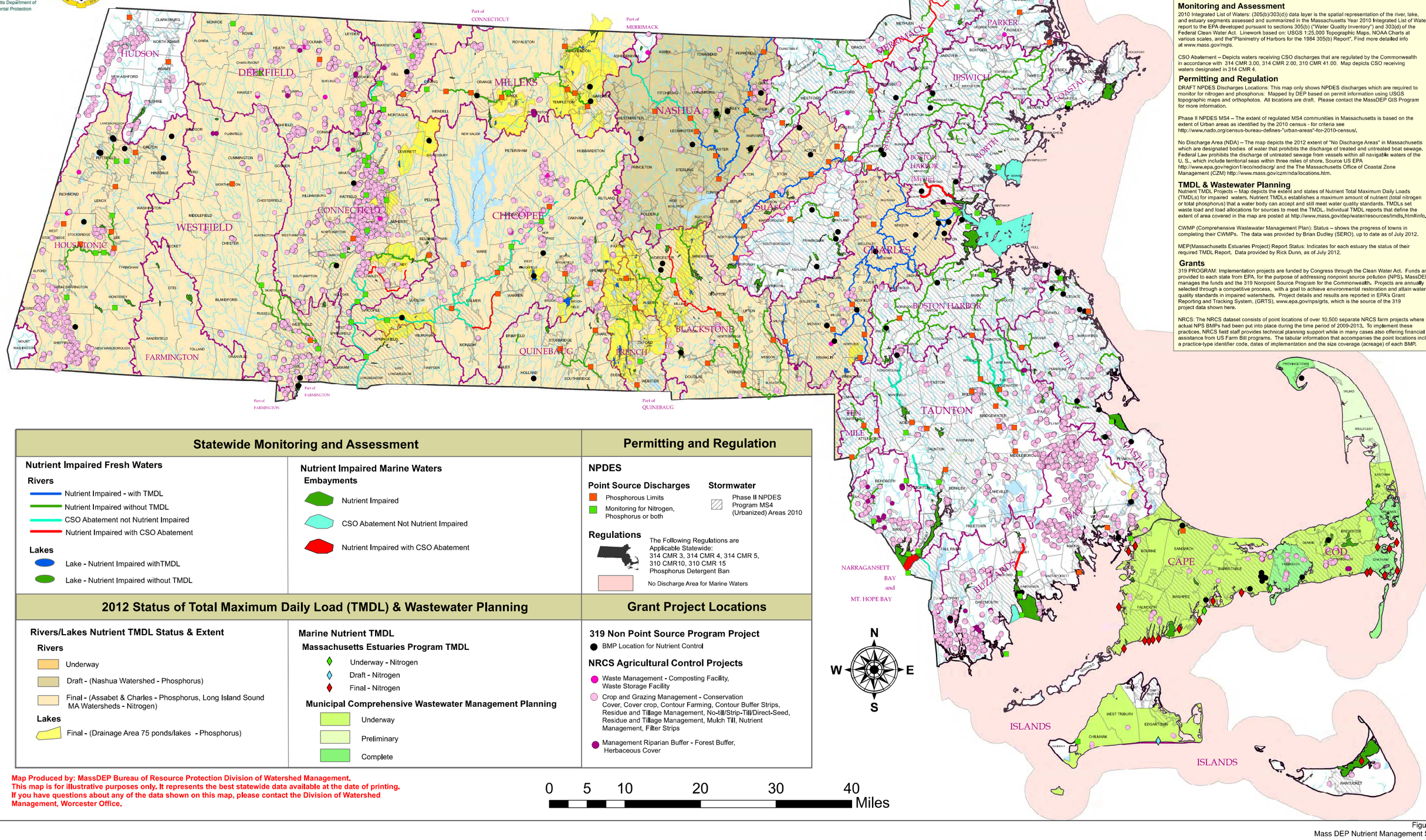
TMDLs can be developed for any pollutant, such as heavy metals, nutrients, or fecal coliform bacteria. Sources considered include both point sources (direct outfalls) and non-point sources such as effluent from septic systems, stormwater runoff, and eroding soils. This is the mechanism through which MassDEP is anticipated to regulate the non-point source releases of nutrients on Cape Cod. The current status of nutrient regulation and TMDLs in Massachusetts is shown on **Figure 6-2**.

6.2.2 Groundwater Discharge Permit Program Regulations

The Massachusetts Groundwater Discharge Permit Program regulations (310 CMR 5.00) control the discharge of pollutants to the groundwater of the Commonwealth to assure that groundwater is protected for actual and potential use as a source of potable water, that surface waters are protected for their existing and designated uses, and that the Surface Water Quality Regulations are met. As these regulations relate to Dennis, they govern the criteria that must be attained in the liquid effluent resulting from treatment of wastewater at a treatment plant that receives 10,000 gallons per day (gpd) or more.

MASSACHUSETTS NUTRIENT MANAGEMENT 2013

MassDEP
Massachusetts Department of Environmental Protection



Statewide Monitoring and Assessment

Nutrient Impaired Fresh Waters

Rivers

- Nutrient Impaired - with TMDL
- Nutrient Impaired without TMDL
- CSO Abatement not Nutrient Impaired
- Nutrient Impaired with CSO Abatement

Lakes

- Lake - Nutrient Impaired withTMDL
- Lake - Nutrient Impaired without TMDL

Nutrient Impaired Marine Waters

Embayments

- Nutrient Impaired
- CSO Abatement Not Nutrient Impaired
- Nutrient Impaired with CSO Abatement

Permitting and Regulation

NPDES

Point Source Discharges

- Phosphorous Limits
- Monitoring for Nitrogen, Phosphorus or both

Stormwater

- Phase II NPDES Program MS4 (Urbanized) Areas 2010

Regulations

The Following Regulations are Applicable Statewide:
314 CMR 3, 314 CMR 4, 314 CMR 5, 310 CMR10, 310 CMR 15
Phosphorus Detergent Ban

No Discharge Area for Marine Waters

2012 Status of Total Maximum Daily Load (TMDL) & Wastewater Planning

Rivers/Lakes Nutrient TMDL Status & Extent

Rivers

- Underway
- Draft - (Nashua Watershed - Phosphorus)
- Final - (Assabet & Charles - Phosphorus, Long Island Sound MA Watersheds - Nitrogen)

Lakes

- Final - (Drainage Area 75 ponds/lakes - Phosphorus)

Marine Nutrient TMDL

Massachusetts Estuaries Program TMDL

- Underway - Nitrogen
- Draft - Nitrogen
- Final - Nitrogen

Municipal Comprehensive Wastewater Management Planning

- Underway
- Preliminary
- Complete

Grant Project Locations

319 Non Point Source Program Project

- BMP Location for Nutrient Control

NRCS Agricultural Control Projects

- Waste Management - Composting Facility, Waste Storage Facility
- Crop and Grazing Management - Conservation Cover, Cover crop, Contour Farming, Contour Buffer Strips, Residue and Tillage Management, No-till/Strip-Till/Direct-Seed, Residue and Tillage Management, Mulch Till, Nutrient Management, Filter Strips
- Management Riparian Buffer - Forest Buffer, Herbaceous Cover

0 5 10 20 30 40 Miles

Map Produced by: MassDEP Bureau of Resource Protection Division of Watershed Management.
This map is for illustrative purposes only. It represents the best statewide data available at the date of printing.
If you have questions about any of the data shown on this map, please contact the Division of Watershed Management, Worcester Office.

Data Sources

Physical and Administrative

HYDROGRAPHY: USGS/MassGIS, 1:25,000 or less. Hydrography from the USGS National Hydrography Database except within public watersupply watersheds where the resolution is approximately 1:10000.

DRAINAGE BASINS: USGS WRD/MassGIS/MA DEP DWP, 1:24,000.MassGIS digitized mylar manuscripts with subbasins, interpreted by USGS WRD and compiled onto paper 1:24,000 USGS topographic quad maps. Major basins were generated by aggregating sub-basins.

POLITICAL BOUNDARIES: MassGIS. This political boundary datalayer has been created from latitude and longitude coordinates found in the 68 volume harbor and Lands Commission Town Boundary Atlas.

Monitoring and Assessment

2010 Integrated List of Waters: (305(b)/303(d)) data layer is the spatial representation of the river, lake, and estuary segments assessed and summarized in the Massachusetts Year 2010 Integrated List of Waters report to the EPA developed pursuant to sections 305(b) ("Water Quality Inventory") and 303(d) of the Federal Clean Water Act. Linework based on: USGS 1:25,000 Topographic Maps, NOAA Charts at various scales, and the"Planimetry of Harbors for the 1984 305(b) Report". Find more detailed info at www.mass.gov/mgis.

CSO Abatement – Depicts waters receiving CSO discharges that are regulated by the Commonwealth in accordance with 314 CMR 3.00, 314 CMR 2.00, 310 CMR 41.00. Map depicts CSO receiving waters designated in 314 CMR 4.

Permitting and Regulation

DRAFT NPDES Discharges Locations: This map only shows NPDES discharges which are required to monitor for nitrogen and phosphorus. Mapped by DEP based on permit information using USGS topographic maps and orthophotos. All locations are draft. Please contact the MassDEP GIS Program for more information.

Phase II NPDES MS4 – The extent of regulated MS4 communities in Massachusetts is based on the extent of Urban areas as identified by the 2010 census - for criteria see http://www.nado.org/census-bureau-defines-"urban-areas"-for-2010-census/.

No Discharge Area (NDA) – The map depicts the 2012 extent of "No Discharge Areas" in Massachusetts which are designated bodies of water that prohibits the discharge of treated and untreated boat sewage. Federal Law prohibits the discharge of untreated sewage from vessels within all navigable waters of the U, S., which include territorial seas within three miles of shore. Source US EPA http://www.epa.gov/region1/eco/nodiscrg/ and the The Massachusetts Office of Coastal Zone Management (CZM) http://www.mass.gov/czm/nda/locations.htm.

TMDL & Wastewater Planning

Nutrient TMDL Projects – Map depicts the extent and states of Nutrient Total Maximum Daily Loads (TMDLs) for impaired waters. Nutrient TMDLs establishes a maximum amount of nutrient (total nitrogen or total phosphorus) that a water body can accept and still meet water quality standards. TMDLs set waste load and load allocations for sources to meet the TMDL. Individual TMDL reports that define the extent of area covered in the map are posted at http://www.mass.gov/dep/water/resources/tmdls.htm#info.

CWMP (Comprehensive Wastewater Management Plan): Status – shows the progress of towns in completing their CWMPs. The data was provided by Brian Dudley (SERO), up to date as of July 2012.

MEP(Massachusetts Estuaries Project) Report Status: Indicates for each estuary the status of their required TMDL Report. Data provided by Rick Dunn, as of July 2012.

Grants

319 PROGRAM: Implementation projects are funded by Congress through the Clean Water Act. Funds are provided to each state from EPA, for the purpose of addressing nonpoint source pollution (NPS). MassDEP manages the funds and the 319 Nonpoint Source Program for the Commonwealth. Projects are annually selected through a competitive process, with a goal to achieve environmental restoration and attain water quality standards in impaired watersheds. Project details and results are reported in EPA's Grant Reporting and Tracking System, (GRTS), www.epa.gov/nps/grts, which is the source of the 319 project data shown here.

NRCS: The NRCS dataset consists of point locations of over 10,500 separate NRCS farm projects where actual NPS BMPs had been put into place during the time period of 2009-2013. To implement these practices, NRCS field staff provides technical planning support while in many cases also offering financial assistance from US Farm Bill programs. The tabular information that accompanies the point locations includes a practice-type identifier code, dates of implementation and the size coverage (acreage) of each BMP.

Figure 6-2
Mass DEP Nutrient Management Status

Criteria vary depending on the location of the effluent recharge to land and its relationship to a public water supply well. Criteria can include total suspended solids, turbidity, total organic carbon, biochemical oxygen demand, and total nitrogen or nitrate nitrogen. Phosphorus may also be regulated in certain areas. The limits for these criteria change based on how close to or far away from a well the effluent recharge site is, in terms of time of travel in the groundwater to the well. Hydrogeologic studies must be done to support the requirements established in a groundwater discharge permit. The level of nitrogen allowed in the effluent of a groundwater discharge basin would also be linked to the receiving coastal or marine water so that nitrogen TMDLs are attained.

At the present time, there are only four facilities in Dennis that have groundwater discharge permits: a 17,000 gpd permitted wastewater discharge from the Patriot Square shopping center on Route 134, just south of Route 6 and three discharge permits from cottage and campgrounds located in Dennis Port, at Camper's Haven (31,020 gpd), Chases Ocean Grove (44,000 gpd), and Salt Air Village (19,360 gpd). Others may be sought in the near future for hotels or resorts along the southern shore of Dennis, in West Dennis and Dennis Port, based on current and anticipated future uses. As described in the Recommended Plan, this CWMP will result in the installation of a municipal wastewater treatment facility with a discharge of over 10,000 gpd. As such the associated effluent recharge will be regulated by a Massachusetts Groundwater Discharge Permit, rather than by a federally issued NPDES permit, which is used for surface water discharges.

6.2.3 Ocean Sanctuaries Act

The Massachusetts Department of Environmental Management (MassDEM) is charged with enforcing 302 CMR 5.00: Ocean Sanctuaries which was promulgated to carry out the provisions of M.G.L. c. 132A, 13 through 16 and 18, the Ocean Sanctuaries Act. This Act created five ocean sanctuaries, of which three relate to Cape Cod: Cape Cod Ocean Sanctuary, Cape Cod Bay Ocean Sanctuary and Cape and Islands Ocean Sanctuary. The Oceans Sanctuaries Act is designed to work through the Commonwealth's Coastal Zone Management program to protect ecologically significant resource areas for their contributions to marine productivity and value as natural habitats and storm buffers.

Specifically excluded activities in the Cape Cod Ocean Sanctuary, the Cape Cod Bay Sanctuary and the Cape and Island Ocean Sanctuary include municipal wastewater treatment discharges (302 CMR 5.08(9)(a)). Potential variance requirements include proving that an ocean discharge would be the only feasible alternative, which includes detailing that there is no approvable method of land application for effluent recharge, and that the ocean discharge is of equal or greater effectiveness in avoiding degradation of water quality of the affected ocean sanctuary.

Several communities on Cape Cod have discussed trying to implement an ocean outfall from a wastewater treatment facility mainly due to the very high quality of the treated effluent and the difficulty in finding acceptable land recharge sites. Currently, MassDEP's policy is that effluent recharge to the land is the preferred approach, as it helps replenish the groundwater table. However, recent legislative efforts have the potential to allow more flexibility in this area in the future.

6.3 Impaired Waterways and Water Bodies

The "Integrated List of Waters" developed by MassDEP documents the quality of waters in Massachusetts per Sections 303(d) and 305(b) of the Clean Water Act (CWA). Section 305(b) of the CWA formalizes the review process of waters and their ability to support the designated uses identified in each states' surface water quality standards. Section 303(d) identifies water bodies in Massachusetts that are not expected to meet surface water quality standards and then schedules them for TMDLs to be assigned for specific contaminants or criteria. The formulation of the 303(d) List includes a more rigorous public review and comment process than does reporting under Section 305(b), and the final version of the list must be formally approved by the U.S. EPA.

The 2012, 2014, 2016 and Draft 2018/2020 Integrated Lists of Waters were reviewed for the inclusion of water bodies in Dennis.

There were minimal changes that pertained to Dennis between the 2012 and 2014 lists. Specifically, the only changes were regarding the timeframes for nutrient TMDL development for the MEP watersheds. While the 2012 list included the MEP watersheds with anticipated years when TMDLs would be developed, the 2014 list revised the timeframes for Dennis watersheds to show the Bass River, Swan Pond River, and Herring River Draft TMDLs as "in progress," and the timing of the final, EPA-approved TMDLs as "TBD." The Sesuit Harbor and Chase Garden Creek MEP-related TMDLs were not listed in either the 2012 or 2014 list of MEP watersheds. The 2014 Integrated List describes "major emphasis" being placed on the development of the nutrient TMDLs required to enforce the MEP goals. All other items on the 2014 and 2016 list described below were also included on the 2012 list.

The 2014, 2016, and draft 2018/2020 lists do not include any waters on the Category 1 list (waters attaining all designated uses) due to a statewide health advisory pertaining to the consumption of finfish. While several water bodies on Cape Cod are listed as Category 2 (attaining some uses; other uses not assessed) in 2014 and 2016 final reports, none of these are located in Dennis or have watersheds located in Dennis. In Category 3 (no uses assessed), Flax Pond and Scargo Lake are listed in Dennis, and Long Pond in Yarmouth is also listed. The latter is notable because a portion of Long Pond is an input of fresh water to the Bass River watershed.

Category 4a waters are those for which a TMDL has been completed for a particular pollutant or list of pollutants. Table 6-1 shows the waterways within Dennis or that have Dennis land area within their watersheds that are listed as Category 4a. The list below has not changed since the 2014 report.

Table 6-1 Category 4a Waters – TMDL has been Completed

Name	Segment ID	Description	Size	Pollutants Addressed by TMDL	EPA TMDL Number
Chase Garden Creek	MA96-35	New Boston Road, Dennis to mouth at Cape Cod Bay, Dennis/Yarmouth	0.13 square miles	Fecal coliform	36771
Herring River	MA96-22	Outlet of Herring River Reservoir (at North Harwich Reservoir Dam) west of Bells Neck Road, Harwich to mouth at Nantucket Sound, Harwich	0.07 square miles	Fecal coliform	36772
Quivett Creek	MA96-09	Outlet of unnamed pond just south of Route 6A, Brewster/Dennis to mouth at Cape Cod Bay, Brewster/Dennis	0.04 square miles	Fecal coliform	36771
Sesuit Creek	MA96-13	Approximately 625 feet east of Route 6A, Dennis to mouth at Sesuit Harbor, Cape Cod Bay, Dennis	0.01 square miles	Fecal coliform	36771

Category 4b waters are where impairment is controlled by alternative pollution control requirements. Massachusetts did not include any waters within Category 4b on the 2014, 2016 or 2018/202 lists. Category 4c is described as "impairment not caused by a pollutant – TMDL not required" and does not contain any waterways in Dennis. Category 5 waters are waters requiring a TMDL. Table 6-2 shows the two Dennis waterways listed as Category 5. Chase Garden Creek was added in the 2016 report.

Table 6-2 Category 5 Waters – Requires a TMDL

Name	Segment ID	Description	Size	Impairment Cause	EPA TMDL Number
Bass River	MA96-12	Route 6, Dennis/Yarmouth to mouth at Nantucket Sound, Dennis/Yarmouth (excluding Grand Cove, Dennis)	0.69 square miles	Estuarine Bioassessments, Fecal Coliform	36771
Chase Garden Creek	MA96-103	Headwaters south of Roads End and west of Jericho Road, Dennis to New Boston Road, Dennis	1.20 miles	Escherichia Coli (E. Coli)	Not listed
Swan Pond River	MA96-14	Headwaters, outlet Swan Pond, Dennis to confluence with Nantucket Sound	0.04 square miles	Estuarine bioassessments, Fecal coliform	36771

All of the waterways listed above were investigated in more detail either as part of the MEP analysis in Section 2 or the freshwater ponds analysis in Section 3 of this CWMP.

6.4 Districts of Critical Planning Concern

The Cape Cod Commission has established a means by which certain sensitive areas that require special planning and regulations can be designated as "Districts of Critical Planning Concern." This program is regulated through Barnstable County Ordinance 90-15. In order for a district to be designated, the Commission must find that: 1) the proposed district will preserve or maintain a value(s) or resource(s) intended to be protected by the Act, 2) regulatory and/or planning tools

are available which are likely to be effective in protecting or otherwise meeting the objectives of the proposed district.

Three such Districts of Critical Planning Concern (DCPCs) apply to the town of Dennis. The first is the Quivett Neck/Crowe's Pasture DCPC, which was designated in March 2002 to "protect natural, historic, water, and coastal resources and to manage residential growth on nearly 250 acres in East Dennis." This DCPC was established per Barnstable County Ordinance 02-04.

The other two DCPCs that apply to Dennis are both Cape-wide districts. The first is the Ocean Management Planning District, established in April 2010. This district only contains water area and extends from 0.3 to 3.0 nautical miles seaward from mean high water along all of Cape Cod's shorelines. This district was designated for the purpose of regulating development in Massachusetts' ocean waters, largely related to renewable energy initiatives, and is unlikely to play a significant role in the present water quality planning efforts.

The other Cape-wide district is the Fertilizer Management DCPC, which was designated in September 2013 via Barnstable County Ordinance 13-07. The Commission is currently working with Cape towns to develop "implementing regulations" for this district. This DCPC was developed in direct relation to the current nitrogen reduction planning efforts, in order to establish regulations that can minimize the nitrogen contributions originating from fertilizer use on the Cape. This and other potential DCPCs can be used to assist in the implementation of any nitrogen reduction planning effort.

6.5 Applicability of Water Quality Standards to Dennis

Implementation of the TMDLs being developed through the MEP research and modeling is intended to result in meeting water quality standards and designated uses in all assessed water bodies in Dennis. However, due to the high costs of achieving these goals, some Cape Cod stakeholders have questioned the cost/benefit of full compliance and whether the appropriate standards are being applied to the specific scenarios encountered in each community. The vast majority believe water quality is extremely important to the quality of life on Cape Cod and that a nutrient problem exists that must be addressed in the near future. The critical question is: how far does Dennis' water quality improvement project need to go in order to adequately address the nutrient issues faced.

The Bass River and Swan Pond River watersheds are sensitive areas that have historically supported ecological diversity, including eelgrass, and should be protected based on current water quality standards. However, Sesuit Harbor, for example, mainly functions as a boat marina. Establishing water quality parameters to be attained based on the highest and best use versus the current use is the current regulatory answer. The discussion below provides an overview of some of the issues that were considered as Dennis completed its water quality planning process.

The MEP studies conducted for Dennis establish water quality criteria with the goal of restoring each embayment back to full compliance with Class SA criteria. This results in significant nitrogen removal requirements in order to achieve those criteria requiring costly programs. This has led some to question the value of 100 percent compliance. For instance it may be worth questioning the restoration of Sesuit Harbor to fishable and swimmable water quality standards when it is in

fact acting as a functioning marina/ boat basin. Similarly, some have questioned whether the oil and grease, turbidity and DO criteria can truly be attained with the present use in boat basins. Sesuit Harbor is quite different than the meandering river and salt marshes in the Swan Pond River system or the large tidal ponds in the Bass River system. Yet the Class SA criteria are the same for each.

Some groups, such as the Cape Cod Collaborative, have begun to discuss ways to try to meet the intent of the regulations while modifying the regulations to account for specific uses. Dennis stakeholders may understand they have a nitrogen related issue in their harbors and embayments but, like many communities facing costly restoration programs, they may be wondering how the regulations might be modified to account for specific uses. Since there is a possibility that modifications could be allowed in the future, an adaptive management approach to water quality improvement implementation is recommended, whereby the highest priority areas are targeted for improvements first, with ongoing monitoring to evaluate successes, and the lower priority areas deferred to later phases of the implementation program or completed in part, again with ongoing monitoring to evaluate progress.

In summary, the Bass River, Swan Pond River, and Herring River study areas need to have nitrogen removed, and the remaining three watersheds may also require some nitrogen removal based on the completion of the MEP studies. At this time, Quivett Creek and Chase Garden Creek only require compliance with its bacteria TMDL, and the town's freshwater bodies require a variety of further investigations or improvements, as described in Section 3. The MEP findings for Sesuit Creek has yet to be issued and may be a nitrogen sink, which was found to be the result for Chase Garden Creek. As noted previously, nitrogen sinks are watersheds that are identified as having the capacity to take on more nitrogen than is presently being input and are thus potential candidates for taking additional nitrogen that is removed from stressed watersheds. The alternative scenarios developed as part of this CWMP and presented in Section 10 were designed according to water quality regulations as they exist today. However, moving forward, the town will continue to discuss the ultimate criteria or endpoint standards that must be attained per the regulations, since getting to that endpoint is a costly endeavor. As the plan for nitrogen reduction is implemented, discussions about the ultimate water quality endpoints will continue and the ultimate recommendations will incorporate an adaptive management approach to the extent feasible, working within Massachusetts' regulatory framework.

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Section 7

Updated Wastewater Needs Assessment

7.1 Introduction

In 2005, the town of Dennis undertook the development of a needs assessment as the first step in preparing a Comprehensive Wastewater Management Plan. This effort was overseen by the Dennis Water District and is summarized in the document, "Comprehensive Wastewater Management Plan Needs Assessment Report" prepared by Stearns and Wheler, LLC, dated September 2005. The purpose of that report, as stated within the Executive Summary, was to:

1. Identify the wastewater needs in the Town, and
2. Outline implementation alternatives that could be initiated while the Town awaited the MEP findings.

The report culminated in the identification of twelve "Areas of Concern," which represented locations in Dennis with documented wastewater problems at the time of its publication, along with a list of interim recommendations prior to MEP report completion.

In this section, the 2005 Needs Assessment results are summarized and then updated to reflect the current status of wastewater needs in Dennis. These needs are then combined with the other water quality needs identified in Sections 2 through 5 of this report pertaining to the MEP results and to the quality of the town's drinking and recreational water resources. Furthermore, areas with identified infrastructure needs are also presented relating to the town's economic growth districts, where planned development is intended. These needs are ultimately aggregated to represent the overall needs of the town with regards to water quality and wastewater infrastructure management.

7.2 Summary of 2005 Needs Assessment

The 2005 Needs Assessment began with consideration of ten criteria to evaluate the wastewater needs of the town. Those criteria were as follows:

- Proximity to Zone II drinking water zones of contribution
- Onsite septic system design constraints including:
  - Poor soils for leaching
  - Small lots
  - High groundwater
  - "A-zone" flood zones
  - "V-zone" flood zones

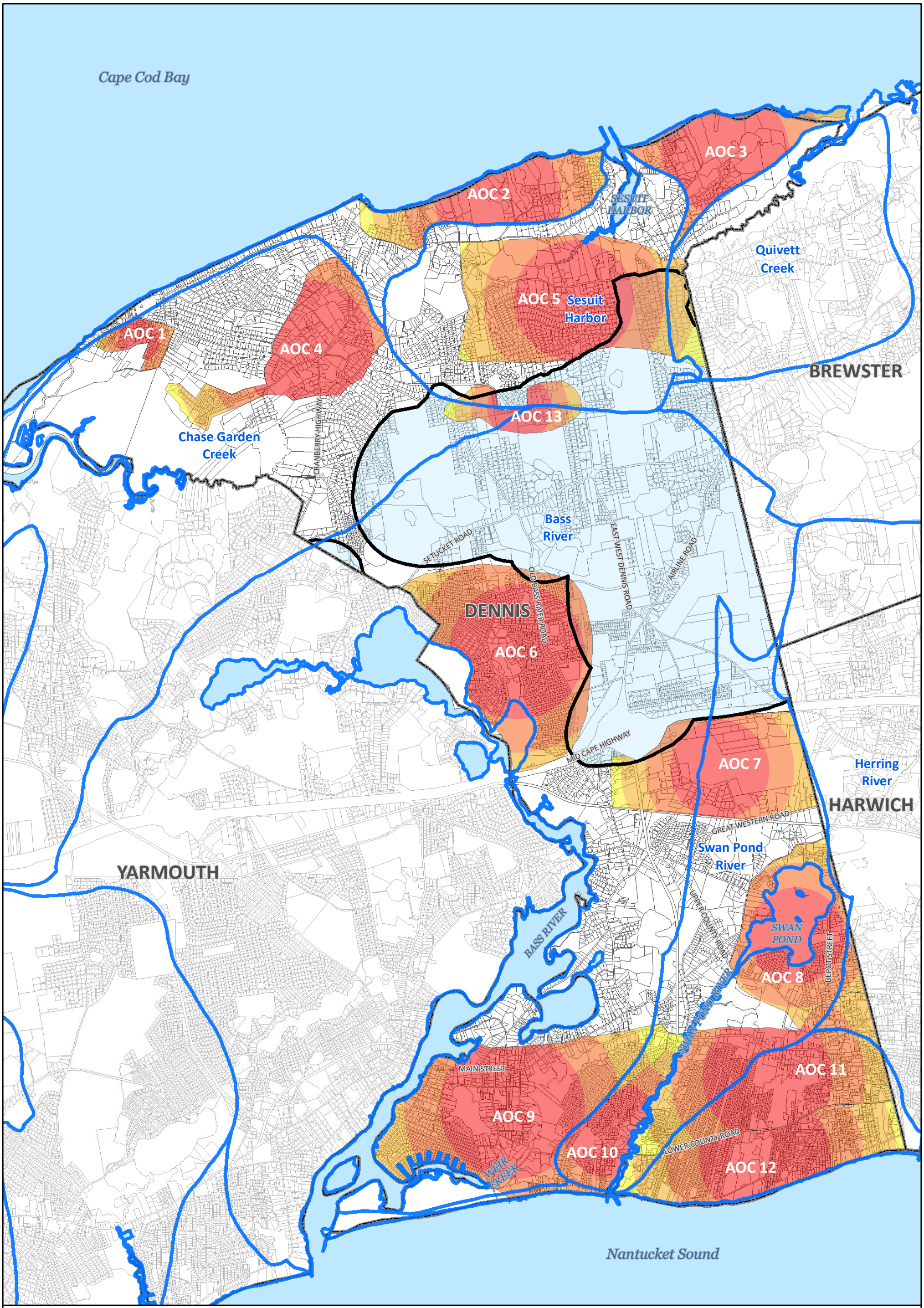
- Onsite septic system failures
- Proximity to shellfish closure areas
- Industrially zoned areas
- Proximity to freshwater ponds and lakes, coastal embayments, and wetlands

The entire town was screened using these ten criteria, and the areas of highest needs were designated where multiple criteria were met. Twelve areas were identified, and those were further subdivided into three tiers of prioritization. These twelve areas and the subsequent prioritization are summarized in **Table 7-1** and are shown on **Figure 7-1**. Note that these Areas of Concern, or AOCs, did not have definitive boundaries but were rather generalized areas where needs for alternative wastewater infrastructure were identified.

Table 7-1 Summary of 2005 Areas of Concern

Area of Concern (AOC)		Reasons for Inclusion									
		Zone IIs	Poor Soils	Small Lots	High Groundwater	A-Zone	V-Zone	Septic Failures	Shellfish Closures	Industrial Landuse	Filled Wetlands
Primary Areas											
DP1	Dennis Port (11)		✓	✓	✓	✓		✓	✓		✓
DPS1	Dennis Port Shore (12)			✓	✓	✓		✓			
FP1	Follins Pond (6)	✓		✓				✓	✓		
SP1	Swan Pond (8)		✓	✓	✓	✓		✓	✓		✓
TP1	Trotting Park (10)			✓	✓	✓	✓	✓	✓		✓
WD1	West Dennis (9)		✓	✓	✓	✓	✓	✓			✓
Secondary Areas											
6AE2	Route 6A East (5)	✓	✓		✓	✓		✓			
6AW2	Route 6A West (4)		✓		✓	✓		✓			✓
TA2	Taunton Avenue (1)		✓	✓	✓	✓		✓			
Tertiary Areas											
DNS3	Dennis North Shore (2)		✓		✓						
HRC3	Hokum Rock Commercial (13)	✓								✓	
SDI3	South Dennis Industrial (7)	✓								✓	

Note that three AOCs shown in Figure 7-1 were modified from the original needs assessment map provided with the 2005 report. Specifically, AOCs 1, 2, and 4 were revised on the map to be consistent with the detailed text-descriptions of their locations as provided in the 2005 report.



Legend

- MEP Watershed Delineations
- Area of Concern
- Zone II

Town of Dennis, MA

2005 Needs Assessment Summary
Areas of Concern
Figure 7-1

N

1 in = 3,200 ft

0 0.5 1

Miles

CDM Smith

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The 2005 Needs Assessment Report concluded that until the MEP results were available, the impact of the identified AOCs and the potential solutions could not be fully assessed. The report also presented a "No Action Alternative" and interim recommendations to be pursued while the MEP results were being finalized.

The No Action Alternative, which entails continued use of onsite septic systems town-wide, was noted to present the risk of the town's losing "natural and economic resources, seeing declines in fin fishing and shell fishing resources, algal blooms in coastal embayments, beach closures, and potential declines in tourism as the aesthetic impacts impair the Town's water resources (coastal, fresh, and drinking). As the water quality degrades, there is the potential for decline in property values and impacts to recreational uses in the affected embayments." The report further notes that while some parcels in town have advanced septic systems designed for some level of nutrient removal, they are neither prevalent enough nor effective enough to reduce nutrients to the degree needed to prevent the impacts described under the No Action Alternative.

The interim recommendations from the 2005 Needs Assessment Report include the following:

- Implement Stormwater Best Management Practices (BMPs), such as the installation of deep sump catch basins, leaching facilities to infiltrate stormwater, and vegetated swales to provide fine sediment, nutrient, and bacteria removal, and redirection of stormwater discharges into or adjacent to upstream wetlands rather than direct discharges to water bodies.
- Consider new funding options for stormwater management.
- Continue stormwater public education, including education on stormwater controls, fertilizers, and animal wastes (domestic and wild).
- Develop an enhanced fertilizer management program, including additional public outreach and education on fertilizer types, application techniques, and over-fertilization, possibly via the town's Clean Green Lawn program.
- Develop an informational handout on the decision to repair an existing Title 5 system if an alternative solution is proposed in a particular area in the near future.
- Begin discussions pertaining to future utility management and which town department may be designated as responsible.
- Continue developing periodic brochures and newsletters to keep water quality issues at the forefront of town planning discussions.
- Continue to consider implementation issues such as site screening for future infrastructure needs, enhanced regulatory requirements for onsite systems, and coordination with neighboring towns, especially with regards to shared watersheds.
- Evaluate and implement wastewater solutions for the various AOCs following finalization of the MEP findings.

Based on the current status of the water quality management initiative in Dennis, each of these recommendations is still pertinent and have been incorporated into the town's final recommended program.

7.3 Updated Baseline Information

The data presented in the needs assessment were gathered over the course of 2004 and 2005 and are presented in a series of figures appended to the report. These figures present baseline data on flood zones, soils, watershed boundaries, natural and historic district areas, wetlands, land uses, drinking water Zone IIs, drinking water well pumping, historic septic system failures, and estimated community build-out. Each of these parameters was reevaluated using the most up-to-date information available in spring 2014 and supplemented with discussions with appropriate town staff.

While the overall conclusion of this analysis was that there have not been major changes with regards to these parameters since the 2005 report was completed, maps were created illustrating the current baseline data for several of the parameters, which are attached herein. Specifically, the following figures are included:

- **Figure 7-2** – 2014 Flood Zone Map (update of 2005 Needs Assessment Figure 4-1)
- **Figure 7-3** – 2014 Soils Map (update of 2005 Needs Assessment Figure 4-2)
- **Figure 7-4** – 2014 Natural and Historic District Areas (update of 2005 Needs Assessment Figure 4-4)
- **Figure 7-5** – 2014 Wetland Map (update of 2005 Needs Assessment Figure 4-5)
- **Figure 7-6** – 2014 MassGIS Land Use Map (update of 2005 Needs Assessment Figure 4-6)

Updated figures relating to drinking water well and Zone II locations were presented previously, in Section 4, and watershed boundaries were presented in Section 2. In addition to these parameters, an additional baseline data map, **Figure 7-7**, was created showing the locations of innovative/alternative septic systems and Groundwater Discharge Permits issued by the Commonwealth of Massachusetts within Dennis.

The data used to complete the analyses of the updated needs assessment are summarized in **Table 7-2**, including the source and the year when the data were last updated.

Table 7-2 Summary of Data Used for Updated Needs Analysis

Parameter	Source	Year
Orthophotos (Aerial Imagery)	MassGIS	2009
Flood Zones	MassGIS	FEMA Preliminary NFHL 2013
Soils	MassGIS	Accessed 2014 (data dated 2002)
Protected Habitats	MassGIS/NHESP	Accessed 2014
Historic/Archaeological Resources	MassGIS	Accessed 2014
Wetlands	MassGIS	Accessed 2014
Land Use	MassGIS	Accessed 2014
Innovative/Alternative Septic Systems	MassGIS	Accessed 2014 (data dated 2013)
Groundwater Discharge Permits	MassGIS/MassDEP	2014
Drinking Water Zone IIs	MassGIS	Accessed 2014 (data dated 2013)
2007-09 Water Use	MEP	Based on 2007-09 Dennis Water District data
Nitrogen Loading (Present and Buildout)	MEP	Uses 2007-09 Dennis Water District data as baseline
Estuary embayment and subembayment boundaries	MEP	MEP reports dated 2011, 2012, and 2013
Freshwater Ponds	MassGIS/PALS	2004-2013
Surface Contours	MassGIS	2003
Groundwater Contours	CCC	June 2014
Boundaries of Town Planning Districts	Town of Dennis	2014
Dennis Parcel Data	Town of Dennis	Accessed 2014
2009 to 2011 Water Use Data	CCC	Based on 2009-11 Dennis Water District data

7.4 Planning and Economic Growth Districts

The town of Dennis has developed several areas where growth and economic development or redevelopment are desired. These areas have been identified by the Dennis Planning Department and Planning Board and factor into the town's long-term goals for economic viability.

In the 10-year period between 1999 and 2009, Dennis' residential tax payers changed from paying 89 percent of the tax burden to 93 percent, with commercial entities only comprising 7 percent of the tax base in 2009. While in 1999, the average home paid $7 in taxes for every dollar paid by commercial entities, in 2009, the average residence paid $12 for every commercial dollar paid. Since the town prioritizes maintaining its existing open spaces and residential neighborhoods, the logical location for economic growth is within the existing commercial areas. The existing village center areas of Dennis Port and West Dennis, the older hotel areas in Dennis Port, the Route 28 commercial strip, and the area around Exit 9 present opportunities to balance the town's tax base and enhance economic stability.

Five specific planning areas have been identified by the town. Each planning district is listed and described below and is shown on **Figure 7-8**.

Dennis Port Growth District – This district is located along Route 28, within the existing commercial area in the eastern portion of town, up to the Harwich town line.

Exit 9 Growth District – This area is located adjacent to Exit 9 from Route 6, encompassing a segment of Route 134 south of the highway, as well as properties to the east, up to the Harwich town line.

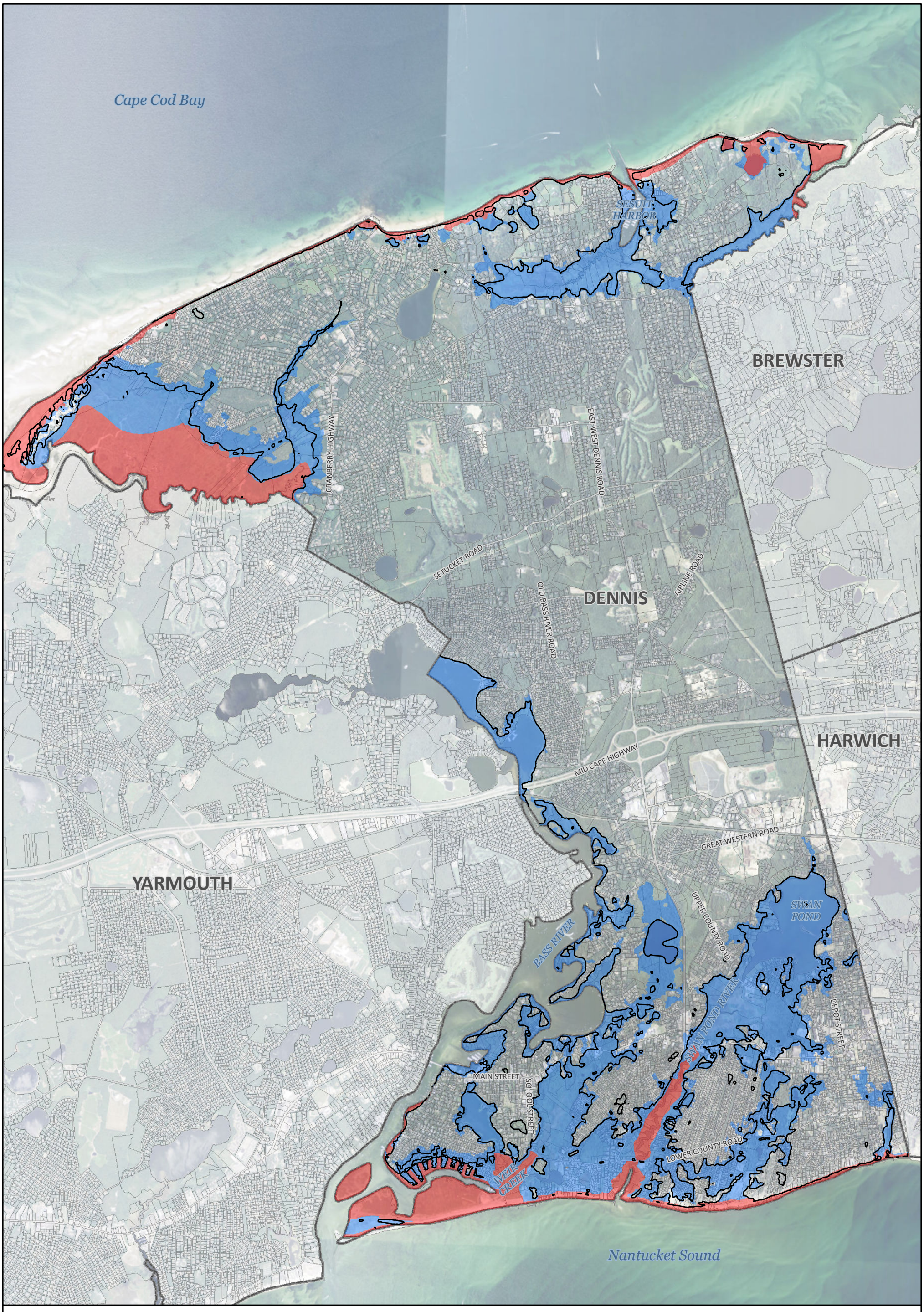
Hotel Resort Districts – Two hotel resort districts have been identified. One is located in the southeastern corner of the town, bounded by Old Wharf Road, Chase Avenue, and the Harwich town line. The other is located in the southwestern corner of Dennis, south of Route 28, in the vicinity of West Dennis Beach.

West Dennis Village Center Growth District – This district is located along Route 28 and School Street in West Dennis and seeks to promote in-fill development within the traditional village center area.

In addition to these specific districts, a seasonal resort community bylaw has been enacted which allows for seasonal cottages to replace former areas for recreational vehicles (RVs) and significant upgrades to existing seasonal cottages, which largely applies to parcels around Old Chatham Road in the Bass River watershed and Old Wharf Road.

Finally, in addition to these economic development areas, the town must also determine suitable locations for affordable housing. Presently, the town only has 4 to 5 percent affordable housing stock, as compared to the state goal of 10 percent which allows a town to avoid the requirements of Chapter 40B development. Reaching the 10 percent goal would entail the addition of approximately 600 units of affordable housing. Furthermore, a conversion of existing seasonal dwellings to year-round homes would increase the total number of housing units, and thus increase the number of affordable units required to reach the 10 percent goal.

For each of these town planning considerations, adequate infrastructure must be provided to achieve the desired development and economic growth. Whereas the southern watersheds in Dennis, specifically Bass River and Swan Pond River, were identified as impaired by the MEP studies, additional nitrogen inputs from onsite systems are problematic. Furthermore, along the coast of Dennis Port and West Dennis, at least 6 properties are currently either under Consent Orders from or in discussions with MassDEP regarding large, non-compliant septic systems. These properties are all resorts or other seasonal communities (i.e., cottages, RV parks, etc.) whose flows in aggregate total over 100,000 gpd during the summer. The town must consider whether these problems should be addressed within the scope of the recommended program for water quality management, or whether they should be dealt with separately. These and other properties in town may also present opportunities for public/private partnerships to achieve common goals at a reduced total cost due to economies of scale.



Legend

- 9 Ft Contour
- AE Zone
- VE Zone

Town of Dennis, MA

2014 Flood Zone Map

Figure 7-2

N

1 in = 3,250 ft

0 0.5 1

Miles

CDM Smith

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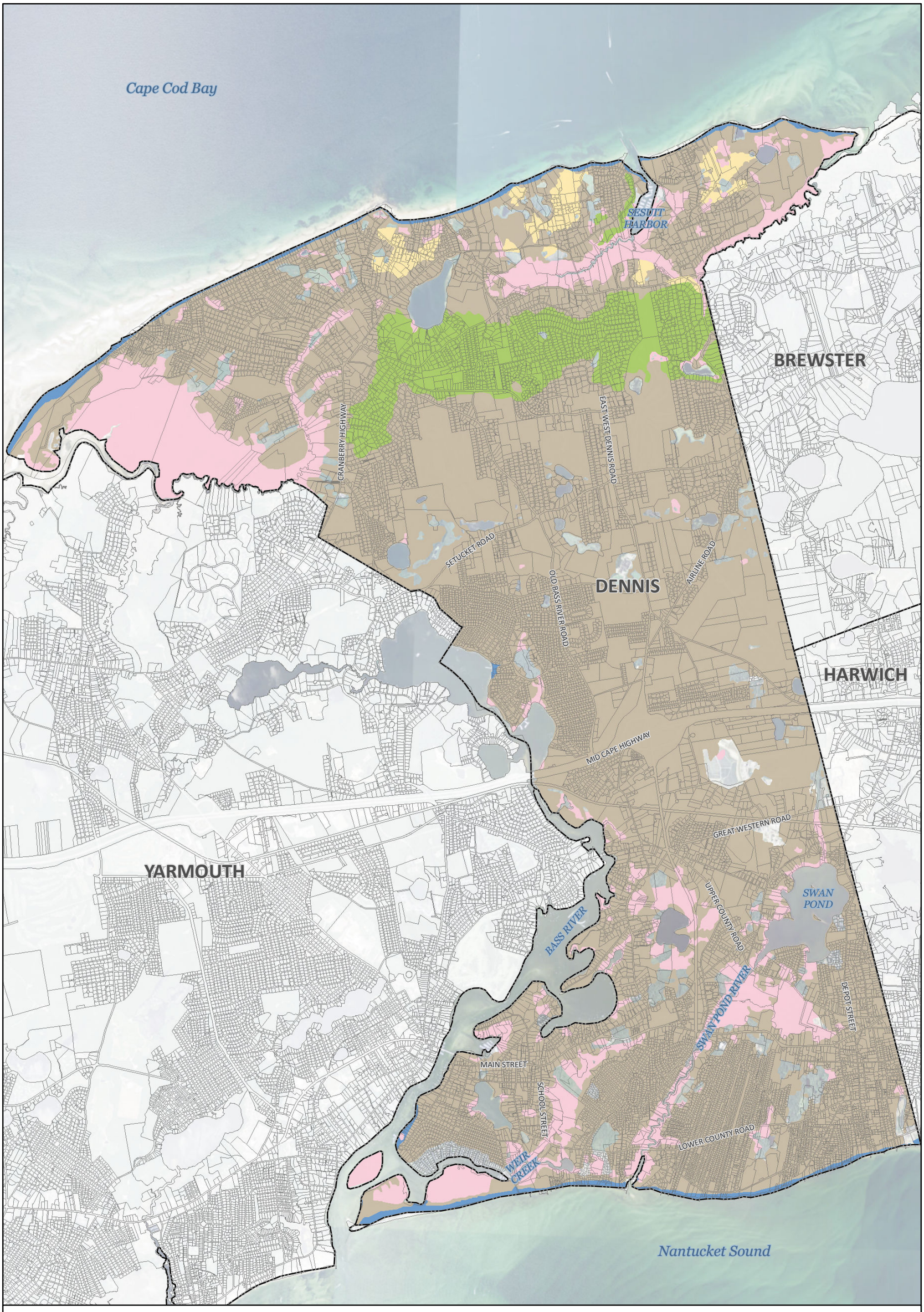

Legend

- Beach
- Boulder
- Muck/Peat
- Sands
- Silty Loam

Town of Dennis, MA

2014 Soils Map

Figure 7-3

N

1 in = 3,250 ft

0 0.5 1

Miles

CDM Smith

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Cape Cod Bay

SESUIT HARBOR

BREWSTER

CRANBERRY HIGHWAY

EAST-WEST-DENNIS-ROAD

SETUCKET ROAD

OLD BASS RIVER ROAD

AIRLINE ROAD

DENNIS

HARWICH

MID CAPE HIGHWAY

GREAT WESTERN ROAD

YARMOUTH

BASS RIVER

UPPER COUNTY ROAD

SWAN POND

SWAN POND RIVER

DEPOT STREET

MAIN STREET

SCHOOL STREET

WEST CREEK

LOWER COUNTY ROAD

Nantucket Sound

Legend

- NHESP Certified Vernal Pool
- MHC Historic Site
- NHESP Potential Vernal Pool
- Conditionally Approved Shellfishing Area
- Prohibited Shellfishing Area
- NHESP Estimated Habitat of Rare Wildlife
- NHESP Priority Habitat of Rare Species
- Dennis Village Cemetery
- East Dennis Center
- Shiverick District
- South Dennis Historic District
- West Dennis - Jericho
- Old King's Highway Regional Historic District

Town of Dennis, MA

2014 Natural and Historic District Areas

Figure 7-4

N

1 in = 3,250 ft

0 0.5 1

Miles

CDM Smith

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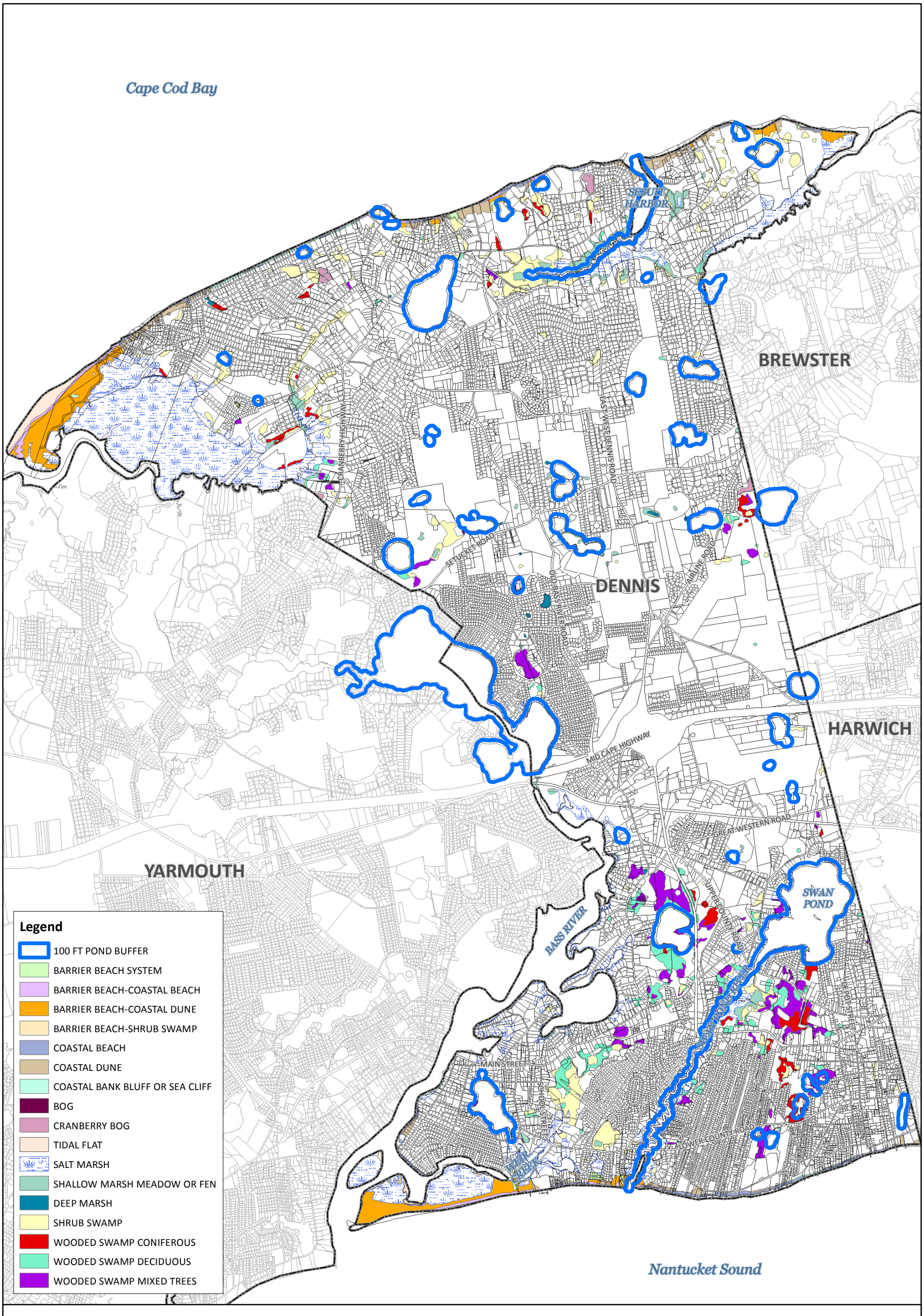

Town of Dennis, MA

2014 Wetland Map

Figure 7-5

N

1 in = 3,250 ft

0 0.5 1

Miles

CDM Smith

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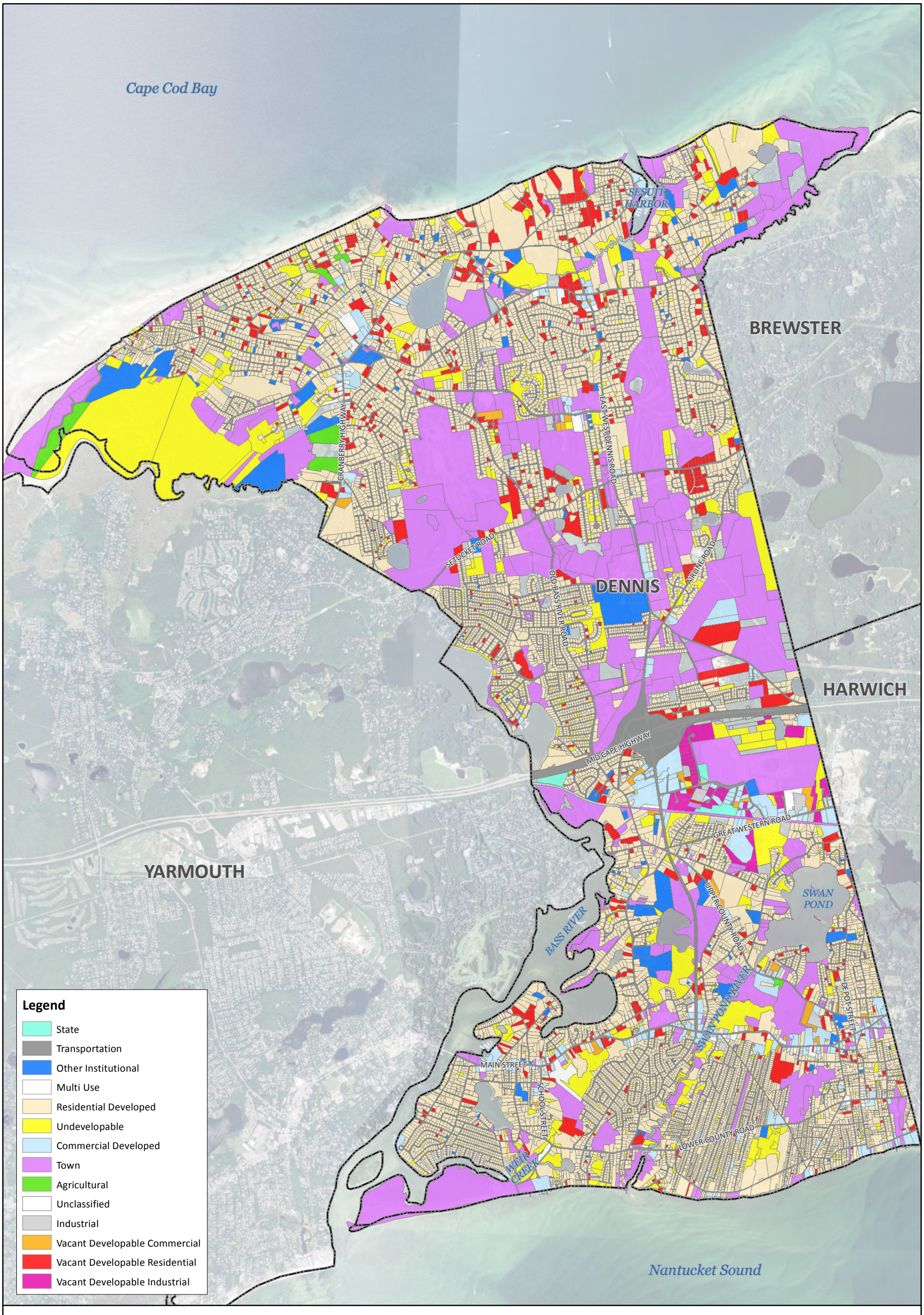

Town of Dennis, MA

2014 Landuse Map

Figure 7-6

N

1 in = 3,250 ft

0 0.5 1

Miles

CDM Smith

Landuse based on use class codes from Assessors data

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Cape Cod Bay

SESUIT HARBOR

BREWSTER

DENNIS

HARWICH

YARMOUTH

BASS RIVER

SWAN POND

SWAN POND RIVER

WEIR CREEK

IA Systems

- Advantex
- Aerobic (Aero-Stream)
- Aerobic (Singulair Bio-Kinetic)
- Amphidrome
- Bioclere
- FAST
- Innoculator/Generator (White Knight)
- JET
- Pressure Dose
- RSF
- RUCK
- Septitech
- Dennis Parcels
- Ground Water Discharge Permits

Town of Dennis, MA

2014 I/A Systems

Figure 7-7

N

1 in = 3,000 ft

0 0.5 1

Miles

CDM Smith

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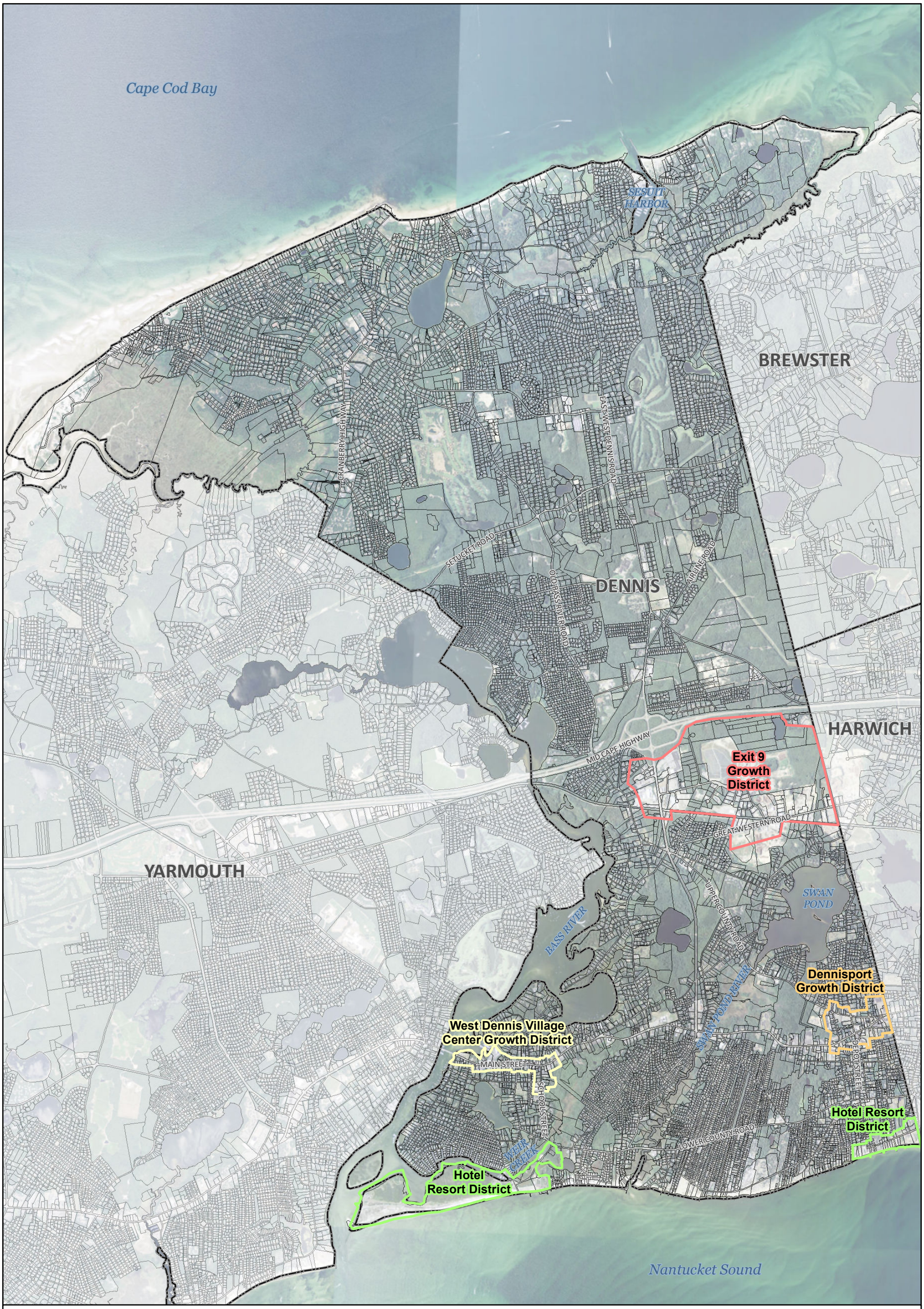

Town of Dennis, MA

Planning Districts

Figure 7-8

N

1 in = 3,250 ft

0 0.5 1

Miles

CDM Smith

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7.5 Updated Areas of Concern

Based on all of the information gathered, the AOCs were updated to arrive at a new list of areas for consideration when developing the recommended program for water quality improvements. **Figure 7-9** presents the updated AOCs, and they are also listed in **Table 7-3.**

Two new AOCs were added based on the updated data analysis and discussions with town staff. AOC #14 encompasses two neighborhoods with small lots that have historically had trouble meeting Title 5, along with the area of Route 134 just north of Route 6, including the location of the new town offices. This area also has portions that are zoned industrial and within the Zone IIs to town drinking water wells. AOC #15 is a small neighborhood on the north side of town along Shore Road that has small lots, poor soils, high groundwater, and a history of septic system failures. In addition, the District of Critical Planning Concern which comprises AOC #3 was shown on the map in the 2005 Needs Assessment Report but was not shown in the associated table (Table 7-1 here). Therefore, this area was added to the updated AOC table.

One other significant change in the updated AOC list is the presence of flood velocity zones within new areas based on the newly issued flood maps from the Federal Emergency Management Agency (FEMA). Previously, only two of the AOCs had area within v-zones; on the updated list, five areas meet this criterion. Lastly, AOC #4 (Route 6A West) was corrected to include the "small lots" criterion, based on the updated location mentioned previously.

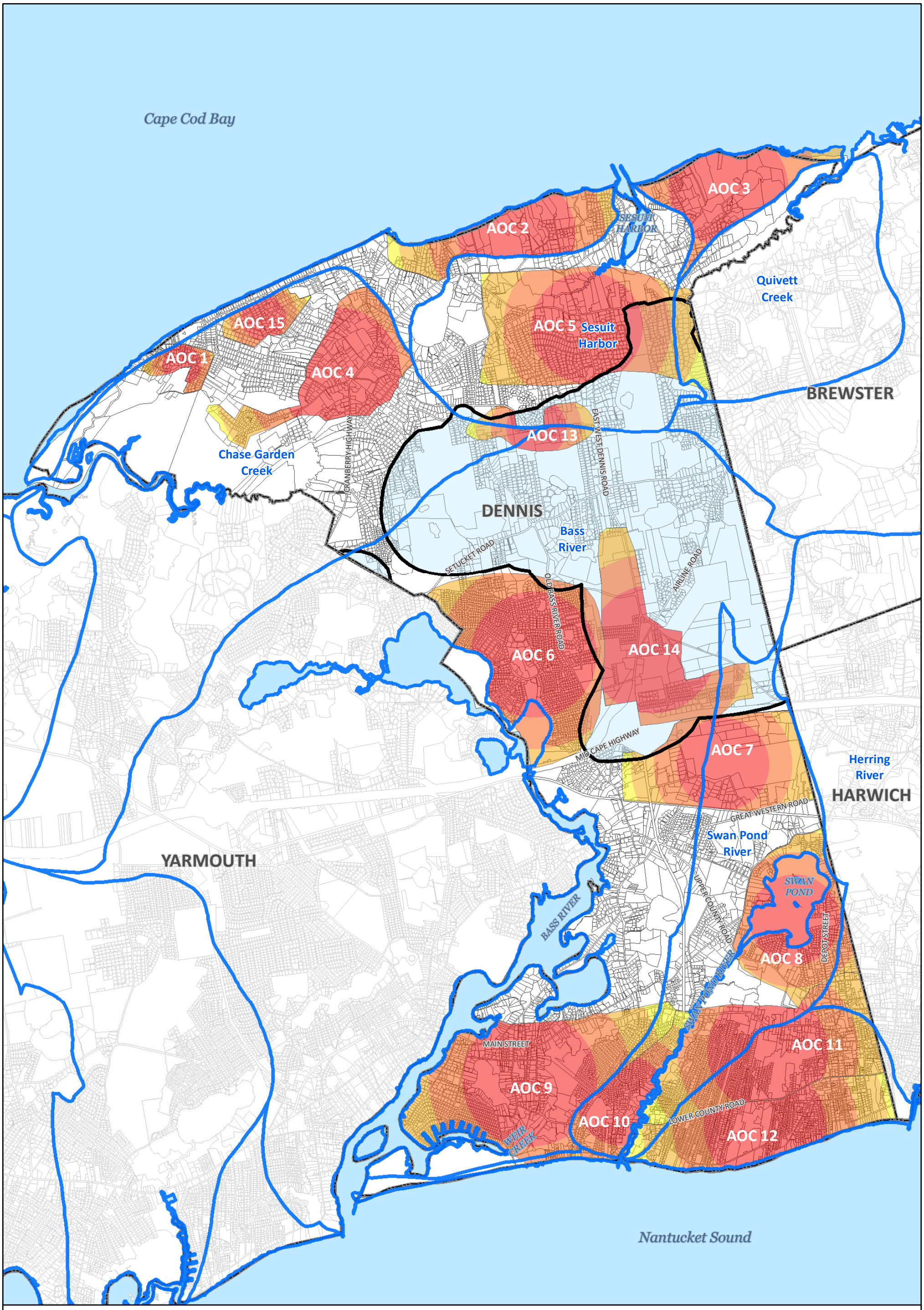
7.6 Aggregated Identification of Needs

The AOCs developed as part of the updated needs assessment described herein do not take into account the needs identified in Section 2 related to the MEP report findings or in Section 3 related to impairment of the town's freshwater ponds, which also must be considered. The analyses in Sections 4 and 5 revealed that needs are minimal with regards to drinking water quality and recreational beach water quality (aside from the impaired ponds noted in Section 3). Therefore, while Zone IIs and recreational beaches are included in the aggregated town water quality needs, they are not driving factors in the development of water quality management scenarios for Dennis.

Figure 7-10 summarizes the water quality management needs in Dennis, including the locations of the updated AOCs, the MEP required nitrogen reduction percentages, the status of freshwater ponds, and the locations of Zone II areas, recreational beaches, and planning districts. Each of these needs is also summarized briefly below.

7.6.1 Updated Areas of Concern

As described in detail above, the updated AOCs are driven by the traditional factors considered when identifying wastewater needs in a community, such as failure to meet state and local onsite septic system regulations and close proximity to sensitive resources such as drinking water wells and waterways. The fifteen updated AOCs are spread throughout town, with some within and others outside of MEP watersheds. The location of each AOC with regards to MEP watersheds is shown in Table 7-3.



Legend

- MEP Watershed Delineations
- Area of Concern
- Zone II

Town of Dennis, MA

2014 Needs Assessment
Update Areas of Concern
Figure 7-9

N

1 in = 3,432 ft

0 0.5 1

Miles

CDM Smith

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Table 7-3 Updated Areas of Concern

Area of Concern (AOC)		MEP Watershed	Reasons for Inclusion									
			Zone IIs	Poor Soils	Small Lots	High Groundwater	A-Zone	V-Zone	Septic Failures	Shellfish Closures	Industrial Landuse	Filled Wetlands
Primary Areas												
DP1	Dennis Port (11)	SP		✓	✓	✓	✓	✓	✓	✓		✓
DPS1	Dennis Port Shore (12)	SP (partial)			✓	✓	✓	✓	✓			
FP1	Follins Pond (6)	BR	✓		✓				✓	✓		
SP1	Swan Pond (8)	SP		✓	✓	✓	✓		✓	✓		✓
TP1	Trotting Park (10)	SP (partial)			✓	✓	✓	✓	✓	✓		✓
WD1	West Dennis (9)	BR		✓	✓	✓	✓	✓	✓			✓
Secondary Areas												
6AE2	Route 6A East (5)	SH	✓	✓		✓	✓		✓			
6AW2	Route 6A West (4)	CGC		✓	✓	✓	✓		✓			✓
TA2	Taunton Avenue (1)	DD		✓	✓	✓	✓	✓	✓			
Tertiary Areas												
DNS3	Dennis North Shore (2)	DD		✓		✓						
HRC3	Hokum Rock Commercial (13)	SH	✓								✓	
SDI3	South Dennis Industrial (7)	SP/BR	✓								✓	
DCPC3	District of Critical Planning Concern (3)	DD		✓						✓		
Newly Added Areas												
134N	Route 134 North (14)	BR	✓		✓				✓		✓	
SR	Shore Road (15)	CGC		✓	✓	✓			✓			✓

MEP Watersheds
SP = Swan Pond/Swan Pond River
BR = Bass River
CGC = Chase Garden Creek
SH = Sesuit Harbor
DD = Direct Discharge to Nantucket Sound or Cape Cod Bay

Cape Cod Bay

Cold Storage Beach

Corporation Beach

SESUIT HARBOR

Quivett Creek

Not Included in MEP

Mayflower Beach

DENNIS

Sesuit Harbor

TBD by MEP

BREWSTER

Chaplin Memorial Beach

Chase Garden Creek

Assumed 0%

SETUCKET ROAD

Bass River

Follins Pond

Mill Pond and Stream

Kelleys Bay

Herring River

West Reservoir

Swan Pond River

Dinah's Pond

Bass River Middle

HARWICH

Swan Pond

SWAN POND

BASS RIVER

Upper Herring River

YARMOUTH

Grand Cove

Swan Pond River N

SWAN POND RIVER

Lower Herring R

Swan Pond River S

School Street Marsh

Bass River Lower

WEIR CREEK

Run Pond

Raycroft Beach

South Village Beach

Sea Street Beach

West Dennis Beach

Nantucket Sound

Legend

- Area of Concern
- MEP Watershed Delineations
- MEP Subwatersheds
- Planning Districts
- Zone II

Pond Water Quality

- High Water Quality
- Impared Water Quality
- No PALS Data

Proposed Controllable Nitrogen Removal from MEP to Meet TMDL

- 80-90%
- 70-80%
- 50-60%
- 0%

Town of Dennis, MA

Summary of Water Quality Management Needs

Figure 7-10

N

1 in = 3,500 ft

0 0.5 1

Miles

CDM Smith

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While the AOCs identified in this list would all benefit from offsite wastewater solutions from a water quality perspective, these needs must be balanced with other town water quality needs and with the economic feasibility of providing such solutions. Addressing the needs of the AOCs is not a requirement from either state or federal regulatory agencies, as the Dennis Board of Health has the ability to issue variances to accommodate some of the more difficult onsite system siting and performance issues. Therefore, while these areas are important to consider in water quality planning moving forward, providing solutions for all of these areas would be expensive and will not be mandated.

7.6.2 MEP Nitrogen Reduction Requirements

As noted in Section 6, the town will be required via Total Maximum Daily Load (TMDL) permits issued by MassDEP to meet the specific nitrogen reduction goals outlined in the completed MEP reports. The nitrogen reduction required in the watersheds in Dennis is summarized in Table 7-4 for the Bass River, Swan Pond River, Herring River, and Chase Garden Creek watersheds and the town is awaiting a completed MEP report for Sesuit Harbor. The Draft MEP report for the Barnstable Great Marshes-Bass Hole Estuarine System, including Chase Garden Creek was issued in 2017 and information from that report is included in the table below. Compliance with these requirements is anticipated to be monitored and enforced by a combination of MassDEP, US EPA, and the Cape Cod Commission. Based on the information from the MEP reports for Dennis, the reduction of nitrogen to restore estuarine water quality is a significant need and thus became the main driver in the development of a final recommended program for water quality management.

Table 7-4 MEP Nitrogen Reduction Summary for Existing Development

Watershed[1]	Total Nitrogen Load Removal Required	% Total Nitrogen Removal Required
Bass River	103.3 kg/day	-47.4%
Swan Pond River	33.0 kg/day	-75.5%
Herring River	14.8 kg/day	-23.6%
Chase Garden Creek	**+22.894 kg/day**	**+46.0%**

[1]MEP report for Sesuit Harbor has not yet been issued. Data from the Draft Bass Hole Estuarine System, including Chase Garden Creek, is included.

7.6.3 Status of Freshwater Ponds

Section 3 summarized water quality data and the trophic status of freshwater lakes and ponds in Dennis for which data were available. As described, an overabundance of phosphorus is the main concern in freshwater systems, as phosphorus is typically the nutrient in limited supply. Therefore, an increase in phosphorus can result in significant plant and algal growth, which can cause a shift in trophic status from oligotrophic, to mesotrophic, to eutrophic (over-enriched) conditions. Six ponds in Dennis were identified in Section 3 as eutrophic, and another two were designated mesotrophic. In the watersheds of those water bodies, when the predominant controllable phosphorus source is wastewater from onsite systems, enhanced phosphorus removal solutions should be considered to limit phosphorus inputs into the groundwater. Table 7-5 summarizes the ponds considered, noting those where phosphorus over-enrichment is a concern for the health of the ecosystem via its trophic status, and further notes where shoreline

development (thus onsite systems) is potentially the cause of water quality deterioration. These areas are thus considered high needs for water quality management solutions.

Table 7-5 Dennis Ponds Health Assessment Summary and Recommendations

Name	Pond Trophic Status	Monitor	Investigate Road Runoff Contribution	Investigate Potential Contaminant Sources	Shoreline Development
Aunt Pattys Pond	*	X	X		Low-Medium
Bakers Pond	Oligotrophic	X	X		Low
Cash Pond	*	X			Low
Cedar Pond	Eutrophic	X	X	X	Medium-High
Clay Pond		X		X	Low-Medium
Coles Pond	Eutrophic	X			Low-Medium
Duck Pond	*	X	X	X	Medium-High
Eagle Pond	Mesotrophic	X	X	X	Low
Flax Pond	Mesotrophic	X	X	X	Low-Medium
Follins Pond	*	X	X	X	High
Fresh Pond	Eutrophic	X		X	Low
Funn Pond**	*	X		X	Medium
Grassy Pond	*	X			Low
Great Pond Plash	*	X			Low
Hiram Pond	Eutrophic	X	X	X	Medium
Jonathans Pond	*	X		X	Low-Medium
Kelleys Pond	*	X		X	Medium-High
Little Coles Pond	*	X			Low
Northern Simmons Pond	Oligo-mesotrophic	X			Low
Pine Pond	*	X	X	X	Medium
Run Pond	Meso-eutrophic	X		X	Low
Scargo Lake	Meso-eutrophic	X	X	X	Medium
Southern Simmons Pond	*	X		X	Low
Swan Pond	*	X	X	X	High
The Plashes	*	X			Low
Uncle Stephens Pond	*	X		X	Medium
Weir Creek	*	X	X	X	Low-Medium
White Pond	Oligo-mesotrophic	X		X	Low
Whittemores Pond	*	X	X	X	Medium-High

Note: (*) PALS data not provided.

(**) Also known as Fund Pond in historical USGS maps and the Pond and Lake Atlas.

Red Fields indicate impaired water quality.

Gray Fields indicate recommendation to explore alternative wastewater management due to shoreline density.

7.6.4 Drinking Water Resources

The Dennis Water District owns considerable tracts of land within the Zone IIs of its 22 drinking water wells, which are all located north of Route 6. Historic drinking water quality data indicate that water quality has been excellent. While nitrate levels have been consistently below EPA and CCC thresholds, higher nitrate levels have been observed in the wells located farthest to the south, with some maximum measured levels since 1993 approaching the CCC's recommended 5 mg/L threshold. In general, though, increasing nitrate trends have not been observed, and water quality appears to be adequately protected.

It should be noted, however, that while drinking water quality is not a major driver in this updated needs assessment, a reduction in onsite septic system inputs into the groundwater, especially in Zone II areas, will result in a beneficial reduction of some constituents of wastewater effluent. These include nutrients such as nitrogen and phosphorus, bacterial and viral pollutants, and contaminants of emerging concern (CECs) such as pharmaceuticals and personal care products. The fate of this latter category of microconstituents in the environment is less well understood, and their impacts to drinking water supplies are increasingly being studied. Thus far, research has largely shown that levels of these microconstituents in drinking water supplies are extremely low, typically well below US EPA action levels. However, any reduction in their inputs to the contributing areas of surrounding groundwater wells has the benefit of reducing their concentrations in the public water supply. Furthermore, the collection and treatment of wastewater can facilitate treatment for these constituents if needed or desired by the town in the future.

7.6.5 Recreational Beaches

As described in Section 5, the water quality at both freshwater and saltwater beaches in Dennis appears to be acceptable under normal conditions, and evidence has not been seen of regular contamination of beaches due to septic systems. The occasional closings observed appear to be primarily due to runoff from large storm events, wildlife, or boat discharges. While mitigation for these sources have been incorporated into the final Recommended Program, the focus would not be on offsite wastewater solutions but rather on public education, improved stormwater controls, and enforcement of boat discharge regulations.

7.6.6 Economic Development Districts

Growth and economic development are necessary components of any healthy community. Dennis' preferred approach to growth management is to promote planned growth in targeted areas to help meet the community's long-term planning goals. Focusing growth in concentrated areas such as village centers that include the appropriate supporting infrastructure (utilities, transportation, etc.) is a "smart growth" approach that allows for better protection of natural resources in town. In order to allow for such growth, especially within nitrogen-sensitive watersheds, consideration must be given to how each area will be supported with the infrastructure it needs to thrive.

In 2018, at the direction of the WIC, CDM Smith subcontracted the UMass Donohue Institute to conduct a study on wastewater development within the Town. Through the information and data collected over the course of the study, evidence shows that water infrastructure has the potential to unlock development and increase investment in the community, both commercially and residentially. Towns on Cape Cod that have already built municipal wastewater systems, are

showing larger relative levels of room occupancy tax revenues than Dennis. Without municipal wastewater treatment, Dennis will have more limited policy levers to help guide its own future and it will be less able to capitalize on economic opportunities as they arise. Results of the full study can be found in **Appendix K**.

Each of the growth districts outlined in Section 7.4 is considered in the development of water quality management scenarios presented later in this report. While all scenarios do not propose to provide infrastructure to all growth areas, it is important to incorporate addressing the needs of these areas to the extent feasible while working within the town's financial constraints. Furthermore, consideration must be given to the increased revenue that can be generated by providing the necessary infrastructure to promote growth, which may offset or even surpass the capital outlay to construct such infrastructure.

7.7 Summary and Conclusions

While each of the needs identified above and shown on Figure 7-10 is important to the community, meeting the MEP nitrogen reduction goals will be of primary importance, as it will not only protect and restore water quality, it will also be mandated by state and federal regulatory agencies through the issuance of TMDL permits. As shown in Figure 7-10, considerable areas of town require significant nitrogen reduction to meet the MEP goals. As such, the development of water quality management scenarios presented later in this report focuses on the MEP goals as the main driver for the locations and layouts of offsite wastewater solutions and other non-traditional nitrogen management technologies.

The other needs identified in this section are considered secondary needs and have been addressed wherever sensible and feasible in the development of water quality management scenarios. Specifically, in building scenarios to meet the MEP goals, areas identified as AOCs, growth districts, or upstream of freshwater ponds were prioritized for inclusion in any proposed offsite solutions. When these other needs areas fell within MEP watersheds, they were targeted first for offsite solutions to help meet the required percentage nitrogen reduction, allowing multiple town goals to be met with a single solution. Needs areas that fell outside the MEP watersheds were considered in later scenarios, building off of those designed to meet the MEP goals, as described further in Section 10.

Finally, additional water quality management solutions located at a greater distance from MEP needs areas, such as those proposed to protect the water quality in Scargo Lake, have ultimately been included in the final recommended program, despite being excluded from the individual scenarios presented in Section 10. These solutions are not required to be included in the scenarios developed for comparative analysis, as they are common to any proposed scenario. Similarly, the final recommended program has incorporated the suggested "interim recommendations" summarized from the 2005 Needs Assessment presented above.

Section 8

Estimated Water Usage and Wastewater Flows

8.1 Purpose

The purpose of this section is to develop wastewater flow projections for the entire Town, including areas inside and outside of the Massachusetts Estuaries Project (MEP) watersheds, to be used in the development of a recommended wastewater program. Using available data, this section also presents a methodology for converting water usage to wastewater flow and for estimating seasonal flow variations. The estimates presented in this section are used later in this report to aid in the development and costing of Dennis' wastewater management alternatives. The flows projected for the planning districts, discussed in detail below, were updated following approval of the Draft Comprehensive Wastewater Management Plan. The discussion of the updated planning districts flows is presented in Section 14.2.5 of the Recommended Plan.

8.2 Data Summary

The most appropriate water quality management solution may incorporate wastewater service areas that fall both inside and outside of the MEP watersheds, in order to address the most important of the needs areas described in Section 7. Since the MEP water usage dataset has been used to develop the nitrogen loads for the sensitive watersheds throughout town, it is most appropriate to use that dataset whenever possible. However, the parcel-by-parcel MEP water usage data is only available for the three nitrogen sensitive watersheds for which MEP Final reports have been issued. Therefore, other water usage data must be used for the remainder of town.

The MEP dataset originated from town water billing records for the period of 2007 through 2009. For the remainder of town, more recent water usage data were obtained from the Cape Cod Commission, based on a period of 2009 through 2011. This latter dataset was used by the Cape Cod Commission (CCC) in the development of their Watershed Multi-variant Planner online tool, or "Watershed MVP." Note that while both datasets originate from Dennis Water District metering data, the MEP and CCC use differing assumptions in certain instances, such as when assigning water usage to parcels with private wells and when parcels are split between multiple watersheds. This, along with the difference in time frame, accounts for the variation between the two datasets. Each dataset has been linked to a Geographic Information System (GIS) database of all town parcels, for ease of analysis.

The comparisons performed in Section 4 showed that the older MEP data can be used for areas inside the MEP watersheds, while the newer CCC data can be used as a supplement in the areas outside of the MEP watersheds, with reasonable accuracy for both planning and design of wastewater management solutions, given the lack of significant changes in water usage since 2001 (see Figure 4-2). In the subsections that follow, both datasets are shown at times for comparison between the MEP and CCC data, with the MEP dataset supplemented with CCC data outside of the Bass River and Swan Pond River watersheds. However, moving forward in later sections of this report, the MEP water usage data is used for all areas within the Bass River and

Swan Pond River watersheds, and the CCC data is used for all other parcels in town. This includes areas in Dennis within the Herring River watershed, given that the Herring River MEP usage data does not differ significantly from the CCC usage (as shown below) and there are only a limited number of Herring River parcels in Dennis.

8.3 Baseline Water Usage – Existing Conditions

Figure 8-1 shows the CCC existing water usage dataset on a parcel-by-parcel basis, to illustrate general trends in water usage across the town.

8.3.1 Water Usage by Land Use

Water usage in Dennis was broken down by Cape Cod Commission land use category for the whole town using the CCC water usage data. Each land use category's water usage was then divided by the number of parcels within that category, to arrive at an average daily usage per parcel in gallons-per-day by category. The analysis was then repeated using the MEP dataset for the Swan Pond River and Bass River watersheds, supplemented by the CCC data for other areas of town, for comparison. This information is presented in **Table 8-1**.

Table 8-1 Total Water Use and Average Water Use per Land Use

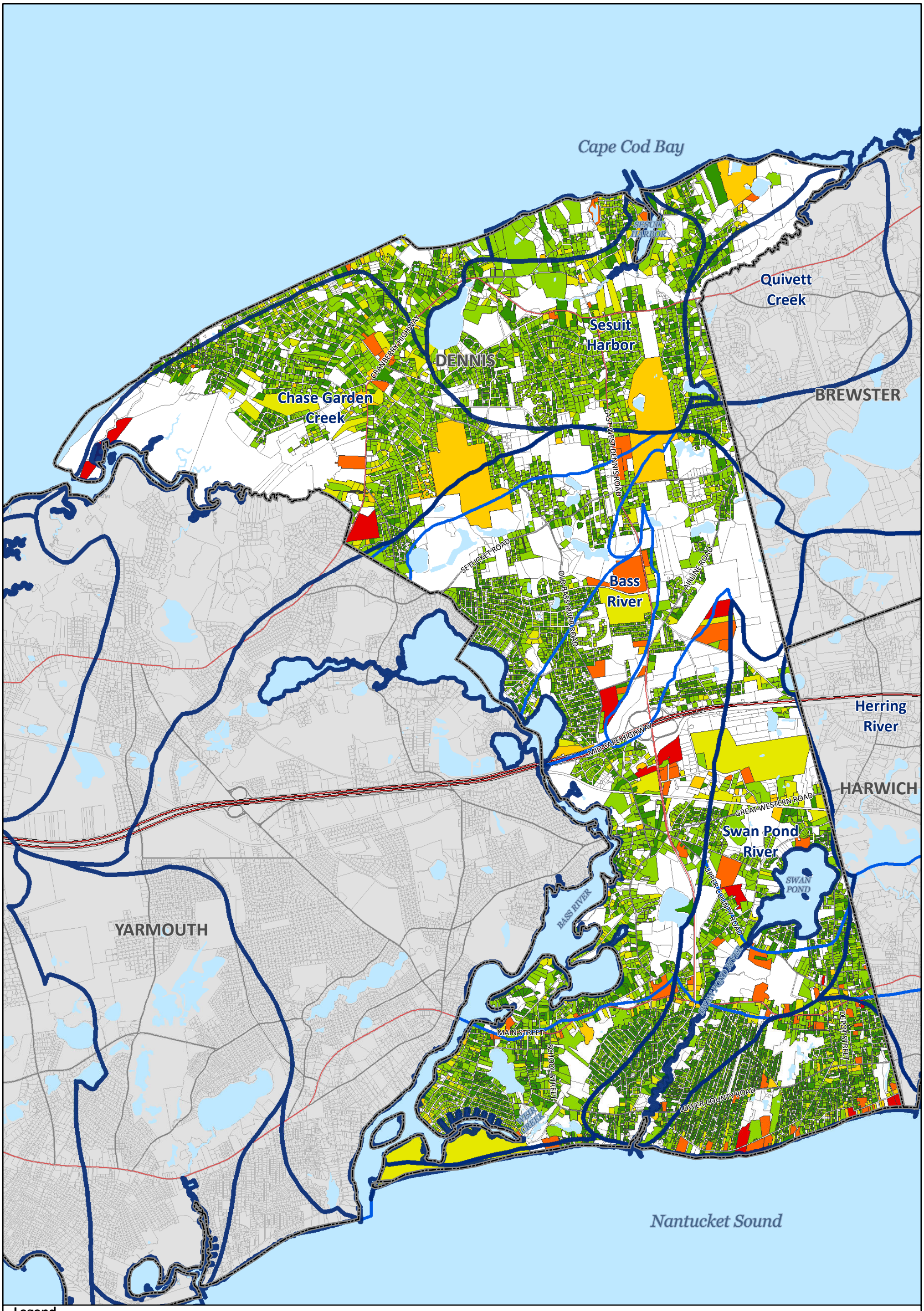
Land Use	CCC Water Use (gpd)	MEP&CCC Water Use (gpd)	Average CCC Water Use (gpd/parcel)	Average MEP&CCC Water Use (gpd/parcel)
Residential – Single Family	1,854,310	1,855,077	161	161
Residential – Multi Family	177,376	171,860	245	237
Residential – Condo/Apt	150,702	114,623	810	616
Commercial	301,922	275,538	812	741
Industrial	12,264	14,181	584	675
Other Developed	62,764	49,131	70	55
Vacant	7,092	10,466	5	8
Grand Total	**2,566,430**	**2,490,876**	**170**	**165**

With the 1,335 parcels coded as "vacant" removed from the total parcel count, the average water usage per parcel town-wide changes from 170 gpd to 187 gpd using the CCC dataset alone and from 165 gpd to 181 gpd using the combined MEP and CCC dataset.

The overall difference in water usage between the two datasets is 3 percent, with the CCC's dataset exceeding the MEP data.

8.3.2 Water Usage by Needs Area

Water usage was calculated for the following types of needs areas presented previously in Section 7: MEP watersheds and subwatersheds, wastewater Areas of Concern (AOCs), and planning districts.



Legend

- MEP Watershed Delineations
- MEP Subwatersheds

Water Use (Gallons per Day)

- 1 - 100
- 100 - 500
- 500 - 1000
- 1000 - 1500
- 1500 - 5000
- 5000 - 9000

Town of Dennis, MA

N

1 in = 3,500 ft

0 0.5 1 Miles

Annual Average Daily Water Usage by Parcel

Figure 8-1

CDM Smith

NEWELLJD F:\Dennis\DATA\MXD\Dennis_CCC_Parcel_Wateruse.mxd 7/10/2015

MEP Watersheds and Subwatersheds

The water usage using both MEP and CCC data by watershed and by subwatershed is shown in **Tables 8-2 and 8-3**, respectively. The average water usage per parcel is based on the total number of parcels within each watershed or subwatershed.

Table 8-2 Water Use by MEP Watershed

Watershed	CCC Water Use (gpd)	MEP Water Use (gpd)	Average CCC Water Use (gpd/parcel)	Average MEP Water Use (gpd/parcel)
Bass River	918,342	867,386	167	158
Swan Pond River	364,338	336,685	154	142
Herring River	29,983	30,808	204	201
Sesuit Harbor	289,170		183	
Chase Garden Creek	400,551		194	
Quivett Creek	25,099		181	
Direct Discharge	538,947		165	
Grand Total	**2,566,430**	**2,490,876**	**170**	**165**

Table 8-3 Water Use by MEP Subwatershed

Sub Watershed	CCC Water Use (gpd)	MEP Water Use (gpd)	Average CCC Water Use (gpd/parcel)	Average MEP Water Use (gpd/parcel)
Bass River Watershed				
Bakers Pond	10,134	10,706	188	198
Bass River Lower LT10	116,927	112,184	254	244
Bass River Mid GT10 Dennis	81,130	65,261	239	192
Bass River Mid LT10	76,985	75,304	197	193
East West Dennis Wells	11,487	10,525	179	164
Flax Pond - Dennis	1,857	1,501	116	94
Follins Pond GT10 Dennis	47,518	48,008	144	145
Follins Pond LT10	103,151	104,651	119	121
Fresh Pond - Dennis	10,896	9,466	165	143
Fresh Pond Gauge	3,364	3,538	129	136
Grand Cove	57,040	57,296	192	193
Grassy Pond - Dennis	10,479	10,482	146	146
Horsefoot Cove	16,769	15,060	212	191
Kelleys Bay GT10 Dennis	46,476	39,451	223	190
Kelleys Bay LT10	79,924	70,859	137	121
Kelleys Pond	32,487	31,933	146	143
Mill Stream GT10 Dennis	528	570	264	285
North Dennis Wells	40,241	36,748	160	146
Northwest Dennis Wells	58,910	57,728	149	146
Old Bass River Wells	7,389	7,224	127	125

Sub Watershed	CCC Water Use (gpd)	MEP Water Use (gpd)	Average CCC Water Use (gpd/parcel)	Average MEP Water Use (gpd/parcel)
School Street Marsh	93,817	91,327	145	141
Simmons Ponds	6,157	3,907	166	106
Uncle Stephans Pond	4,675	3,658	120	94
Swan Pond River Watershed				
Eagle Pond - Dennis	352	198	176	99
Hydaway Lane Stream	3,147	4,183	143	190
Swan Pond GT10	60,764	50,416	287	238
Swan Pond LT10	76,683	70,911	158	147
Swan Pond River N GT10	13,378	13,596	197	200
Swan Pond River N LT10	78,251	66,133	251	212
Swan Pond River S	131,762	131,248	104	104
Herring River Watershed				
Lower Herring R Main GT10	856	937	107	117
Upper Herring River GT10	27,458	27,965	213	207
West Reservoir LT10	1,364	1,408	227	235
White Pond - Harwich	306	317	153	159
Sesuit Harbor Watershed				
Cedar Lake	2,222		159	
Scargo Lake GT10	10,749		96	
Scargo Lake LT10	22,425		166	
Sesuit Creek East GT10	29,411		190	
Sesuit Creek East LT10	56,532		207	
Sesuit Creek West GT10N	8,534		138	
Sesuit Creek West GT10S	56,054		192	
Sesuit Creek West LT10	56,883		187	
Sesuit Harbor GT10	18,798		214	
Sesuit Harbor LT10	27,563		189	
Other				
Direct Discharge/Quivett Creek/Chase Garden Creek	964,598		177	
Grand Total	**2,566,430**	**2,490,876**	**170**	**165**

Overall, there is very good agreement between the MEP and the CCC water usage data at the MEP subwatershed level. Only six subwatersheds have differences greater than 20%, with four of those belonging to small waterways with low total water usage (Flax Pond, Uncle Stephan's Pond, Eagle Pond, and Hydaway Lane Stream). The largest difference is in the "Bass River Mid GT10 Dennis" subwatershed, where the CCC water usage is almost 16,000 gpd higher than the MEP data, for a difference of 24 percent. The other area with a substantial difference is Swan Pond GT10, where the CCC data is approximately 10,000 gpd, or 21 percent, higher than the MEP data.

Wastewater Areas of Concern (AOCs)

Table 8-4 presents the water usage for each of the wastewater needs AOCs. Although these areas are not intended to have distinctive boundaries, the information in Table 8-4 reflects the water usage based on the shaded areas shown on Figure 7-10. Therefore, the values are not intended to be exact figures, but instead approximations of average and total water usage within each AOC.

Table 8-4 **Water Use in Areas of Concern**

AOC	CCC Water Use (gpd)	MEP&CCC Water Use (gpd)	Average CCC Water Use (gpd/parcel)	Average MEP&CCC Water Use (gpd/parcel)
AOC 1	29805	30221	128	130
AOC 2	66489	67293	208	211
AOC 3	28,051	28,051	187	187
AOC 4	96828	96965	217	217
AOC 5	158,414	158,414	185	185
AOC 6	222,940	215,477	133	128
AOC 7	82301	66929	484	394
AOC 8	74,404	73,471	136	134
AOC 9	283,226	272,767	179	173
AOC 10	57,875	57,312	103	102
AOC 11	250,418	250,627	146	146
AOC 12	219,128	219,257	159	159
AOC 13	11,924	11,246	161	152
AOC 14	70924	62048	168	147
AOC 15	37397	37397	200	200

Planning Districts

The existing water usage within each of the five planning districts as outlined in Figure 7-10 is shown in **Table 8-5**. Note that since these areas comprise largely commercial and other non-residential development, the average usage per parcel is much greater than that of residential areas in Dennis and of the overall average usage per parcel in the town.

Table 8-5 **Water Use by Planning District**

Planning District	CCC Water Use (gpd)	MEP&CCC Water Use (gpd)	Average CCC Water Use (gpd/parcel)	Average MEP&CCC Water Use (gpd/parcel)
Dennis Port Growth District	51,455	51,725	500	502
Exit 78 (formerly 9) Growth District	69,061	50,780	404	297
Hotel Resort District (Dennis Port)	41,680	41,680	969	969
Hotel Resort District (West Dennis)	6,895	6,861	689	686
West Dennis Village Center	32,074	28,943	345	311

8.4 Buildout Water Usage

The analyses presented in Section 8.3 above were then repeated using buildout water usage estimated by the Cape Cod Commission. For the purposes of this analysis, the CCC buildout is assumed to approximate the MEP buildout values; however, these buildout values will be cross-checked with the MEP buildout values during the next phase of this planning study, and a decision will be made which dataset to use moving forward. The buildout information used for the MEP reports was developed through collaboration and consultation with Dennis' Town Planner. Based on a meeting with the Town Planner in 2014, the buildout assumptions used for the MEP reports are still considered reasonable approximations of future buildout within those areas, with the possible exception of flows that may be added in the hotel districts and based on the seasonal community bylaw. The information presented herein is preliminary and only intended to show order of magnitude projected increases.

MEP Watersheds and Subwatersheds

The water usage using CCC buildout data by watershed and by subwatershed is shown in **Table 8-6 and Table 8-7**, respectively.

Table 8-6 **Buildout Water Use by MEP Watershed**

Watershed	CCC Buildout Water Use (gpd)	Average CCC Buildout Water Use (gpd/parcel)
Bass River	1,130,466	205
Chase Garden Creek	465,219	226
Direct Discharge	707,639	217
Herring River	37,265	254
Quivett Creek	28,571	206
Sesuit Harbor	352,593	223
Swan Pond River	520,151	220
Grand Total	**3,241,903**	**215**

Table 8-7 Buildout Water Use by MEP Subwatershed

Subwatershed	CCC Buildout Water Use (gpd)	% Increase from Existing CCC Water Use	Average CCC Buildout Water Use (gpd/parcel)
Bass River Watershed			
Bakers Pond	11,436	13%	212
Bass River Lower LT10	120,638	3%	262
Bass River Mid GT10 Dennis	146,374	80%	431
Bass River Mid LT10	105,547	37%	271
East West Dennis Wells	13,223	15%	207
Flax Pond - Dennis	2,074	12%	130
Follins Pond GT10 Dennis	56,632	19%	171
Follins Pond LT10	110,746	7%	128
Fresh Pond - Dennis	20,540	89%	311

Subwatershed	CCC Buildout Water Use (gpd)	% Increase from Existing CCC Water Use	Average CCC Buildout Water Use (gpd/parcel)
Fresh Pond Gauge	3,581	6%	138
Grand Cove	64,760	14%	218
Grassy Pond - Dennis	12,347	18%	171
Horsefoot Cove	21,410	28%	271
Kelleys Bay GT10 Dennis	52,228	12%	251
Kelleys Bay LT10	87,736	10%	150
Kelleys Pond	33,789	4%	152
Mill Stream GT10 Dennis	528	0%	264
North Dennis Wells	54,422	35%	216
Northwest Dennis Wells	75,116	28%	190
Old Bass River Wells	8,474	15%	146
School Street Marsh	115,644	23%	179
Simmons Ponds	7,459	21%	202
Uncle Stephans Pond	5,760	23%	148
Swan Pond River Watershed			
Eagle Pond - Dennis	1,860	428%	930
Hydaway Lane Stream	14,616	364%	664
Swan Pond GT10	129,933	114%	613
Swan Pond LT10	107,598	40%	222
Swan Pond River N GT10	16,771	25%	247
Swan Pond River N LT10	107,089	37%	343
Swan Pond River S	142,284	8%	113
Herring River Watershed			
Lower Herring R Main GT10	1,461	71%	183
Upper Herring River GT10	33,483	22%	260
West Reservoir LT10	1,798	32%	300
White Pond - Harwich	523	71%	261
Sesuit Harbor Watershed			
Cedar Lake	2,222	0%	159
Scargo Lake GT10	12,485	16%	111
Scargo Lake LT10	27,199	21%	201
Sesuit Creek East GT10	33,847	15%	218
Sesuit Creek East LT10	70,458	25%	258
Sesuit Creek West GT10N	15,704	84%	253
Sesuit Creek West GT10S	57,991	3%	199
Sesuit Creek West LT10	79,815	40%	262
Sesuit Harbor GT10	19,666	5%	223
Sesuit Harbor LT10	33,205	20%	227
Other			
Direct Discharge/Quivett Creek/Chase Garden Creek	1,201,429	25%	220
Grand Total	**3,241,903**	26%	**215**

Wastewater Areas of Concern (AOCs)

Table 8-8 presents the water usage for each of the wastewater needs AOCs based on the CCC buildout data.

Table 8-8 Buildout Water Use in Areas of Concern

AOC	CCC Buildout Water Use (gpd)	% Increase from Existing CCC Water Use	Average CCC Buildout Water Use (gpd/parcel)
AOC 1	32,418	198	220
AOC 2	82,547	240	259
AOC 3	37,382	265	249
AOC 4	118,407	235	265
AOC 5	197,009	241	230
AOC 6	240,083	195	143
AOC 7	206,053	586	1,212
AOC 8	89,466	229	163
AOC 9	317,447	207	201
AOC 10	61,900	193	110
AOC 11	297,473	225	174
AOC 12	327,371	309	238
AOC 13	26,372	506	356
AOC 14	87,113	237	207
AOC 15	40,652	198	217

Planning Districts

Table 8-9 shows the projected buildout water usage associated with each of the planning districts according to the CCC buildout water usage values.

Table 8-9 **Buildout Water Use in Planning Districts**

Planning District	CCC Buildout Water Use (gpd)	% Increase from Existing CCC Water Use	Average CCC Buildout Water Use (gpd/parcel)
Dennis Port Growth District	65,185	27%	633
Exit 78 (Formerly 9) Growth District	209,511	203%	1,225
Hotel Resort District (Dennis Port)	49,105	18%	1,142
Hotel Resort District (West Dennis)	8,197	19%	820
West Dennis Village Center	41,669	30%	448

8.5 Estimated Wastewater Flows

Wastewater flows can be estimated on a per-parcel basis or by using a percentage of water usage. For a seasonal community such as Dennis, per-parcel estimates are not apt to be accurate and can be misleading. Therefore, estimating wastewater generation based on water usage is the best approach.

A typical factor used for wastewater generation is to assume 90 percent of water usage becomes wastewater. This accounts for outdoor uses such as lawn watering, where the water does not end

up becoming wastewater, as well as consumptive uses. Seasonal variations exist in water usage due to lawn watering, but this impact is difficult to distinguish from seasonal trends due to population changes. Therefore, the 90 percent factor is applied as an annual average, with the knowledge that a greater proportion of the 10 percent difference between water use and wastewater generation is likely used in the summer versus the winter, due to the increase in outdoor uses.

8.5.1 Existing Conditions

Wastewater flows by AOC and by MEP watershed are calculated from the CCC water usage information presented above using the 90 percent factor and are presented **in Tables 8-10 and 8-11**, respectively.

Table 8-10 Wastewater Flows by AOC

AOC	CCC Wastewater Flows (gpd)
AOC 1	26,825
AOC 2	59,840
AOC 3	25,246
AOC 4	87,145
AOC 5	142,573
AOC 6	200,646
AOC 7	74,071
AOC 8	66,964
AOC 9	254,903
AOC 10	52,087
AOC 11	225,376
AOC 12	197,215
AOC 13	10,731
AOC 14	63,832
AOC 15	33,657

Table 8-11 Wastewater flows by MEP watershed

Watershed	CCC Wastewater Flows (gpd)
Bass River	780,648
Swan Pond River	303,016
Herring River	26,970
Sesuit Harbor	260,995
Chase Garden Creek	361,586
Quivett Creek	22,464
Direct Discharge	486,111
Grand Total	**2,241,788**

8.5.2 Buildout

This process was then repeated using 90 percent of buildout water usage projections for both the MEP watersheds and the AOCs that fall within them, as presented in **Tables 8-12 and 8-13**.

Table 8-12 Buildout Wastewater Flows by MEP Watershed

Watershed	CCC Buildout Wastewater Flows (gpd)
Bass River	1,130,466
Swan Pond River	520,151
Herring River	37,265
Sesuit Harbor	352,593
Chase Garden Creek	465,219
Quivett Creek	28,571
Direct Discharge	707,639
Grand Total	**3,241,903**

Table 8-13 Buildout Wastewater Flows by AOC

AOC	CCC Buildout Wastewater Flows (gpd)
AOC 1	29,176
AOC 2	74,292
AOC 3	33,644
AOC 4	106,566
AOC 5	177,308
AOC 6	216,075
AOC 7	185,448
AOC 8	80,520
AOC 9	285,703
AOC 10	55,710
AOC 11	267,725
AOC 12	294,634
AOC 13	23,735
AOC 14	78,401
AOC 15	36,587

8.6 Seasonal Variations and Peaking Factors

8.6.1 Seasonal Wastewater Flow Ratios

Communities on Cape Cod routinely see a four to fivefold increase in water usage between the lowest flow months of the year and the highest flow months. Monthly water pumping records, as presented in Section 4, were gathered for the years 2001 through 2004 and 2008 through 2012 from the Dennis Water District. Using data from the five year period of 2008 through 2012, seasonal variations were calculated. Monthly flows in this period range from a low of

approximately 30 million gallons in February 2012 to a high of approximately 225 million gallons in July 2010. This represents a swing of almost 7.5 times higher flow in the highest flow month than the lowest over a five year period. Such flow variation is a substantial consideration when sizing wastewater conveyance and treatment systems. **Table 8-14** presents seasonal flow variation specific to Dennis, based on the period of 2008 through 2012.

Table 8-14 Seasonal Variation in Water Use based on 2008 to 2012 Water Pumping Data

Parameter	Monthly Flow (gallons)	Average Daily Flow (gpd)	Peaking Factor (Monthly/Avg)
Average Monthly Flow	81,969,842	2,694,899	1.0
Peak Flow Month of Record (July 2010)	225,325,900	7,268,577	2.75
Lowest Flow Month of Record (February 2012)	30,135,800	972,123	0.37
Average June-August Daily Flow	165,817,240	5,407,084	2.02
Average Dec- Feb Daily Flow	35,509,947	1,183,665	0.43
June-Aug / Dec-Feb Flows	N/A	N/A	4.67

8.7 Summary and Conclusions

The information presented in this section provides baseline data for the consideration of wastewater planning scenarios, which require flow data to determine approximate infrastructure sizing, for the purpose of comparing the level of complexity and the costs between various alternative scenarios under consideration. The parcel-by-parcel water usage that comprises the basis of the data presented in this section is used throughout the subsequent phases of planning. As noted previously, for parcels within the Bass River and Swan Pond River watersheds, the MEP data associated with existing water usage has been used at this time. For all other areas of town, the CCC dataset has been utilized. For planning-level analyses, these datasets are close enough to be considered interchangeable.

Section 9
Dennis Parcel Screening

9.1 Overview

This section presents the site screening process utilized for the Dennis Water Quality Evaluation and Mitigation Alternative Study. The main objective was to identify and evaluate publicly owned properties which may be used for the advancement of water quality improvement goals. Parcels have been evaluated for their potential use for wastewater treatment, treated wastewater effluent recharge, water reuse, and non-traditional nitrogen removal systems.

The physical features of each parcel, as well as the ownership and land uses, were considered in this evaluation to determine the best candidate sites.

The Town performed an additional parcel screening exercise in 2016, included as Appendix F, and is currently planning to conduct another evaluation in the fall of 2021. The aim of these additional screening efforts, is to identify additional parcels specifically for recharge of the highly treated effluent from the future wastewater treatment plant. Findings from the most recent study will be shared with the Massachusetts Environmental Policy Act (MEPA) office, Cape Cod Commission (CCC) and the Massachusetts Department of Environmental Protection (MassDEP).

9.2 Wastewater Treatment/Effluent Recharge Sites

The first component of this evaluation was to identify potential sites for wastewater treatment facilities and for the recharge to groundwater of highly treated wastewater effluent. This town-wide analysis was performed in two phases, as described below, and ultimately resulted in the selection of the 10 most viable sites.

Figure 9-1 shows the multi-step process that was used to establish the best sites. The first step applied 10 site-screening criteria to all parcels in Dennis. While the original scope specified only town-owned sites were to be considered, it was prudent to begin with a broader base, to ensure that opportunities on privately-owned sites were not missed. This step narrowed the total 15,114 parcels in Dennis down to 183 parcels. Further analysis, factoring in several additional considerations, reduced the number of parcels to 10. In Section 10, during the development of specific water quality management scenarios, these 10 parcels were narrowed down further to arrive at the best candidate sites in appropriate proximity to identified needs areas. The results of this final screening step to arrive at the three top sites in relation to the scenarios being developed is presented in Section 9.4 below.

It is important to note that while the 10 most feasible sites have been determined, all 183 sites identified in the initial screening could still be revisited as potential sites. The sections below summarize the criteria, selection process, and resulting sites that are considered to be the best candidates in Dennis for treated effluent recharge and potentially also wastewater treatment.

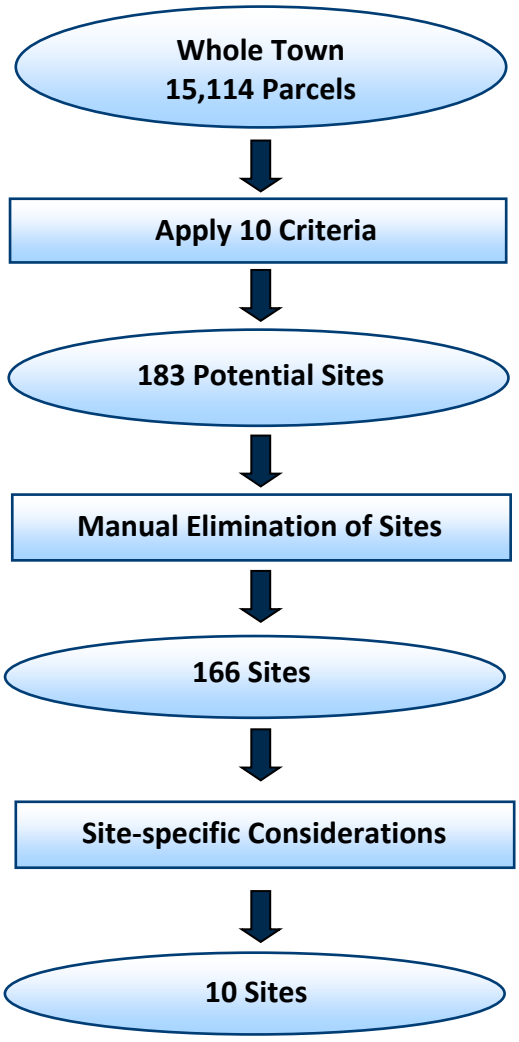


Figure 9-1 Flowchart of Site Screening Process for Wastewater Treatment and Treated Effluent Recharge

In order to determine the most feasible locations for wastewater treatment and effluent recharge within the town of Dennis, it was necessary to evaluate all possibilities and use selection criteria to identify sites which best meet the program objectives. For the initial screening, all parcels within the town boundaries were considered, and many were eliminated through a series of applied selection criteria. Criteria were established based on the needs of the program such as continued water resource and rare and endangered species protection, favorable soil and groundwater conditions, minimum parcel size, and property ownership. Five criteria were applied as 'exclusion criteria,' whereby if a certain condition was met, the parcel was excluded from further analysis. The other five criteria were applied with a ranking, whereby one point was given for 'more favorable' conditions, and no points were assigned for 'less favorable' conditions.

Each of the 10 criteria is described below and shown, respectively, in **Figures 9-2 through 9-11** at the end of Section 9.2. Any exceptions to the methodology are described in the pertinent section below.

9.2.1 Data Sources

The most up-to-date Geographic Information Systems (GIS) data available in 2014 were used to conduct the site screening analysis. The sources are the same as those described in Section 7 and are listed in Table 7-2.

9.2.2 Criterion #1: Parcel Size Greater than Three Acres

The minimum parcel size which could be effectively utilized for wastewater treatment or effluent recharge was determined to be three acres. Therefore, this criterion eliminated all parcels less than three acres in size. See **Figure 9-2** for the parcel areas which met this criterion.

9.2.3 Criterion #2: Outside Zone of Contribution

A well zone of contribution (ZOC) is the groundwater area that regularly supplies water to a municipal drinking water supply well. This area is calculated based on a variety of factors, including soil permeability, transmissivity within the aquifer, and the rate of pumping based on past use.

The zone delineations used in this evaluation were developed by the UMass Dartmouth School for Marine Science and Technology (SMAST). SMAST calculated well contribution protection perimeters using a steady state model simulation of the area surrounding each municipal well. These zones of contribution were shown in the Massachusetts Estuaries Project (MEP) reports for Bass River and Swan Pond River and were developed for the following areas: North Dennis Wells, Northwest Dennis Wells, East Dennis Wells, and Old Bass River Wells.

Note that these zones differ from the MassDEP Zone II delineations, which consider the most severe pumping rates for 180 days under drought (no recharge) conditions. Zone II areas are considered later in this analysis.

All parcels which were located within a zone of contribution were excluded from further consideration in this analysis. Parcels that were partially within a zone of contribution were maintained if more than three acres of the parcel were outside zones of contribution. **See Figure 9-3** for well ZOCs within Dennis and the associated parcels maintained after applying this criterion.

9.2.4 Criterion #3: Outside Special Flood Hazard Areas

Continuously recharging wastewater effluent requires highly permeable soils with sufficient depth to groundwater to account for groundwater mounding. Thus, areas prone to flooding or which have limited soil permeability due to existing wet conditions were eliminated as part of this assessment. In addition, wastewater treatment facilities or components should not be sited within floodplain areas, in order to ensure their continued operation during storm conditions.

The new 2014 Federal Emergency Management Agency (FEMA) flood maps were used for this analysis, and any parcel within a Special Flood Hazard Area (SFHA) was eliminated. This SFHA

designation includes zones AE, A, VE, and AO. If a parcel had more than three acres outside of the SFHA, it was maintained in the analysis. **Figure 9-4** identifies the parcels within Dennis which were maintained after the application of this criterion.

9.2.5 Criterion #4: Outside of Wetlands

As noted above, soil permeability is a key component to effective effluent recharge. Wetlands are areas where soils are fully saturated either seasonally or permanently. MassDEP defines wetlands as "areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas."

All parcels located within the Massachusetts Department of Environmental Protection (MassDEP) wetlands GIS layer were eliminated from further analysis. Parcels with three or more acres outside of wetlands depicted in the MassDEP layer were maintained. These results are shown on **Figure 9-5**.

9.2.6 Criterion #5: Favorable Depth to Groundwater

Estimated depth to groundwater is another measure of the capacity of soils to accept effluent recharge. Portions of land which are not wetlands but maintain a high groundwater table may only be able to infiltrate a limited volume of additional water. Because wastewater effluent volume is variable and groundwater mounding will occur as a result of effluent recharge, selecting a site with a minimum depth to groundwater of at least five feet below the ground surface will provide a minimum buffer for this screening level of analysis.

The depth to groundwater calculations were performed using Cape Cod Commission groundwater elevation data combined with LiDAR ground surface elevation data. The mean depth to groundwater on a parcel was computed for each parcel, and where it was less than five feet, the parcel was eliminated from further analysis. **Figure 9-6** shows the resulting parcels that were maintained after the application of this criterion.

9.2.7 Criterion #6: Permeable Soils

Soil permeability is one of the limiting factors which determines effective effluent recharge rates at a particular location. The higher the permeability of the soil, the more water recharge capacity a location can accommodate. For a parcel to be a good candidate, it should be outside a low-permeability soil zone. In this assessment, low-permeability soils were generally soils which formed through deposition from flowing water such as clays and silts. These soils are comprised of particles that are small and light enough to be carried by moving water, but large enough to settle out. Over time, the soils form as well sorted layers which, once settled, can be nearly impermeable. In addition, properties with significant bedrock are also not conducive to effective recharge. Ideal soils for an effluent recharge site are poorly sorted, well drained sands and gravels that allow high permeability, and thus higher potential effluent recharge rates.

Natural Resources Conservation Service (NRCS) Soil Survey Geographic Database (SSURGO) data were used to classify soils that may not be conducive to effluent recharge. Any parcels that intersected areas classified as 'boulder,' 'silty loam,' or 'muck/peat' were considered 'less

favorable,' and were thus not assigned any points. All parcels outside of these areas were given one point as 'more favorable.' The results of this criterion are shown in **Figure 9-7**.

9.2.8 Criterion #7: Favorable Development Status

It is often more cost effective and resource efficient to develop an effluent recharge site from a parcel which is not currently developed. This can also alleviate social issues which often arise when developing sites for wastewater handling. Thus, development status was surveyed as part of this investigation. However, some developed properties with large areas of open space or recreational land, such as ball fields, may be appropriate for subsurface effluent recharge. As such, development status was applied as a ranking criterion, rather than an elimination criterion. Undeveloped parcels were given one point to designate a 'more favorable' condition. These results are shown on **Figure 9-8**.

9.2.9 Criterion #8: Outside Priority Habitat Areas

Priority habitat areas refer to the geographical boundaries of known state-listed rare plant and animal species. Parcels which contain priority habitat areas would be subject to the Massachusetts Endangered Species Act (MESA) and regulatory review by the Natural Heritage and Endangered Species Program (NHESP) under the Massachusetts Division of Fisheries and Wildlife. NHESP defines priority habitats as "the geographic extent of Habitat for State-listed Species as delineated by the Division pursuant to 321 CMR 10.12."

Parcels identified as being within a Priority Habitat of Rare Species zone were considered 'less favorable.' One point was assigned to parcels with more than three acres outside of NHESP designated areas. The results are shown on **Figure 9-9**.

9.2.10 Criterion #9: Outside Municipal Wellhead Protection Zone II

Wellhead protection Zone II designated areas are conservatively delineated to provide buffer space around the contribution zone for a public drinking water well. A Wellhead Protection Zone II, as defined by MassDEP, is "an area of an aquifer which contributes water to a well under the most severe pumping and recharge conditions that can be realistically anticipated (180 days of pumping at safe yield, with no recharge from precipitation)." MassDEP may require a higher level of treatment before allowing effluent recharge in a Zone II area.

Parcels within a Wellhead Protection Zone II area were ranked as part of this screening but not excluded. Specifically, parcels that fall outside of Zone II areas were given one point as 'more favorable.' The results are shown on **Figure 9-10**.

9.2.11 Criterion #10: Town-owned Property

Parcels owned by the town of Dennis were preferred in this assessment. Parcels already owned by the town provide a significant financial, logistical, and legal advantage due to the relative ease by which access, development, and permitting could be obtained. If a parcel is privately owned, the town would have to go through a legal process to obtain or purchase the property before it could be permitted and developed. Such processes may take months or years to complete, depending on the relationship with the owner, and may be expensive depending on the value of the parcel. Town-owned parcels were therefore given a ranking of one point as 'more favorable.' The results are shown on **Figure 9-11**.

9.2.12 Manual Elimination of Parcels

Following this first step, parcels were then manually eliminated based on several additional factors. Parcels removed during this step included:

1. Cemeteries
2. Parcels that had been very recently and substantially developed
3. Undeveloped parcels owned by the Dennis Water District

9.2.13 Results of Criteria Application

The results of the application of these first 10 criteria and the manual elimination step are shown on **Figure 9-12.** A total of 183 parcels remained after the five exclusion criteria were applied (parcels greater than three acres, outside of well zones of contribution, wetlands, and flood hazard areas, and with a mean depth to groundwater of at least five feet). The latter five criteria were then applied to develop rankings for each parcel. The highest ranking a parcel could achieve was five points, indicating that all of the five ranking criteria were ranked 'more favorable.' Following the manual exclusion of additional parcels, 166 parcels remained. Figure 9-12 shows the ultimate ranking of each parcel that fully met the exclusion criteria, including the manual elimination step. The ranking for each parcel that remained is also shown. These rankings were developed by adding up the points from the five ranking criteria.

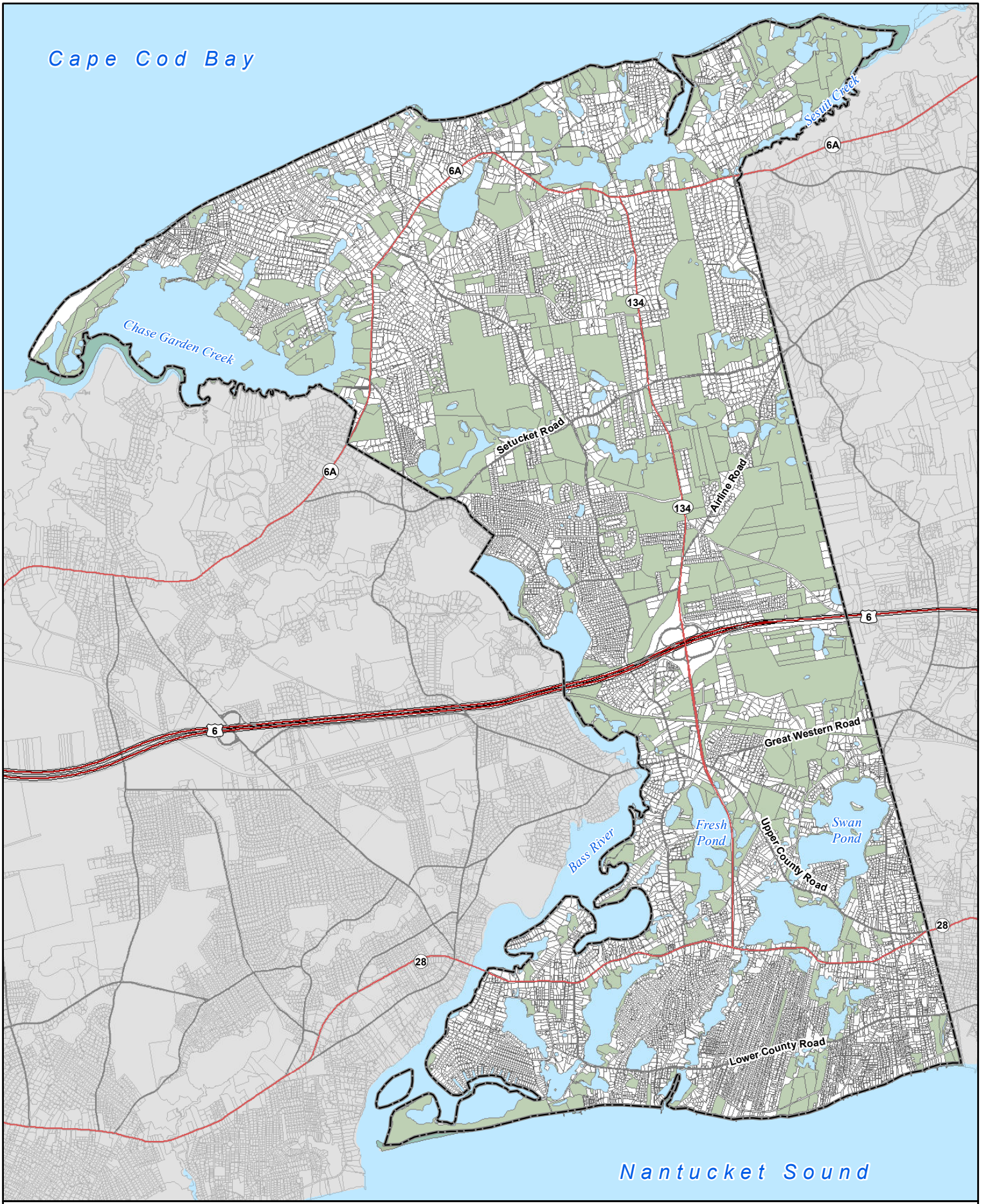
9.2.14 Site-specific Parcel Consideration

Following these first steps, the remaining parcels were looked into in more detail to determine the appropriateness of continued consideration. Figure 9-13 considers protected open space and recreational open space criteria that were also considered subjectively.

9.3 Recommended Sites

The list of the top 166 sites was provided to several town staff to receive local input. The objective analysis presented above can provide many of the logistical and practical details of the feasibility of a site to be used for effluent recharge. But local knowledge is required to arrive at a final list of sites that are consistent with other community planning and development endeavors and are anticipated to garner the most widespread support.

Based on the input from the Assistant Town Administrator, Town Planner, and Health Director, as well as review by the CWMTF members, the site-screening criteria results were narrowed down to 10 preferred sites, as shown in Figure 9-14. (Note that some sites are a combination of several parcels.) These sites received high scores in the screening process and were also favored by the town staff and committee members. MEP watershed boundaries are also shown on Figure 9-14, such that sites can be considered in relation to which watershed effluent would discharge into from each location.



Legend

- Parcel Area is Less Than 3 Acres
- Parcel Remaining After Site Screening (Parcel Area > 3 Acres)

Town of Dennis, MA

1 inch = 4,500 feet

0 1,000 2,000 4,000 Feet

Site Screening Criterion 1
Minimum Parcel Size

Figure 9-2

CDM Smith

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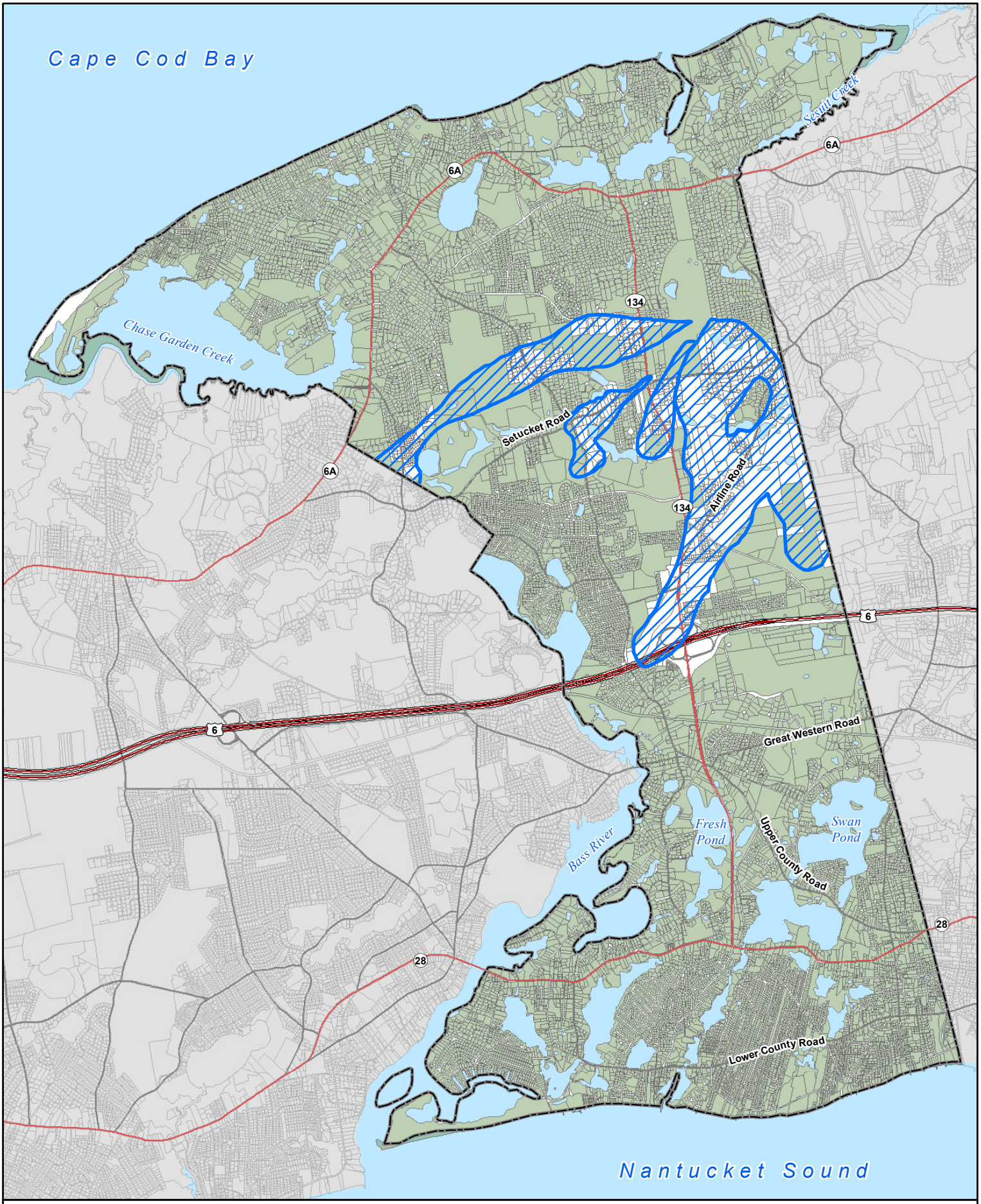

Legend

Well Zone of Contribution

Parcel Remaining After Site Screening

Town of Dennis, MA

1 inch = 4,500 feet

0 1,000 2,000 4,000 Feet

Site Screening Criterion 2
Outside Zone of Contribution

Figure 9-3

CDM Smith

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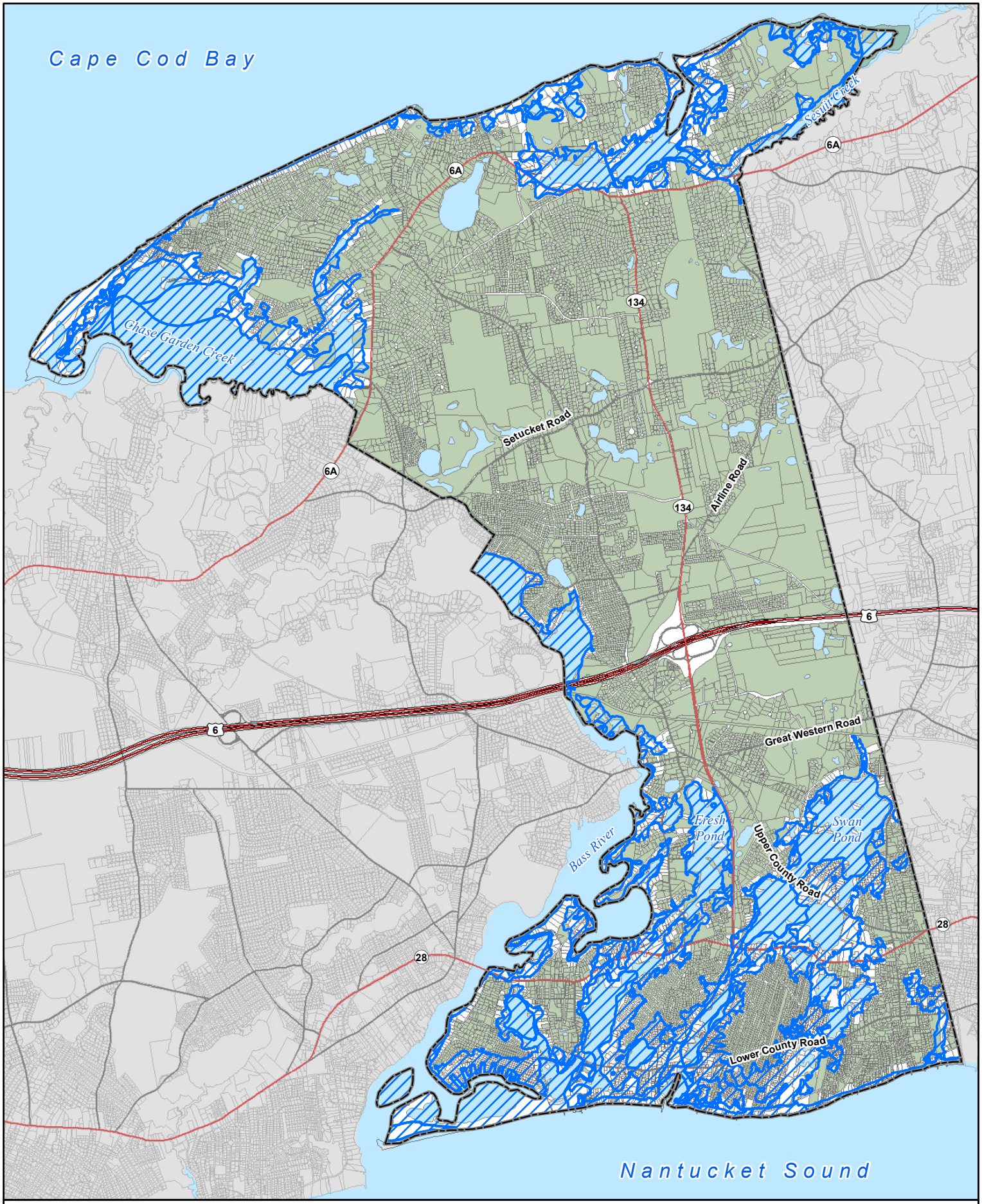

Legend

100-year Floodplain Boundary

Parcel Remaining After Site Screening

Town of Dennis, MA

1 inch = 4,500 feet

0 1,000 2,000 4,000 Feet

Site Screening Criterion 3
100-year Flood Zone

Figure 9-4

CDM Smith

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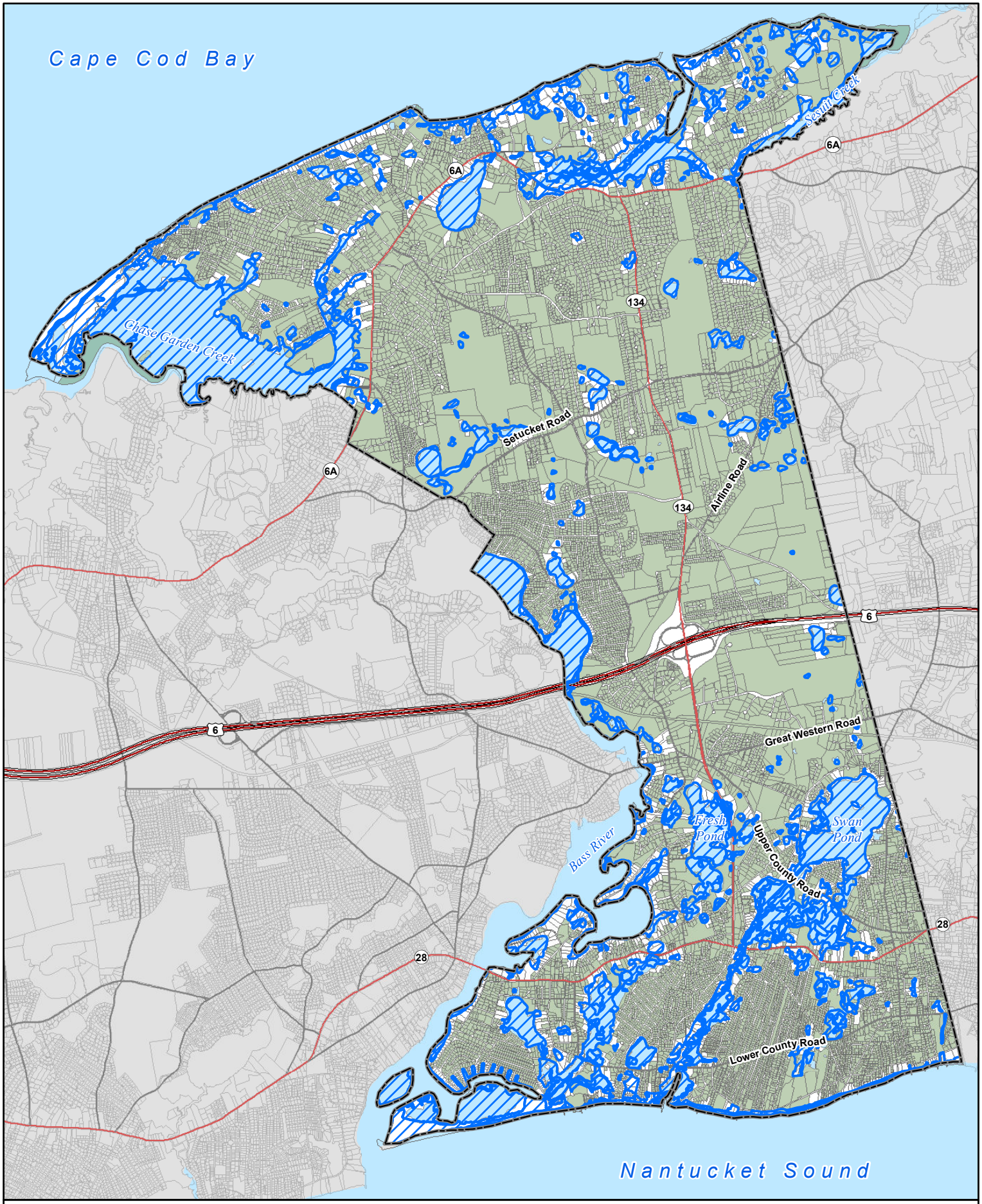

Legend

Wetlands

Parcel Remaining After Site Screening

Town of Dennis, MA

1 inch = 4,500 feet

0 1,000 2,000 4,000 Feet

Site Screening Criterion 4
Wetlands
Figure 9-5

CDM Smith

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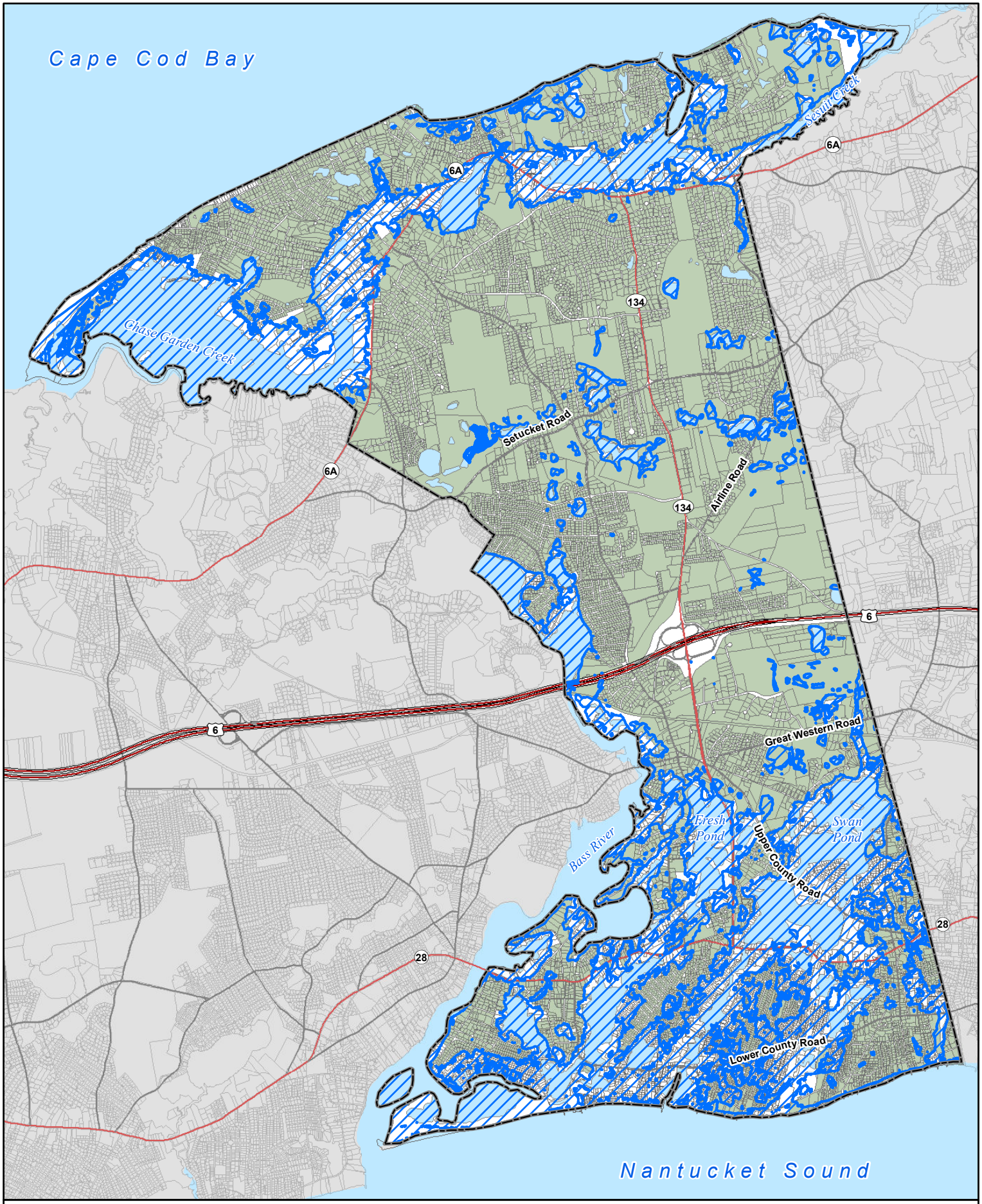

Legend

Zone Where Depth to Groundwater is Less Than 5 Feet

Parcel Remaining After Site Screening

Town of Dennis, MA

1 inch = 4,500 feet

0 1,000 2,000 4,000 Feet

Site Screening Criterion 5
Depth to Groundwater
Figure 9-6

CDM Smith

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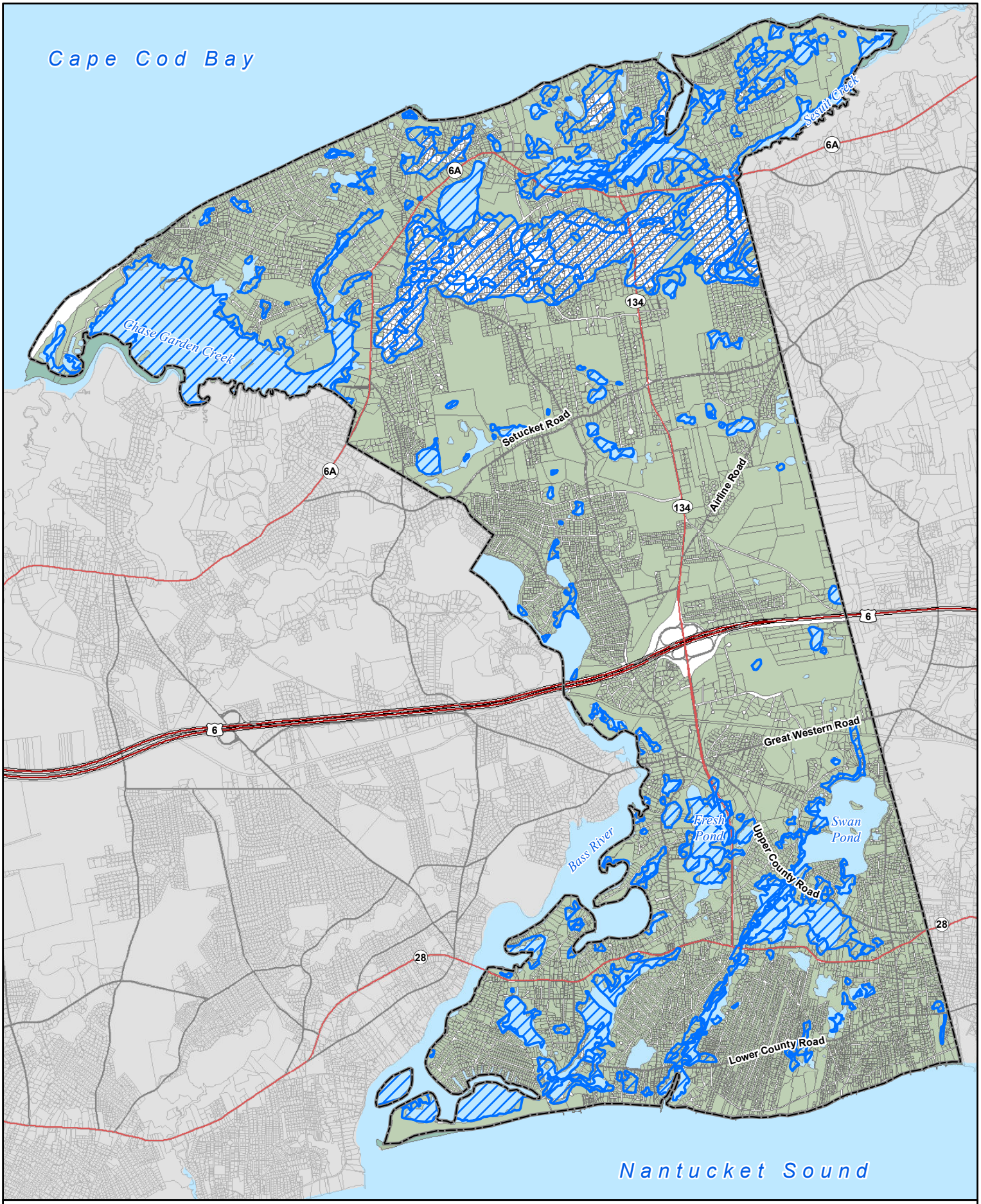

Legend

- Low Permeability Soils
- Parcel Meeting Criteria (+1 Point)

Town of Dennis, MA

1 inch = 4,500 feet

0 1,000 2,000 4,000 Feet

Site Screening Criterion 6
Soil Permeability
Figure 9-7

CDM Smith

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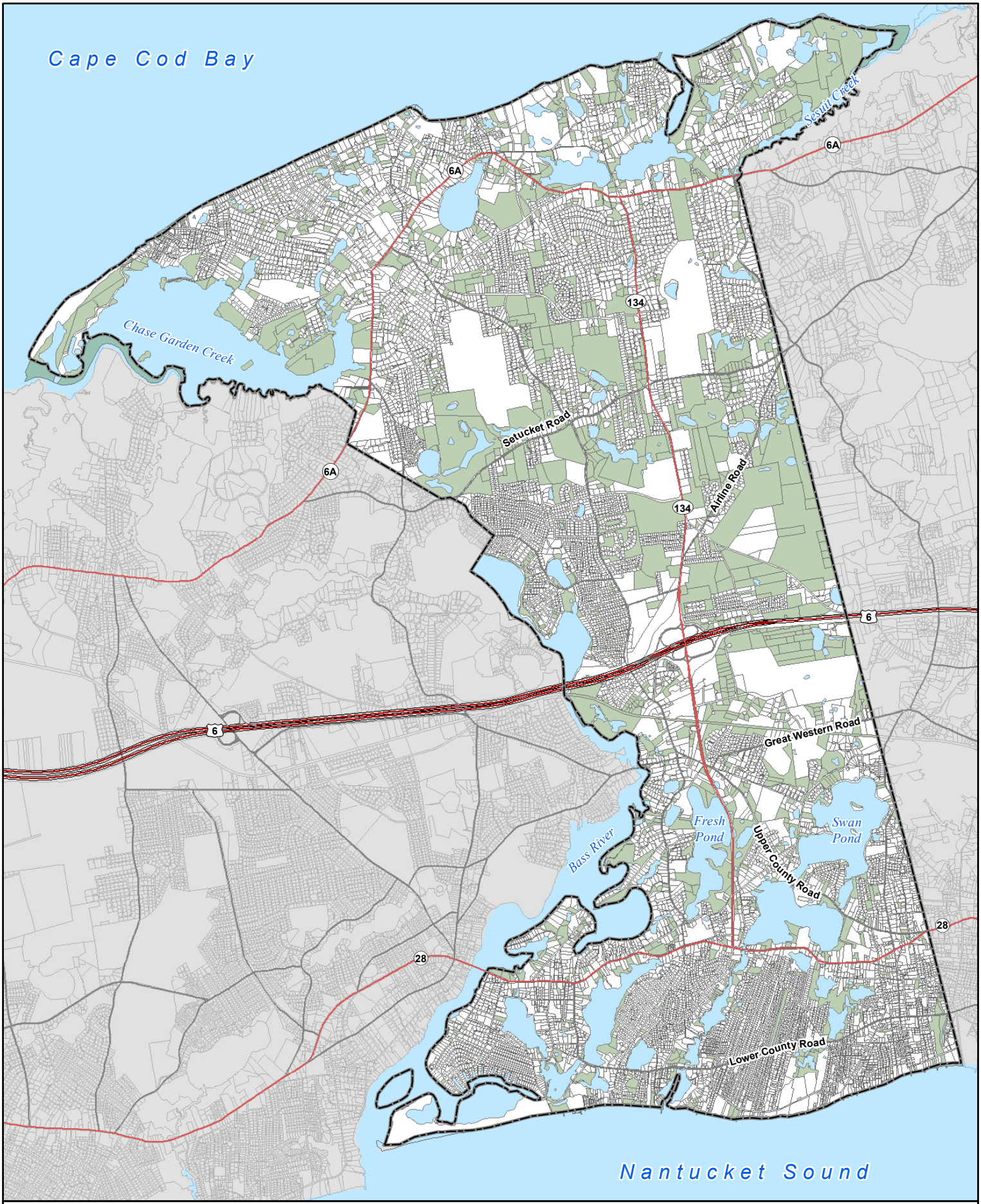

Legend

- Parcel Meeting Criteria (+1 Point)
- Developed Parcel

Town of Dennis, MA

Site Screening Criterion 7
Favorable Developement Status

1 inch = 4,500 feet

0 1,000 2,000 4,000 Feet

Figure 9-8

CDM Smith

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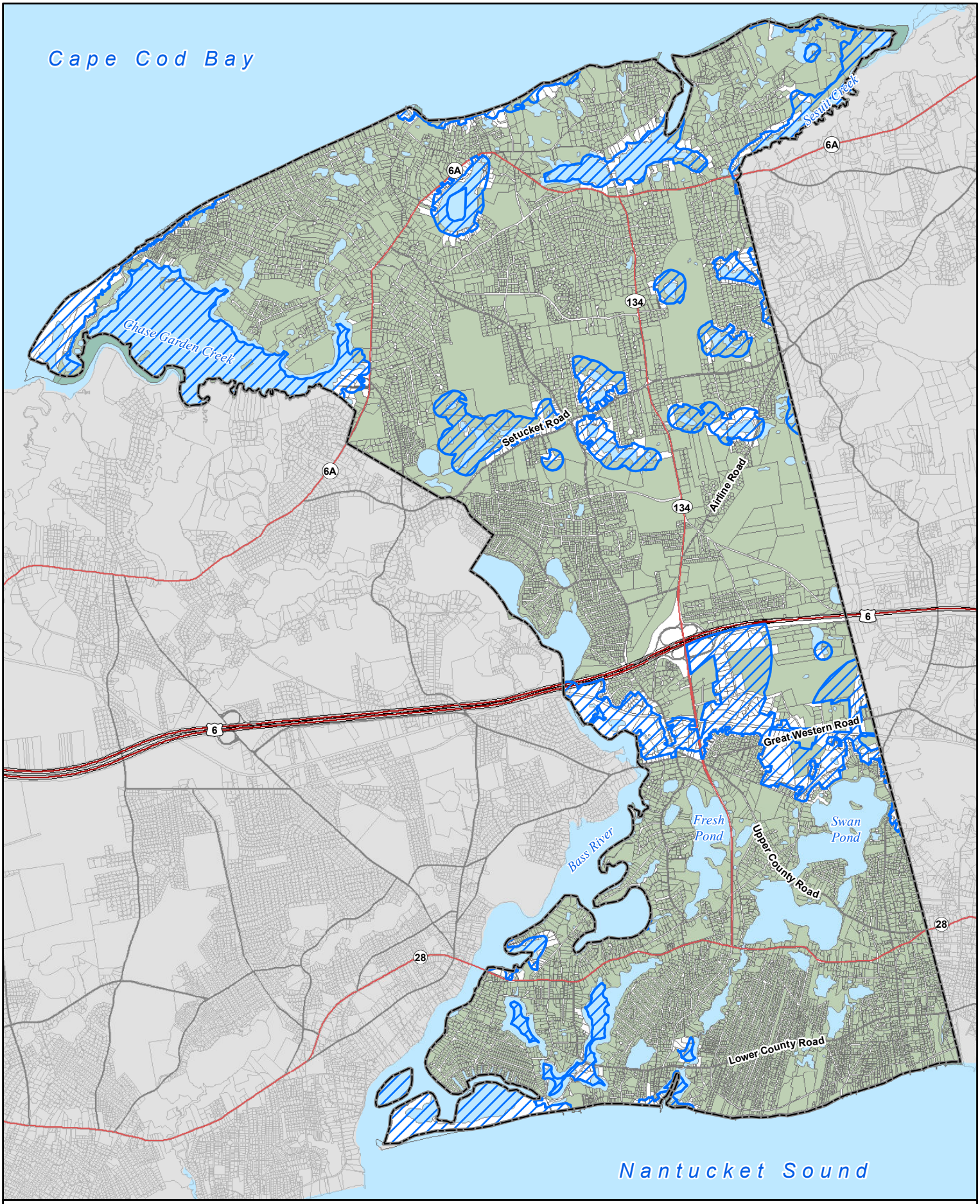

Legend

- Parcel Meeting Criteria (+1 Point)
- NHESP Priority Habitats of Rare Species

Town of Dennis, MA

1 inch = 4,500 feet

0 1,000 2,000 4,000 Feet

Site Screening Criterion 8
Priority Habitats
Figure 9-9

CDM Smith

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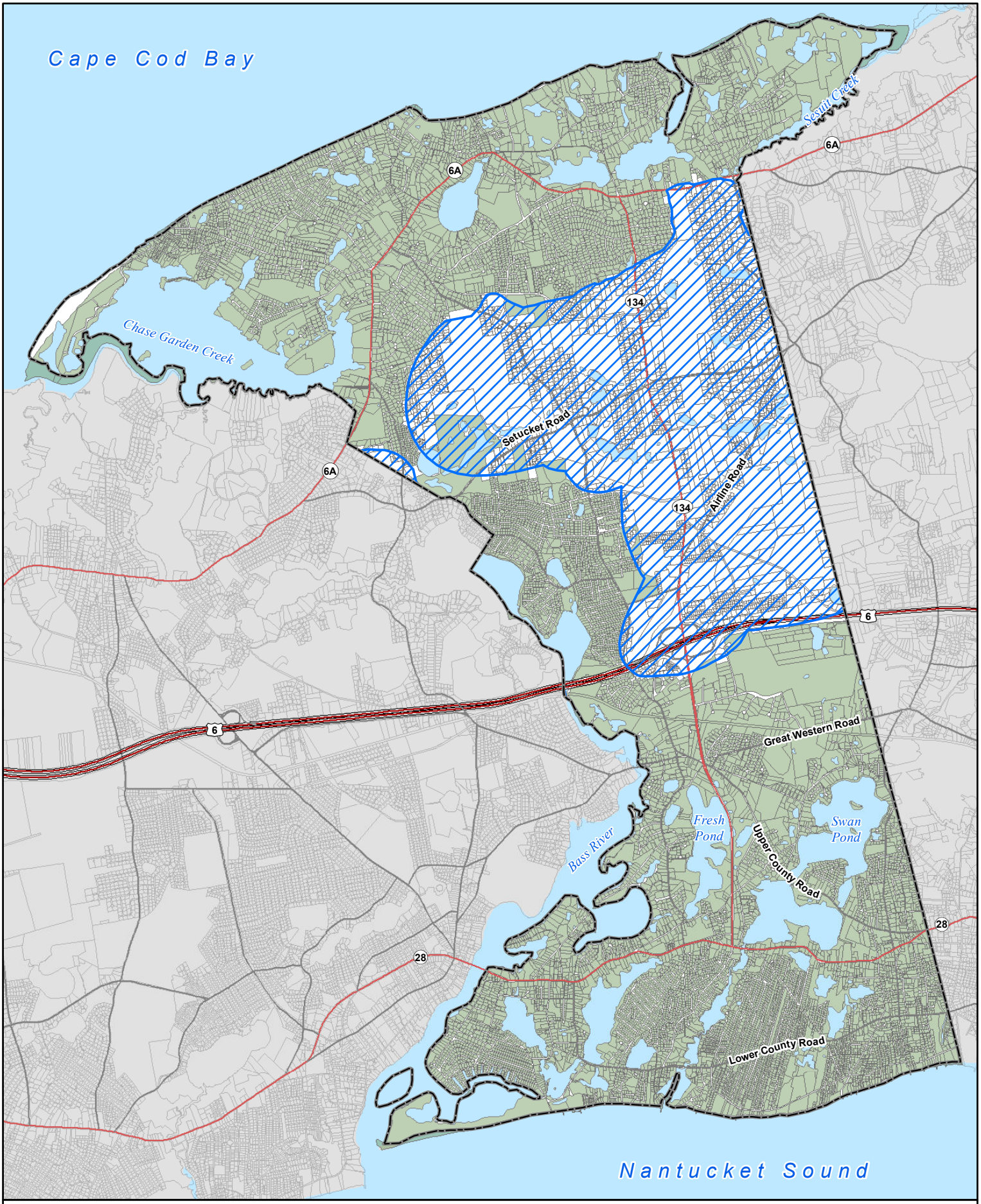

Legend

- Parcel Meeting Criteria (+1 Point)
- Well Protection Zone II

Town of Dennis, MA

1 inch = 4,500 feet

0 1,000 2,000 4,000 Feet

Site Screening Criterion 9
Zone II Areas
Figure 9-10

CDM Smith

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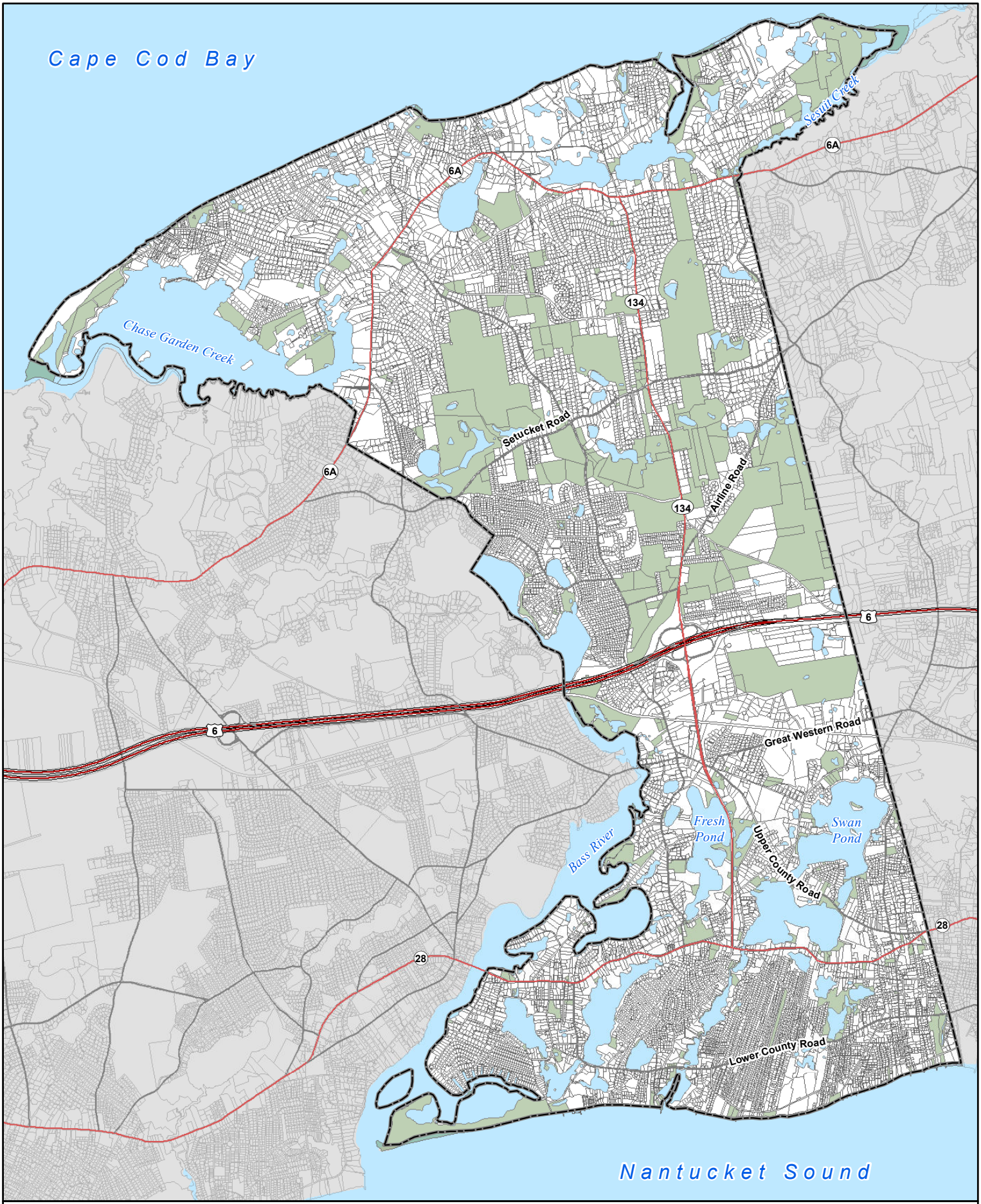

Legend

Town Owned Parcels (+1 Point)

Town of Dennis, MA

1 inch = 4,500 feet

0 1,000 2,000 4,000 Feet

Site Screening Criterion 10
Town Owned Parcels
Figure 9-11

CDM Smith

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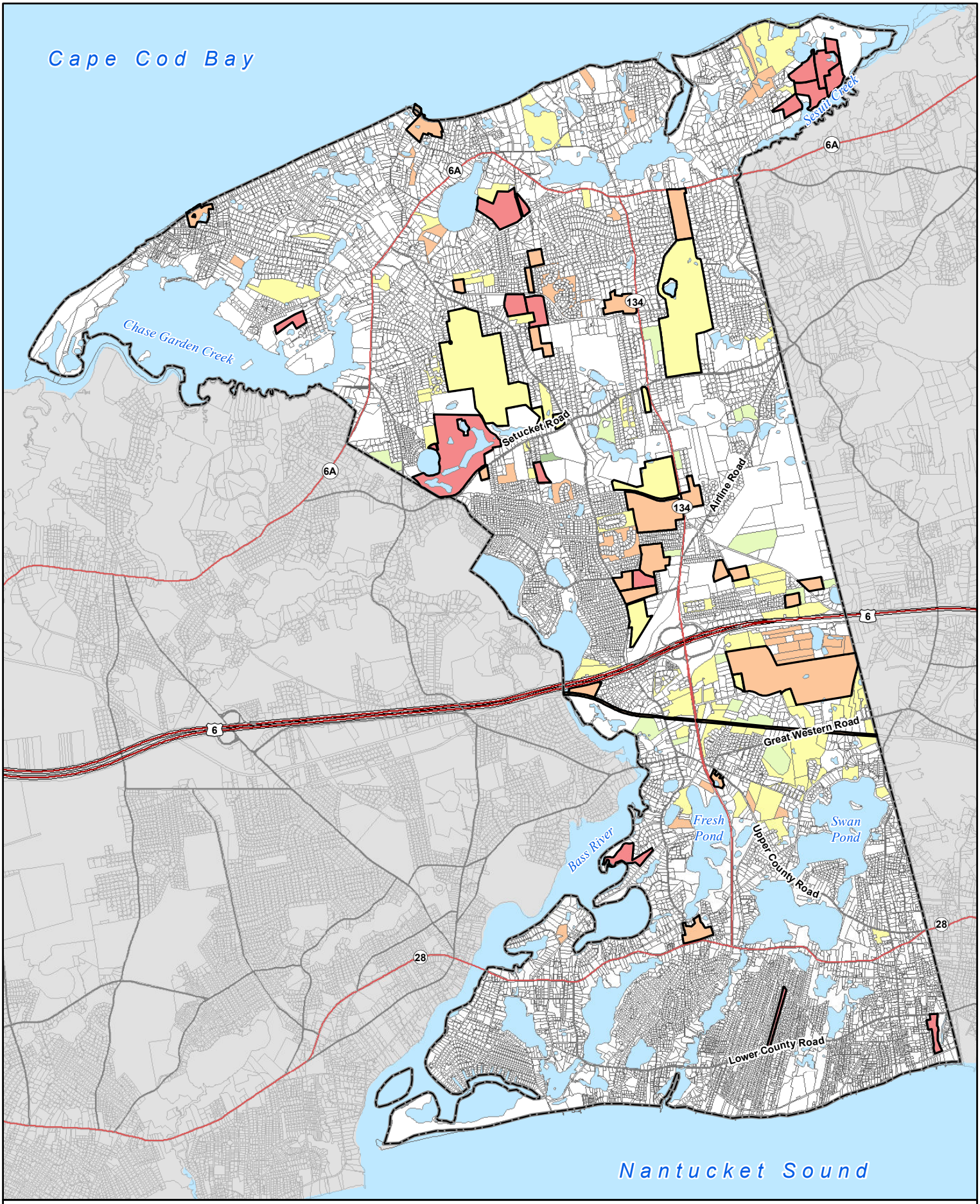

Legend

Parcel Rankings

1
2
3
4
5
Town Owned Parcels

N

Town of Dennis, MA

1 inch = 4,500 feet

0 1,000 2,000 4,000 Feet

Site Screening Criteria Results

Figure 9-12

CDM Smith

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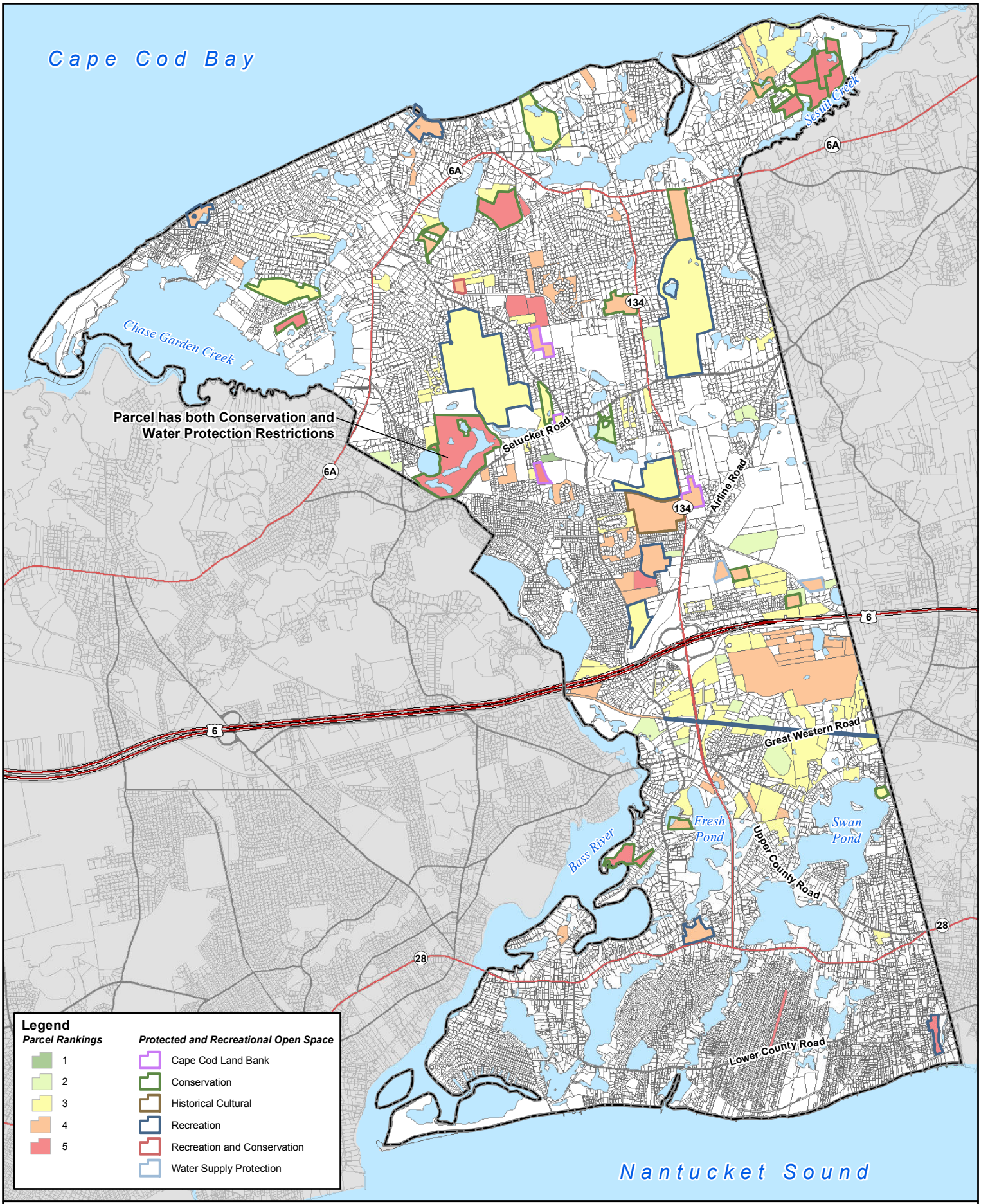

Town of Dennis, MA

Site Screening Results
Protected and Recreational Open Space
Figure 9-13

N

1 inch = 4,500 feet
0 1,000 2,000 4,000 Feet

CDM Smith

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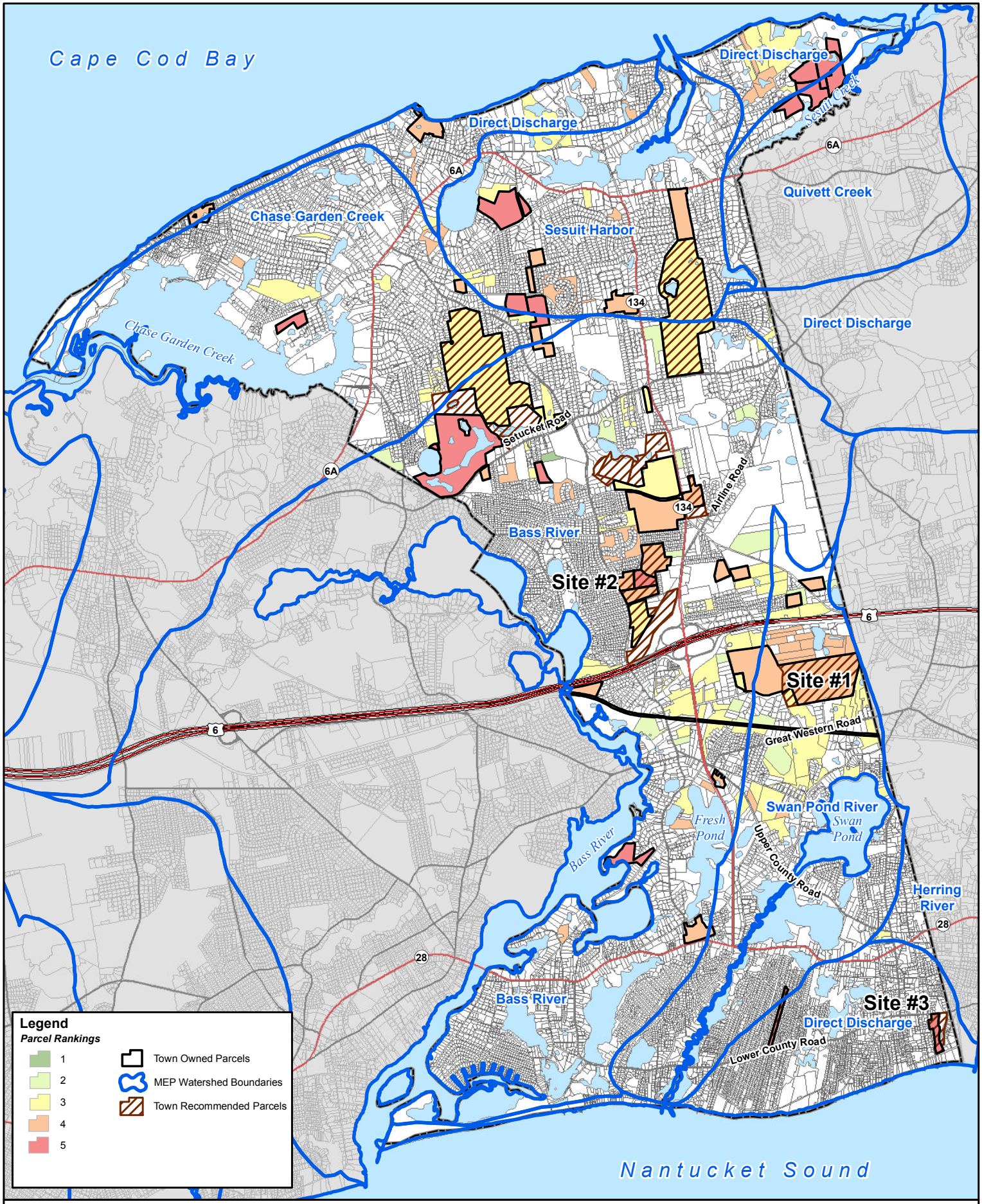

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9.4 Selection of Top Three Sites for Further Investigation

During the development of the water quality management scenarios presented in Section 10, the Comprehensive Wastewater Management Task Force (CWMTF), now the Wastewater Implementation Committee (WIC) evaluated the final ten sites and selected three sites to move forward for further investigation for wastewater treatment and effluent recharge, based on their proximity to the proposed water quality management solutions, the appropriateness of the site from a public opinion standpoint, and other known community interests in using the sites. The final three sites are described below and are called out on Figure 9-14.

9.4.1 Site #1

Site #1 is a Town-owned parcel in the Swan Pond River watershed located off of Theophilus Smith Road, near where the current DPW office and garage are located. A 91-acre portion of this approximately 148 acre parcel was purchased by the town partially with the intention of using it to advance wastewater treatment to meet the MEP goals. The majority of this 91 acre area is undeveloped and is outside the municipal well zones of contribution, Zone II areas, and the flood zones. There is a small area of wetlands onsite that can likely be worked around if a treatment facility and effluent recharge basins were to be constructed. The site has permeable soil throughout and varying depth to groundwater. The east and west portions of the site have NHESP priority habitats, so the exact locations proposed to be utilized will need to be further analyzed in the next phase of study.

The scenarios described in Section 10 consider the summertime flows that could be treated at this site. The theoretical effluent recharge capacity of a 91 acre site is 10.9 million gallons per day (mgd). This planning level estimate assumes effluent recharge requires 1 acre per 120,000 gallons per day and does not yet consider the land required for treatment or other infrastructure. This value is just used as an outside estimate to begin to consider the overall recharge potential of the site. Field work and modeling has been performed to evaluate more closely the recharge capabilities of Site #1 and is discussed in more detail in Section 11

Site #1 received a high score of 4 out of a possible 5 points in the site screening process. The site will be further evaluated for its wastewater treatment and effluent recharge capabilities using a combination of modeling and field investigations during future planning phases.

9.4.2 Site #2

Site #2 is a combination of five Town-owned parcels in the Bass River watershed, bringing the site's total acreage to 71.5 acres. The parcels are located on either side of Bob Crowell Road between Old Bass River Road and East-West Dennis Road and are located outside the municipal well zones of contribution, flood zones, priority habitats, and wetlands. The parcels have permeable soils with an average depth to groundwater of 20 to 60 feet. There are some Zone II well protection areas on the parcels that will need to be further evaluated in the future.

The scenarios described in Section 10 consider the peak flows that may be treated at this site. The theoretical effluent recharge capacity of a 71.5 acre site is 8.6 MGD. This planning level estimate assumes effluent recharge requires 1 acre per 120,000 gallons per day and does not yet consider the land required for treatment or other infrastructure. Preliminary field work and modeling has

been performed to evaluate the recharge capabilities of Site #2 and is discussed in more detail in Section 11.

Three parcels making up Site #2 received scores of 4, one parcel received a score of 5, and the final parcel received a score of 3. The combination of these parcels resulted in a high ranking for Site #2.

9.4.3 Site #3

Site #3 is a town-owned parcel located in the southern direct discharge area of Dennis, in the Dennis Port neighborhood off of Lower County Road. The site is approximately 8.4 acres, meeting the minimum parcel size requirement. The parcel is outside the well zones of contribution, wetlands, priority habitats, and Zone II areas. The site has permeable soils and a somewhat shallow depth to groundwater. During screening, this site had a favorable development status. The proximity to the flood zone will need to be further evaluated at this location.

The scenarios described in Section 10 consider the peak flows that would be treated at this site. The theoretical effluent recharge capacity of an 8.4 acre site is 1.0 MGD. This planning level estimate assumes effluent recharge requires 1 acre per 120,000 gallons per day and does not yet consider the land required for treatment or other infrastructure. Field work and modeling may be performed later in this study process to evaluate the recharge capabilities of Site #3 if its use is brought forward to the next level of analysis.

This site received a maximum score of 5 in the site screening process and will be further evaluated as a candidate for wastewater treatment and effluent recharge in this study. This site may not have sufficient capacity to make it a feasible candidate.

The town intends to move forward with Sites 1 and 2 to implement Phase 1 of the recommended plan but also intends to continue evaluating other sites in town including the possibility of using either of the town's golf courses as a potential location for either water reuse, using treated wastewater effluent, or fertigation wells, as described further in Section 10 of this report. These evaluations will also focus on sites located outside of Zone IIs.

9.5 Sites Identified to Achieve Other Water Quality Goals

The Town of Dennis has identified additional sites that may be able to achieve other water quality goals. These sites include potential PRB locations, stormwater BMP locations, and additional non-traditional technology locations per the Cape Cod Commission's Site Screening Viewer. These locations are described in more detail below.

9.5.1 Permeable Reactive Barrier Locations

As is discussed in Section 10, the Town of Dennis has included permeable reactive barriers (PRBs) in their wastewater management scenarios. These barriers would provide increased nitrogen removal from the watersheds. For the scenarios that involve PRBs, the intention would be to install them around the perimeter of the effluent recharge basins as a final polishing step or downgradient of Town owned landfills and other sites that are suspected of contributing high concentrations of nitrogen to the surrounding watersheds in the areas of Sites #1, #2 or #3. Site specific investigations will need to be performed in order to determine the PRB's effectiveness in

removing nitrogen in each of the areas discussed below. Under certain scenarios, PRBs would be installed at or near any combination of Sites #1, #2, and #3. As stated in the CCC 208 plan, treatment of wastewater through a PRB can result in a 75% to 95% reduction in the concentration of nitrogen in the effluent. The treatment technologies chosen for application at the WWTP are capable of achieving an effluent nitrogen concentration of 3 mg/L, which is required by the TMDL set in the MEP reports for the Bass River and Swan Pond River watersheds. Assuming that the application of a PRB around effluent recharge ponds will result in an effluent nitrogen concentration of 1 mg/L is a conservative approach, as this would indicate that the PRB was capable of reducing nitrogen by 67%.

On June 30, 2015, The Town submitted a grant application to the US EPA Region 1 in response to their Solicitation for a PRB Characterization Study, dated June 1, 2015.

The town proposed two potential PRB site locations in response to this solicitation. PRB Sites #1 and #2 were selected based on the physical features of each site, their ownership and designated land uses, and their potential to treat nitrogen via the use of PRBs. PRB Site #1 is the same as Site #1 described above, where the existing DPW building is located. PRB Site #2 is located in the Bass River watershed north of Kelleys Bay. The subembayments in which each site is located require 90 to 100 percent septic system nitrogen removal to restore water quality in receiving waters. The two sites are described in more detail below.

PRB Site #1 - Near Town DPW

Site 1 is located north of the Dennis DPW Facility on Theophilus Smith Road and is the town-owned property adjacent to the former town landfill and current solar array. A PRB could be located downgradient of the existing Town of Dennis Landfill, S&J Exco and Robert Childs Inc sites. A PRB located along Center Street adjacent to Swan Pond would allow placement of the PRB cross-gradient to the flow and likely intercept the nitrogen load from these locations. As noted previously, a 91-acre portion of this site was acquired by the town several years ago for future wastewater purposes. This site is located in the Swan Pond River watershed and is currently heavily wooded. Located south of the Mid-Cape Highway (Route 6), it lies outside of any Zone II wellhead protection areas. It also lies outside flood zones and wetland areas. The Eagle Pond Nursing Home, which has a wastewater treatment plant, is situated north of the site. Groundwater generally flows to the south-southeast in this region. The proposed site is located in an area where the depth to groundwater varies depending on the exact location selected but is generally greater than 10 feet.

As discussed in the MEP report, the upper reaches of the Swan Pond River System are beyond the point at which the water body can assimilate additional nutrient loads without impacting the ecological health of the system. Additionally, the Swan Pond River Embayment System falls under the classification of SA waters under the State Surface Water Classification and is not currently meeting the water quality standards as set by the federal Clean Water Act. The loss of eelgrass in the area is classified as significantly impaired, as noted in the MEP report. Consideration of utilizing a PRB around the perimeter of the recharge infiltration basins at this site for further nitrogen removal is to be studied if the PRB grant from EPA is obtained.

PRB Site #2 - Mayfair Road

The proposed location of the PRB at PRB Site #2 is along Mayfair Road, near the curve where the Mayfair Boatyard is located and the intersection of Poplar Lane. The site is located in the Kelleys Bay subwatershed of the Bass River watershed. A similar location was proposed by the Cape Cod Commission in their evaluation of non-traditional approaches to nitrogen management in this watershed. The PRB could potentially be located in the town's right-of-way but off the paved road surface. The site lies outside of any Zone II wellhead protection area. The PRB would be located south of a densely populated area of the Kelleys Bay subwatershed, with the potential to capture a significant portion of nitrogen in the groundwater from upgradient septic systems. This area is also close to the groundwater table to help minimize PRB depths.

PRB Site #2 is also located in an area with a steep groundwater gradient and shallow depth to groundwater elevation (<10 feet below ground surface). Groundwater generally flows to the southwest in this region. A PRB in this location has the potential to capture nitrogen inundated groundwater traveling from the northeast. PRB Site #2 is also located in a watershed to an area classified as SA waters and is also not meeting water quality standards. Additionally, loss of eelgrass in this area is classified as significantly impaired.

Southeast New England Program (SNEP) PRB Pilot Study

On October 15, 2015 the Town received confirmation from the USEPA that at least one of the proposed sites in Dennis would be selected for further study. The USEPA in partnership with the USGS and CCC chose to move forward with the site located on Vineland Drive near Bass River at Kellys Bay. The site lies on town owned land, on the eastern edge of Kellys Bay within the upper embayment of Bass River. Initial site characterization work was performed by WaterVision LLC, selected by the USEPA. In July 2016, WaterVision submitted the *Cape Cod Permeable Reactive Barrier Initial Hydrogeological Site Characterization Results and Evaluation of Site Suitability for Permeable Reactive Barrier Installation* report for Vinland Drive in Dennis. Field work was performed between February and May of 2016 and involved the installation of water table wells, piezometer clusters, subsequent water level measurement at these wells, analysis of field parameters and samples from the wells for a variety of laboratory parameters. Two rounds of water table elevations and sampling were performed at the side, one month apart. Using the data gathered during the field activities, an evaluation of hydrogeologic and geochemical data was performed as well mass flux calculations of nitrate-N. Important findings from this characterization study included the matrix of the subsurface materials which primarily consisted of medium to coarse sands and a substantial clay layer around 66 feet below ground surface, depth to groundwater and groundwater velocity, as well as Nitrate-N concentrations in the groundwater and other subsurface conditions.

Following completion of the characterization report, in August 2016 a scope of work was drafted by WaterVision for additional site characterization to be performed for the design of a pilot scale PRB at the Vinland Drive Site. The scope of work included the installation of additional monitoring wells, collection of sediment cores, and two rounds of water level measurements and water quality sampling. Results from the additional site characterization work are currently pending.

9.5.2 Stormwater BMP Locations

CDM Smith has worked with the Town of Dennis' Engineering Division to determine sites that may be suitable for stormwater Best Management Practices (BMPs). The Town's stormwater system consists predominately of catch basins with single leaching basins or, sometimes, two basins connected to one another. The catch basins are currently not connected in large networks and diverted. Therefore, with a lack of large catchment areas suitable for treatment, the town has instead been considering certain locations where adjustments to the site can help improve stormwater runoff to minimize contaminants entering the impaired watersheds.

The Scargo Lake Boat Launch and Scargo Lake Beach parking lot have been considered for stormwater BMPs. These areas are candidates for re-grading and potential stormwater control through pervious pavement and pervious concrete. The Scargo Boat Launch has a surface area of approximately 6,200 square feet. The Scargo Beach parking lot has a surface area of approximately 13,000 square feet.

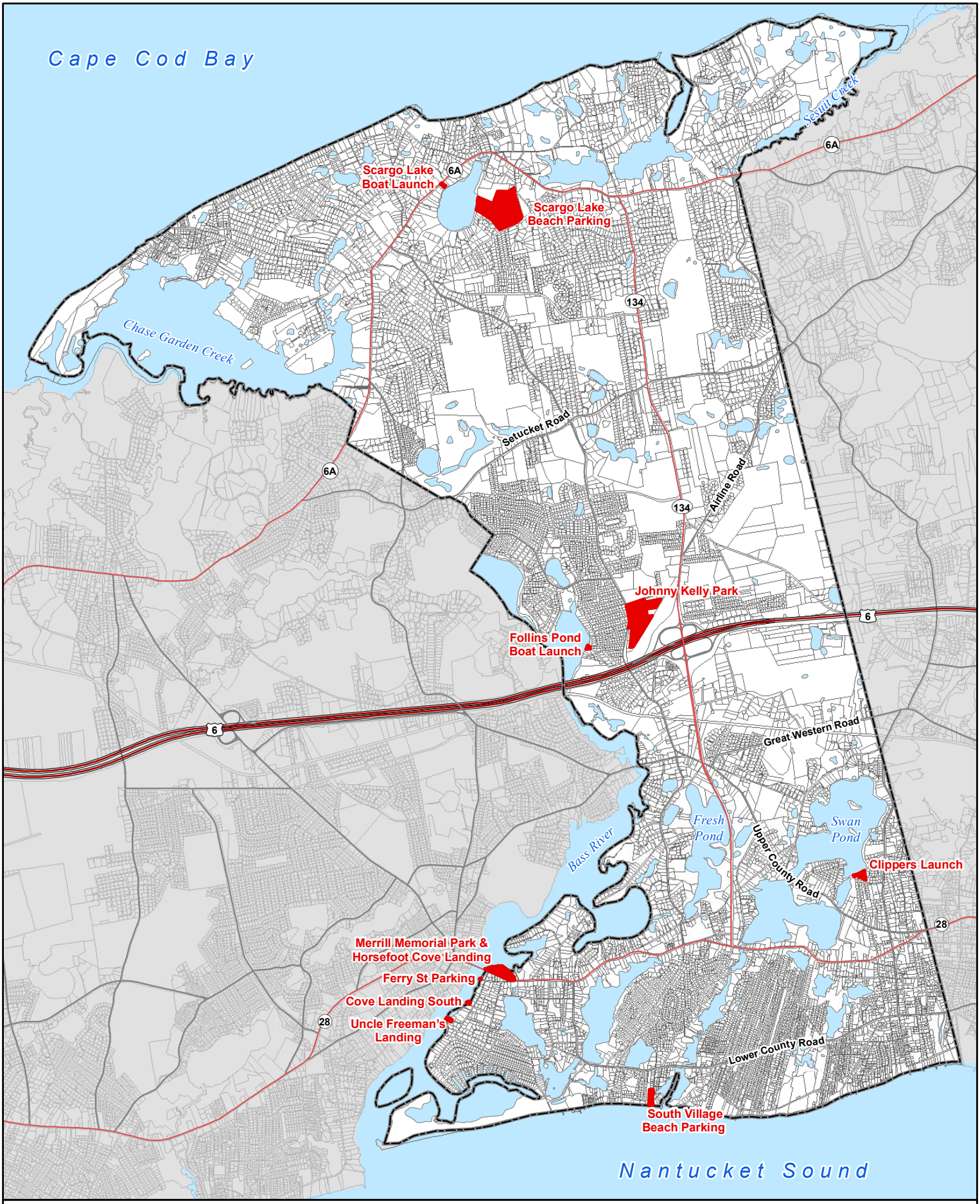
In addition, several town-owned boat launches and parking lots in the Swan Pond River and Bass River watersheds have been identified as potentially good locations for stormwater BMPs. These locations are listed in **Table 9-1** and shown in Figure 9-15. A more comprehensive discussion on past, current and future stormwater infrastructure improvements is included in Section 14.

Table 9-1 Potential Stormwater BMP Locations

Watershed	Parcel
Swan Pond River	▪ Clippers Launch ▪ South Village Beach Parking
Bass River	▪ Cove Landing South ▪ Ferry Street Parking ▪ Follins Pond Boat Launch ▪ Johnny Kelly Park (Rear) ▪ Merrill Memorial Park & Horsefoot Cove Landing ▪ Uncle Freeman's Landing
Sesuit Harbor	▪ Scargo Lake Beach Parking ▪ Scargo Lake Boat Launch

9.5.3 Non-Traditional Technology Locations per CCC's Site Screening Viewer

The CCC released a site screening viewer that shows potential locations for select non-traditional technologies. These technologies include: constructed wetlands wastewater treatment, constructed wetlands saltwater wetland, constructed wetlands groundwater treatment, and phytoremediation technology. Any nitrogen reducing technology used has the potential to reduce the number of parcels requiring sewers in the area. Alternatively, some of these technologies may be considered to help achieve the 25 percent stormwater input reduction. The results of the CCC's site screening viewer analysis are shown on Figure 9-16. This information will be further considered during implementation of the Final CWMP, should additional nitrogen reduction be required.



Legend

Stormwater BMP Locations

Town of Dennis, MA

1 inch = 4,500 feet

0 1,000 2,000 4,000 Feet

Potential Stormwater BMP Locations

Figure 9-15

CDM Smith

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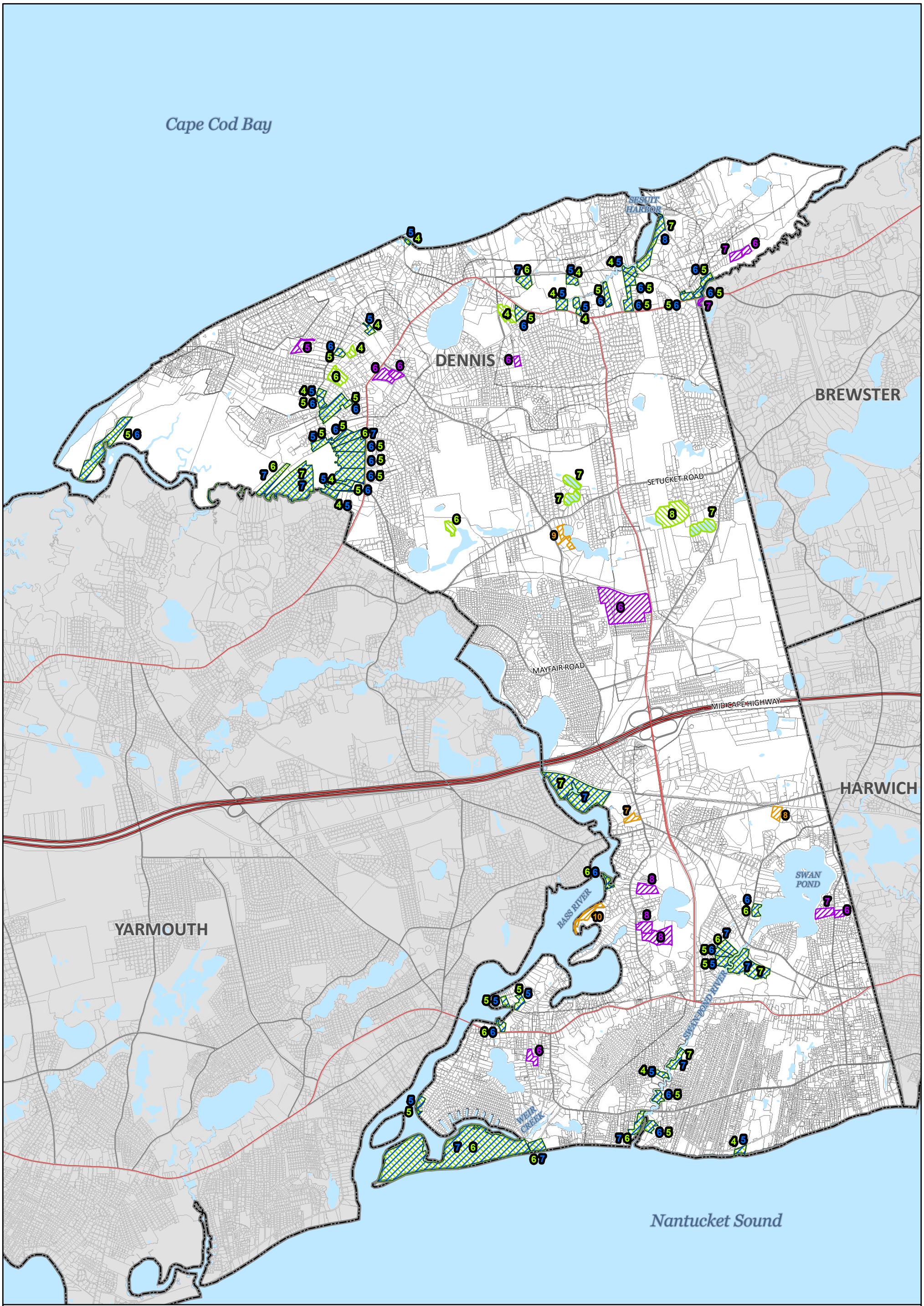

Legend

- Constructed Wetlands Wastewater Treatment
- Constructed Wetlands Saltwater Wetland
- Constructed Wetlands Groundwater Treatment
- Phytoremediation Technology

Town of Dennis, MA

N

1 in = 3,500 ft

0 0.5 1

Miles

Cape Cod Commission Site Screening Viewer Results

Figure 9-16

CDM Smith

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Section 10

Assessment of Water Quality Management Scenarios

10.1 Purpose and Scope

The updated needs assessment presented in Section 7 identifies existing and future areas in Dennis that would benefit from improved methods of water quality management to meet community goals. This section discusses water quality management scenarios developed to address the identified areas of need, utilizing the information developed in Section 8 (water use) and Section 9 (siting evaluation) to aid in their development. The information presented in this section was developed in preparation for the Draft CWMP, filed in 2017. Updated costs for the recommended plan are included in Section 14. Cost values presented herein were used for comparison purposes, in order to rank each of the options against one another.

10.2 Massachusetts Estuaries Project Impact

The Town understands that the environmental and financial impacts of good water quality in a tourist community like Dennis are of paramount importance. The town's water quality problem carries an economic burden for all property owners. The Cape Cod Commission's 2015 Three Bays Economic Study found that a 1% decrease in water quality is associated with a 0.61% decrease in sales prices.[1] For example, a home valued at $500,000 loses $3,050 of value for every 1% reduction in water quality. The water quality problem is an issue the whole town must address in order to avoid future economic consequences.

Dennis' goals of maintaining a high quality of life for its year round residents and seasonal visitors and restoring its degraded estuaries, embayments, and ponds require a robust, multi-faceted approach. The degradation of Dennis's estuaries and bays is the main driver for the Town to change its approach to water quality management. As noted previously, the MEP goals will become requirements in the near future as Total Maximum Daily Load (TMDL) permits are issued to communities by watershed, which will include a component of regulatory enforcement. The completed MEP reports provide both the locations and quantities of nutrient reductions necessary to preserve or restore long-term ecological health in the Town's saltwater estuaries and embayments.

As described previously, Dennis has five watersheds being modeled as part of the MEP:

- Bass River completed in 2011 (Dennis, Yarmouth, and Brewster)
- Swan Pond River completed in 2012 (predominantly Dennis)

[1]Cape Cod Commission. *Water Quality and Cape Cod's Economic Future: Nitrogen Pollution's Economic Impact on Homes and Communities*. March 11, 2015.

- Herring River completed in 2012 (Harwich, Brewster, and Dennis)
- Sesuit Harbor in progress (Dennis only)
- Chase Garden Creek in progress (Dennis, Yarmouth and Barnstable; being completed as part of the Barnstable Harbor/Great Marshes MEP)

There is one additional watershed in Dennis, Quivett Creek, which is not included in the MEP nitrogen modeling effort. This watershed is predominantly in Brewster but crosses into Dennis along the town's northeast border. In addition, several areas along both Nantucket Sound to the south and Cape Cod Bay to the north have direct discharge from both groundwater and surface watersheds to those adjacent water bodies, rather than to an estuary or embayment.

The MEP results and required nitrogen load reductions are discussed in more detail in Section 2. The results of these evaluations were used by the Town as the basis for the water quality management scenarios presented in this section. To achieve the required nitrogen load reductions in the subject embayments, the approximate reductions in septic loads shown in Table 10-1 were used. These reductions represent existing conditions in the watersheds. The values in Table 10-1 are for the entirety of each watershed, including those portions in other communities; the exact reduction required by the town of Dennis is calculated based on the percentage of the attenuated nitrogen load in each subwatershed originating in Dennis.

Table 10-1 **Required Attenuated Nitrogen Load Reduction in MEP Watersheds**

Watershed	Nitrogen Load Reduction Required in Watershed	
	Total Nitrogen	Septic Nitrogen
Bass River	47.4%	59.5%
Swan Pond River	75.5%	100%
Herring River	23.6%	38.5%
Chase Garden Creek	+13.8%	+53.1%

10.3 Water Quality Management Scenarios

The Town developed fourteen water quality management scenarios to evaluate that meet the MEP nitrogen removal requirements. As noted in Section 7, the other identified needs which are not associated with the MEP nitrogen goals were also considered in the scenario development, both where MEP and other goals could be simultaneously met, and where MEP-compliant scenarios could be supplemented to meet other goals. These other needs included protection of freshwater ponds (phosphorus reduction) and drinking water resources, addressing issues meeting Title 5 septic system regulations, and providing infrastructure to the town's planning districts.

10.3.1 Nutrient Reduction Technologies

The water quality management scenarios were developed using a suite of nutrient reduction technologies. The town's Comprehensive Wastewater Management Task Force (CWMTF), now

the Wastewater Implementation Committee (WIC), began the process with the Cape Cod Commission's 208 Plan technologies matrix, which is summarized graphically on Figure A-1 in Appendix A of this report. Appendix A also provides the 208 Plan's technology descriptions for each technology discussed in this section.

Early on in the process, the CWMTF concluded that the best solution for Dennis would include a range of technologies, including both traditional wastewater treatment technologies and other, non-traditional means of reducing nutrients both at the source and in the receiving water bodies. Following detailed discussion of the many technologies presented in the 208 Plan, the committee developed a short-list of technologies that appeared to show the most promise for solving Dennis' water quality concerns. These technologies include the following:

- Source Reduction
  - Fertilizer management and education
  - Waste reduction toilets (where deemed feasible, possibly including public buildings or large water users)
- Onsite Wastewater Treatment Technologies
  - Maintaining Title 5 septic systems in areas where feasible and appropriate
  - Advanced innovative/alternative (I/A) septic systems for nutrient reduction
- Offsite Wastewater Treatment Technologies
  - Wastewater collection and decentralized treatment/effluent recharge
  - Wastewater collection and centralized treatment/effluent recharge
- Stormwater Treatment Technologies
  - Installation of stormwater Best Management Practices (BMPs)
  - Stormwater bioretention areas or other vegetated treatment swales or basins
  - Stormwater education/source reduction
- In-situ Treatment Technologies
  - Inlet/culvert widening (specifically at the Route 6 bridge over Bass River)
  - Shellfish aquaculture (oysters)
  - Pond and estuary circulators (for use in freshwater ponds)
  - Floating constructed wetlands
- Other Technologies

- Permeable reactive barriers (PRBs, most likely surrounding effluent recharge basins as a polishing step, but could also be used elsewhere in town)
- Fertigation wells (specifically using pumped nutrient-laden groundwater to irrigate golf courses or other town properties with high irrigation and fertilizing needs)
- Phytoremediation
- Coastal habitat restoration

As part of the 208 Plan, descriptions were developed of each of these technologies including performance metrics for both nitrogen and phosphorus reduction, approximate costs per pound of each nutrient removed, lifespan, and time frame to realize beneficial results within the impacted water body. All of this information is presented in Appendix A to this report.

While this wide range of nutrient reduction technologies was considered in scenario development, the desire to focus on less traditional, sometimes lower-cost options than the installation of sewers and treatment facilities had to be balanced with the level of nutrient reduction required in each watershed. In some areas, a scenario involving all onsite and in-situ technologies is not deemed feasible or cost-effective where nearly 100 percent reduction of nitrogen is needed to meet a particular subwatershed's MEP goals. In these areas, a combination of the required level of nitrogen reduction and economies of scale may result in sewering becoming the most feasible option. Given the varying conditions across subwatersheds, the scenarios were built to evaluate the areas best served by non-traditional technologies versus those best served by traditional sewer infrastructure (either centralized or decentralized).

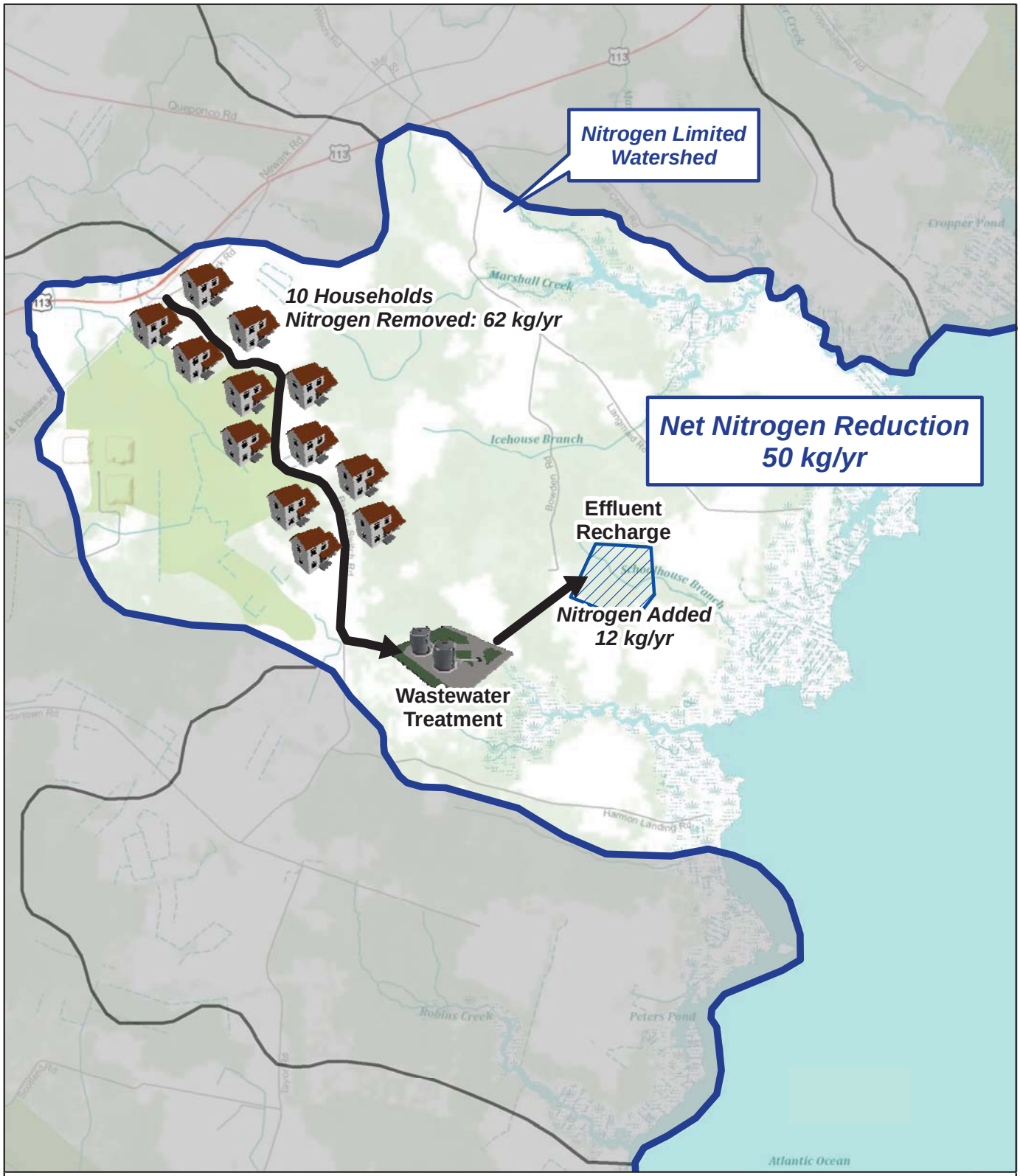
10.3.2 Nitrogen Balancing Methodology

When considering offsite wastewater treatment solutions, the concept of "nitrogen balancing" is an important consideration as implementable scenarios are developed. It is difficult and extremely costly to remove all of the nitrogen from treated wastewater, thus care must be taken to recharge treated effluent to a watershed that is capable of receiving the resulting nitrogen load without exceeding the MEP nitrogen requirements.

Since it is not always possible to send treated effluent into a watershed that is not nitrogen sensitive, the wastewater removed by sewering can be counted as a nitrogen reduction, but the remaining nitrogen after treatment in the effluent recharge must be counted as a nitrogen addition in the subwatershed containing the effluent recharge site. Therefore, in the scenarios described later in this section, the nitrogen balance involves a subtraction of the nitrogen removed, then the addition of the nitrogen component that is returned to the environment in the treated effluent at the recharge site. The net nitrogen removal must then meet the MEP reduction requirements.

Since septic system effluent is estimated to have a concentration of 26 mg/L (or ppm) of nitrogen, the average household will contribute approximately 6.2 kg/year of nitrogen (63,000 gallons (typical) per year of wastewater flow x 26 mg/l of nitrogen x 3.785 liters per gallon/1,000,000 mg/kg). If the wastewater were treated to 5 mg/l of nitrogen and recharged to the same watershed, the post-treatment contribution of nitrogen from this household would be 1.2 kg/year

for a net decrease of 5.0 kg/year (6.2 kg/year in – 1.2 kg/year out = 5 kg/year). By today's standards, even with the most advanced wastewater treatment, wastewater effluent will have some nitrogen remaining and must be accounted for in the overall management strategy. **Figure 10-1** illustrates this point. In this example, ten homes in a nitrogen limited watershed are connected to the wastewater treatment facility and an estimated 62 kg/year of nitrogen is removed from the watershed. In the wastewater treatment facility, 50 kg/year of nitrogen is removed and 12 kg/year remain. This remaining load of 12 kg/year is recharged back into the watershed in the effluent. If the MEP TMDL requirement for nitrogen removal was 50 kg/year, then this example would satisfy the requirement.



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Town of Dennis, MA

Nitrogen Balance for a Typical Nitrogen Limited Watershed: 10 households

Figure 10-1

CDM Smith

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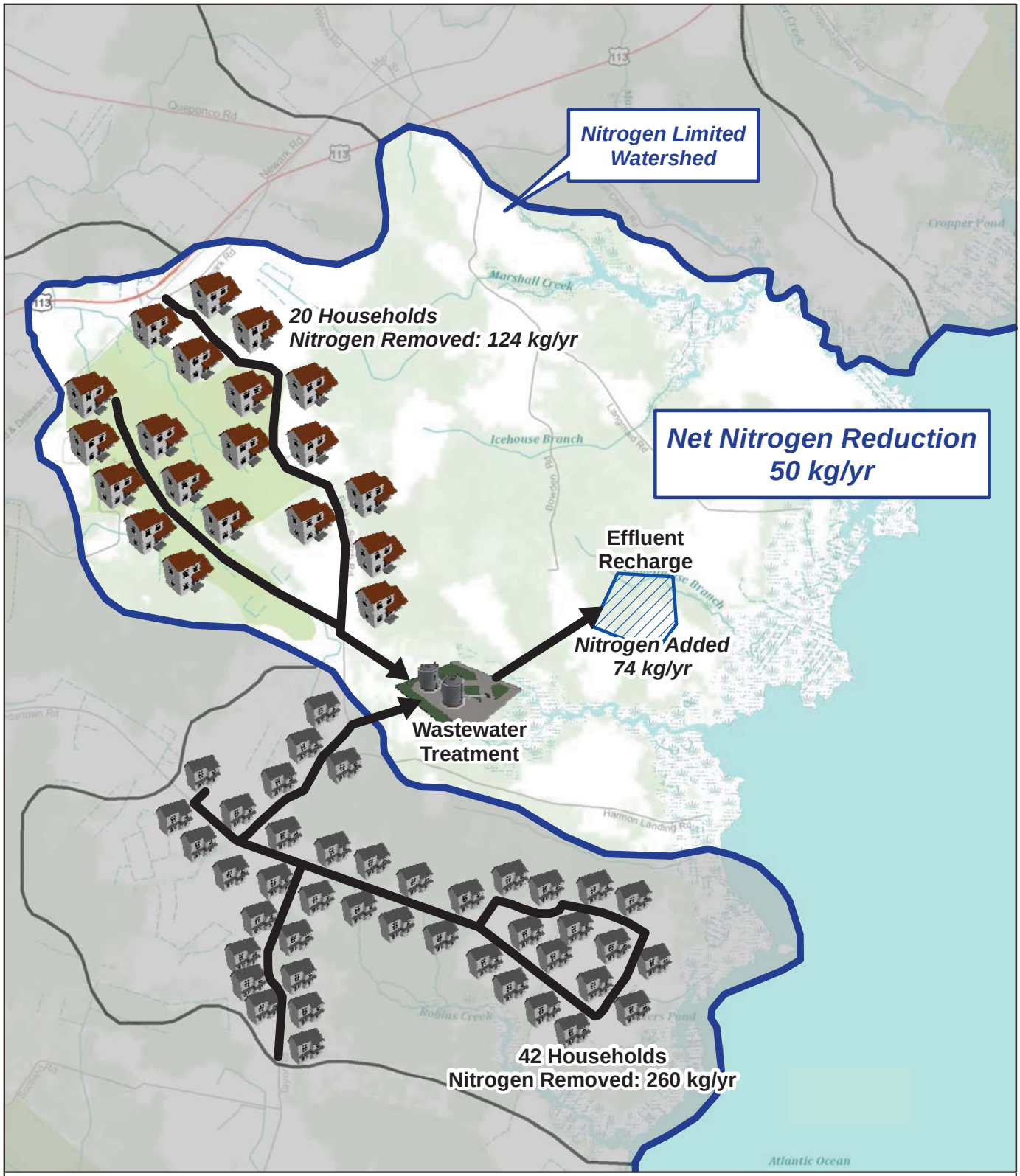
Taking this example a step further, nitrogen balancing can also be utilized for scenarios that remove wastewater from one watershed and recharge it to another watershed. **Figure 10-2** shows 20 households sewered within the nitrogen sensitive watershed and treated effluent from 62 households (20 from within the watershed and 42 from outside) recharged back into the same watershed. In this example, the 20 households sewered within the nitrogen sensitive watershed equate to a reduction of 124 kg/year of nitrogen which is now brought to the treatment facility. Another 42 homes from outside the watershed are also connected to the treatment facility and contribute 260 kg/year to the facility, for a total of 384 kg/year. In the wastewater treatment facility, 310 kg/year of nitrogen is removed and 74 kg/year remain. This remaining load of 74 kg/year is recharged back into the watershed in the effluent. Therefore, the net reduction within the nitrogen sensitive watershed is still 50 kg/year, as it was in the first example (124 kg/year removed + 74 kg/year recharge = 50 kg/year net). This example illustrates how an additional ten households sewered in the MEP sensitive watershed allowed for an additional 42 households from other watersheds to be managed within the nitrogen sensitive watershed without changing the nitrogen balance in the nitrogen sensitive watershed.

These examples illustrate how the balance of nitrogen can be used when deciding how to meet the MEP established requirements and the needs of the community while working within the constraints of the effluent recharge sites, both within and outside of nitrogen sensitive watersheds.

10.3.3 Nitrogen Loading Spreadsheets

To create the water quality management scenarios, CDM Smith developed detailed nitrogen loading spreadsheets that closely approximate the nitrogen loading model used in the MEP reports. The spreadsheets are based on the septic component of nitrogen loading; however, reductions in other nitrogen sources such as stormwater and fertilizer inputs can be used to offset a portion of the septic load in the spreadsheet model.

The nitrogen loading spreadsheets allowed the town to develop water quality management scenarios using a systematic approach. The spreadsheets display all of the subwatersheds within an estuarine system. They also present all of the freshwater bodies (ponds and streams) that are modeled with natural attenuation. Since the spreadsheets are divided into subwatersheds and their potential for natural nitrogen attenuation, proposed sewersheds can be targeted at areas that do not receive any natural attenuation. By doing this, the town can minimize the areas that require wastewater collection and thus maximize cost savings, but sewering parcels from which 100 percent of the nitrogen reaches a sensitive water body, rather than sewering parcels that may presently have half or more of the nitrogen removed naturally via attenuation.



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Town of Dennis, MA

Nitrogen Balance for a Typical Nitrogen Limited Watershed: Multiple Watersheds

Figure 10-2

CDM Smith

\\camgissvr1\Projects\Harwich\Harwich_cwmp\MXD\Nitrogen_removal_figure3.mxd 3/26/2012 pescatoreec

Table 10-2 shows an example of a nitrogen loading spreadsheet for the Swan Pond River watershed. While there are many behind-the-scenes calculations in the spreadsheets, the table shows some of the complexities that are involved in the overall nitrogen model including natural attenuation factors, nitrogen removal from both traditional and non-traditional technologies, nitrogen inputs from treated effluent recharge, and the ability to follow the path of septic system effluent through each subwatershed until it reaches the embayment. This Swan Pond River embayment system example involves only three subwatersheds, while the Bass River spreadsheet model includes all forty-two subwatersheds included in that system. The end result of developing these nitrogen loading spreadsheets is a very powerful planning tool that is the basis for many of the decisions involved in the building of water quality management scenarios.

These spreadsheets have been developed for both existing and buildout conditions, as presented in the MEP reports and included in the MEP "data disk" tabulations. The water quality management scenarios presented in this section were all developed using the spreadsheets reflecting existing development conditions. While buildout conditions will need to be considered during the next phase of analysis, for the purposes of comparing a large number of conceptual strategies for nutrient management, addressing known existing conditions was deemed more appropriate than considering buildout at this time.

10.3.4 GIS Data Obtained from the MEP Data Disks

Once the nitrogen loading spreadsheets were completed, a Geographic Information Systems (GIS) database was utilized to graphically link data from the MEP data disks for each watershed on a parcel-by-parcel basis to town data. The MEP data disks contain information such as parcel boundary data, water use data for the years 2007 through 2009, buildout data, and the estimated annual nitrogen load from each parcel.

A powerful feature of the GIS is its ability to calculate an estimated annual nitrogen load for any parcel, street, or user-identified area and display it graphically. With this tool, possible sewer service areas can be developed to match the nitrogen reductions required in the MEP reports during the building of scenarios.

10.3.5 Development of Scenarios

Based on the information presented in previous sections, the information presented herein and discussions with the Dennis CWMTF, fourteen scenarios were defined and are referred to as Scenarios 1 though 7D. As discussed previously, the goal of the water quality management scenarios was to define several logical and implementable scenarios to be screened down to a few preferred options to be evaluated in further detail during a later phase of this study.

Table 10-2 **Example Nitrogen Loading Spreadsheet for Swan Pond River Watershed**

Name	WS #	% Dennis	Total (kg/yr)	Septic (kg/yr)	Outflow %	Total (kg/yr)	Septic (kg/yr)	% Removal	Net Septic Load (kg/yr)	Attenuation %	Attenuated Septic Load (kg/yr)	Fertilizer (kg/yr)	Impervious Surfaces (kg/yr)	Attenuated Septic Load (kg/day)	Threshold Met?	Fertilizer Credit with 25% Reduction (kg/day)	Stormwater Credit with 25% Reduction (kg/day)	Aquaculture Reduction (# acres listed below)	Adjusted Attentuated Septic Load With Credits (kg/day)	Threshold Met with Credits?
Swan Pond																				
Hydaway Lane Stream	1	100%	121	78	100%	121	78	0%	78	0%	78	4	29							
Eagle Pond	2	100%	55	6	100%	55	6	0%	6	50%	3	0	17							
Swan Pond GT10	3	100%	2290	1499	100%	2290	1499	100%	0	0%	0	59	290							
Swan Pond LT10	4	100%	3234	2535	100%	3234	2535	100%	0	0%	0	179	362	**0.775**	0.00 kg/day	**-0.24**	**-0.54**		**-0.009**	0.00 kg/day
Northwest Dennis Wells	NW	100%	3365	2406	30%	1025	733	69%	227	11.159%	202	113	92							
Swan Pond Atmospheric	Air	100%	688	0	100%	688	0	0%	0	0%	0	0	0					**0.00**		
										Swan Pond Total	**283**	**356**	**788**		**Threshold Not Met**					**Threshold Met**
Swan Pond River North																				
Swan Pond River N GT10	5	100%	573	430	100%	573	430	70%	129	0%	129	28	102							
Swan Pond River N LT10	6	100%	3090	2640	100%	3090	2640	100%	0	0%	0	119	273	**0.353**	0.00 kg/day	**-0.10**	**-0.26**		**-0.004**	0.00 kg/day
Swan Pond River N Atmospheric	Air	100%	38	0	100%	38	0	0%	0	0%	0	0	0							
										Swan Pond River North Total	**129**	**146**	**375**		**Threshold Not Met**					**Threshold Met**
Swan Pond River South																				
Swan Pond River South	7	100%	5618	4204	100%	5618	4204	92%	336	0%	336	560	815							
Swan Pond River S Atmospheric	Air		85	0	100%	85	0	0%	0	0%	0	0	0	**0.921**	0.00 kg/day	**-0.38**	**-0.56**		**-0.020**	0.00 kg/day
										Swan Pond River South Total	**336**	**560**	**815**		**Threshold Not Met**					**Threshold Met**

The fourteen scenarios include combinations of traditional sewering methods, both centralized and decentralized, as well as non-traditional nitrogen management options including aquaculture, innovative/alternative (I/A) septic systems, and permeable reactive barriers (PRB). Furthermore, the baseline of each scenario is the assumption that the town will implement fertilizer and stormwater management programs. This accounts for a 25% nitrogen reduction of the stormwater and fertilizer nitrogen contributions to each watershed, as suggested by the CCC as a credit to be provided to towns that implement such programs. To achieve 25% nitrogen reduction, 50% of the total roads in the Bass River and Swan Pond River watersheds are assumed to require stormwater BMPs. The Town plans to achieve 25% nitrogen reduction in fertilizers by implementing a town-wide fertilizer education program.

The other non-traditional technologies noted above for consideration but not included in the specific scenarios below are considered to have potential to help offset some degree of sewering; however, they were deemed less reliable to include in this first level of scenario building and analysis. For instance, while floating constructed wetlands are reported to have the potential for substantial in-situ removal of nitrogen, local data are not readily available for either detailed reduction percentages or costs. Similarly, while widening the bridge crossing of the Bass River at Route 6 would allow for a reduction in the degree of sewering required, this infrastructure improvement is dependent upon coordination with the Massachusetts Department of Transportation (MassDOT). While efforts have been made to advance this coordination (see letter attached in Appendix B), the town cannot count on this work being completed. Thus, it has not been taken into account in the present scenarios.

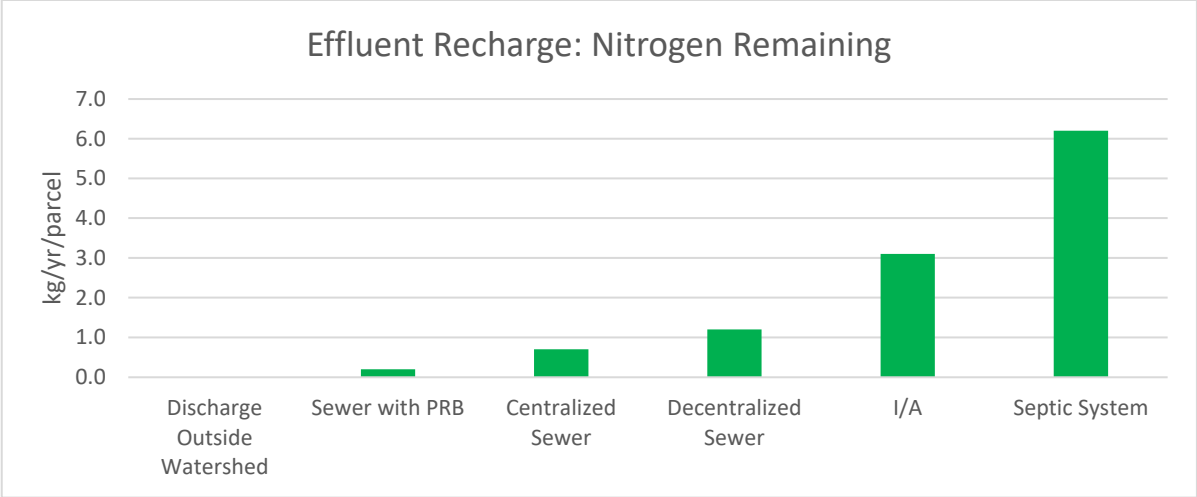
Each of the technologies listed in Section 10.3.1 above that is not incorporated into the specific scenarios below continues to be under consideration by the town and may become factored into the final recommended program in a later phase of this planning study.

As calculated previously, one parcel of developed residential land is assumed to produce 6.2 kg nitrogen/year. **Table 10-3** describes the nitrogen removal for each of the wastewater management technologies included in the fourteen scenarios.

Table 10-3 Nitrogen Removal per Technology

Technology	Nitrogen Removal	Nitrogen Concentration in Recharged Effluent (mg/L)
Discharge Outside Watershed	6.2 kg/yr/parcel	N/A
Centralized Sewer	5.5 kg/yr/parcel	3 mg/L
Decentralized Sewer	5.0 kg/yr/parcel	5 mg/L
I/A	3.1 kg/yr/parcel	13 mg/L
Sewer with PRB	6.0 kg/yr/parcel	1 mg/L
Aquaculture	0.88 kg/day/acre of aquaculture	N/A

Figure 10-3 shows a graphic interpretation of the various wastewater treatment technologies and their effect on nitrogen removal. Discharging outside of the watershed, although very difficult to find a non-nitrogen sensitive recharge area, removes all nitrogen from the septic load within the watershed. Wastewater collection and treatment combined with a perimeter PRB around the effluent recharge site is estimated to remove a significant amount of nitrogen, while a traditional septic system leaves the full 6.2 kg/year of nitrogen per parcel in the watershed.



F10-3 Nitrogren Remaining in Effluent Discharge

Additional details regarding the nitrogen removal potential from aquaculture are provided in the document attached in Appendix C, which provides an analysis specific to the town of Dennis performed by Scott Lindell, Director of the Scientific Aquaculture Program at Cape Cod's Marine Biological Laboratory.

When deciding which areas require sewering, high density areas closest to the embayment were given highest priority for three reasons. First, sewering those areas would have the most immediate beneficial effect on the receiving water body. Second, areas immediately upstream of water bodies are not typically subject to any natural attenuation; therefore, 100 percent of the septic system nitrogen would presently be reaching the water body. Third, sewering densely populated areas is most cost effective. Title 5 areas of concern (AOCs) and socio-economic development areas (growth districts) were also targeted when in the subject watersheds. The effluent recharge areas of the scenarios that involve sewering are discussed further below.

10.3.6 Effluent Recharge Sites

Each scenario accounts for effluent recharge in the watersheds where applicable. As described in more detail in Section 9, the site screening analysis was initiated as a way to identify the best candidate sites for effluent recharge in Dennis. While the main focus was for effluent recharge sites, several of the top sites were also considered to be acceptable decentralized wastewater treatment facility sites. This analysis was used to narrow down the final sites to be used in the water quality management scenarios. The fourteen water quality management scenarios (1 to 7D) presented below utilize three different effluent sites that were considered to be the best candidate sites based on the analysis in Section 9. Two of these three sites were also identified as feasible and acceptable sites for a wastewater treatment facility, as noted below.

The sites are as follows:

Site #1: This site is a town-owned parcel in the Swan Pond River watershed located off of Theophilis Smith Road, near where the current DPW office and garage are located. The portion of this site under consideration is a 91-acre portion that was acquired by the town in part to help meet community water quality goals. This site is outside the municipal well zones of contribution, Zone II areas, and the

flood zones. There is a small area of wetlands onsite that can likely be worked around if a treatment facility and effluent recharge basins were to be constructed. The site has permeable soil throughout and varying depth to groundwater. The east and west portions of the site have NHESP priority habitats, so the exact locations proposed to be utilized will need to be further analyzed in the next phase of study.

Site #2: Site #2 is a combination of five town-owned parcels in the Bass River watershed, bringing the site's total acreage to 71.5 acres. The parcels are located on either side of Bob Crowell Road between Old Bass River Road and East-West Dennis Road and are located outside the municipal well zones of contribution, flood zones, priority habitats, and wetlands. The parcels have permeable soils with an average depth to groundwater of 20 to 60 feet. There are Zone II well protection areas on the parcels that will need to be further evaluated.

Site #3: Site #3 is a town-owned parcel located in the southern direct discharge area of Dennis, in the Dennis Port neighborhood off of Lower County Road. The site is approximately 8.4 acres, meeting the minimum parcel size requirement. The parcel is outside the well zones of contribution, wetlands, priority habitats, and Zone II areas. The site has permeable soils and a somewhat shallow depth to groundwater. During screening, this site had a favorable development status. The proximity to the flood zone will need to be further evaluated at this location.

The locations of each site are shown on the applicable figures for each water quality management scenario described below. Note that Sites #1 and #2 were selected to be used together so that effluent from wastewater generated north of Route 6 could be recharged on a site north of Route 6 within the Bass River watershed, and likewise effluent generated south of Route 6 could be recharged south of the highway, within the Swan Pond River watershed. Site #3 was selected to provide an option for recharge within a direct discharge area, which is therefore not as nitrogen sensitive. Site #3 is within a direct discharge area to Nantucket Sound.

10.3.7 Water Quality Management Scenarios 1 through 7D

As noted above, the fourteen scenarios include a combination of I/A systems, aquaculture, sewer collection and treatment systems with perimeter PRBs around the effluent recharge areas, sewer collection and treatment without PRBs, centralized treatment facilities, decentralized treatment facilities, and fertilizer/stormwater reduction plans. Table 10-4 summarizes Scenarios 1 though 7D. The scenarios progress from those including all non-traditional, onsite and in-situ solutions to those that include increasing levels of sewer collection and treatment. Scenario 1 is the only scenario of the fourteen that does not meet the MEP goals and has just been included for comparative purposes.

Scenarios with an 'A' designation include centralized treatment at Site #1 and recharge at Sites #1 and #2. Scenarios with a 'B' designation include decentralized treatment and recharge at each of Sites #1 and #2. Scenario 7C includes decentralized treatment at Sites #1 and #2 with a third effluent recharge location at Site #3. Scenario 7D utilizes an ocean outfall rather than an effluent recharge land site.

Table 10-4 Summary of Dennis Scenarios

Scenario	Description	Fertilizer/ Stormwater Credits	Total Acres of Aquaculture	Number of Parcels with I/A Systems	Number of Sewered Parcels	PRB at Recharge Site	WWTPs
1	All I/A	X		6,905			none
2A	All I/A with Aquaculture	X	28	6,472			none
2B	All Non-traditional (TBD)	X	28	6,472			none
3A	Sewer with PRB and I/A	X	6.25	395	4,826	X	1 WWTP, 2 recharge locations
3B	Sewer with PRB and I/A	X	6.25	395	4,826	X	2 WWTPs with recharge at the plants
4A	Sewer with PRB	X			5,092	X	1 WWTP, 2 recharge locations
4B	Sewer with PRB	X			5,092	X	2 WWTPs with recharge at the plants
5A	Sewer without PRB, with Aquaculture	X	9.5		5,234		1 WWTP, 2 recharge locations
5B	Sewer without PRB, with Aquaculture	X	9.5		5,234		2 WWTPs with recharge at the plants
6A	Sewer with PRB and Aquaculture (includes planning districts)	X	3.25		5,471	X	1 WWTP, 2 recharge locations
6B	Sewer with PRB and Aquaculture (includes planning districts)	X	3.25		5,471	X	2 WWTPs with recharge at the plants
7A	Sewer with PRB and Aquaculture (includes planning districts and several AOCs)	X	5		8,297	X	1 WWTP, 2 recharge locations
7B	Sewer with PRB and Aquaculture (includes planning districts and several AOCs)	X	5		8,297	X	2 WWTPs with recharge at the plants
7C	Sewer with PRB and Aquaculture (includes planning districts and several AOCs)	X	3.75		8,297	X	3 WWTPs, 3 recharge locations
7D	Sewer with Ocean Outfall (includes planning districts and several AOCs)	X			8,297		1 WWTP, 1 ocean outfall

All scenarios that involve some element of wastewater collection and treatment were developed with the assumption that wastewater effluent would be treated to 3 mg/L total nitrogen. Where a PRB is proposed around an effluent recharge site to further reduce nitrogen, the effluent nitrogen from the PRB is assumed to be at a concentration of 1 mg/L.

Each scenario and its nitrogen removal potential are described in more detail below. **Figures 10-4 through 10-12** following Section 10.3.6 show the components and conceptual layout for each scenario. The nitrogen table on each scenario figure lists the nitrogen removed by each technology, any potential recharge, and whether the required nitrogen removal threshold was met.

It must be noted that, within the MEP results, there are nitrogen removal requirements within each subwatershed, as well as in the entire watershed as a whole. Meeting the whole watershed nitrogen removal threshold does not necessarily mean that the subwatershed thresholds have been met, and vice versa. Because of this, some scenarios remove extra nitrogen in order to meet subwatershed thresholds and therefore show a negative nitrogen removal required after all of the technologies have been applied.

Scenario 1

Scenario 1 addresses existing developed parcels and assumes that the Town would take the 25% stormwater and fertilizer credits suggested by the CCC by implementing a stormwater control plan, as well as a fertilizer education program. This scenario assumes that an advanced I/A system will be installed on all existing developed parcels within the Bass River and Swan Pond River watersheds. **Figure 10-4** shows the scenario map and nitrogen removal table for Scenario 1. This figure demonstrates that even with installing an advanced I/A system on all parcels in Bass River and Swan Pond River watersheds, the minimum nitrogen removal requirements are not met.

Scenario 2

Scenario 2 also assumes that the town would take the 25% stormwater and fertilizer credits by implementing a stormwater management program and a fertilizer education program. Scenario 2 includes advanced I/A systems on existing developed parcels in the Bass River and Swan Pond River watersheds, similar to Scenario 1, and adds aquaculture in order to meet the minimum nitrogen removal required. The aquaculture is included in Mill Pond and Follins Pond in the Bass River watershed, as well as in Swan Pond in the Swan Pond River watershed.

Figure 10-5 shows the scenario map and nitrogen removal table for Scenario 2.

Scenario 3A

Scenario 3A addresses the majority of existing developed parcels in the Swan Pond River and Bass River watersheds and assumes that the town would reduce its stormwater and fertilizer nitrogen contributions by 25%, as described above for Scenarios 1 and 2. Scenario 3A includes a combination of advanced I/A systems on parcels over 1 acre in size, and sewering as many parcels as required to meet with MEP goals, with a perimeter PRB around the effluent recharge sites. The sewering areas were chosen for smaller parcels in high density neighborhoods where an I/A system may not otherwise be practical. Scenario 3A includes centralized treatment at Site

#1 and recharge at Sites #1 and #2. Scenario 3A includes two PRBs, one for each of the recharge areas.

Figure 10-6 shows the scenario map and nitrogen removal table for Scenario 3A. **Scenario 3B** Scenario 3B includes all of the same fertilizer and stormwater credits, sewer footprint, and nitrogen removal quantities as Scenario 3A, but includes decentralized treatment, rather than centralized treatment, meaning there are two smaller treatment facilities at Sites #1 and #2, with recharge on each facility's site. Scenario 3B also includes two PRBs for the two recharge areas.

Figure 10-6 shows the scenario map and nitrogen removal table for Scenario 3B. Since the sewer footprint and recharge areas are the same for Scenarios 3A and 3B, and the only difference is the treatment location, the nitrogen balance shown in the table on Figure 10-6 is the same for both scenarios.

Scenario 4A

Scenario 4A includes fertilizer and stormwater credits and sewering as many existing developed parcels as necessary in the Bass River and Swan Pond River watersheds in order to meet the nitrogen removal requirements. Parcels within the West Dennis Planning District along Route 28 were targeted for sewering, as well as parcels within previously identified AOCs and other high density neighborhoods. In Scenario 4A, there is centralized treatment at Site #1 and recharge at Sites #1 and #2, each with a PRB.

With the elimination of new I/A systems from Scenario 4A as compared to Scenarios 3A and 3B, Scenarios 4A and 4B are considered to demonstrate the minimum footprint of sewering if non-traditional technologies (aside from the PRBs proposed around the effluent recharge sites) are deemed infeasible or inappropriate in the future for any reason.

Figure 10-7 shows the scenario map and nitrogen removal table for Scenario 4A.

Scenario 4B

Scenario 4B includes all of the same fertilizer and stormwater credits, sewer footprint, and nitrogen removal quantities as Scenario 4A, but instead includes decentralized treatment and recharge at each of Sites #1 and #2. Scenario 4B also includes PRBs at the two effluent recharge sites.

Figure 10-7 shows the scenario map and nitrogen removal table for Scenario 4B.

Scenario 5A

Scenario 5 includes fertilizer and stormwater credits, aquaculture, and sewering without PRBs. The sewer footprint includes the same existing developed parcels in the Bass River and Swan Pond River watersheds as Scenarios 4A and 4B, including the West Dennis Planning District along Route 28. Aquaculture is included in both the Bass River and Swan Pond River watersheds to compensate for the lost nitrogen reduction provided in Scenarios 4A and 4B by the PRBs, which have been eliminated from Scenario 5A. Scenario 5A includes centralized treatment at Site #1 and recharge at Sites #1 and #2.

Figure 10-8 shows the scenario map and nitrogen removal table for Scenario 5A.

Scenario 5B

Scenario 5B includes the same fertilizer and stormwater credits, aquaculture, and sewering without PRBs as Scenario 5A, but includes decentralized treatment and recharge at each of Site #1 and Site #2.

Figure 10-8 shows the scenario map and nitrogen removal table for Scenario 5B.

Scenario 6A

Scenario 6A includes fertilizer and stormwater credits, aquaculture, and sewering with PRBs and the recharge sites. The sewering plan in Scenario 6A includes a similar footprint of sewers as Scenarios 4 and 5 including a portion of existing developed parcels, plus all of the planning districts and the entire southern coast of town. While this Scenario exceeds the nitrogen removal requirements of the MEP, it has been laid out to meet the infrastructure needs of other town goals such as economic growth and Title 5 issues. Scenario 6A also includes centralized treatment at Site #1, recharge at Sites #1 and #2, a PRB for each recharge area, and aquaculture in Swan Pond.

Figure 10-9 shows the scenario map and nitrogen removal table for Scenario 6A.

Scenario 6B

Scenario 6B includes the same fertilizer and stormwater credits, aquaculture, sewer footprint, and PRBs at the effluent recharge sites as Scenario 6A. Scenario 6B includes decentralized treatment with recharge at Site #1 and Site #2, with two PRBs.

Figure 10-9 shows the scenario map and nitrogen removal table for Scenario 6B.

Scenario 7A

Scenario 7 includes fertilizer and stormwater credits, aquaculture in Swan Pond, and sewers with PRBs in order to meet the nitrogen removal requirements as well as other town goals. The sewering footprint includes the same existing developed parcels as Scenarios 4, 5, and 6 required to meet the MEP goals, along with all of the town's planning districts, and several additional AOCs discussed in Section 7. The specific AOCs which have been added in Scenario 7A are located in West Dennis and Dennis Port, in the southern portion of town. Scenario 7A includes centralized treatment at Site #1, recharge at Sites #1 and #2, and two PRBs.

Figure 10-10 shows the scenario map and nitrogen removal table for Scenario 7A.

Scenario 7B

Scenario 7B includes the same fertilizer and stormwater credits, aquaculture in Swan Pond, and sewered areas as Scenario 7A, but includes decentralized treatment and recharge at each of Sites #1 and #2. Scenario 7B also includes two PRBs.

Figure 10-10 shows the scenario map and nitrogen removal table for Scenario 7B.

Scenario 7C

Scenario 7C includes the same fertilizer and stormwater credits, aquaculture in Swan Pond, and sewer footprint as Scenarios 7A and 7B, but includes three decentralized treatment facilities with recharge locations at each of Sites #1, #2, and #3. Scenario 7C includes three PRBs.

Figure 10-11 shows the scenario map and nitrogen removal table for Scenario 7C.

Scenario 7D

Scenario 7D includes the same fertilizer and stormwater credits, aquaculture in Swan Pond, and sewer footprint as Scenarios 7A, 7B, and 7C. Scenario 7D includes centralized treatment at Site #1 with an ocean outfall for the facility's discharge. The ocean outfall is assumed to discharge beyond Nantucket Sound and has a total estimated length of six miles.

Figure 10-12 shows the scenario map and nitrogen removal table for Scenario 7D.

	Bass River	Swan Pond River
N Removal Required -Dennis (kg/day)	*46.50*	*33.00*
Fertilizer	*-2.04*	*-0.73*
Stormwater	*-2.14*	*-1.36*
I/A Systems	*-37.68*	*-16.49*
Remaining N Removal Required	***4.64***	***14.42***
Threshold Not Met		

Scenario #1

Cape Cod Bay

SESUIT HARBOR

Quivett Creek

Sesuit Harbor

DENNIS

BREWSTER

Chase Garden Creek

SETUCKET ROAD

Bass River

MAYFAIR ROAD

Herring River

HARWICH

Swan Pond River

SWAN POND

BASS RIVER

YARMOUTH

WEIR CREEK

Nantucket Sound

Legend

MEP Watershed Delineations

MEP Subwatersheds

Wastewater Options

I/A

Sewer

Town of Dennis, MA

Existing Developed Parcels, Stormwater and Fertilizer Credits, All Advanced I/A Systems

Figure 10-4

N

1 in = 3,500 ft

0 0.5 1

Miles

CDM Smith

NEWELLJD F:\Dennis\DATA\MXD\Figure_10-4_Dennis_Scenario1.mxd 8/27/2015

Scenario #2A

	Bass River	Swan Pond River
N Removal Required -Dennis (kg/day)	46.50	33.00
Fertilizer	-2.04	-0.73
Stormwater	-2.14	-1.36
I/A Systems	-32.61	-16.49
Aquaculture	-10.08	-14.47
Remaining N Removal Required	*-0.34*	*-0.05*
Threshold Met		

Cape Cod Bay

Aquaculture
5.75 Acres
5.75 mil oysters
5.04 kg/day
N-Removed

Aquaculture
5.75 Acres
5.75 mil oysters
5.04 kg/day
N-Removed

Aquaculture
16.5 Acres
16.5 mil oysters
14.47 kg/day
N-Removed

Nantucket Sound

Legend
- MEP Watershed Delineations
- MEP Subwatersheds

Wastewater Options
- I/A
- Sewer

Town of Dennis, MA

Existing Developed Parcels, Stormwater and Fertilizer Credits, All Advanced I/A Systems, Aquaculture

Figure 10-5

1 in = 3,500 ft

0 0.5 1 Miles

CDM Smith

NEWELLJD F:\Dennis\DATA\MXD\Figure_10-5_Dennis_Scenario2.mxd 7/30/2015

	Bass River	Swan Pond River
N Removal Required -Dennis (kg/day)	*46.50*	*33.00*
Fertilizer	*-2.04*	*-0.73*
Stormwater	*-2.14*	*-1.36*
I/A Systems	*-2.16*	*-1.55*
Sewer with PRB	*-41.13*	*-29.53*
Effluent Recharge	*+1.16*	*+1.49*
Aquaculture	*-3.07*	*-2.41*
Remaining N Removal Required	***-2.88***	***-1.09***
Threshold Met		

Scenario #3

3A: Centralized Treatment at Site #1 and Recharge at Sites #1 and #2

3B: Decentralized Treatment and Recharge at Site #1 and Site #2

Cape Cod Bay
SESUIT HARBOR
Quivett Creek
Sesuit Harbor
DENNIS
BREWSTER
Chase Garden Creek
SETUCKET ROAD
Bass River
Aquaculture
3.5 Acres
3.5 mil oysters
3.07 kg/day
N-Removed
Site 2
Herring River
HARWICH
Site 1
Aquaculture
2.75 Acres
2.75 mil oysters
2.41 kg/day
N-Removed
Swan Pond River
SWAN POND
YARMOUTH
BASS RIVER
SWAN POND RIVER
WEST CREEK
Nantucket Sound

Legend
- MEP Watershed Delineations
- MEP Subwatersheds

Wastewater Options
- I/A
- Sewer
- Possible Treatment and Recharge Sites

Town of Dennis, MA

Stormwater and Fertilizer Credits, Existing Developed Parcels, Sewer with PRB All Advanced I/A Systems, and Aquaculture - **Figure 10-6**

N

1 in = 3,500 ft

0 0.5 1 Miles

CDM Smith

NEWELLJD F:\Dennis\DATA\MXD\Figure_10-6_Dennis_Scenario3.mxd 8/27/2015

	Bass River	Swan Pond River
N Removal Required -Dennis (kg/day)	*46.50*	*33.00*
Fertilizer	*-2.04*	*-0.73*
Stormwater	*-2.14*	*-1.36*
Centralized Sewers with PRB	*-44.62*	*-32.29*
Effluent Recharge	*+1.42*	*+1.38*
Remaining N Removal Required	***-0.87***	***0.00***
Threshold Met		

Scenario #4

4A: Centralized Treatment at Site #1 and Recharge at Sites #1 and #2

4B: Decentralized Treatment and Recharge at Site #1 and Site #2

Cape Cod Bay

SESUIT HARBOR

Quivett Creek

Sesuit Harbor

DENNIS

BREWSTER

Chase Garden Creek

SETUCKET ROAD

Bass River

MAYFAIR

Site 2

Herring River

HARWICH

Site 1

Swan Pond River

BASS RIVER

SWAN POND

SWAN POND RIVER

YARMOUTH

WEIR CREEK

Nantucket Sound

Legend

- MEP Watershed Delineations
- MEP Subwatersheds

Wastewater Options

- I/A
- Sewer
- Possible Treatment and Recharge Sites

Town of Dennis, MA

Stormwater and Fertilizer Credits, Existing Developed Parcels, and Sewers with PRB

Figure 10-7

N

1 in = 3,500 ft

0 0.5 1

Miles

CDM Smith

NEWELLJD F:\Dennis\DATA\MXD\Figure_10-7_Dennis_Scenario4.mxd 8/27/2015

	Bass River	Swan Pond River
N Removal Required -Dennis (kg/day)	46.50	33.00
Fertilizer	-2.04	-0.73
Stormwater	-2.14	-1.36
Aquaculture	-1.53	-6.79
Sewer without PRB	-46.66	-31.33
Effluent Recharge	+4.22	+5.82
Remaining N Removal Required	*-1.65*	*-1.38*
Threshold Met		

Scenario #5

5A: Centralized Treatment at Site #1 and Recharge at Sites #1 and #2

5B: Decentralized Treatment and Recharge at Site #1 and Site #2

Cape Cod Bay

SESUIT HARBOR

Quivett Creek

Sesuit Harbor

DENNIS

BREWSTER

Chase Garden Creek

SETUCKET ROAD

Bass River

MAYFAIR

Site 2

Herring River

HARWICH

Site 1

Aquaculture
1.75 Acres
1.75 mil oysters
1.53 kg/day
N-Removed

Aquaculture
7.75 Acres
7.75 mil oysters
6.79 kg/day
N-Removed

Swan Pond River

BASS RIVER

SWAN POND

SWAN POND RIVER

YARMOUTH

WEIR CREEK

Nantucket Sound

Legend

- MEP Watershed Delineations
- MEP Subwatersheds

Wastewater Options

- I/A
- Sewer
- Possible Treatment and Recharge Sites

Town of Dennis, MA

N

1 in = 3,500 ft

0 0.5 1

Miles

Stormwater and Fertilizer Credits, Existing Developed Parcels, and Sewers without PRB

Figure 10-8

CDM Smith

NEWELLJD F:\Dennis\DATA\MXD\Figure_10-8_Dennis_Scenario5.mxd 8/27/2015

	Bass River	Swan Pond River
N Removal Required -Dennis (kg/day)	46.50	33.00
Fertilizer	-2.04	-0.73
Stormwater	-2.14	-1.36
Sewer with PRB	-45.60	-31.19
Effluent Recharge	+1.16	+1.79
Aquaculture	-	-2.85
Remaining N Removal Required	*-2.12*	*-1.34*
Threshold Met		

Scenario #6

6A: Centralized Treatment at Site #1 and Recharge at Sites #1 and #2

6B: Decentralized Treatment and Recharge at Site #1 and Site #2

Cape Cod Bay

Nantucket Sound

DENNIS

YARMOUTH

BREWSTER

HARWICH

Chase Garden Creek

Sesuit Harbor

Quivett Creek

Bass River

Herring River

Swan Pond River

Site 1

Site 2

Aquaculture
3.25 Acres
3.25 mil oysters
2.85 kg/day
N-Removed

SESUIT HARBOR

SETUCKET ROAD

MAYFAIR ROAD

BASS RIVER

SWAN POND

SWAN POND RIVER

WEIR CREEK

Legend

- MEP Watershed Delineations
- MEP Subwatersheds

Wastewater Options

- I/A
- Sewer
- Sewer within Planning Districts
- Possible Treatment and Recharge Sites

Town of Dennis, MA

Stormwater and Fertilizer Credits, Existing Developed Parcels, Aquaculture, and Sewers with PRB

Figure 10-9

N

1 in = 3,500 ft

0 0.5 1 Miles

CDM Smith

NEWELLJD F:\Dennis\DATA\MXD\Figure_10-9_Dennis_Scenario6.mxd 8/27/2015

	Bass River	Swan Pond River
N Removal Required -Dennis (kg/day)	46.50	33.00
Fertilizer	-2.04	-0.73
Stormwater	-2.14	-1.36
Sewer with PRB	-59.30	-31.19
Effluent Recharge	+1.16	+3.33
Aquaculture	-	-4.38
Remaining N Removal Required	*-15.82*	*-1.33*
Threshold Met		

Scenario #7A/7B

7A: Centralized Treatment at Site #1 and Recharge at Sites #1 and #2

7B: Decentralized Treatment and Recharge at Site #1 and Site #2

Cape Cod Bay

SESUIT HARBOR

Quivett Creek

Sesuit Harbor

DENNIS

BREWSTER

Chase Garden Creek

SETUCKET ROAD

Bass River

MAYFAIR ROAD

Site 2

Herring River

HARWICH

Site 1

Aquaculture
5 Acres
5 mil oysters
4.38 kg/day
N-Removed

Swan Pond River

BASS RIVER

SWAN POND

SWAN POND RIVER

YARMOUTH

WEIR CREEK

Nantucket Sound

Legend

- MEP Watershed Delineations
- MEP Subwatersheds

Wastewater Options

- I/A
- Sewer
- Sewer within Planning District
- Possible Treatment and Recharge Sites

Town of Dennis, MA

Stormwater and Fertilizer Credits, Existing Developed Parcels, Aquaculture, and Sewers with PRB

Figure 10-10

N

1 in = 3,500 ft

0 0.5 1

Miles

CDM Smith

NEWELLJD F:\Dennis\DATA\MXD\Figure_10-10_Dennis_Scenario7AB.mxd 8/27/2015

Scenario #7C

7C: Decentralized Treatment and Recharge at Site #1, Site #2, and Site #3

	Bass River	Swan Pond River
N Removal Required -Dennis (kg/day)	46.50	33.00
Fertilizer	-2.04	-0.73
Stormwater	-2.14	-1.36
Sewer with PRB	-59.30	-31.19
Effluent Recharge*	1.16	2.12
Aquaculture	-	-3.29
Remaining N Removal Required	-16.977	-1.44
Threshold Met		

*1.21 Kg/D N Discharged to Nantucket Sound Watershed

Cape Cod Bay

SESUIT HARBOR

Quivett Creek

Sesuit Harbor

DENNIS

BREWSTER

Chase Garden Creek

SETUCKET ROAD

Bass River

MAYFAIR ROAD

Site 2

Herring River

HARWICH

Site 1

Aquaculture
3.75 Acres
3.75 mil oysters
3.29 kg/day
N-Removed

Swan Pond River

BASS RIVER

SWAN POND

SWAN POND RIVER

YARMOUTH

WEIR CREEK

Site 3

Nantucket Sound

Legend

- MEP Watershed Delineations
- MEP Subwatersheds

Wastewater Options

- I/A
- Sewer
- Sewer within Planning District
- Possible Treatment and Recharge Sites

Town of Dennis, MA

Stormwater and Fertilizer Credits, Existing Developed Parcels, Aquaculture, and Sewers with PRB

Figure 10-11

N

1 in = 3,500 ft

0 0.5 1

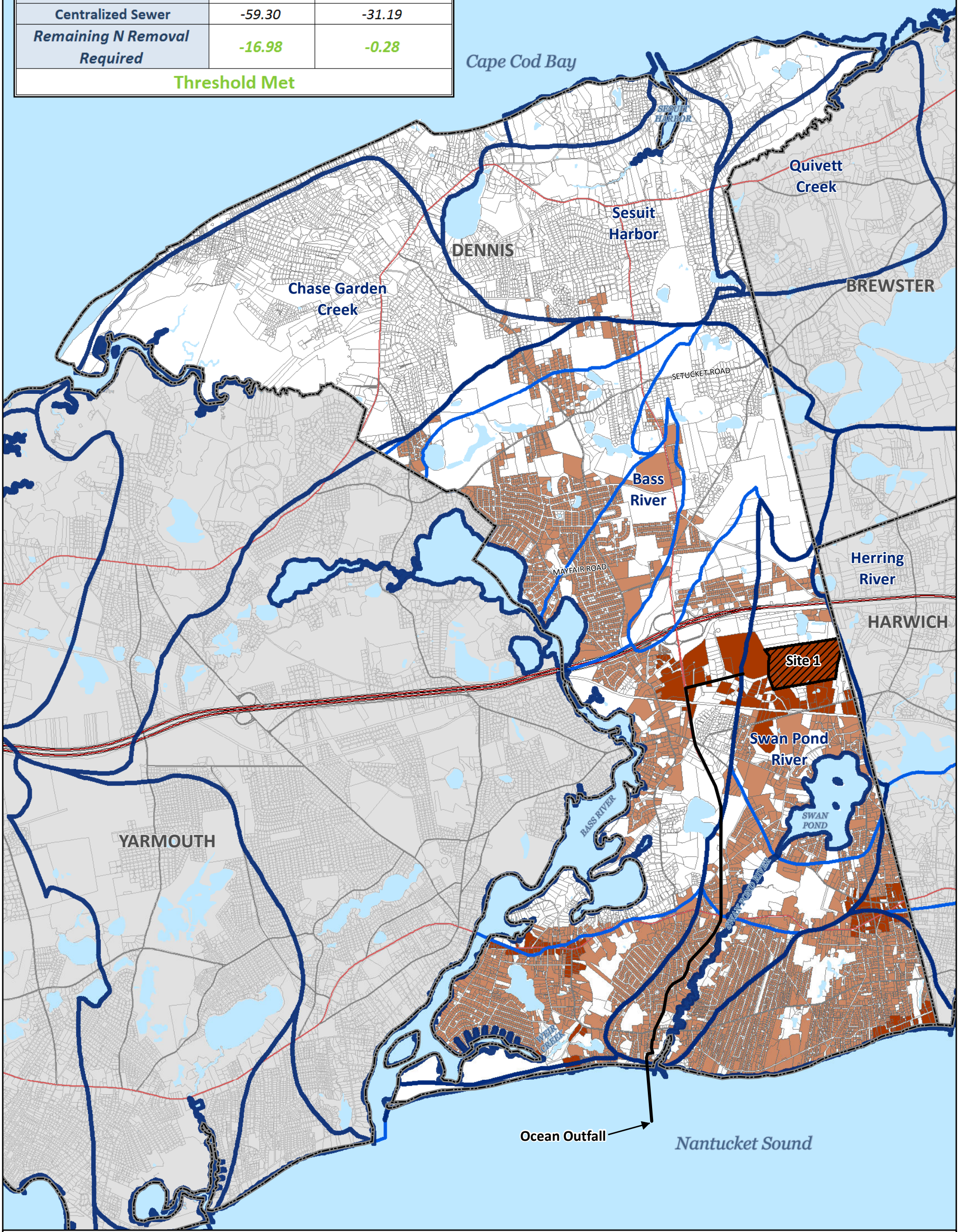
Miles

CDM Smith

NEWELLJD F:\Dennis\DATA\MXD\Figure_10-11_Dennis_Scenario7C.mxd 8/27/2015

Scenario #7D

	Bass River	Swan Pond River
N Removal Required -Dennis (kg/day)	46.50	33.00
Fertilizer	-2.04	-0.73
Stormwater	-2.14	-1.36
Centralized Sewer	-59.30	-31.19
Remaining N Removal Required	*-16.98*	*-0.28*
Threshold Met		



Legend

- MEP Watershed Delineations
- MEP Subwatersheds

Wastewater Options

- I/A
- Sewer
- Sewer within Planning District
- Possible Treatment and Recharge Site

Town of Dennis, MA

Stormwater and Fertilizer Credits,
Centralized Treatment at Site 1,
Discharge at Ocean Outfall

Figure 10-12

N

1 in = 3,500 ft

0 0.5 1 Miles

CDM Smith

NEWELLJD F:\Dennis\DATA\MXD\Figure_10-12_Dennis_Scenario7D.mxd 8/27/2015

10.4 Comparative Assessment of Scenarios

Following the development of the fourteen scenarios, a comparative analysis was performed to screen the options to arrive at the four scenarios deemed most favorable for further consideration. The intent of the screening process was to gather enough data to perform fair comparisons between the scenarios. The first step of the comparative analysis was to establish planning-level cost estimates for each scenario, considering both short-term and long-term costs.

10.4.1Cost Analysis

The comparative costs were developed using the tools presented in the Barnstable County Wastewater Cost Task Force's report entitled, "Comparison of Costs for Wastewater Management Systems Applicable to Cape Cod, Guidance to Cape Cod Towns Undertaking Comprehensive Wastewater Management Planning" dated April 2010, and updated April 2014 (v2), referred to herein as the 208 Plan cost document. Capital Costs were supplemented by CDM Smith for unit costs not readily available in the 208 Plan cost document. The information presented in this subsection is supplemented by the cost estimate details and assumptions provided in Appendix D.

Capital costs developed using the tools include collection, conveyance, treatment, and effluent recharge. These capital costs include design and permitting costs as well. Collection and transport costs are determined based on the linear footage of roadways within the proposed sewer collection areas for each scenario. Conveyance costs for pumping stations are based on the total number of parcels served. Treatment and recharge costs were determined using a cost curve in the 208 Plan cost document based on flows at the proposed wastewater treatment facilities. A peaking factor of 2.2 was used to account for short term peak flows. The average daily flow (ADF) for each treatment facility is included in the cost summary table, Table 10-5. Effluent recharge costs are based on the acreage of the recharge sites and an assumed recharge rate per acre. Ocean outfall costs were estimated per linear foot of outfall pipe.

In addition to these capital costs, costs were estimated for the non-traditional technology components of each scenario using the 208 Plan cost document as well. These included advanced I/A system costs calculated per parcel, PRB costs per linear foot, aquaculture per acre, and stormwater BMPs per curb mile. Fertilizer education was assumed to have no capital costs associated. PRB costs were also supplemented using information developed in CDM Smith's pilot study for the town of Falmouth, MA. The amount of aquaculture required to meet nitrogen reduction loadings was based on Scott Lindell's "Introduction to Shellfish Bioremediation Case Studies of Relevance to Town of Dennis," included here as Appendix C.

Operations and maintenance (O&M) costs were also developed using the 208 Plan cost document. These costs include labor, chemicals, electricity, laboratory analysis, repairs, administrative costs, and sludge removal for wastewater treatment facilities. The O&M costs are determined separately for each proposed treatment facility based on a cost curve in the 208 Plan cost document which provides the annual cost per gallon treated. Similar to the capital costs, the peaking factor of 2.2 was applied to the average daily flows taken directly from the MEP water usage (or CCC water usage for parcels outside of the MEP watersheds with completed reports) for each area tributary to each treatment facility. These flows will be adjusted in the next study phase to account for infiltration and inflow components of various sewer collection systems.

Equivalent annual costs were developed using the capital and O&M costs together, as presented in Section 10.4.2 below. Cost efficiency was then developed by dividing the equivalent annual cost by the pounds of nitrogen removed by each scenario, to arrive at an annual cost per pound of nitrogen removed.

10.4.2Cost Results

All of the costs described above were tabulated into a detailed spreadsheet that shows each component of the proposed wastewater system for each scenario including collection, conveyance, treatment, and effluent recharge (or ocean outfall), along with each applicable non-traditional technology including aquaculture, advanced I/A systems, PRBs, stormwater BMPs, and fertilizer education. The spreadsheet is provided in **Appendix D**, along with additional details regarding the calculations included therein. A summary of this information for each scenario is presented in Table 10-5.

The estimated total capital cost of each option is presented along with the estimated total O&M cost for each option. For comparison of costs on an annualized basis, an Equivalent Annual Cost (EAC) is calculated. The EAC is calculated on the basis that the entire capital cost is borrowed in Year 1 and paid back over a 20-year period at an interest rate of 2 percent, consistent with the typical lending rate of the Clean Water State Revolving Fund (SRF). This annualized capital cost is then added to the estimated annual O&M cost, to arrive at a total EAC for each scenario. While this mechanism and schedule of borrowing is not a realistic financing plan since implementation would be phased in over many years, it allows for a fair comparison of scenarios to one another using a methodology that combines capital with O&M costs.

From the summary table, the equivalent annual cost of Scenario 4A is the lowest among the scenarios, since it utilizes the economy of scale from a single wastewater treatment facility to accomplish the Town's wastewater goals with a minimal sewering footprint. However, Scenarios 3A, 3B, 4B, 5A, and 5B are within 15 percent of each other. Scenarios 6A, 6B, 7A, 7B, and 7C include more sewered areas, and therefore are more costly. Scenario 7D is extremely costly because it includes an ocean outfall laid out to discharge beyond Nantucket Sound. Scenarios 1 and 2 are the most costly because of the large number of individual advanced I/A systems required, which carry both expensive capital and annual O&M costs. Throughout the cost estimate, the decentralized options ('B' Scenarios) are estimated to be more expensive than their centralized counterpart ('A' Scenarios). The decentralized treatment scenarios include multiple treatment facilities to design, construct, operate, and maintain versus one larger facility. However, the centralized treatment facility options each require two crossings of Route 6 with collection piping and return piping of treated effluent recharge, which also adds cost and complexity.

The nitrogen removed in each scenario is also tabulated in Table 10-5. This shows that each scenario must remove between 64,297 and 89,125 pounds of nitrogen every year in order to meet the MEP requirements for existing nitrogen removal and other town goals. The differing amount of nitrogen removed in each scenario is a result of the particular areas chosen for wastewater collection (including several outside of MEP watersheds in Scenarios 6 and 7), natural attenuation variations throughout the subwatersheds, and the nitrogen balancing that is required for each scenario that recharges effluent within a nitrogen sensitive watershed. Table

10-5 also presents the cost per pound of nitrogen removed for each scenario and reflects similar results to the EAC.

Table 10-5 Comparative Cost Summary

	1	2A	3A	3B	4A	4B	5A	5B	6A	6B	7A	7B	7C	7D
Fertilizer/Stormwater Credits	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Number of Parcels with I/A Systems	6,905	6,472	395	395										
Acres of Aquaculture		28	6.25	6.25			9.5	9.5	3.25	3.25	5	5	3.75	
Number of Parcels Sewered			4,826	4,826	5,092	5,092	5,234	5,234	5,471	5,471	8,297	8,297	8,297	8,297
Miles of Sewer Collection Pipes			67	67	76	76	79	79	83	83	121	121	121	121
Number of Pumping Stations			24	24	25	25	26	26	27	27	41	41	41	41
Number of WWTPs			1	2	1	2	1	2	1	2	1	2	3	1
Number of Effluent Recharge Sites			2	2	2	2	2	2	2	2	2	2	3	
PRB at Recharge Site			X	X	X	X			X	X	X	X	X	
Average Daily Flow to WWTP #1 (Swan Pond)			635,000	367,000	732,000	443,000	756,000	463,000	873,000	584,000	1,234,000	927,000	586,000	1,234,000
Average Daily Flow to WWTP #2 (Bass River)				268,000		289,000		293,000		289,000		308,000	308,000	
Average Daily Flow to WWTP #3 (Dennis Port)													340,000	
Collection System Capital Cost			$95 M	$95 M	$107 M	$107 M	$111 M	$111 M	$116 M	$116 M	$170 M	$170 M	$170 M	$170 M
Conveyance System Capital Cost			$30 M	$30 M	$32 M	$32 M	$33 M	$33 M	$34 M	$34 M	$52 M	$52 M	$52 M	$52 M
Total Collection & Conveyance Cost			$125 M	$125 M	$138 M	$138 M	$144 M	$144 M	$150 M	$150 M	$222 M	$222 M	$222 M	$222 M
Treatment Capital Cost	$202 M	$191 M	$59 M	$66 M	$50 M	$59 M	$42 M	$45 M	$57 M	$67 M	$71 M	$80 M	$86 M	$144 M
Total Capital Cost	$202 M	$191 M	$184 M	$191 M	$189 M	$197 M	$186 M	$189 M	$207 M	$217 M	$293 M	$302 M	$307 M	$366 M
Annual O&M Cost	$27 M	$25 M	$6 M	$7 M	$5 M	$6 M	$5 M	$6 M	$6 M	$7 M	$8 M	$9 M	$9 M	$8 M
Equivalent Annual Cost	$39 M	$37 M	$17 M	$19 M	$17 M	$18 M	$17 M	$18 M	$18 M	$20 M	$26 M	$27 M	$28 M	$30 M
Annual Pounds Nitrogen Removed	48,644	64,297	67,179	67,179	64,684	64,684	66,422	66,422	71,184	71,184	89,125	89,125	88,307	88,396
Cost per Pound Nitrogen Removed	$800	$570	$260	$280	$260	$280	$250	$270	$260	$280	$290	$310	$320	$340

Notes: Reference Appendix D for details on basis of cost estimate. Costs are based and methodology published in "*Comparison of Costs for Wastewater Management Systems Applicable to Cape Cod, Guidance to Cape Cod Towns Undertaking Comprehensive Wastewater Management Planning*," dated April 2014 (version 2). ENR = 9702.

10.4.3 Evaluation Criteria

To distinguish between these scenarios, a detailed evaluation matrix was developed. The following evaluation criteria were selected for analysis and divided into four major categories:

- Relative Costs
  - Capital Costs
  - O&M Costs
  - Equivalent Annual Cost (EAC)
  - Cost per Pound of Nitrogen Removed
- Technical Criteria
  - Complexity of Transport
  - Reliability
  - Effluent Recharge Issues
  - Future Recharge Capacity
  - Phosphorus Removal
  - Ability to Handle Contaminants of Emerging Concern (CECs)
- Institutional Criteria
  - Phasing
  - Addresses Other Community Needs
  - Regulatory Considerations
  - Municipal vs. Property Owner
- Environmental Criteria
  - Effluent Recharge Impacts
  - Water Balance Considerations
  - Sensitive Receptors
  - Construction Impacts

Each individual criterion was weighted individually by the Dennis Comprehensive Wastewater Task Force to reflect preferences in Dennis. The relative costs category is weighted at 50 percent in this analysis since project costs are oftentimes the deciding factor in whether a project is

implemented. Capital costs have been the greatest obstacle to the advancement of other Cape Cod wastewater projects in recent years.

All criteria were ranked on a scale of 1 to 5, with 1 being the least favorable and 5 being the most favorable. Thus, the scenario with the highest total score would rank most favorable. The definition and ranking approach for each criterion is described below.

Relative Costs (50 Percent Weight)

Capital Costs (5%): The planning-level capital cost of each scenario was estimated based on the 208 Plan cost document, as outlined above and summarized in Appendix D. Capital costs were supplemented by CDM Smith for some unit costs not readily available. More detailed cost estimates will be established during later phases of the planning process for the selected scenarios carried on to the next phase. Capital costs were ranked as follows:

Table 10-6 Capital Costs (5%)

Rating	Range
1	>$320 M
2	$280 M - $320 M
3	$240 M - $280 M
4	$200 M - $240 M
5	<$200 M

Operations and Maintenance Costs (5%): The O&M costs of each alternative were also developed using the 208 Plan cost document and were supplemented as needed by CDM Smith. O&M costs are shown on an average annual basis at 2014 dollars and were ranked as follows:

Table 10-7 Operations and Maintenance Costs (5%)

Rating	Range
1	>$15 M
2	$11M - $15 M
3	$7 M - $11 M
4	$5 M - $7 M
5	<$5 M

Equivalent Annual Cost (25%): The Equivalent Annual Cost (EAC) of the system is calculated using the 20-year life cycle at an interest payment rate of two percent plus the annual O&M cost. This gives a good comparative estimate of the annual cost for the system by accounting for loan payments and O&M costs. Note, however, that this method presumes all capital costs are accrued at once, therefore it is useful for comparative purposes only. The EAC was ranked as follows:

Table 10-8 Equivalent Annual Cost (25%)

Rating	Range
1	>$35M
2	$30 M-$35 M
3	$25 M-$30 M
4	$20 M- $25 M
5	<$20 M

Cost per Pound of Nitrogen Removed (15%): The capital cost of each scenario was divided by the amount of nitrogen removed to develop a cost per pound of nitrogen removed to determine the scenario's effectiveness in removing nitrogen inputs from Dennis' waterways:

Table 10-9 Cost per Pound of Nitrogen Removed (15%)

Rating	Range
1	≥$350/lb N
2	$316/lb N - $350/lb N
3	$283/lb N - $316/lb N
4	$250/lb N - $283/lb N
5	≤$250/lb N

Technical Criteria (18 Percent Weight)

Complexity of Transport System (3%): The various scenarios may involve collecting wastewater from sewer service areas and conveying the collected wastewater via pumping stations and force mains to treatment facilities and effluent recharge areas. The number of major pumping stations required to convey collected wastewater to the treatment facilities and effluent recharge sites is a consideration as this will have short-term construction impacts and long-term O&M impacts. The complexity of each scenario's transport system was evaluated by considering the total length of force mains required to convey wastewater to the treatment facility sites and effluent to the recharge sites (including outfall pipes) to arrive at the following rankings:

Table 10-10 Complexity of Transport System (3%)

Rating	Range
1	Requires greater than 80,000 lf of force mains
2	Requires greater than 75,000 lf up to 80,000 lf of force mains
3	Requires greater than 70,000 lf up to 75,000 lf of force mains
4	Requires greater than 65,000 lf up to 70,000 lf of force mains
5	Requires 65,000 lf or less of force mains

Reliability Issues (3%): Reliability issues explore the likelihood of a technology's success. Technologies considered tried and true are ranked with a higher score. Newer technologies that have not been widely used in the industry are ranked with a lower score. These criteria are used in the following rankings:

Table 10-11 Reliability Issues (3%)

Rating	Range
1	Includes 4 or more non-traditional technologies
2	Includes 3 non-traditional technologies
3	Includes 2 non-traditional technologies
4	Includes 1 non-traditional technology
5	Includes no non-traditional technologies

Effluent Recharge Issues (3%): Effluent recharge issues from a technical perspective include the required hydrogeologic investigations and groundwater discharge requirements to approve each recharge site. Technical considerations are anticipated to relate directly to the number of effluent recharge sites. Based on those criteria the following rankings were defined as follows:

Table 10-12 Effluent Recharge Issues (3%)

Rating	Range
1	2-3 wastewater facilities, 2-3 recharge locations with non-traditional technologies
2	2-3 wastewater facilities, 2-3 recharge locations without non-traditional technologies
3	1 wastewater facility, 2 recharge locations with non-traditional technologies
4	1 wastewater facility, 2 recharge locations without non-traditional technologies
5	On-site recharge

Future Recharge Capacity (3%): The Future Recharge capacity describes the ability to recharge additional effluent if the Town decided to expand its wastewater system and sewer additional areas in the future. This criterion looks at each wastewater scenario and considers the potential recharge capacity of the effluent recharge sites. Recharge Site #1 is 91 acres, Site #2 is 71.5 acres, Site #3 is 8.4 acres. The ratings for each scenario are listed below.

Table 10-13 Future Recharge Capacity (3%)

Rating	Range
1	Under 20 acres of total recharge sites
2	20-70 acres of total recharge sites
3	70-120 acres of total recharge sites
4	120-170 acres of total recharge sites
5	Over 170 acres of total recharge sites

Phosphorus Removal Potential (3%): This criterion reflects the ability of a scenario to remove phosphorus from environmentally sensitive areas. To evaluate phosphorus removal potential, the impact on six impaired ponds is considered. The impaired ponds, per Section 3, are Cedar Pond, Coles Pond, Fresh Pond, Hiram Pond, Run Pond, and Scargo Lake. Each scenario is ranked based on the wastewater removed from nearby impaired ponds:

Table 10-14 Phosphorus Removal Potential (3%)

Rating	Range
1	Scenario contains minimal phosphorus removal
2	Scenario helps 1-2 impaired ponds
3	Scenario helps 3-4 impaired ponds
4	Scenario helps 5-6 impaired ponds
5	Scenario helps more than six impaired ponds

Ability to Handle CECs (3%): This criterion reflects the ability of a scenario to handle contaminants of emerging concern (CECs). The town's total water use is 2,566,431 per the MEP water usage data, and thus the town's total wastewater generation is estimated to be 2,309,788 gpd. The percentage of the town's total wastewater collected reflects the ability to potentially treat the collected wastewater in the future to remove CECs. The rankings are therefore evaluated based on the percent of total wastewater collected:

Table 10-15 Ability to Handle CECs (3%)

Rating	Range
1	Minimal area with wastewater collected
2	0%-16% of Town's total wastewater collected
3	16%-32% of Town's total wastewater collected
4	32%-50% of Town's total wastewater collected
5	Greater than 50% of Town's total wastewater collected

Institutional Criteria (16 Percent Weight)

Phasing (4%): The scenarios vary in their ability to be divided into suitable implementation phases and the associated ability to meet nitrogen reduction goals without creating temporary increases in nitrogen sensitive areas due to removal from one watershed and recharge in another. The timeline to permit a given scenario was also considered. The availability of a logical phasing strategy for each scenario was compared and ranked as follows:

Table 10-16 Phasing (4%)

Rating	Range
1	Phasing strategy will be very difficult since an ocean outfall is included
2	Phasing strategy is more difficult since thousands of I/A systems or hundreds of I/A systems with a wastewater facility will require additional regulatory efforts
3	Logical phasing strategy is less apparent since the permitting of one large wastewater facility to meet nitrogen goals will require additional regulatory efforts
4	Straightforward and logical phasing strategy is apparent since two wastewater facilities exist with distinct wastewater service areas
5	Straightforward and logical phasing strategy is apparent since three wastewater facilities exist with distinct wastewater service areas

Other Community Needs (4%): Some scenarios address wastewater needs in other parts of town beyond meeting the watershed goals. The opportunity for addressing other community needs associated with each scenario is ranked as follows:

Table 10-17 Other Community Needs (4%)

Rating	Range
1	No planning districts or AOCs included
2	West Dennis planning district included
3	Multiple planning districts included
4	Multiple planning districts and some AOCs included
5	Sewer in all planning districts and maximizes AOCs

Regulatory Considerations (4%): Regulatory considerations include the permitting required to both construct and operate the proposed facilities, which can depend on their locations, the number of facilities proposed, and the proximity to areas requiring additional regulatory review such as coastal zones, flood plains, sensitive habitats, etc. Regulatory considerations were ranked as follows:

Table 10-18 Regulatory Considerations (4%)

Rating	Range
1	Many regulatory hurdles anticipated as ocean outfall would be challenging to permit
2	Several regulatory hurdles anticipated for over 6,000 parcels with I/A systems
3	Several regulatory hurdles anticipated for one to two treatment facilities and one to two effluent recharge locations and the use of several hundred I/A systems
4	Some regulatory hurdles anticipated for two to three treatment facilities and one to three effluent recharge locations
5	Few regulatory hurdles anticipated for one treatment facility with effluent recharge

Municipal vs. Property Owner (4%): Various technologies are run by the Town, while other technologies are managed by individual property owners. Therefore, the alternatives were ranked based on the inclusion of Town-run oversight, which is expected to result in more reliable nitrogen removal performance:

Table 10-19 Municipal vs. Property Owner (4%)

Rating	Range
1	0%-20% Town-operated
2	20%-40% Town-operated
3	40%-60% Town-operated
4	60%-80% Town-operated
5	80-100% Town-operated

Environmental Criteria (16 Percent Weight)

Effluent Recharge Impacts (4%): Each scenario has on-site recharge or one or more effluent recharge areas proposed. The potential challenges resulting from recharge in those locations include recharge into nitrogen sensitive watersheds and resultant mounding from recharge into areas with known high groundwater. The potential impacts from effluent recharge were ranked as follows:

Table 10-20 Effluent Recharge Impacts (4%)

Rating	Range
1	Impacts at multiple recharge sites are anticipated and will require greater mitigation due to shallow depth to groundwater at several sites
2	Impacts at multiple recharge sites are anticipated and will require greater mitigation due to shallow depth to groundwater at one site
3	Impacts from shallow depth to groundwater are anticipated to be moderate to surrounding areas but can be mitigated
4	Impacts from recharge anticipated to be minimal due to moderate to excellent depth to groundwater
5	No impacts from wastewater treatment plant recharge expected

Water Balance Considerations (4%): Preserving a water balance between the many watersheds in Dennis may be a consideration if any of the existing sub-basins are perceived to be stressed from a water management perspective. The water balance criterion was ranked as follows:

Table 10-21 Water Balance Considerations (4%)

Rating	Range
1	Scenario transfers water to the greatest extent (four or more watersheds) to other watersheds
2	Scenario maintains water balance in some locations but transfers water from three watersheds to other locations
3	Scenario maintains water balance in some locations but transfers water from two watersheds to other locations
4	Scenario maintains water balance to most locations, and transfers flow only from one watershed
5	Scenario maintains water balance in all locations

Sensitive Receptors (4%): The presence of sensitive receptors (e.g., schools, residents, natural resources, etc.) in the vicinity of proposed treatment and effluent recharge system locations or other areas which could have significant construction or other perceived impacts must be considered. The potential impacts to sensitive receptors of each scenario were ranked as follows:

Table 10-22 Sensitive Receptors (4%)

Rating	Range
1	Contains 8 or more sensitive receptors within 500' buffer zone of treatment/recharge sites
2	Contains 6 or 7 sensitive receptors within 500' buffer zone of treatment/recharge sites
3	Contains 4 or 5 sensitive receptors within 500' buffer zone of treatment/recharge sites
4	Contains 2 or 3 sensitive receptors within 500' buffer zone of treatment/recharge sites
5	Contains minimal sensitive receptors within 500' buffer zone of treatment/recharge sites

Construction Impacts (4%): Each scenario will involve some level of construction impacts. Scenarios anticipated to require deeper construction, more time-consuming construction, more challenging construction methods (e.g., trenchless technologies or complex dewatering systems), or work in more challenging areas (e.g., major roads, wetland areas, etc.) are ranked less favorably due to the higher likelihood of impacts to surrounding areas than those for which construction is anticipated to be straightforward. The construction impacts were ranked as follows:

Table 10-23 Construction Impacts (4%)

Rating	Range
1	Construction is anticipated to be very complex or have impacts needing more significant mitigation (e.g. many I/A systems on small lots)
2	Construction is anticipated to be more complex with a higher likelihood of impacts and utilize one facility for treatment and two effluent recharge sites, including Route 6 crossings
3	Construction is anticipated to be more complex with a higher likelihood of impacts and utilize three facilities for treatment and three effluent recharge sites and no Route 6 crossings
4	Construction is anticipated to be relatively straightforward and impacts limited by mitigation and utilize two treatment facilities and two effluent recharge sites with no Route 6 crossings
5	Construction is anticipated to be straightforward, with no I/A systems on small lots and no Route 6 crossings

10.4.4 Matrix Results

All of the factors described above were tabulated below into a matrix which shows the ranking for each evaluation criterion and respective assigned weight. The evaluation criteria are presented in Table 10-6. Each criterion is ranked from 1 to 5 and each criterion was weighted by the CWMTF based on preference for that particular category. The relative costs are weighted at 50 percent because the Task Force believes that the cost of the system will be a significant deciding factor in the outcome of the final recommended program. The end result is a matrix that ranks each of the fourteen options with a low score of 204 and a high score of 419. In this matrix, the low score of 204 is given to Scenario 1, and the high score of 419 is given to Scenario 5A. These results are similar to those of the cost per pound of nitrogen removed shown in the summary table in Table 10-5 and is not unexpected given the high weighting factor assigned to the cost criteria.

10.5 Recommended Scenarios for Further Analysis

The Dennis Comprehensive Wastewater Management Task Force discussed the evaluation results and recommended that Scenarios 3B, 5A, 5B, and 6B be brought forward into the next study phase to be evaluated in more detail. While these were not the four highest scoring scenarios, the CWMTF selected them to allow for the best comparison of specific desirable components moving forward.

Scenarios 5A and 5B were selected because they had the highest scores. These scenarios both include sewering and aquaculture. By selecting both 5A (which includes one treatment plant and two effluent recharge sites) and 5B (which includes two treatment plants with two recharge sites), a detailed, direct comparison can be performed between a more centralized approach and a more decentralized approach using the same sewer service area as a baseline.

While Scenario 4B was the next highest ranked scenario, it was eliminated from detailed consideration because it has the exact same sewer footprint as 5B but replaces aquaculture with a permeable reactive barrier (PRB) around the effluent recharge site. This difference was considered to be a nuance that did not warrant a detailed comparison in the next phase. Aquaculture was deemed desirable by the community and the committee wished to maintain its inclusion. 4A was likewise eliminated due to its similarity to 5A. The final recommended program could re-incorporate a PRB at one or both effluent recharge sites if deemed appropriate at that stage of the analysis.

Scenarios 1, 2, 7A, 7B, 7C, and 7D were ranked too low for further consideration. Therefore, Scenarios 3A, 3B, 6A, and 6B remained for possible inclusion. Since Scenarios 3A and 3B incorporate I/A systems on larger lots and thus reflect a more decentralized, non-traditional approach, there was interest in maintaining at least one of the “3” scenarios. Similarly, since Scenarios 6A and 6B include sewers to solve other community needs (such as economic development areas and areas with a high percentage of non-compliant Title 5 systems), there was interest in maintaining one of the “6” scenarios. Therefore, a decision was made to maintain one “3” scenario and one “6” scenario.

Furthermore, in order to allow for a more direct comparison, the committee decided that it would be best to maintain either 3A and 6A, or 3B and 6B, rather than a combination of “A” and “B” options. Despite their slightly lower ranks, Scenarios 3B and 6B were selected as they maximize the decentralized approach (with two treatment facilities rather than one), which was anticipated to be more in line with community preferences.

Table 10-24 Nitrogen Management Alternatives Evaluation Criteria

Evaluation of Alternatives															
Evaluation Criteria	**Criteria Weight**	**1**	**2**	**3A**	**3B**	**4A**	**4B**	**5A**	**5B**	**6A**	**6B**	**7A**	**7B**	**7C**	**7D**
RELATIVE COSTS	**50%**														
Capital Costs	5%	20	25	25	25	25	25	25	25	20	20	10	10	10	5
O&M Costs	5%	5	5	20	15	20	20	20	20	20	20	15	15	15	15
Equivalent Annual Cost (EAC)	25%	25	25	125	125	125	125	125	125	125	100	75	75	75	50
Cost per lb of N Removed	15%	15	15	60	60	60	60	75	60	60	60	45	45	30	30
TECHNICAL CRITERIA	**18%**														
Complexity of Transport	3%	15	15	12	15	12	12	12	12	9	12	3	6	6	3
Reliability	3%	12	9	9	9	12	12	12	12	9	9	9	9	9	15
Effluent Recharge Issues	3%	15	15	9	3	9	6	12	6	9	3	9	3	3	12
Future Recharge Capacity	3%	3	3	12	12	12	12	12	12	12	12	12	12	15	15
Phosphorus Removal	3%	3	3	6	6	6	6	6	6	6	6	6	6	6	6
Ability to Handle CECs	3%	3	3	9	9	9	9	12	12	12	12	15	15	15	15
INSTITUTIONAL CRITERIA	**16%**														
Phasing	4%	8	8	8	8	12	16	12	16	12	16	12	16	20	4
Addresses Other Community Needs	4%	4	4	4	4	8	8	12	12	16	16	20	20	20	20
Regulatory Considerations	4%	8	8	12	12	20	16	20	16	20	16	20	20	20	4
Municipal vs. Property Owner	4%	4	4	16	16	20	20	20	20	20	20	20	20	20	20
ENVIRONMENTAL CRITERIA	**16%**														
Effluent Recharge Impacts	4%	20	20	12	12	12	12	12	12	12	12	12	12	8	20
Water Balance Considerations	4%	20	20	16	12	16	12	16	12	16	12	8	8	8	8
Sensitive Receptors	4%	20	20	8	8	8	8	8	8	8	8	8	8	4	16
Construction Impacts	4%	4	4	4	4	8	16	8	16	8	16	8	16	12	4
TOTAL WITH WEIGHTING	**100%**	204	206	367	355	394	395	419	402	394	370	307	316	296	262

In summary, the Dennis CWMTF believes that the four chosen scenarios (3B, 5A, 5B, and 6B), as shown in Table 10-7, will provide the Town with the best variety of viable options to reduce nitrogen in the Town's watersheds to meet MEP and other community goals, and their more detailed analysis will provide valuable feedback to inform the development of a final recommended program.

Table 10-**25 Summary of Four Selected Scenarios**

Description	3B	5A	5B	6B
	Aquaculture, I/A and Sewer with PRB	Aquaculture and Sewer without PRB	Aquaculture and Sewer without PRB	Aquaculture and Sewer with PRB (includes planning districts)
Fertilizer/Stormwater Credits	X	X	X	X
# of Parcels with I/A Systems	395			
Acres of Aquaculture	6.25	9.5	9.5	3.25
Number of Parcels Sewered	4,826	5,234	5,234	5,471
Number of WWTPs	2	1	2	2
# of Effluent Recharge Sites	2	2	2	2
PRB at Recharge Site	X			X
Average Daily Flow to WWTP #1 (Swan Pond)	367,000	756,000	463,000	584,000
Average Daily Flow to WWTP #2 (Bass River)	268,000		293,000	289,000
Annual Pounds Nitrogen Removed	67,179	66,422	66,422	71,184
Cost per Pound Nitrogen Removed	$280	$250	$270	$280

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Section 11

Hydrogeologic Evaluations of Effluent Recharge Sites

11.1 Introduction

One of the most significant aspects of developing a Comprehensive Wastewater Management Plan (CWMP) is to find suitable effluent recharge sites to incorporate into the overall recommended program. As discussed in Section 9, a screening of the whole town was performed to identify the best available sites for this purpose. In addition, in Section 10, a discussion was provided of the nitrogen balance issues associated with adding more nitrogen to a given watershed as a result of recharging effluent. Section 11 evaluates the ability of the preferred sites to accept the highly treated effluent from a hydrogeologic perspective. Thus, the two highest rated effluent recharge sites are evaluated herein. In addition, results from the 2016 Cape Cod Commission Grant to study additional suitable effluent recharge sites are summarized.

The Hydrogeologic Evaluation summarized in this section is for use in planning and selecting potential recharge sites and developing preliminary designs. It is insufficient for submission to the Massachusetts Department of Environmental Protection (MassDEP) in support of the required groundwater discharge permit application. Per MassDEP regulations and guidance, site walks will need to be conducted with the DEP and a Scope of Work will need to be submitted to and approved by MassDEP prior to conducting field work and developing a formal Hydrogeologic Evaluation to support the discharge permit application. The Scope of Work to support the Hydrogeologic Evaluation for a discharge permit may require additional subsurface borings, well installation, multiple groundwater measurement events, infiltration testing and additional transient groundwater flow modeling. As of the fall of 2021, the Town is working with CDM Smith to carry out the formal process for submitting the Scope of Work for the two prioritized sites discussed in this section. The intent is that these two sites would accept flow from the first several phases of the Recommended Plan. Additional site screening is also being conducted to determine other suitable effluent recharge sites to be added in the future, when the wastewater treatment facility is expanded.

Supplemental memos are attached in **Appendix E** which provide additional detail on site visits, site screening, subsurface boring data, and steady-state and transient model development and calibration which is summarized herein.

11.2 Overview of Work

In support of the Dennis CWMP, effluent recharge at two potential sites was simulated using the United States Geological Survey (USGS) Monomoy Flow Lens groundwater model, which includes the towns of Dennis, Harwich, Chatham, Brewster, and parts of Orleans. This groundwater flow simulation model was developed in the 1990s and early 2000s and was used to delineate groundwater contribution areas to embayments as part of the Massachusetts Estuaries Project (MEP). The model was implemented in MODFLOW, a finite-difference groundwater flow simulation modeling code developed by the USGS and widely used for groundwater flow modeling applications. The simulated groundwater elevations generated by the model represent

steady-state 2003 pumping and recharge conditions. In addition, a transient model representing variations during a typical year was used to assess the seasonal impacts of recharge and pumping at the proposed sites. The typical year represents average pumping and long-term recharge conditions and does not simulate extremely wet or dry years. Assignment of pumping at public supply wells was based on 2003 pumping rates. USGS Monomoy Flow Lens Model documentation is provided in the USGS report *Simulated Water Sources and Effects of Pumping on Surface and Ground Water, Sagamore and Monomoy Flow Lenses, Cape Cod, Massachusetts* (SIR 2004-5181) with updates described in *Simulated Responses of Streams and Ponds to Groundwater and Wastewater Return Flows in Southeastern Massachusetts (SIR 2015-5168)*.Discharge locations were determined using particle tracks developed using the MODFLOW generated flow-fields and MODPATH, a particle tracking code developed by the USGS. Documentation of local-area updates for purposes of the CWMP are summarized herein and described in detail within **Appendix E**.

As part of this CWMP, a program for hydrogeologic data collection and groundwater flow modeling was conducted to predict the impacts of effluent recharge to groundwater at potential sites in Dennis. Data collection included installation of a boring and monitoring well, elevation surveys of existing wells, streams, and potential vernal pools, as well as the measurement of groundwater levels at six wells, shown in **Table 11-1**, starting in November 2016 on an approximately monthly basis. Additional borings and pairs of wells were installed in December 2017 and water levels were recorded in January 2018 and the April and May 2018. Based on water levels recorded at USGS well MA-DGW 158, water levels in Dennis during April of 2018 represent near historic high water levels.

Table 11-1 Observed Groundwater Elevations (ft NGVD 29) at Site Monitoring Wells

Observation Date	CDM-1	MW-25	MW-27D	MW-27S	MW-28D	MW-28S	MW-1S	MW-1D	MW-2S	MW-2D
11/14/2016	9.90	7.98	8.70	15.66	9.12	13.90				
3/22/2017		8.73	9.45	16.66	9.80	14.72				
4/21/2017	11.08	9.46	10.18	17.66	10.61	15.50				
5/24/2017	11.73	9.64	10.35	17.73	10.87	15.75				
6/28/2017	11.89	9.69	10.39	17.96	10.93	15.76				
7/31/2017	11.45	9.21	9.92	17.45	10.45	15.32				
8/30/2017	11.35	9.65	10.28	17.54	10.86	15.91				
9/29/2017	11.28	9.69	10.32	17.86	10.91	16.07				
10/30/2017	11.57	NM	10.79	18.13	11.29	16.63				
11/29/2017	11.89	NM	10.79	18.47	11.34	16.52				
1/31/2018	12.04	NM	10.49	18.36	11.04	16.37	17.97	9.24	18.90	9.71
4/10/2018	15.42	NM	12.66	21.10	13.44	19.29	19.37	11.15	20.75	11.63
4/20/2018	NM	NM	12.54	21.06	13.47	19.26	NM	NM	NM	NM
4/30/2018	15.40	NM	12.35	20.82	13.25	19.06	18.90	10.86	20.26	11.38
5/10/2018	NM	NM	NM	NM	NM	NM	18.87	10.87	20.22	11.37

Notes
Wells MW-1S, MW-1D, MW-2S and MW-2D were installed in December 2017.
NM = not measured

Three sites were included in the initial site evaluation and site walk. These include a site south of Route 6 near the current Dennis Department of Public Works (DPW) office and garage and east of the former landfill in the Swan Pond River watershed (Site1), an area north of Route 6 near the former DPW site on Bob Crowell Road in the Bass River watershed (Site 2) and a site in Dennis Port off of Lower County Road (Site 3). Two sites, Site 1 and Site 2 were retained for further evaluation including water level collection and steady-state and transient modeling. Site 3 was screened out due to high water table and lack of suitable area for recharge.

11.3 Recharge Site Descriptions

Site walks were conducted at three sites on November 24, 2015 and the information collected was used to identify potential issues to determine the most likely locations for effluent recharge basins. The three sites included:

- **Site 1** - south of Route 6 near the current DPW office and garage, east of the former landfill off of Theophilis Smith Road in the Swan Pond River watershed
- **Site 2** – north of Route 6 near the former DPW site on Bob Crowell Road in the Bass River watershed
- **Site 3** – south of Route 6 off of Lower County Road in a Direct Discharge area to Nantucket Sound

Detailed notes from the site visits can be found in **Appendix E**. Based on the site walk and CWMP analysis, two sites, Sites 1 and 2, were selected for simulation of effluent recharge. Detailed information on Sites 1 and 2 is provided below.

Based on the site walk evaluation, Site 3 was deemed to be unsuitable as an effluent recharge location. Initial assessment of the Site 3 showed that the depth to groundwater in the portion of the site which is currently undeveloped would not be sufficient for effluent recharge. Signage at the site as well as the presence of sand indicates possible turtle nesting on the site. Because of these findings, Site 3 was not considered for effluent recharge. As such this was no longer carried in any further recharge analysis.

11.3.1Site 1 in Swan Pond River Watershed

Site 1, the Swan Pond River watershed site, is located south of Route 6 near the current DPW office and garage and east of the former landfill). The site walk identified five potential vernal pools on the DPW parcel, an active cranberry bog east of the site and industrial activities located in excavated areas south of the site which may be impacted by increases in groundwater levels, shown in **Figure 11-1**. Three of these potential vernal pools were identified as functioning vernal pools which meet the NHESP vernal pool certification requirements based on a presence-absence survey conducted in April 2018. An area in the northeast portion of the site was selected as the location for potential recharge. This area was selected based on the relatively flat terrain, the ground surface elevations of between 40 and 50 feet above mean sea level (MSL) and estimated depth to groundwater of around 20 feet below ground surface (ft bgs).

Data for the Dennis sanitary landfill, located to the west of the DPW site, was obtained from a file review conducted at the MassDEP Southeast Region Office in February 2016. Boring logs for wells

installed as part of Comprehensive Site Assessments in the 1990's and other monitoring activities indicate the presence of a clay layer beneath the DPW site. Boring log data along transects shown in **Figure 11-2** indicate sand and sand/clay layers at 30 to 50 ft bgs beneath the uplands site and the current DPW compost and storage area as shown in **Figure 11-3** (West-East Cross-section A-A'). Clay and silt occur at similar elevations in many of the boring logs from the site wells. Layers of clay were recorded in borings south of the site beneath the excavation of the former gravel pit as shown in **Figure 11-4** (North-South Cross-section B-B'). Two borings and pairs of monitoring wells were installed in the area selected for the effluent recharge in December 2017. The boring logs confirm the presence of clay at between 38.5 and 26 feet below the ground surface, at a depth 20 feet shallower than the estimates used for the initial transient modeling. Monitoring well screens were installed at each boring location above and below the clay layer. The measured head in the well screen above the clay was 8 to 9 feet higher than the head in the well screened below the clay at each location. This head difference indicates that the clay is extensive at the site and acting as a significant impediment to vertical flow, forcing local recharge to remain and flow mostly in the sandy sediments above the clay.

11.3.2Site 2 in Bass River Watershed

Site 2, the Bass River watershed site, is located north of Route 6 near the former DPW site on Bob Crowell Road (see **Figure 11-5**). Based on the site walk, public water supply Zone II extent, and land use limitations on other portions of the property, the area west of the former DPW site was selected for effluent recharge. This area has ground surface elevations of around 50 feet above MSL with an estimated depth to groundwater of around 20 to 30 ft bgs. There were no potential vernal pools or other concerns that were identified downgradient of Site 2.

A boring was advanced in October 2016 to collect subsurface data at this location. A monitoring well was installed at this location and water levels collected in November 2016 showed a depth to water of 29 ft bgs. The boring log indicates the presence of a clay layer at 45 ft bgs The presence of clay at this depth is also seen in borings installed as part of Permeable Reactive Barrier Site Characterization conducted at Vinland Drive by the USEPA (WaterVision, July 2016), discussed in more detail in Section 9.6.1. The Vinland Drive site is located downgradient to the west of the proposed recharge site at Bob Crowell Road.

11.4 Effluent Recharge Simulations

The effluent recharge sites analyzed herein are located in the Monomoy Lens, one of six groundwater flow lenses under Cape Cod. The Monomoy Lens is located under the towns of Dennis, Brewster, Orleans, Harwich, and Chatham. This lens can be thought of as a mound of fresh groundwater bordered by saline marine waters at the edges, and bedrock on the bottom. Surface features define watersheds that create different recharge points to the groundwater table within the lens area. The entire layer of fresh groundwater beneath the Cape is known as the Cape Cod Sole Source Aquifer.

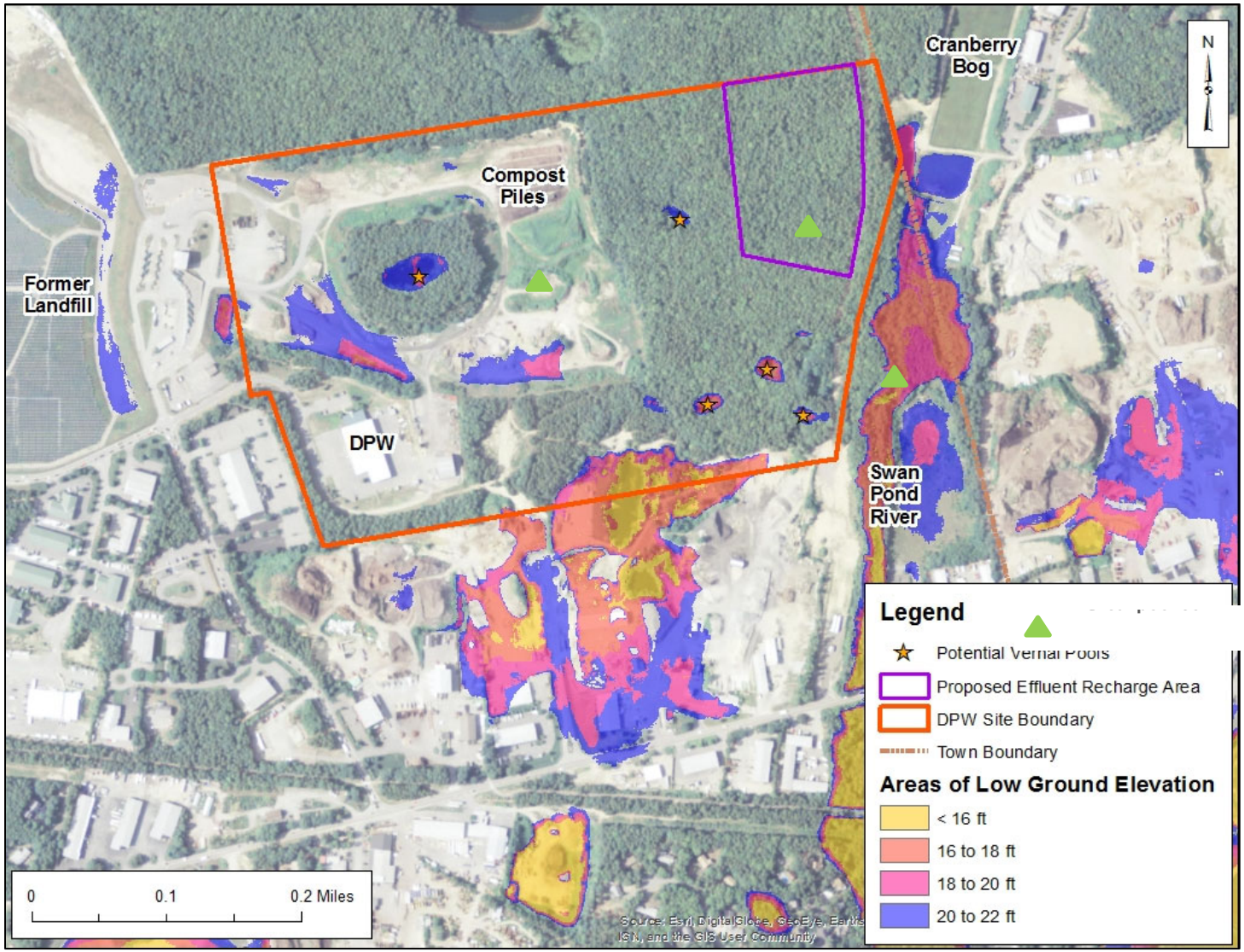


Figure 11-1 Site 1 - Areas of Low Ground Elevation and Vernal Pools

Figure 11-2 Boring Log Locations

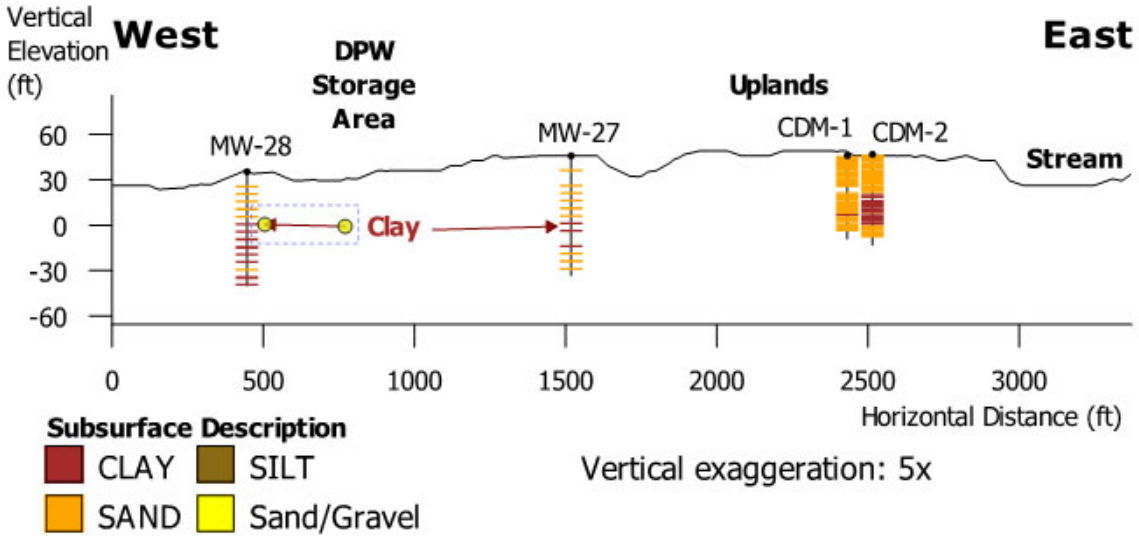


Figure 11-3 Cross-section West-East (A-A')

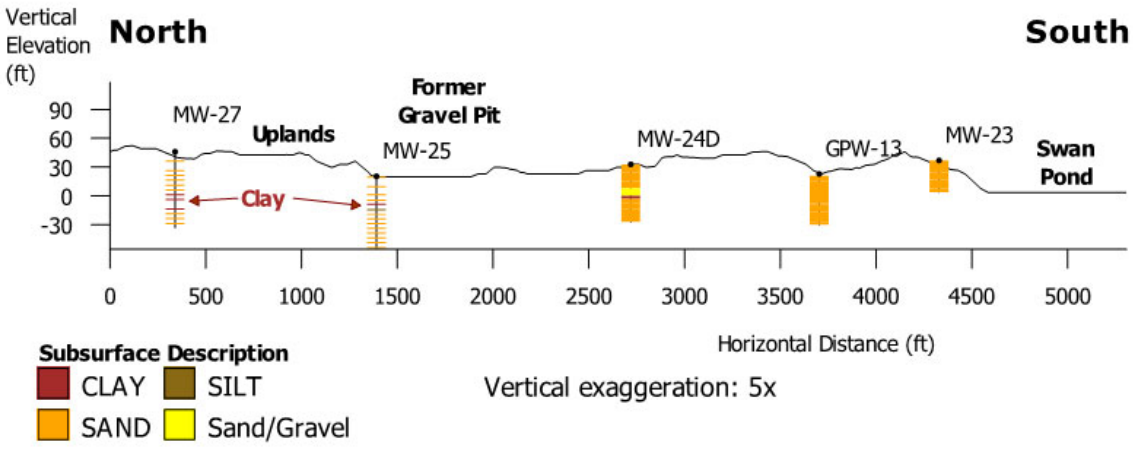


Figure 11-4 Cross-section North-South (B-B')

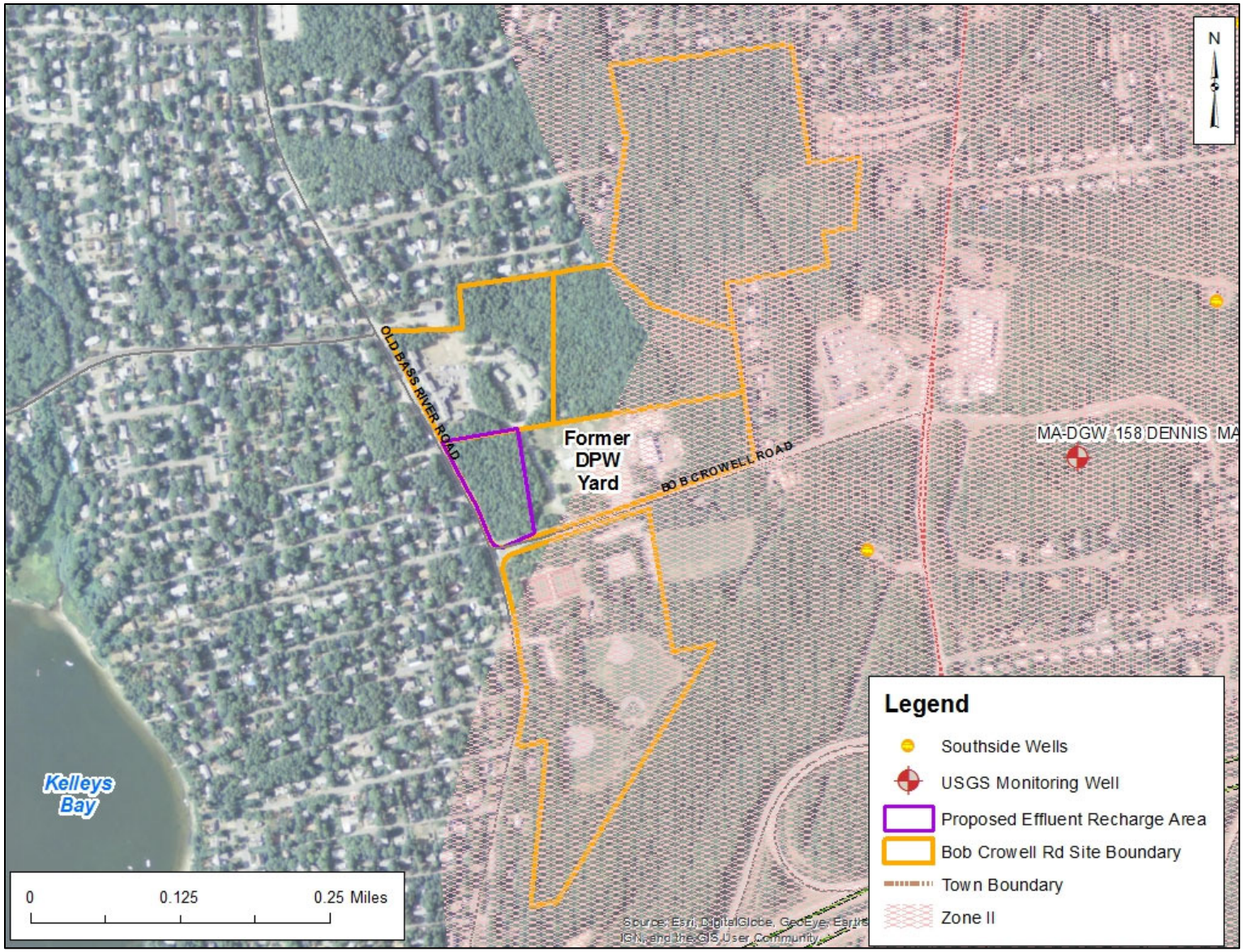


Figure 11-5 Site 2 - Bass River Effluent Recharge Site

Recharge from various forms of precipitation is the primary source of water to the aquifer system on a regional basis. On the Cape, about 45 inches of precipitation falls during an average year (LeBlanc and others, 1986) with generally over half reaching the groundwater table. The rest is lost to evapotranspiration and some minor runoff (generally minimal on Cape Cod due to sandy soils) as well as consumptive use through irrigation, commercial, and residential activities. This results in about 27 inches per year of recharge to the aquifer or about 137 million gallons per day (MGD) in the Monomoy Lens (USGS, 2004). Some have estimated that 5 to 10 percent of the water recharging the Cape Cod aquifer system is removed for water supply (Masterson and others, 1997), but most of the water is recharged back in the form of disposed wastewater from septic systems or other point discharges.

Groundwater elevation and flow direction was simulated in the proposed recharge areas using both steady-state and transient groundwater flow models. Steady-state groundwater models use average recharge and pumping conditions to simulate the average flow direction and groundwater elevation over time. Transient groundwater models vary the model boundaries to simulate changes in groundwater elevation and flow directions. This is important in Dennis since the groundwater table can rise and fall several feet in some locations during a typical year. For this evaluation, the recharge and pumping inputs were changed monthly. The values used represent the average pumping and recharge each month, so the transient model can be thought of a representing the variation in water table elevation during a typical year.

Four steady-state model simulations were initially completed to assess potential groundwater recharge capacity. Particle tracks were used with the steady-state flow fields to identify discharge locations. Complete discussion of model simulations and results is included in the site screening memo in **Appendix E**. Recharge simulations were conducted to simulate the wastewater flow rates developed as part of the CWMP, based on current wastewater flow estimates and build-out wastewater flow estimates. The model simulations are shown in **Table 11-2**:

Table 11-2 Initial Steady-State Effluent Recharge Model Simulations

Steady-State Model Simulation No.	Site	Watershed	Site Size (acres)	Wastewater Flows (gpd)	Loading Rates (gpd/ft^2)
1	1	Swan Pond River	8.7	575,000[1]	1.51
2	1	Swan Pond River	8.7	1,045,000[2]	2.75
3	2	Bass River	3.2	410,000[1]	1.51
4	2	Bass River	3.2	540,000[2]	3.86

Notes
1. Current wastewater flows
2. Build-out wastewater flows

After initial effluent recharge model simulations were performed, the model was then refined based on boring log data obtained from the landfill Comprehensive Site Assessment (CSA) documentation, the Vinland Road PRB study, the boring installed at Site 2 in 2016, and survey data and water level observations conducted in 2016. The model refinements, including simulation of clay layers beneath the sites, and model calibration are discussed in the model memo included in **Appendix E**. The calibrated steady-state model was then enhanced for transient simulation of typical seasonal variations through a year. The transient modeling used

monthly recharge from precipitation and septic system return flows and pumping withdrawals for an average year developed by the USGS (SIR 2015-5168). The transient model was used to assess the impacts of the significant seasonal variation in the proposed groundwater discharge area.

Five transient simulations were conducted and are shown in **Table 11-3**. A brief description of each simulation is below:

- Simulation 5 uses average annual flows specified in steady-state model simulations 1 and 3 (see Table 11-2) and spreads them across the potential discharge areas shown in Figures 11-1 and 11-5. Discharge for each month is calculated by multiplying the average annual discharge at the Site with a multiplier based on the reported Dennis pumping for that month. Monthly recharge varies from a low of 0.43 times the average annual pumping in February to a high of 2.34 times the average annual pumping in July. Return flows from septic systems were applied only in areas that are proposed to remain unsewered. Monthly pumping withdrawals and recharge from precipitation were taken from the calibrated model.

- Simulation 6 was conducted to assess the impact of increasing the proposed recharge rate at Site 1. No changes were made to Site 2. A higher recharge rate would allow for a smaller recharge area and move the recharge north. This would reduce the overall mound at off-site areas to the south of Site 1.

- Simulation 7 is similar to simulation 6 but the recharge area at Site 1 was moved to a parcel north of the site boundary. This would further reduce mounding at vernal pools and low-lying areas south of Site 1.

- Simulation 8 was conducted to evaluate the maximum potential monthly discharge at Site 2. The water table under Site 2 was constrained at a fixed elevation of 27 ft (approximately 6 feet below the lowest elevation on-site). The model then calculated the flux or recharge that was needed during each month at Site 2 in order to maintain the specified water table elevation. This represents a potential maximum discharge at Site 2. Discharge at Site 1 was based on simulation 6. Based on the maximum potential monthly discharge calculated in simulation 8, there is excess capacity at Site 2 to discharge flows from both Sites 1 and 2 during the winter months.

- Simulation 9 discharges flows from both Sites 1 and 2 at Site 2 during the winter months (October to April) and splits the flows between Sites 1 and 2 during the summer period based on the Simulation 6 flow assignments. Discharge of all flows at Site 2 during the winter would allow the groundwater table at Site 1 to drop and permit the vernal pools to dry out each year.

Table 11-3 Transient Effluent Recharge Model Simulations

Transient Model Simulation No.	Swan Pond River – Site 1		Bass River – Site 2		Simulation Description
	Area (acres)	Maximum Loading Rate [3] (gpd/ft²)	Area (acres)	Maximum Loading Rate [3] (gpd/ft²)	
5	8.95	3.45	2.75	7.99	Discharge at each site spread over entire potential recharge area
6	2.75	11.21	2.75	7.99	Discharge at Site 1 spread over smaller recharge area
7	2.75 [2]	11.21	2.75	7.99	Discharge at Site 1 moved to parcel to the North
8	2.75	11.21	2.75	8.40 [3]	Potential discharge at Site 2 calculated based on maintaining constant water table elevation
9	2.75	11.21	2.75	7.99	Discharge at Site 1 assigned to Site 2 during off-peak period (Oct – Apr)

Notes
1. Maximum Loading occurs in July except as noted
2. Recharge area located on parcel north of DPW site
3. Maximum potential load at Site 2 occurs in October

The impact of water table mounding is typically evaluated by plotting the "separation distance", or "depth-to-water" between the simulated water level with effluent loading and the ground surface. MassDEP requires a minimum vertical separation distance between the bottom of the recharge bed and the top of the maximum seasonal groundwater elevation plus mounding (i.e. maximum groundwater table) of four feet. This is a standard requirement of Title 5 systems (310 CMR 15) that MassDEP typically applies to all wastewater discharges to groundwater, i.e. recharge beds, regardless of the quality of the treated wastewater effluent. The depth to water will be addressed as part of the groundwater discharge permit application process. It is important to note that the use of recharge basins instead of septic systems will improve groundwater quality since the recharged water will be treated before discharge.

As discussed in Section 11.2, borings installed in December 2017 indicate that clay is more extensive and shallower at Site 1 than previously simulated in the transient MODFLOW model. The previous transient modeling simulated a saturated thickness above the clay of 30 feet. Revised boring logs indicate that the saturated thickness is 10 feet or less in some areas beneath the proposed recharge beds. The transient model was updated with a shallower representation of the clay to revise the recharge capacity estimates at Site 1. However, the fluctuation of the water table near and across the clay layer at Site 1 prevented the transient MODFLOW model to properly converge and reliably replicate the observed data.

An alternative approach to estimates mounding and impacts for Site 1 was developed, based on the previous steady-state and transient modeling, as well as analytical, desktop calculations of mounding using the Hantush method. Simulation of the mounding using the Hantush method assuming an initial saturated thickness of 30 feet, compared to the simulated mounding from the transient MODFLOW model produces very similar estimated mounding, as shown in Figure 11-6. The Hantush produces slightly higher mounding in the months when the water table is rising

(April to July) because the Hantush calculations were conducted as essentially steady-state solutions. Since the Hantush results are so similar to the prior transient modeling results, the Hantush method was used to revise the estimate of the site capacity at Site 1 due to the presence of a shallower clay layer.

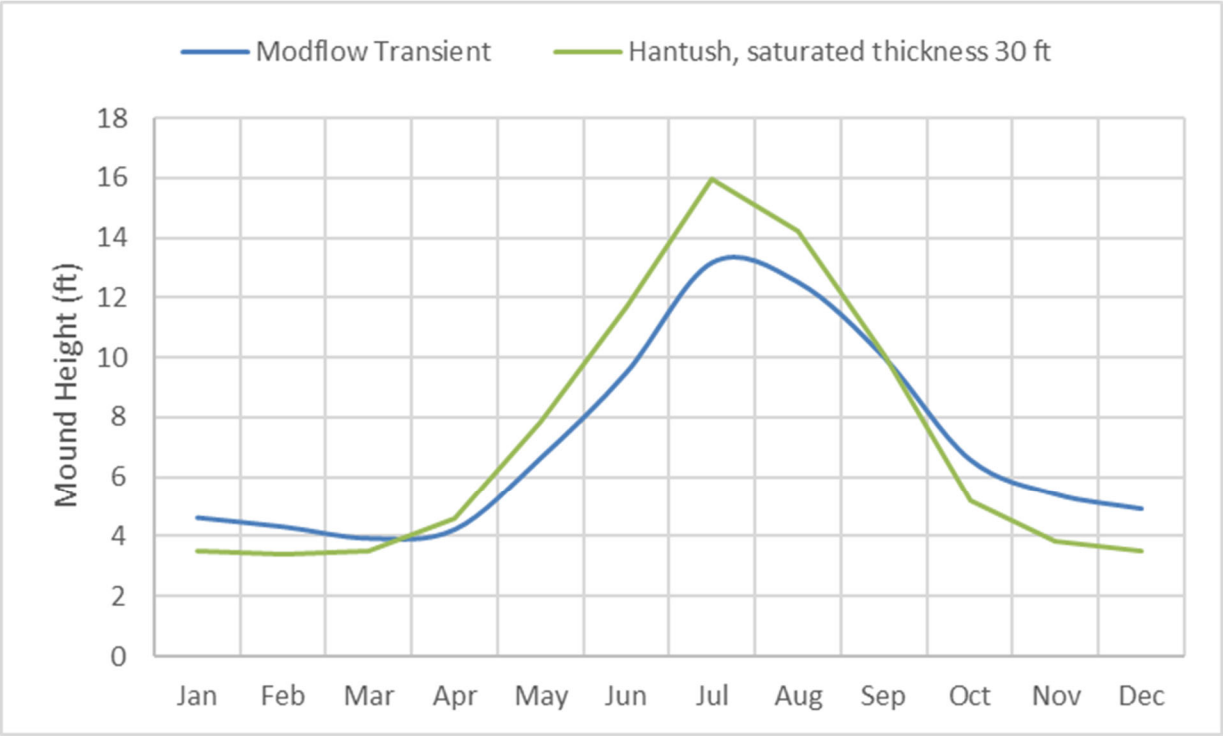


Figure 11-6 Comparison of Mounding (Site 1) for Transient Groundwater Model Simulations and Hantush Method Calculations with a Saturated Aquifer Thickness of 30 ft

11.4.1 Site 1 in Swan Pond River Watershed

Initial steady-state simulation indicates average mounding at Site 1, the Swan Pond River site, is around three feet for average effluent recharge flows of 575,000 gallons per day (gpd) and six feet for average effluent recharge flows of 1,045,0000 gpd. Particle tracks indicate that effluent from this site will discharge to the Swan Pond River, Herring River, and Swan Pond, as shown in **Figure 11-7** Recharge to the rivers and water bodies, shown on Figure 11-7, will not negatively impact the water quality to the surface waters because the recharged water is highly treated. The treated water will help to improve baseflows and dilute existing nitrogen loads to these waterbodies.

Transient simulations indicate the maximum groundwater mound will be over 10 feet during the highest recharge period in July, as shown in **Figure 11-8**. The colors on the figure show ranges of expected rise in the groundwater table, or mound, due to the proposed recharge. Based on estimated seasonal variation in flow, the July effluent recharge is estimated to be 1,340,000 gpd. The groundwater level at the former gravel pit south of the site may increase by almost two feet (blue/purple color on Figure 11-8), which would result in flooding and expansion of the existing groundwater pond in this area. Groundwater levels at the nearest vernal pool would potentially increase by several feet (orange color).

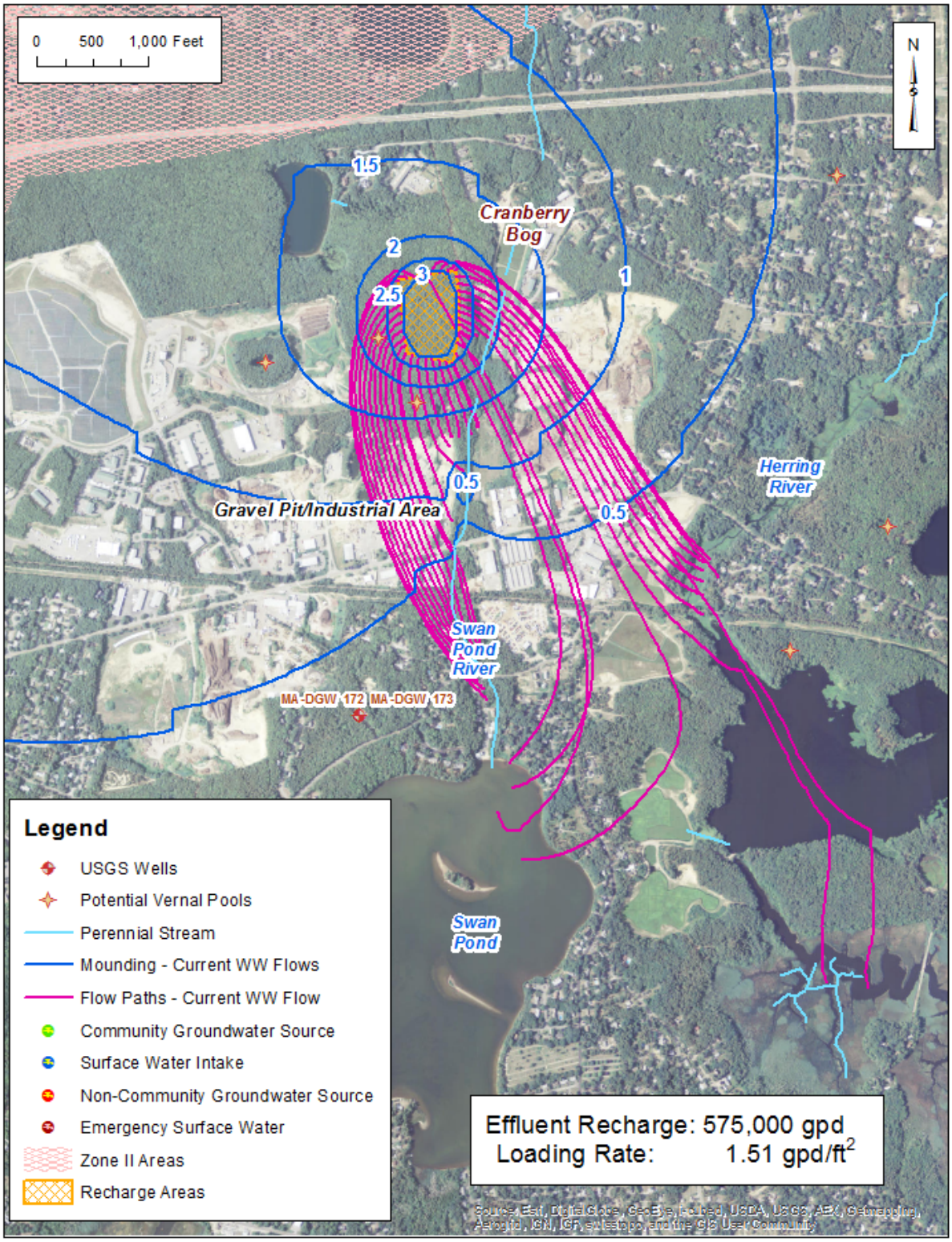


Figure 11-7 Site 1 (Swan Pond) Effluent Recharge, Current Flows – Average Mounding and Particle Flow Direction – Initial Steady-state Simulations

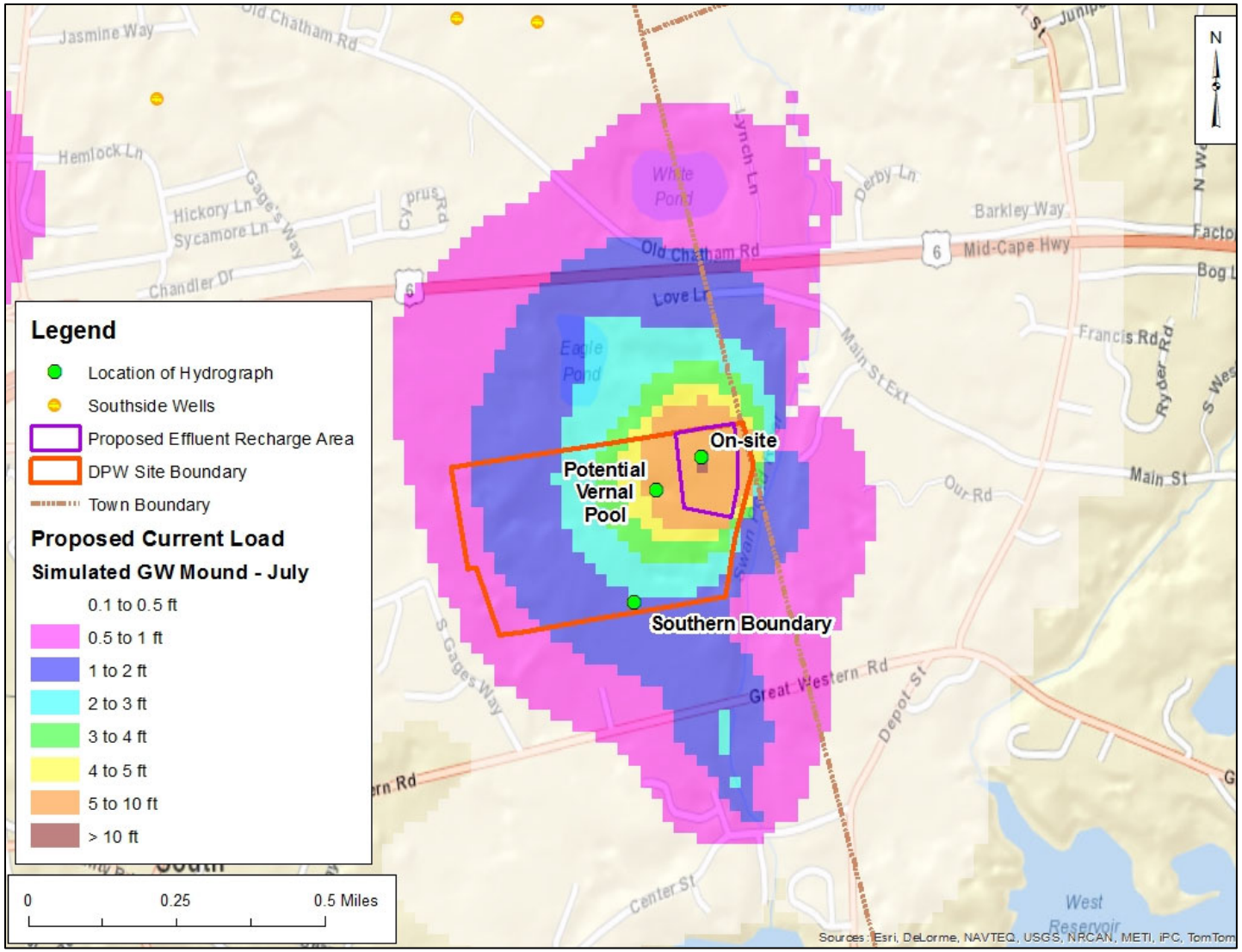


Figure 11-8 Site 1 (Swan Pond) Effluent Recharge – July Effluent Recharge of 1,340,000 gpd– Simulated Groundwater Mound with Hydrograph Locations

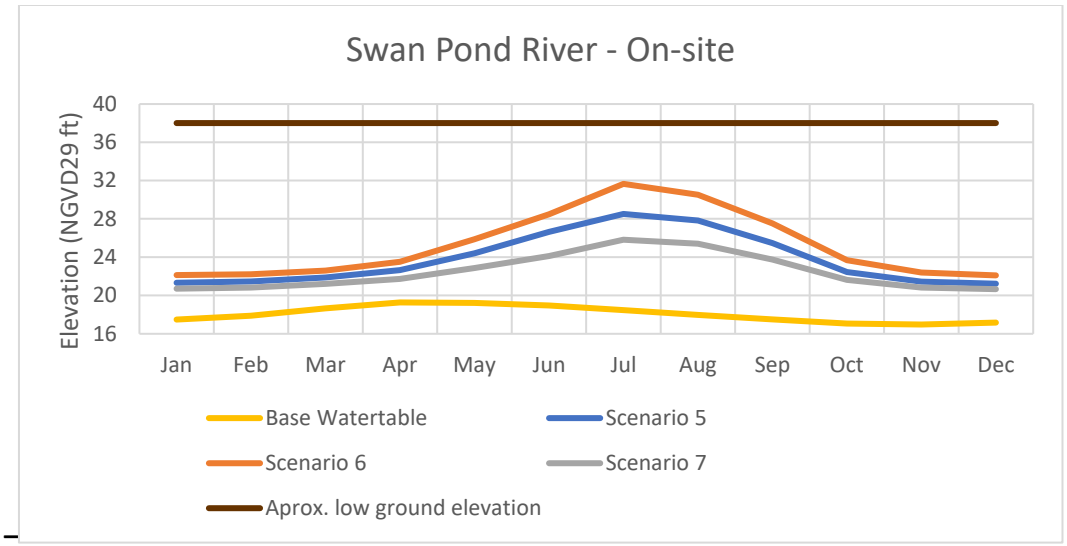
Since the seasonal fluctuations in water levels may be important at vernal pools, groundwater hydrographs were created at three locations, shown as green dots on Figure 11-8. These locations include a location near the recharge area, the location of a vernal pool, and a location at the southern boundary of the site. Hydrographs of monthly groundwater levels are shown in **Figure 11-9** for the base water table and Simulations 5, 6, and 7. Each hydrograph show the water elevation at the location under current conditions (yellow) line for each month simulation and the approximate elevation of the lowest ground elevation near the point (brown line). The base water table hydrograph shows that the water table is highest in the spring during April and May and lowest in the late fall. The scenarios are shown with colored lines as indicated on the figures. The hydrographs for the vernal pool and southern boundary show that the water table regularly rises to the ground surface in May under average year conditions. The addition of recharge raises the water table five feet above the ground surface at the vernal pool and over a foot at the southern boundary. Moving the recharge area to a smaller area and farther north (Simulations 6 and 7) does little to reduce the high water table.

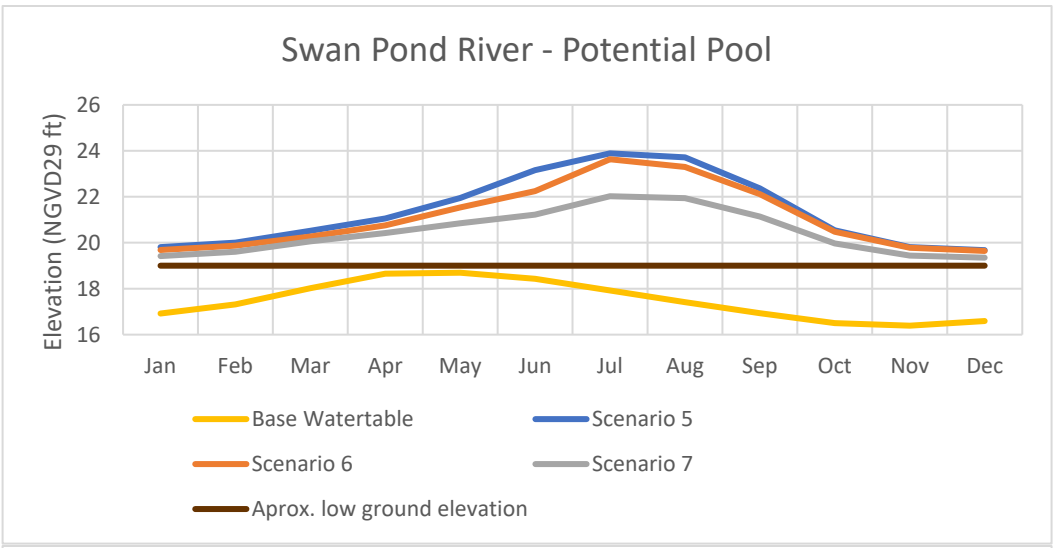
Figure 11-10 shows the hydrographs for Simulation 9 which moves flows during the winter season to Site 2. The reduction in flows still results in a water table which is elevated above base conditions due to the slow response time of the aquifer south of the site. However, shifting the flows in the winter allows the water table at the vernal pool to drop below the ground surface and reduces the overall mound at the southern boundary. Additional mitigation measures at the southern boundary to allow for seasonal flooding will still be needed as part of this scenario. Possible mitigation approaches include enlarging the existing pond, construction of wetlands to reduce nitrogen and increase evapotranspiration or simply allowing the low-lying areas to flood. Since vernal pools are based on the existence of particular species and the absence of predator species such as fish, they do not need to dry out for a specified time period, just long enough to prevent predator species from thriving. The scenario shown in Figure 11-10 is one possible solution which would allow the pools to dry out during the winter months and would prevent the predator species from surviving.

Clay encountered in borings at MW-1 and MW-2 at Site 1, along with the significant head difference measured vertically across the clay layer, indicate that local recharge will be forced to flow in the sediments above the clay, with an initial saturated aquifer thickness of around 10 feet. The Hantush method was used to revise the estimate of site recharge capacity. As discussed in Section 11.4 above, the Hantush method assuming an initial saturated thickness of 30 feet matches the estimates of mounding using the transient MODFLOW model with a similar saturated thickness. Therefore, the Hantush method can be adapted to the simulation of a 10-foot initial saturated thickness. The Hantush calculations indicate the peak site capacity is 0.788 MGD based on the assumption of the top of the mound reaching the ground surface during the peak recharge months. Assuming a peaking factor of 2.34, the average annual rate which can be discharged at the site would be 0.336 MGD. The Hantush method indicates that the groundwater mound beneath the recharge beds would be 9.3 ft.

11.4.2 Site 2 in Bass River Watershed

Initial steady-state simulations indicate that the average mounding at Site 2, the Bass River site, is around 4.5 feet for average effluent recharge flows of 410,000 gpd, as shown in **Figure 11-11**. Particle tracks indicate the recharged effluent discharges to the Bass River and is not captured by





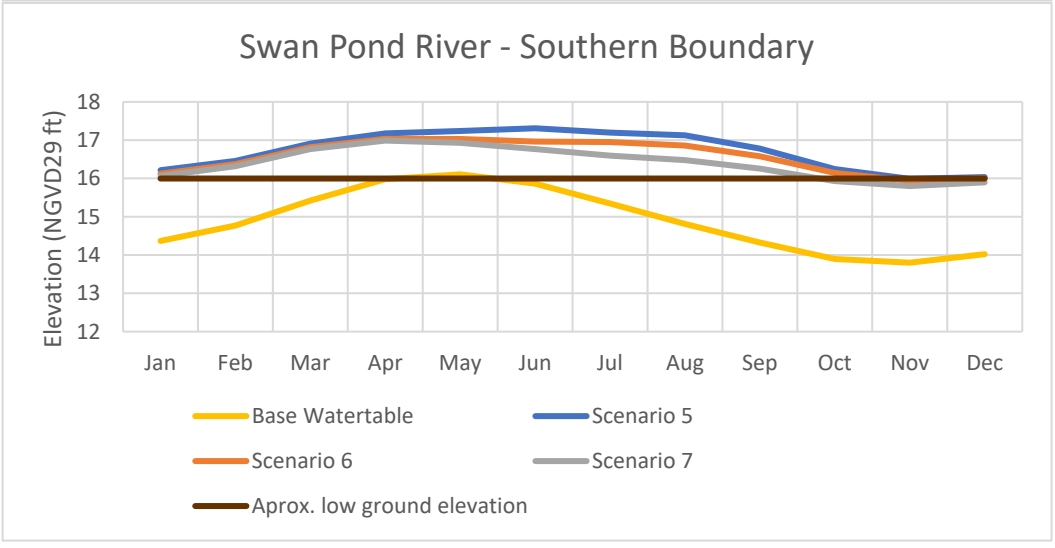


Figure 11-9 Site 1 (Swan Pond) Effluent Recharge, Hydrographs for Simulations 5, 6 and 7
Average Effluent Recharge: 575,000 gpd, July Peak Effluent Recharge: 1,340,000 gpd

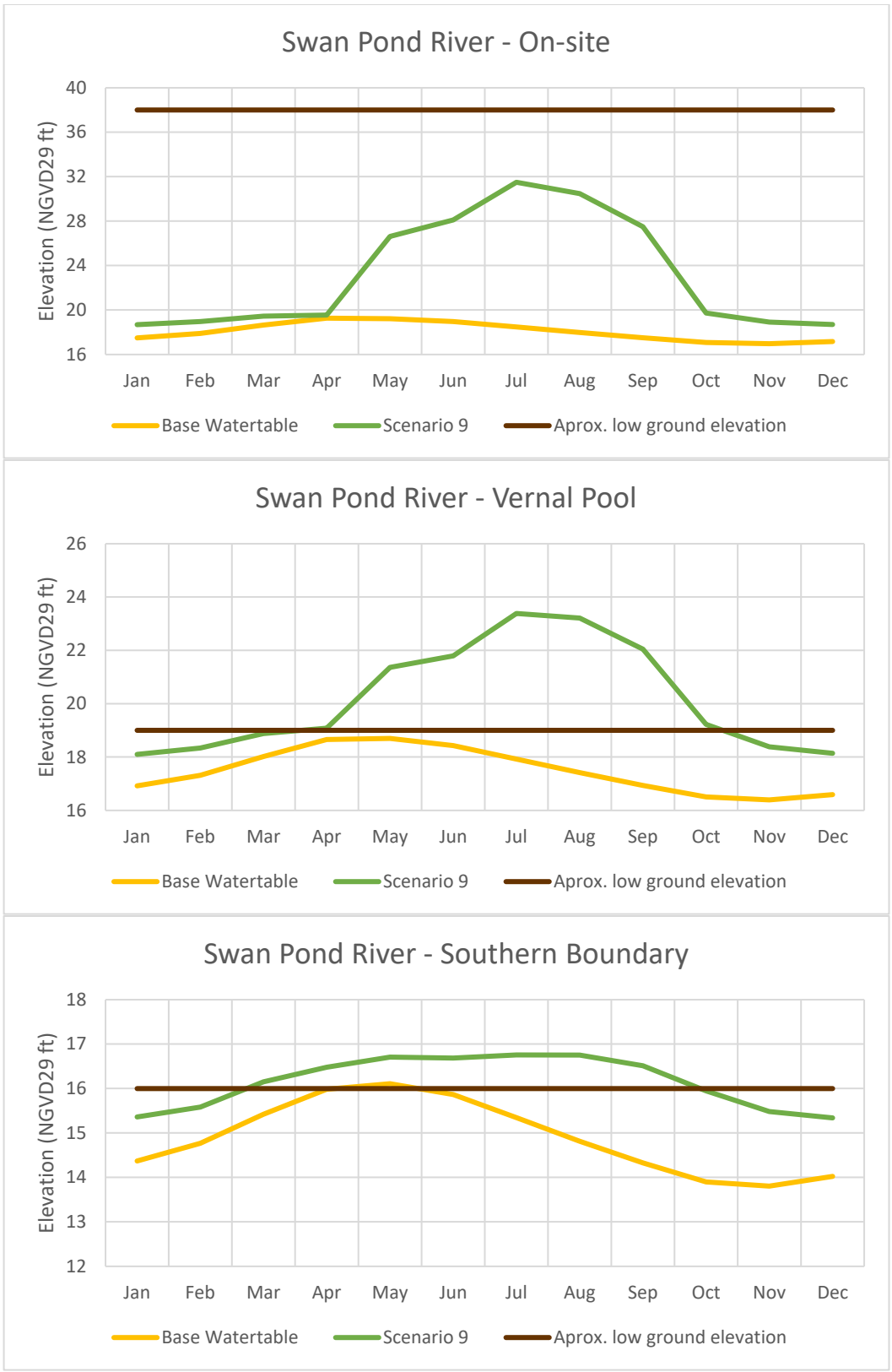


Figure 11-10 Site 1 (Swan Pond) Effluent Recharge, Hydrographs for Simulation 9 Winter Effluent Recharge: 0 gpd, July Peak Effluent Recharge: 1,340,000 gpd

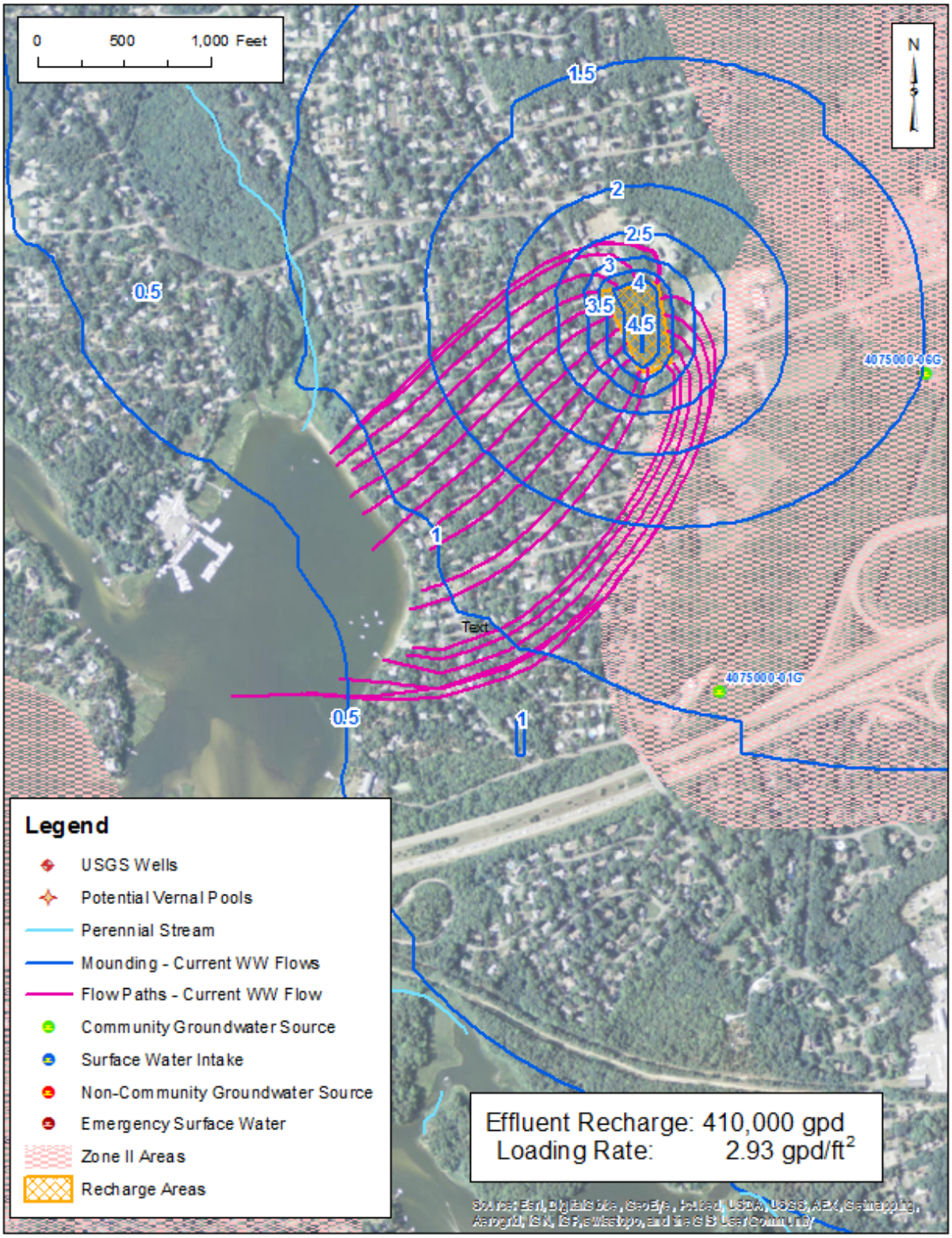


Figure 11-11 Site 2 (Bass River) Effluent Recharge, Current Flows – Average Mounding and Particle Flow Direction – Initial Steady-state Simulations

the public water supply wellfield 4075000-01G, which is located south of the site. It should be noted that this wellfield is pumping at a rate of 0.19 MGD in this simulation. Data obtained for 2013 and 2014 Dennis public water supply pumping indicate that a larger percentage of the overall water is supplied from the wells in the northern portion of Dennis than is simulated in the model. Model simulations should be conducted to test for potential impacts to this well under various recharge and pumping scenarios. The current simulation uses pumping data from 2003. It is important to note that the wastewater is highly treated and disinfected before recharge to the groundwater and will be cleaner than the current discharges from septic systems.

Transient simulations indicate the maximum groundwater mound will be over 10 feet during the highest recharge period in July as shown in **Figure 11-12**. Hydrographs were created at one location on-site, shown on Figure 11-12, to show seasonal fluctuations in water levels. Hydrographs of monthly groundwater levels are shown in **Figure 11-13** for the base water table and Simulations 5 and 9. Simulation 9 moves flows during the winter season to Site 2. The figure shows that higher flows can be discharged during the winter months without raising the water table to within 5 feet of the ground surface, below the Title 5 requirement. The MassDEP uses 5-foot separation distance specified in the Title 5 requirements for evaluation of groundwater recharge beds.

11.5 June 2016 CCC Grant Study

In June, 2016 the Town of Dennis received a grant from the Cape Cod Commission to conduct a study on assessing the potential for additional suitable effluent recharge sites within the town. The major components of this study included:

- Verifying, revising and/or expanding effluent site screening criteria used previously to identify potential sites as part of the Water Quality Evaluation and Mitigation Alternative Study Final Report completed in August 2015 (2015 Report);
- Developing a list of additional top rated sites with highest potential flow recharge capacity. The goal is to identify as a minimum, enough sites to recharge the estimated build-out flows from Scenario 7A as identified in the 2015 Report; and
- Completing an evaluation of additional top rated sites by visually reviewing each of the top sites to document surface conditions, surrounding area conditions and other unique site features; and using existing geological and soils information, develop a conceptual groundwater model for each site. The goal of the modeling is to determine order of magnitude flow potential for each site; potential groundwater mounding impacts, and to identify downgradient receptors.

Following completion of the expanded effluent screening criteria analysis, six new sites were identified for additional recharge analysis. In addition to Sites 1 and 2, the following sites were identified:

- **Site No. 3 (New) - S92:** Located north of Setucket Road, west of Greenland Circle and east of Route 134 (East-West Dennis Road), the northern section of the Dennis Pines Golf Course consists of 117.6 acres. It is located approximately 3 miles from the proposed location of

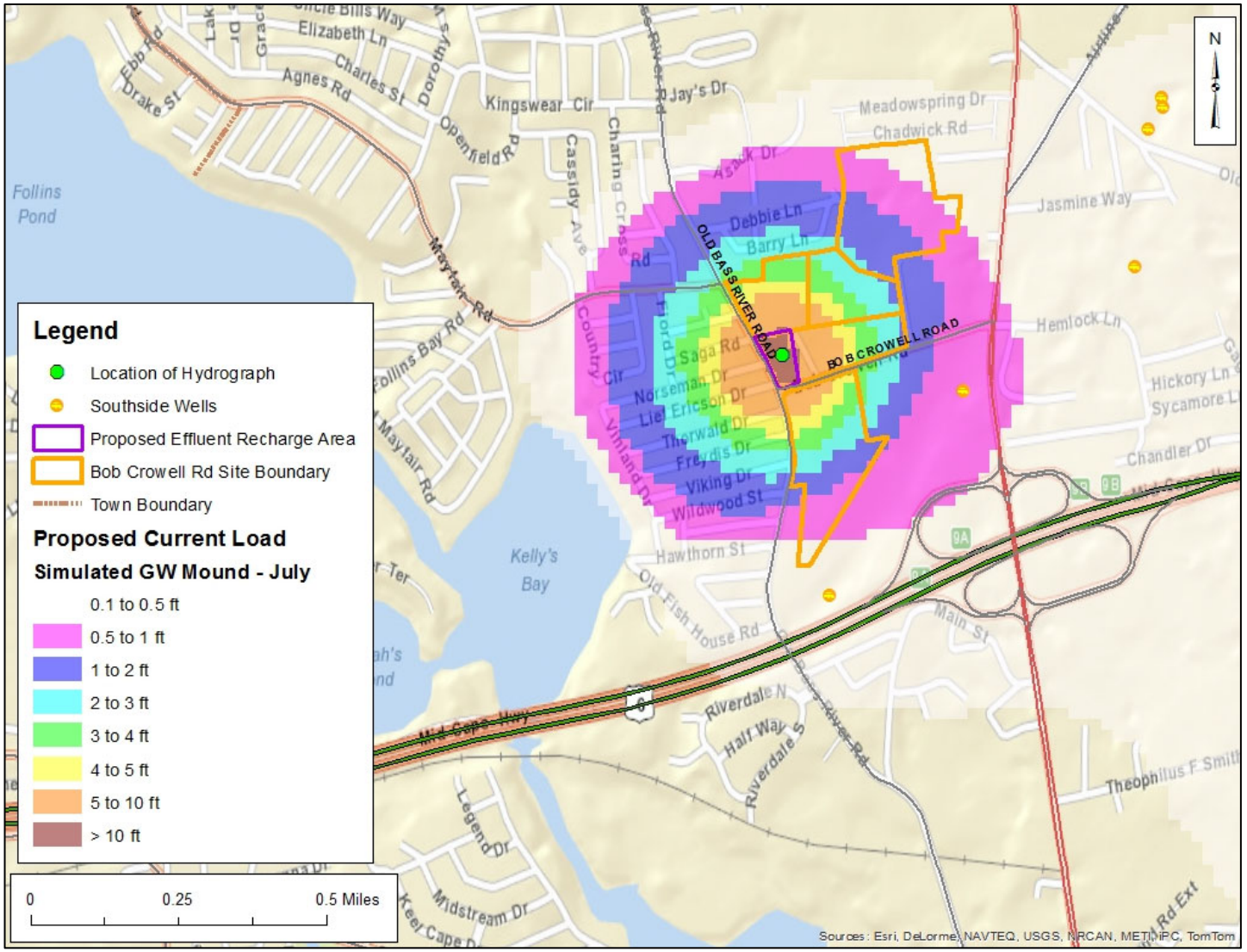


Figure 11-12 Site 2 (Bass River) Effluent Recharge, July Effluent Recharge of 960,000 gpd – Simulated Groundwater Mound with Hydrograph Location

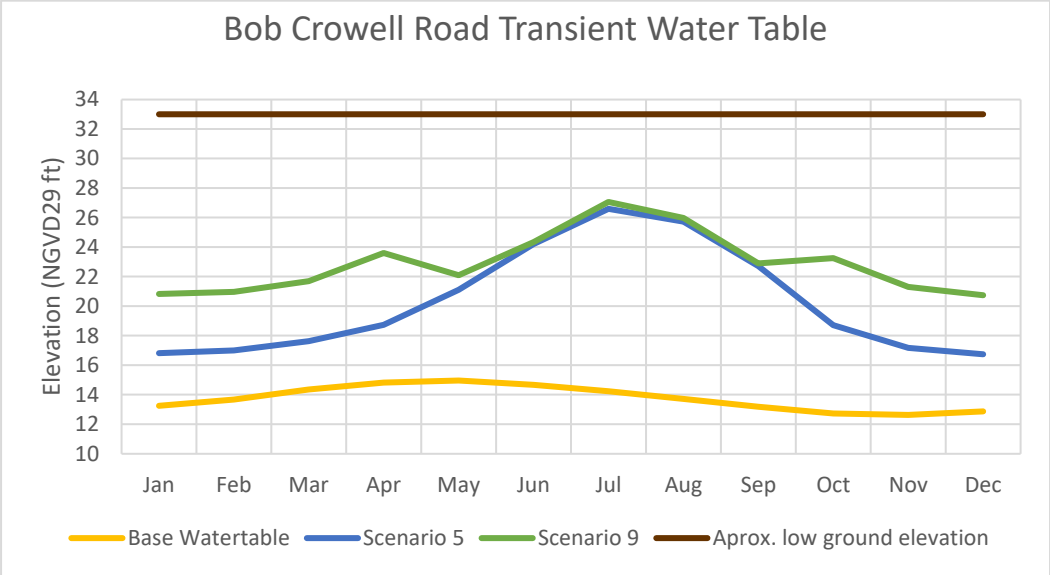


Figure 11-13 Site 2 (Bass River) Effluent Recharge, Hydrographs for Scenarios 5 and 9
Scenario 5 - Average Effluent Recharge: 410,000 gpd, July Peak Effluent Recharge: 960,000 gpd
Scenario 9 – Average Effluent Recharge: 580,000 gpd, July Peak Effluent Recharge: 960,00 gpd

the Dennis WWTF. While the town is proposing development of some of these parcels, subsurface leaching may be viable on portions of the site.

- **Site No. 4N/S - S39, S43, S6, S95, and S98:** Located north and south of Hokum Rock Road between Paddocks Path and Fox Run Circle, these four town-owned parcels and one privately-owned parcel are adjacent to one another and together total 45.5 acres. It is located approximately 3.5 miles from the proposed location of the Dennis WWTF.

- **Site No. 5 - S97:** Located south of Old Bass River Road and west of Ronda Lane, the northern section of the Dennis Highland Golf Course consists of 118 acres. It is located approximately 4 miles from the proposed location of the Dennis WWTF.

- **Site No. 6 - S62, S117 and S71:** Located in or adjacent to the Cape Cod Rail Trail right-of-way, these parcels are state or federally-owned. Combined these parcels total 25.8 acres and the proposed length spans approximately 2 miles. The site is located approximately between 0.5 miles at the closest point to 1.5 miles at the furthest point from the proposed location of the Dennis WWTF.

- **Site No. 7 - S112, S106, and S115:** Located south of Old Chatham Road, North of Route 6 and just west of Atlantic Avenue, these three private parcels consist of 24.3 acres. The site is located approximately 1 mile from the proposed location of the Dennis WWTF.

- **Site No. 8 - S50:** Located west of Route 134 and south of Old Chatham Road, the western, unused portion of Oak Ridge Cemetery consists of approximately 31 acres. It is located approximately 1.5 miles from the proposed location of the Dennis WWTF.

Recharge capacities for these sites are shown in **Table 11-4**. The full letter report can be found in **Appendix F**.

Previously identified Site Nos. 1 and 2 remain the recommended sites for effluent recharge the recommended wastewater management scenario (6A). The additional sites identified above serve as potential alternatives for the remaining areas of concern (AOCs) within the town as well as potential recharge locations for effluent in scenario 7A. Further assessment of these recharge sites would need to be performed in the future to better define actual recharge potential.

Table 11-4 Estimated Site Recharge Capacities for 2016 CC Grant Study

Site	Watershed	Site Size (acres)	Loading Rates (gpd/ft^2)	Time of Travel (years)	Potential Effluent Flow (MGD)
1st Model Run					
3 (new)	Sesuit Harbor	61.0	1.9	< 3	5.1
4N	Sesuit Harbor/Chase Garden Creek	8.8	4.1	~ 14	1.6
4S	Sesuit Harbor/Chase Garden Creek	14.1	8.1	< 4	5.0
5	Chase Garden Creek	48.7	3.5	< 1	7.4
6	Swan Pond	16.6	6.3	NA[1]	4.6
7	Swan Pond/Bass River	23.7	0.9	< 2	1.0
8	Bass River	16.3	3.6	< 3	2.5
2nd Model Run					
3	Sesuit Harbor	16.5	5.6	> 10	4.0
4N/S	Sesuit Harbor/Chase Garden Creek	22.9	2.1	> 10	2.1
5	Chase Garden Creek	20.2	4.5	~ 4	4.0
3rd Model Run					
3	Sesuit Harbor	16.5	1.9	Outside zone of contribution	1.4
4N/S	Sesuit Harbor/Chase Garden Creek	22.9	0.3	Outside zone of contribution	0.30
5	Chase Garden Creek	20.2	0.3	Outside zone of contribution	0.25

Notes

1. NA: Not applicable due to no nearby downstream drinking water wells

11.6 Conclusions and Recommendations

The model simulations indicate that effluent can be recharged for all months at the Swan Pond River site (Site 1) and Bob Crowell Road site (Site 2) for average annual wastewater flows of 336,000 gpd and 410,000 gpd respectively while maintaining the depth to water of approximately 4 feet that likely will be required by MassDEP. These sites have an estimated capacity, based on model simulations, to recharge peak flows in July of 788,000 gpd at Site 1 and 960,000 gpd at Site 2.

In addition to the criteria for depth to water beneath the recharge area, impacts to downgradient areas were reviewed as part of the hydrogeologic evaluation. Impacted resources include downgradient water users such as cranberry bogs, natural areas such as certified vernal pools, Zone II areas, low elevation areas and building basements. At the Bob Crowell Road site (Site 2) modeling and site walks did not identify any resources described above that would limit the disposal of treated wastewater. However, at the Swan Pond River site (Site 1), the modeling indicates concerns in regard to elevated water table at the cranberry bog east of the site, at vernal pools on-site and at an excavated area with ground surface elevation close to the existing water table south of the site. Mitigation options for these areas include recharge of all effluent at Site 2 during the winter months and negotiating to allow the low elevation area to flood during wet

periods. The transient modeling indicates that water levels at the vernal pools can be adjusted if effluent is discharged only at Site 2 for a few months. Model results must be verified with load testing, but results indicate that additional recharge capacity is needed for the peak usage months in the summer under current and build-out conditions.

In addition to Sites 1 and 2, three additional sites were selected as alternative discharge locations as part of the 2016 CC Grant Study. The total combined estimated average annual recharge capacity at the five identified sites is 2.7 MGD, shown in **Table 11-5**.

Table 11-5 Site Recharge Capacities for Selected Disposal Sites

Site	Watershed	Site Size (acres)	Loading Rates (gpd/ft^2)	Estimated Site Capacity (MGD)
1	Swan Pond River	8.7	0.9	0.3
2	Bass River	3.2	2.9	0.4
3	Sesuit Harbor	16.5	1.9	1.4
4N/S	Sesuit Harbor/Chase Garden Creek	22.9	0.3	0.30
5	Chase Garden Creek	20.2	0.3	0.25

Prior to final design, the following steps are recommended:

- Information should be obtained about the cranberry bog located to the East of Site 1 on the Swan Pond River. Information about water levels required for bog operations and bog construction would help assess potential impacts to these bogs.
- Collection of synoptic water level measurements on a monthly basis should be continued to provide data on baseline conditions prior to project start-up
- Geophysical methods should be used to map the depth to clay in areas beneath proposed bed areas. This will allow for determination of the depth continuity of the clay and water table and allow for optimization of recharge bed location.
- Load testing at multiple rates should be conducted before and during system start-up. Water levels should be measured in wells and in adjacent water bodies to assess groundwater mounding and flow directions.
- The regional USGS model has undergone revisions to address the water table fluctuations by setting model layer elevations to bracket the water table (Walter et al, 2016, SIR 2016-5058). This model should be updated with information collected on the clay location, used for optimization of bed location and for final determination of site capacity as part of the groundwater permit application process.

Section 12

Collection, Treatment, and Effluent Recharge System Evaluations

12.1 Purpose and Scope

This section evaluates the wastewater scenarios recommended for further study as identified in Section 10. The evaluation includes an analysis of various types of sewer collection systems, treatment systems and recharge systems that are considered suitable for the flows and treatment levels required in these scenarios. The scenarios include:

- 3B - Aquaculture, I/A systems, Sewer with PRB, 2 WWTPs and 2 recharge sites;
- 5A - Aquaculture, Sewer without PRB, 1 WWTP and 2 recharge sites;
- 5B – Aquaculture, Sewer without PRB, 2 WWTPs and 2 recharge site;
- 6A- Aquaculture, Sewer with PRB (including planning districts), 1 WWTP, and 2 recharge sites (basis of community partnership scenarios);
- 6B – Aquaculture, Sewer with PRB (including planning districts), 2 WWTPs and 2 recharge sites;
- 8A – Dennis' Scenario 6A with Yarmouth, one shared WWTP in Yarmouth, recharge in Dennis and Yarmouth
- 8B – Dennis' Scenario 6A with Harwich, one shared WWTP in Dennis, recharge in Dennis and Harwich; and
- 8C – Dennis' Scenario 6A with Harwich and Yarmouth, one shared WWTP in Dennis, recharge in Dennis, Harwich, and Yarmouth.

In preparation for the Draft CWMP filing in 2017, capital and operation and maintenance costs are generated for each scenario. Costs presented herein were used for comparative purposes. Updated system flows and loads as well as costs for the Recommended Plan are included in Section 14.

12.2 Collection System Technologies

Dennis currently has no municipal sewers. When evaluating the most cost-effective long-term collection system technology, the important variables to consider include the density of the area being sewered, the topography of the area, climatic conditions, whether high groundwater exists, the variability of the wastewater flows to be collected both daily and seasonally, and the amount of labor and associated equipment required to maintain a sewer system. The intent of this section is to present some of the more common types of sewers in use, discuss the advantages and

disadvantages of each type, and recommend a collection system type. Based on this recommendation, a conceptual level sewer collection system and planning level costs are developed. This approach provides a guide for implementing the overall system, however detailed decisions on the type and extent of sewer and the exact layout would not be made until the final design phase.

12.2.1 Types of Sewer Collection System Technologies

There are several types of sewer collection system technologies available, however the technologies that appear most feasible for consideration in Dennis are described below. The advantages and disadvantages of each are discussed with the intent of screening down to the type to be utilized in developing the Dennis sewer collection system master plan.

The five sewer collection system types evaluated for Dennis are as follows:

- Conventional gravity sewers
- Low pressure sewers
- Vacuum sewer
- STEP or STEG systems
- Hybrid systems

12.2.1.1 Conventional Gravity Sewers

Conventional gravity sewers are the most common and simple form of wastewater collection. The technology relies on installing sewer pipes at constant downhill slopes. Pipe diameter sizes and slopes are designed to maintain adequate velocities that keep solids suspended within the conveyed wastewater. Conventional gravity sewers typically start with a minimum pipe diameter of 8 inches to ease equipment access during maintenance. Downstream pipe sizes increase proportionately as flow is collected. Gravity connections can be used from the house to the main sewer pipe in the road or right-of-way (ROW) and are typically 6 inches. Homes abutting a gravity sewer that cannot connect by gravity due to elevation differences can pump up to the gravity pipe using a 1- to 2-inch force main as an alternate connection means. Most main sewer pipes are buried 8 feet deep to allow for gravity house connections and to avoid other utilities in the road; however, this depth changes with topography. Manholes are periodically located in the main sewer pipelines to allow for maintenance access. Flows collected at low points require a pumping station to be installed to convey the wastewater to another gravity sewer or to an appropriate treatment facility. Areas where topography changes frequently can require pumping stations that can significantly impact the cost and maintenance requirements for conventional gravity sewers.

Advantages:

- Typically requires the least amount of energy to operate and works during power outages
- Least amount of system maintenance required
- A well designed system can handle greater flow fluctuations (seasonal and infilling)

- Can accept pressurized flows discharged to it
- Simple system to expand to service additional areas or receive flows from adjacent areas
- Most municipalities have staff familiar with this type of pipe construction and network

Disadvantages:

- Requirement for constant slope pipes in changing topographic areas can lead to a costly number of pumping stations
- Constant slope pipes can lead to deep sewer pipes.
- In high groundwater areas, infiltration into the pipes can lead to costly conveyance and treatment of non-wastewater.
- In low flow periods, the potential for odors may occur.

An alternate to conventional gravity sewers is a system that essentially operates in the same manner but utilizes smaller diameter pipes and shallower slopes relying on peak flows to flush the system. This unconventional gravity sewer system has been utilized with limited success and is not recommended for widespread use in Dennis.

12.2.1.2 Low Pressure Sewers

Low pressure sewers require each home or small cluster of homes to have a grinder pump which moves wastewater into a low pressure force main located in the road or right of way (ROW). Wastewater from the home flows by gravity into the pump chamber where the pump starts once the flow volume reaches a specific capacity. The wastewater is then conveyed out into a smaller diameter (1.25- to 4-inch) pipeline network installed at a 5 to 6 foot depth. Rather than manholes, air release and flow isolation valves are installed within the mainline piping network. Typically, individual homeowners are responsible for the long-term maintenance of the grinder pump. Monthly power usage, which is also the responsibility of the property owner, is typically the same as that required to operate a small kitchen appliance. With grinder pump systems, extended power outages have the potential to cause sewer backups unless provisions for connection to a portable generator are incorporated into the design of the system.

Advantages:

- Cheaper pipeline system to install than conventional gravity systems due to smaller diameter pipes at shallower depth
- Water tight system prevents infiltration/inflow (I/I) from occurring
- Can more readily service areas with changing topography or with minimal slopes
- Less disruption to areas during construction

Disadvantages:

- Requires a mechanical component (pump) at each major connection to discharge to and operate the sewer system

- Typically overall higher energy use
- Less flexibility in future system expansion
- Requires specialized operator training for the system and regular maintenance of the grinder pump units
- More sensitive to wastewater flow fluctuations (daily and seasonal)
- Prolonged power outages can lead to sanitary issues if backup power is not provided

12.2.1.3 Vacuum Sewers

Vacuum sewer collection system technology has been used for over 100 years. In the late 1960s, vacuum technology was expanded to municipal wastewater collection systems and has expanded more recently. More than 200 systems are in operation nationwide. On Cape Cod, the towns of Provincetown and Barnstable both use vacuum sewer system technology.

Vacuum sewer systems have three components: valve pits, vacuum pipelines, and vacuum/pumping stations. Wastewater flows from each property via gravity to a valve pit that typically serves one to four homes. When a sufficient volume of wastewater builds up in the valve pit, the valve opens and allows the wastewater to be drawn into the mainline. A vacuum pump located at a main vacuum/pumping station pumps air out of the pipeline network creating the vacuum inside the pipes. Vacuum mains typically range in size from 4 to 10 inches in diameter, depending on the number of homes served and the distance from the vacuum station. Similar to low pressure sewers, vacuum mains can be installed at shallow depths and follow existing topography. Isolation valves are also installed periodically along main sewer lines for accessibility during maintenance of individual pipe segments.

The main component of a vacuum sewer conveyance system is a vacuum pumping station. This station must be centrally located within the system to minimize the length of vacuum mains. Equipment within the station includes vacuum pumps, a collection tank, and wastewater pumps. Vacuum pumps maintain suction in collection mains, delivering wastewater to the collection tank, while wastewater pumps convey sewage from the collection tank to another collection system segment or directly to the treatment facility. The only power demands for a vacuum system are at the vacuum/pumping station. Typical service areas range from 500 to 1,200 homes per vacuum station. This number is limited by the capacity of the vacuum pumps, which can produce enough vacuum to overcome 15 to 20 feet of hydraulic head in the collection system.

Typical maintenance issues for vacuum sewers include valve pits where valves may become clogged and stuck in the open position. This triggers a low vacuum pressure alarm at the pumping station and can easily be rectified. Since valve pits are normally installed in the town's right-of-way and are town-owned and maintained, this maintenance would be the responsibility of the town. Property owner responsibility is limited to the gravity connections on their individual lots, essentially equivalent to the responsibility with conventional gravity collection systems. The pressurized portion of vacuum systems is not susceptible to leaks from groundwater infiltration, because it is a closed system.

Advantages:

- Similar to low pressure sewers, typically less costly to install than conventional gravity sewers due to smaller pipes and shallower depths of pipe installation
- Fewer mechanical components than a low pressure sewer system
- Less potential for infiltration of groundwater unless system breaks occur
- The main vacuum/pumping station can be equipped with backup power during power outages allowing the overall sewer system to continue operating
- Less disruption to areas during construction

Disadvantages:

- Less flexible and more sensitive to wastewater flow fluctuations
- Requires constant vacuum to be maintained for whole system to work properly
- Limited to relatively flat topographic areas
- Requires specialized operator training in order to provide adequate system monitoring and response times when problems develop
- Less flexible for future system expansion

12.2.1.4 STEP or STEG Systems

Most homeowners and businesses in Dennis currently have a Title 5 septic system on their property for wastewater disposal. Title 5 system regulations were enacted in 1977 and required a two-part system consisting of a septic tank at the front end for solids removal followed by an effluent recharge or liquid disposal field. Other communities have tried to utilize this existing infrastructure and incorporate it into the development of a sewer system. Two different types of uses have emerged as discussed below.

A Septic Tank Effluent Pumping (STEP) system involves the installation of an effluent pump in the back end of the septic tank or in a separate pumping chamber after the septic tank. The pump conveys the lower solids wastewater to a pressurized piping network similar to a low pressure sewer system. Periodically, about every 3 to 5 years, the septic tank is inspected and the solids removed for treatment at the wastewater treatment facility. Regular maintenance of the pump is required by the homeowner.

A Septic Tank Effluent Gravity (STEG) system operates similar to a Title 5 system except that the effluent is conveyed by gravity to a smaller diameter unconventional gravity sewer system. Similar to a STEP system, about every 3 to 5 years, the septic tank is inspected and the solids removed for treatment at the wastewater treatment facility.

An example of a wastewater STE system producer is Orenco Systems® Inc.

The Town of Dennis reviewed the Town of Orleans analysis[1] of STEP/STEG systems (STE). The town's analysis compared STE versus a full conventional sewer system. The Orleans analysis noted that STE technology is typically used for smaller systems. Under Orleans' decentralized STE scenario, more properties required sewering than under the conventional sewer scenario and more than twice the amount of individual property pumps were required. This significantly increased the capital cost of infrastructure on each individual lot. Additionally, the O&M costs associated with the STE system were nearly double that of a centralized hybrid system.

The Town of Orleans calculated an equivalent uniform annual cost (EUAC) for both centralized hybrid and a decentralized STE system. The decentralized STE system would cost Orleans approximately $1.15 Million more than a centralized hybrid system each year. Because of the higher annual costs associated with a decentralized STE system, the Town of Orleans chose to move forward with a centralized hybrid system.

Advantages:

- Potential to re-utilize an existing new septic tank (must be water tight)
- Fewer solids are transported in the sewer system minimizing potential for blockages
- STEP has similar advantages to a low pressure sewer system.
- STEG has similar advantages to an unconventional gravity sewer system.

Disadvantages:

- The solids (septage) must be pumped periodically from individual septic tanks.
- Odor and corrosion issues are common with these types of systems.
- These systems are typically small, and are not effective as a town-wide solution.
- Treatment plant design is more difficult due to the dilute waste stream without organics needed for biological nutrient removal and the need to increase the size of septage receiving facilities.
- Difficult to assess water tightness of existing septic tanks.
- STEP has similar disadvantages to a low pressure sewer system.
- STEG has similar disadvantages to an unconventional gravity sewer system. Gravity system relies on topography and will require an increased number of individual pumps.

The Town of Dennis may consider using a STE system instead of installing a grinder pump system where applicable. This will be considered on an individual parcel basis during the design phase.

12.2.1.5 Hybrid Systems

In many communities, the combination of wastewater flow fluctuations, hilly and flat areas, high and low groundwater conditions and the sequencing of sewer construction over several phases can result in a combination of sewer system technologies being used. This combination of sewer

[1] Orleans: http://www.town.orleans.ma.us/sites/orleansma/files/file/file/tech-review-2012-04-18.pdf

systems, or a hybrid system, utilizes the most cost-effective and efficient technology in a given area.

Conventional gravity sewer systems are often the backbone of a hybrid system due to their ability to accept wider flow fluctuations and to be expanded in the future. Low pressure sewer systems or vacuum systems often supplement the gravity systems to help offset deep sewer construction, additional pumping stations and extraneous flows (I/I). STEP systems could be utilized in localized areas but STEG systems would not be used as it would be mixing flows with and without solids, negating the benefits of smaller pipes.

12.2.2Recommended Collection System Technology

The town of Dennis evaluated the collection system technology options and has chosen to develop a hybrid system of gravity sewers, pressure sewers, and vacuum sewers. Each system type will be applied in the appropriate location, allowing each technology to take advantage of the natural geography and topography in Dennis.

12.3 Wastewater Flow Estimates

In Section 8, preliminary wastewater flow projections were developed for all of Dennis for the development of a recommended wastewater program. The wastewater flow estimates presented here are specific to the wastewater scenarios chosen for further evaluation.

Existing and build-out wastewater flows were estimated for Bass River, Herring River, Swan Pond River, and Direct Discharge areas for each of the scenarios. As detailed in Section 8, the wastewater flows were estimated to be 90 percent of the water consumption for a given parcel excluding summer irrigation.

12.3.1 Build-out Wastewater Flow Estimates

Build-out wastewater flows were calculated using the Massachusetts Estuaries Project (MEP) model. The MEP developed a build-out estimate for the town as part of its nitrogen loading model. The build-out estimate took into account the town's planning projections with input from town planner and current zoning and land use classifications. These MEP build-out estimates have been reviewed and approved by the Dennis' Planning Department. The MEP build-out estimates were utilized in the comparison of all scenarios under consideration.

Section 12.3.3 below presents the wastewater flows estimated for each area proposed to be sewered, under both current and build-out conditions. The entire sewer service area is expected to have an initial daily average wastewater flow of between 0.74 to 0.78 mgd and a build-out daily average wastewater flow of 1.19 to 1.24 mgd. More detailed flow estimates are presented in **Table 12-1**.

12.3.2 Infiltration and Inflow

Infiltration is only a concern in the gravity pipe sewer areas. Infiltration occurs due to groundwater entering the sewer through pipe joints over time, house service connections, defective pipes and manholes. *Technical Review - 16, Guide for the Design of Wastewater Treatment Works*, prepared by the New England Interstate Water Pollution Control Commission, recommends an average infiltration estimate for gravity sewers of 250 gallons per day per inch-

diameter-mile for new pipe (gpd/idm), and as the sewers age that estimate increases to 500 gpd/idm. This is similar to the MassDEP CWMP guidelines, which suggest 200 and 500 gpd/idm for new and older sewers, respectively. The more conservative estimate has been used at this time due to high groundwater conditions in some areas to be sewered in Dennis. Actual infiltration flows will change as the groundwater table elevation fluctuates throughout the year.

Inflow can occur in older sewer systems due to illegal connections from roof leaders, sump pumps, foundation drains, and surface drains connected to the sewer. It can also occur due to cross-connections with storm drains and catch basins. Because the proposed sewer system will be a new sewer system, no inflow should occur. Efforts will be made to prevent these illegal connections during and after the start-up of the sewer system. Extensive public education regarding illegal inflow will accompany sewer connection information for residents and businesses to ensure the public understands the issue and the ramifications of making illegal connections. The town will require each parcel owner seeking a tie-in permit to sign a form acknowledging that they were informed about illegal connections and that they will not connect their sump pumps, downspouts, etc., to their sewer services. The form will also have them acknowledge that they were informed that it is against the State Plumbing Code, as well as local sewer use ordinances.

The additional flow from I/I is expected to be between 134,000 and 437,000 gpd.

In addition to projected wastewater flows, Table 12-1 includes the additional flow anticipated from infiltration for the entire sewer service area.

12.3.3 Summary of Flows

Table 12-1 summarizes the annual average daily flows associated with the scenarios being considered.

Table 12-1 Summary of Wastewater Flows

Scenario	Number of Parcels Being Sewered	Current Average Annual Wastewater Flow (gpd)	Current Average Estimated I/I Flow (gpd)	Total Current Average Daily Flow (gpd)	Build-out Average Annual Wastewater Flow (gpd)	Build-out Average Estimated I/I Flow (gpd)	Total Build-out Average Daily Flow (gpd)
3B	5,815	784,000	134,000	918,000	1,239,000	268,000	1,507,000
5A/5B	6,114	760,000	173,000	933,000	1,146,000	345,000	1,491,000
6A/6B/ 8A/8B/8C	6,276	747,000	219,000	966,000	1,117,000	437,000	1,554,000

12.3.4 Peaking Factors

To develop flows for pipe and pumping station sizing, peaking factors were applied to the current and build-out wastewater flows for each area, using flow curves from the Cape Cod Commission's 208 Plan for determining the ratio between average daily and peak hour wastewater flows. In addition, the ratio of summer (June, July and August) to annual average daily flow was determined to be 2.02 from monthly municipal well pumping records. To evaluate low flows, the ratio of winter to annual average daily flow was determined to be 0.43. Peak hour infiltration was

estimated at 1.75 times the average daily infiltration. Each of these factors will be used to refine collection system pipe sizing and pumping station selection and sizing.

12.4 Sewer Collection System Layouts

Utilizing the recommended hybrid system approach, preliminary layouts for wastewater program scenarios were developed. These layouts reflect the updated wastewater collection system areas that are needed to meet MEP watershed goals under build-out wastewater flows.

12.4.1 Sewer Collection System for Scenario 3B

The sewer collection system layout for scenario 3B is presented in **Figure 12-1**. In this scenario, the total number of parcels sewered is 5,815 and the total build-out flow, based on average wastewater flow, is about 1.24 mgd. The amount of infiltration/inflow from the gravity pipes at build-out is estimated to be an additional 268,000 gpd.

Sewering for Scenario 3B would consist of collecting wastewater from each residential area through local pipe networks utilizing conventional gravity pipes, pumping stations, low pressure sewers, and vacuum sewers. The proposed gravity system utilizes approximately 27 miles of gravity pipes, 26 miles of pressure sewer, 20 miles of vacuum sewer, and 1 mile of force mains ranging in size from 4-inches to 18-inches. The system contains approximately 20 pumping stations to convey the wastewater to the two treatment facilities, which will process all collected wastewater for the town and recharge at each of the two sites. The treatment facilities are located at Site 1 in Swan Pond and the second at Site 2 in Bass River.

12.4.2 Sewer Collection System for Scenarios 5A and 5B

The sewer collection system layout for scenarios 5A and 5B are presented in Figure 12-2. Under these two scenarios, the sewer footprint is the same in both A & B, but the number of treatment plants differ under each scenario. The total number of parcels sewered is 6,114 and the total build-out flow, based on average wastewater flow, is about 1.15 mgd. The amount of infiltration/inflow from the gravity pipes at build-out is estimated to be an additional 345,000 gpd.

Sewering for Scenarios 5A and 5B would consist of collecting wastewater from each residential area through local pipe networks utilizing conventional gravity pipes, pumping stations, low pressure sewers, and vacuum sewers. The proposed gravity system utilizes approximately 32 miles of gravity pipes, 28 miles of pressure sewer, 21 miles of vacuum sewer, and 2.5 miles of force mains ranging in size from 4-inches to 18-inches. The system contains approximately 21 pumping stations in Scenario 5A and 20 pumping stations in Scenario 5B to convey the wastewater to the treatment facilities. Under Scenario 5A, there would be one wastewater treatment facility at Site 1 in Swan Pond, and recharge would take place at both Site 1 and Site 2. Under Scenario 5B, there would be two treatment facilities, one at Site 1 in Swan Pond and the second at Site 2 in Bass River, and recharge at each of the two site.

12.4.3 Sewer Collection System for Scenarios 6A, 6B, 8A, 8B, and 8C

The sewer collection system layout for scenarios 6A, 6B, 8A, 8B, and 8C are presented in Figure 12-3. Under these scenarios, the sewer footprint is the same and the number of treatment plants differ under each scenario. These scenarios incorporate sewering in the economic development

areas of Dennis. The total number of parcels sewered is 6,276 and the total build-out flow, based on average wastewater flow, is about 1.12 mgd. The amount of infiltration/inflow from the gravity pipes at build-out is estimated to be an additional 437,000 gpd.

Sewering in scenarios 6A, 6B, 8A, 8B, and 8C would consist of collecting wastewater from each residential area through local pipe networks utilizing conventional gravity pipes, pumping stations, low pressure sewers, and vacuum sewers. The proposed gravity system utilizes approximately 41 miles of gravity pipes, 27 miles of pressure sewer, 21 miles of vacuum sewer, and 3.5 miles of force mains ranging in size from 4-inches to 18-inches. The system contains approximately 24 pumping stations in Scenario 6B and 25 in Scenarios 6A, 8A, 8B, and 8C to convey the wastewater to the treatment facilities. Under Scenario 6A, there would be one wastewater treatment facility at Site 1 in Swan Pond, and recharge would take place at both Site 1 and Site 2. Under Scenario 6B, there would be two treatment facilities, one at Site 1 in Swan Pond and the second at Site 2 in Bass River, and recharge at each of the two sites. Under Scenario 8A, the wastewater would be conveyed to a shared treatment facility in Yarmouth, and conveyed back to Dennis' Sites 1 and 2 for recharge. Under Scenario 8B, the wastewater would be conveyed to a shared treatment facility with Harwich at Dennis' Site 1, and recharge would take place at both Site 1 and Site 2 in Dennis. Under Scenario 8C, the wastewater would be conveyed to a treatment facility shared with Harwich and Yarmouth at Site 1 in Dennis, and recharge would take place at both Site 1 and Site 2.

12.4.4 Sewer Collection System Summary

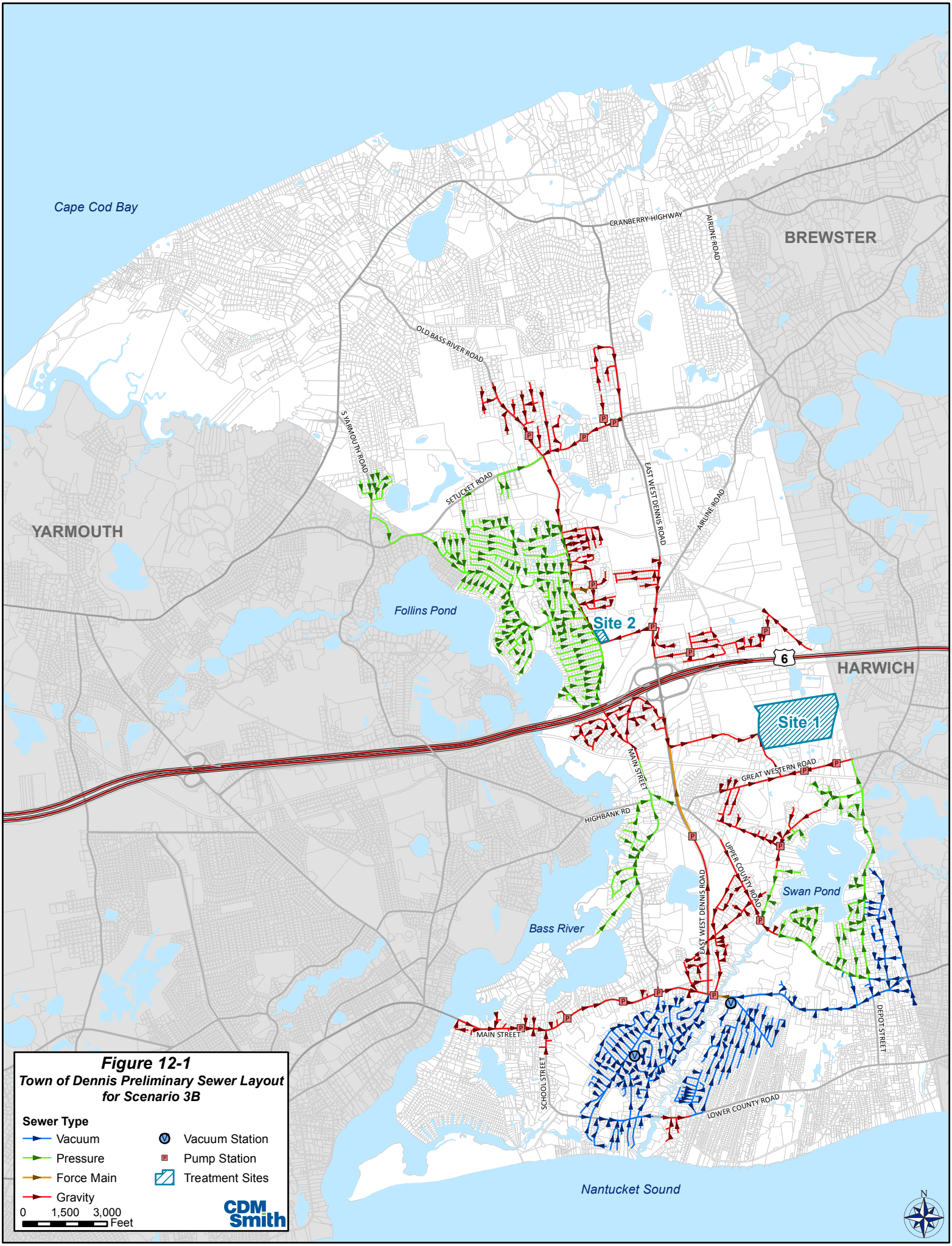
Table 12-2 Summary of Sewer Collection System

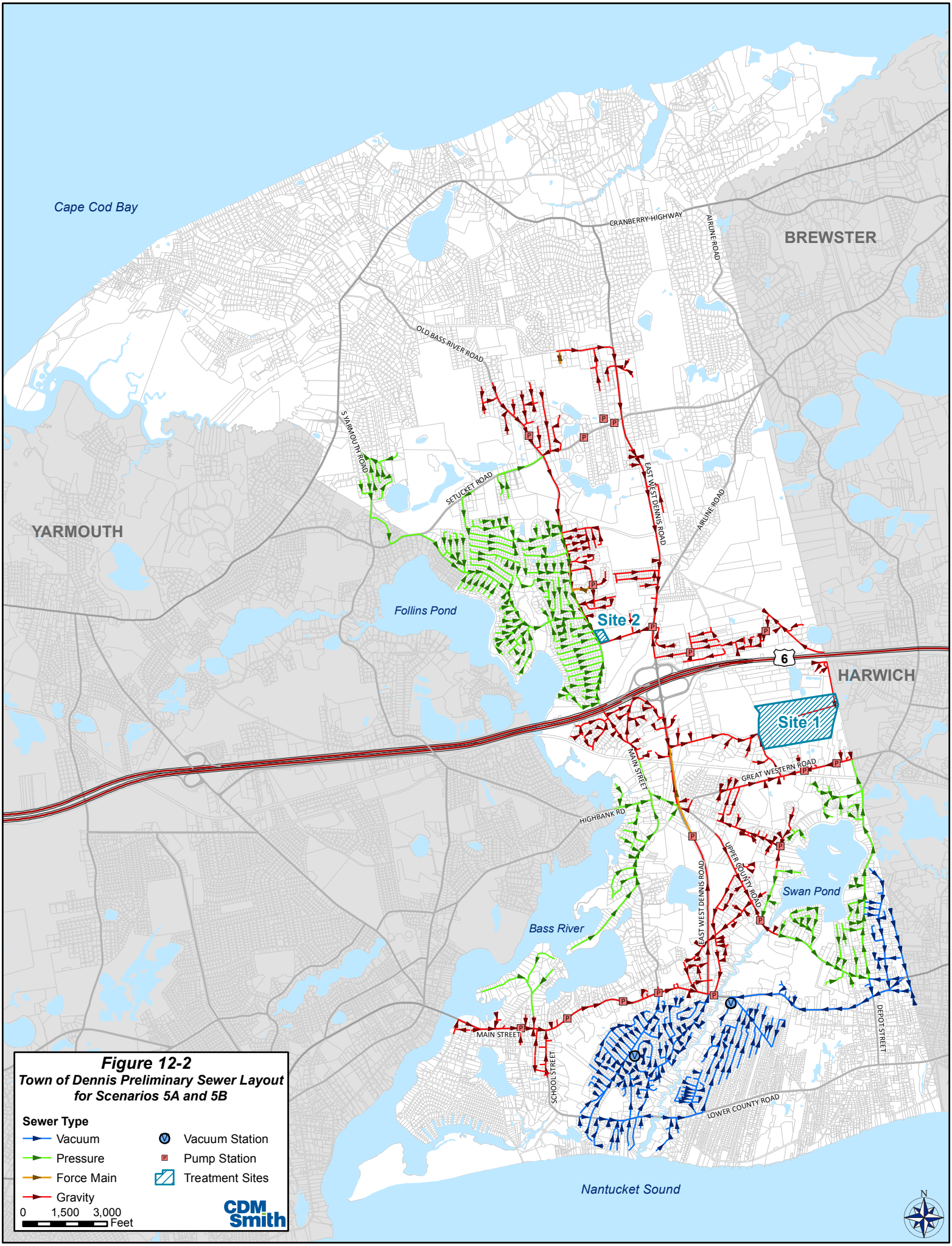
Scenarios			
	3B	5A/5B	6A/6B/8A/8B/8C
Number of Parcels Sewered	5,815	6,114	6,276
Build-out Wastewater Flow (mgd)	1.24	1.15	1.12
I/I Flow (gpd)	268,000	345,000	437,000
Total Average Daily Flow (mgd)	1.51	1.49	1.55
Length of Gravity Sewers (miles)	27	32	41
Length of Pressure Sewers (miles)	26	28	27
Length of Vacuum Sewers (miles)	20	21	21
Length of Force Main (miles)	1	2.5	3.5
Range of Pipe Sizes	4" – 18"	4" – 18"	4" – 18"
Number of Pumping Stations	20	20/21	24/25
Number of WWTPs	2	1	1/2
Number of Effluent Recharge Sites1	2	2	2

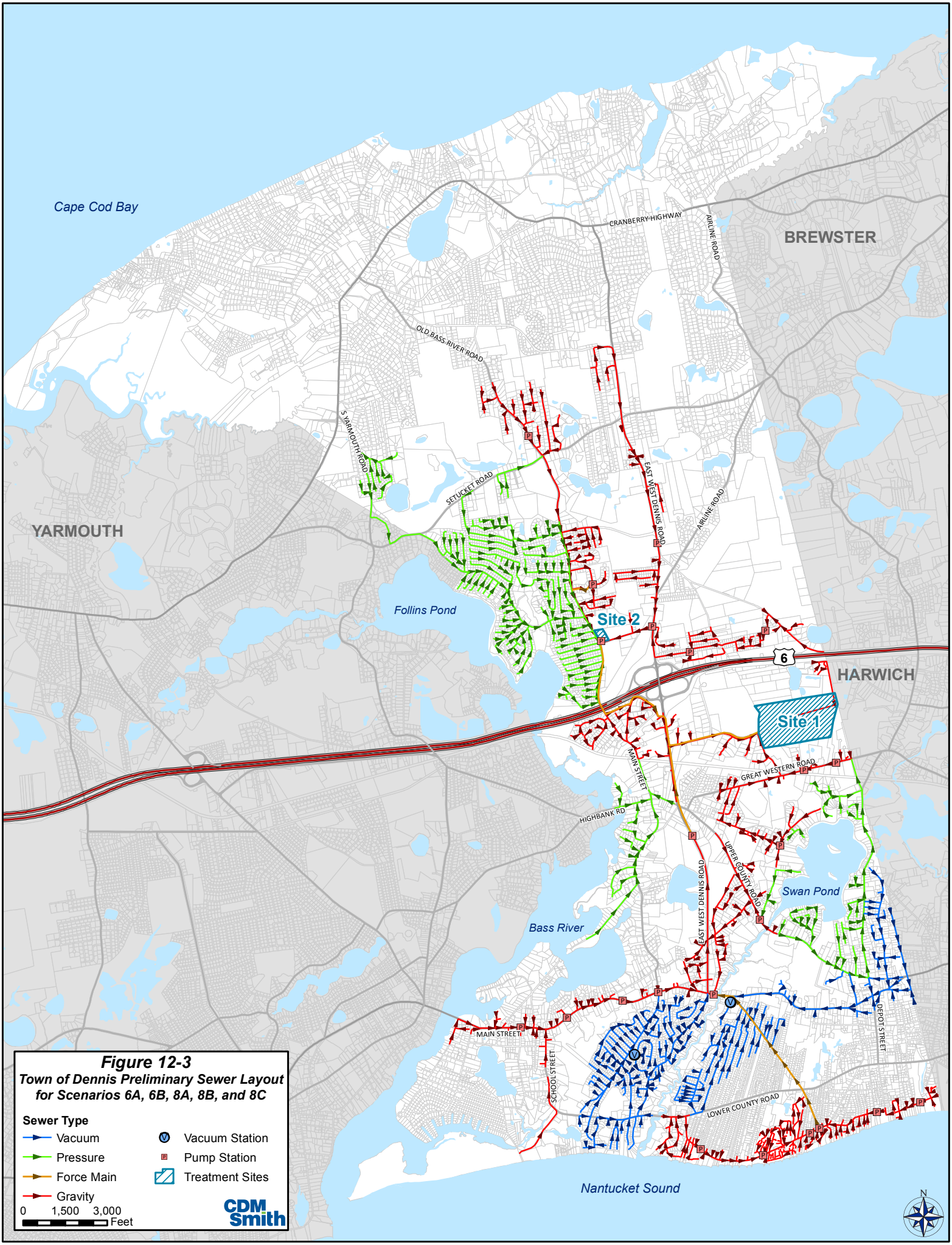
Notes: Since the development of the Draft CWMP, hydraulic modeling of effluent recharge sites has shown that additional capacity will be needed. This is discussed further in Section 11.

12.5 Sewer Conveyance System

The recommended conveyance systems, as shown in the sewer layouts in **Figures 12-1 through 12-3**, include pumping stations which are fed by gravity sewers, and force mains. Proposed pumping station locations are only approximate and represent idealized locations, based on topography. As Dennis moves forward with the selected collection system, final pumping station sites will need to be reviewed and specific sites identified.


Cape Cod Bay
BREWSTER
YARMOUTH
HARWICH
CRANBERRY HIGHWAY
AIRLINE ROAD
OLD BASS RIVER ROAD
YARMOUTH ROAD
SETUCKET ROAD
EAST WEST DENNIS ROAD
Follins Pond
Site 2
Site 1
6
MAIN STREET
GREAT WESTERN ROAD
HIGHBANK RD
UPPER COUNTY ROAD
Swan Pond
Bass River
DEPOT STREET
SCHOOL STREET
LOWER COUNTY ROAD
Nantucket Sound
N
Figure 12-1
Town of Dennis Preliminary Sewer Layout for Scenario 3B
Sewer Type
Vacuum
Pressure
Force Main
Gravity
Vacuum Station
Pump Station
Treatment Sites
0 1,500 3,000 Feet
CDM Smith


Cape Cod Bay
BREWSTER
YARMOUTH
HARWICH
CRANBERRY HIGHWAY
AIRLINE ROAD
OLD BASS RIVER ROAD
YARMOUTH ROAD
SETUCKET ROAD
EAST WEST DENNIS ROAD
Follins Pond
Site 2
Site 1
6
MAIN STREET
GREAT WESTERN ROAD
HIGHBANK RD
UPPER COUNTY ROAD
Swan Pond
Bass River
SCHOOL STREET
DEPOT STREET
LOWER COUNTY ROAD
Nantucket Sound
N
Figure 12-2
Town of Dennis Preliminary Sewer Layout for Scenarios 5A and 5B
Sewer Type
Vacuum
Pressure
Force Main
Gravity
Vacuum Station
Pump Station
Treatment Sites
0 1,500 3,000
Feet
CDM Smith


Cape Cod Bay
BREWSTER
YARMOUTH
HARWICH
CRANBERRY HIGHWAY
AIRLINE ROAD
OLD BASS RIVER ROAD
S YARMOUTH ROAD
SETUCKET ROAD
EAST WEST DENNIS ROAD
Follins Pond
Site 2
Site 1
6
MAIN STREET
GREAT WESTERN ROAD
HIGHBANK RD
UPPER COUNTY ROAD
Swan Pond
Bass River
EAST WEST DENNIS ROAD
DEPOT STREET
MAIN STREET
SCHOOL STREET
LOWER COUNTY ROAD
Nantucket Sound
N
Figure 12-3
Town of Dennis Preliminary Sewer Layout
for Scenarios 6A, 6B, 8A, 8B, and 8C
Sewer Type
Vacuum
Pressure
Force Main
Gravity
Vacuum Station
Pump Station
Treatment Sites
0 1,500 3,000
Feet
CDM Smith

The final sites would be selected according to the following criteria:

1. Proximity to the low point of the collection system – gravity pumping stations should be located as close as possible to the low points.
2. Property ownership – ideally the selected parcels are already owned by the town.
3. Minimize permitting requirements – avoid work within wetland areas, the 100-foot buffer zone to wetlands, or the 200-foot riverfront area, where applicable.
4. The location of the 100-year floodplain – structures within the floodplain have to meet more stringent design and construction standards, to ensure that the stations continue to function properly during an anticipated flooding event, resulting in higher risks and more costly construction.

Location within EOEEA Article 97 Sites – these sites are preserved as open space and require an act of the Massachusetts state legislature for the construction of any structures. If possible, Article 97 should be avoided. The pumping stations in the gravity system will mostly be submersible-type stations with on-site standby power. The stations will be predominately precast concrete underground stations, with the standby power and instrumentation and control panels above ground either in pedestal cabinets or housed in a prefabricated building. The larger stations, which will pump more than 2.5 mgd at peak flow to the wastewater treatment facility at build-out, will likely be a cast-in-place concrete wet pit/dry pit station with a building to house electrical equipment and controls.

12.6 Collection and Conveyance System Costs

12.6.1 Collection and Conveyance System Capital Costs

Cost estimates were developed for the collection and conveyance systems discussed in Sections 12.4 and 12.5 respectively. These estimates are shown in **Table 12-3**.

Table 12-3 Estimated Sewer Collection System Capital Costs

	3B	5A	5B	6A	6B	8A	8B	8C
Number of Properties Served	5,815	6,114	6,114	6,276	6,276	6,276	6,276	6,276
Gravity System Cost	$36 M	$42.2 M	$42.2 M	$52.8 M	$52.8 M	$52.8 M	$52.8 M	$52.8 M
Pressure Sewer Cost	$39.1 M	$40.3 M	$40.3 M	$39.1 M	$39.1 M	$39.1 M	$39.1 M	$39.1 M
Vacuum Sewer Cost	$13.4 M	$13.9 M	$13.9 M	$13.9 M	$13.9 M	$13.9 M	$13.9 M	$13.9 M
Collection System Cost (Rounded)	$89 M	$97 M	$97 M	$106 M	$106 M	$106 M	$106 M	$106 M
Pumping Station Cost	$10 M	$11.5 M	$10 M	$13.5 M	$12 M	$17 M	$13.5 M	$13.5 M
Force Main Cost	$800 K	$3.2 M	$700 K	$3.9 M	$1.5 M	$18.6 M	$3.7 M	$3.7 M

	3B	5A	5B	6A	6B	8A	8B	8C
Conveyance System Cost (Rounded)	$11 M	$15 M	$11 M	$18 M	$14 M	$36 M	$17 M	$17 M
Total Collection and Conveyance System Costs (Rounded)	**$100 M**	**$112 M**	**$108 M**	**$123 M**	**$120 M**	**$142 M**	**$123 M**	**$123**

Notes: Refer to Appendix D for details on basis of cost estimate. Costs are based and methodology published in "*Comparison of Costs for Wastewater Management Systems Applicable to Cape Cod, Guidance to Cape Cod Towns Undertaking Comprehensive Wastewater Management Planning*," dated April 2014 (version 2). ENR = 9702.

The cost for gravity piping includes pipe, manholes, wye connections for each parcel, 6-inch service connections extending an average of 20 feet for each lot (from the street to the property line), excavation support, state highway construction considerations where applicable (flowable fill, etc.), paving, police details, and some allowances for drainage and mobilization. Paving is assumed to include a 2-inch trench patch and a 1.5-inch full width overlay on all currently paved roads. The cost for individual homeowner hookups is also included in the collection system costs, and includes an assumed cost for a service connection to the property line where the municipal collection system connects to the private service connection.

The cost for vacuum sewers includes the purchase of equipment and furnishing and installing the major vacuum system components including the vacuum main, service laterals, and vacuum stations. The cost of the valve pits and air terminals for each property are also included in the cost estimate.

The cost for pressure sewers includes the cost for valves, grinder pumps, lateral piping, as well as piping in the street.

Similar to the cost analysis performed in Section 10, the collection system costs for the options are similar and differ by 20 percent across all scenarios. The costs for scenarios 6A, 6B, 8A, 8B, and 8C are slightly higher because the sewer layout includes the economic development planning districts in Dennis.

The collection system costs were derived from the 208 plan, from vacuum and pressure sewer vendors, and supplemented by CDM Smith's past experience on similar projects. A more detailed cost breakdown can be found in Appendix D.

12.6.2Collection and Conveyance System O&M Costs

Annual operation and maintenance costs for the wastewater collection system alternatives under build-out conditions are shown in **Table 12-4**. These costs have been divided into system type costs, are only for the operation and maintenance of the collection system, and do not include the costs associated with the town's proposed wastewater treatment facilities and recharge. These costs were derived from the 208 plan, from vacuum and pressure sewer vendors, and supplemented by CDM Smith's past experience on similar projects.

Table 12-4 Estimated Collection and Conveyance System O&M Costs

O&M Costs	3B	5A	5B	6A	6B	8A	8B	8C
Gravity Sewer	$279 K	$332 K	$332 K	$427 K	$427 K	$427 K	$427 K	$427 K
Pressure Sewer	$182 K	$187 K	$187 K	$182 K	$182 K	$182 K	$182 K	$182 K
Vacuum Sewer	$115 K	$116 K	$116 K	$117 K	$117 K	$117 K	$117 K	$117 K
Pump Station	$1.25 M	$1.3 M	$1.25 M	$1.6 M	$1.5 M	$1.6 M	$1.56 M	$1.56 M
Force Main	$5 K	$13 K	$5 K	$19 K	$10 K	$80 K	$18.5 K	$18.5 K
Total Collection & Conveyance	**$1.83 M**	**$1.95 M**	**$1.89 M**	**$2.35 M**	**$2.24 M**	**$2.38**	**$2.30**	**$2.30**

Notes: Refer to Appendix D for details on basis of cost estimate. Costs are based and methodology published in "Comparison of Costs for Wastewater Management Systems Applicable to Cape Cod, Guidance to Cape Cod Towns Undertaking Comprehensive Wastewater Management Planning," dated April 2014 (version 2). ENR = 9702.

12.7 Treatment Technology Evaluations

Four types of treatment technologies were evaluated to determine the most appropriate treatment technology for the size flows to be treated from Dennis. At the time of evaluation, Dennis was considering four scenarios – Scenario 3B, 5A, 5B, and 6B. Since that time, four additional scenarios have been added – Scenarios 6A, 8A, 8B, and 8C. Scenario 6A was an original scenario evaluated by Dennis in earlier phases of CWMP planning. Dennis is considering a variety of wastewater partnering arrangements with neighboring communities (Scenarios 8A, 8B, and 8C) and permutations of Scenario 6A make the most economic sense. As a result Scenario 6A has been included in treatment cost analysis and has been estimated based on a comparison of projected flow rates at the treatment facilities. The selected technology was then incorporated into the wastewater scenarios along with the proposed wastewater collection and effluent recharge systems to compare costs across scenarios.

12.7.1 Description of Treatment Technologies

The four technologies selected for evaluation include:

- Sequencing batch reactors (SBR)
- Oxidation ditches (OD)
- membrane bioreactors (MBR), and
- Trickling filters (TF)

Each is a biological process. These technologies were selected for their ability to remove total nitrogen down to low levels (3-5 mg/L annual average) and their ability to meet effluent criteria required for recharge to infiltration basins. Although the SBR, OD, MBR and TF technologies can periodically achieve limits as low as 3 mg/L total nitrogen, it is assumed for this evaluation that an additional denitrification technology (along with supplemental carbon addition) will be necessary to routinely achieve an annual average of 3 mg/L total nitrogen.

Sequencing Batch Reactors (SBR)

Sequencing batch reactors function as a combined aeration tank and clarifier, where all the biological reactions and settling/separation occur in a single unit operating as a batch process. It is an activated sludge process and all the kinetics relationships apply that pertain to any other mode of activated sludge. The SBR operates between a constant low water level and a varying high water level, depending on the influent flow rate. Typically, more than one reactor is required to allow for constant fill of one of the reactors. The SBR is operated under a predetermined cycle and typically follows the following six steps: Mixed Fill, Aerated Fill, React, Settle, Decant and Idle, as discussed below:

- ***Mixed Fill*** - Wastewater enters a partially filled reactor containing biomass. Bacteria biologically degrade the organics and use residual oxygen or alternative electron acceptors, such as nitrate. It is during this period that anoxic conditions are utilized for the selection of biomass with better settling characteristics.
- ***Aerated Fill*** - The influent flow continues under mixed and aerated conditions.
- ***React*** - Influent flow is terminated and directed to the other batch reactor. Mixing and aeration continue in the absence of raw waste.
- ***Settle*** - The aeration and mixing is discontinued after the biological reactions are complete and the biomass settles under quiescent conditions. Excess biomass can be wasted at any time during the cycle. The settling time is adjustable during operations to match prevailing process needs.
- ***Decant*** – After solid/liquid separation is complete during the settling period, the treated effluent is removed through a decanter. The reactor is then ready to receive the next batch of raw influent.
- ***Idle*** - The length of this step varies depending on the influent flow rate and the operating strategy.

Figure 12-4 presents a schematic diagram of the SBR process.

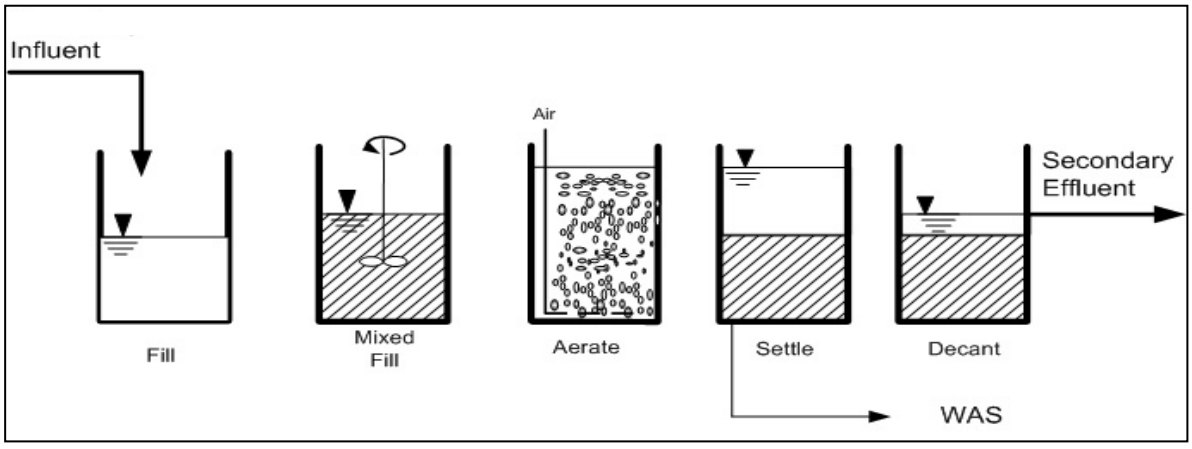


Figure 12-4 Schematic Diagram of the SBR Process

Since clarification and aeration occur within the same tank there is no internal recycle or return activated sludge common to conventional activated sludge treatment processes. Sludge is typically removed and recycled during the decant phase. A crucial feature of the SBR system is the control unit, including the automatic switches and valves that sequence and time the different operations. Since the heart of the SBR system is the controls, automatic valves, and automatic switches, these systems require more sophisticated maintenance than a conventional activated sludge system.

An important consideration for the SBR system is that the effluent discharges only intermittently and therefore would greatly affect the size of the downstream process units. The decant rate is substantially higher than the plant inflow, hence requiring a post-equalization tank to dampen the peak flows so as not to require oversizing of downstream process equipment.

An SBR wastewater treatment facility (WWTF) is capable of handling the seasonal flow variations by fluctuating water levels, as well as changing cycle times as needed for nitrification and denitrification. Whereas proper operation and the potential use of a supplemental carbon source could result in meeting the 3 mg/L total nitrogen limit, provisions should be made for effluent filters to ensure compliance. Additionally, an SBR WWTF capacity can be increased in phases, with the typically square or rectangular shaped tanks lending themselves to common wall construction. Major components required for an SBR WWTF are listed below:

- Headworks Building – Coarse Screening and Grit/Grease Removal
- SBR Tanks
- Effluent Equalization Tank
- Effluent Filters
- Disinfection
- Odor Control
- Septage Receiving Facilities
- Administration/Process Building
- Residuals Processing and Storage
- Infiltration Basins for Recharge

The wastewater treatment facilities for the towns of Falmouth and Provincetown utilize SBR technology.

Oxidation Ditches (OD)

The oxidation ditch is an activated sludge process in a ring- or oval-shaped channel that is equipped with mechanical aerators. Wastewater is aerated as it circulates around the perimeter of the ditch. For denitrification, anoxic zones can be created within the ditch but external anoxic tanks are recommended for low total nitrogen limits. These systems are typically designed without primary clarifiers and require secondary clarifiers to separate the activated sludge from the flow stream.

Typically, mechanical mixing and aeration devices are provided and in some cases a diffused air system is installed. Several varieties of mechanical equipment are commonly used, including horizontal brush rotors, rotating discs, or mechanical aerators, all of which should provide comparable performance. Flow is continuously moving in a circular motion around these tanks as influent is fed and effluent diverted off.

An oxidation ditch, operating as extended aeration, will generate less overall sludge and provide good buffering for peak flows and variations in loading. Because of the long sludge age, a larger tank is required compared to conventional activated sludge. Oxidation ditches have very simple operational requirements, and thus can be more favorable for smaller communities. However, because the process utilizes larger aeration tanks and requires longer solids retention time than the conventional process, the capital cost of the treatment structure is increased. In addition, depending on treatment requirements, oxidation ditch facilities may require supplemental aeration to the mechanical aerators to avoid low dissolved oxygen levels in the treatment unit. As with the SBR, provisions during the planning stage should be made for the use of effluent filters to ensure meeting the required 3 mg/L total nitrogen required for discharge. Major components required for an oxidation ditch WWTF are listed below.

- Headworks Building – Coarse Screening and Grit/Grease Removal
- Anoxic Tanks
- Oxidation Ditch
- Secondary Clarifier
- Effluent Filters
- Disinfection
- Odor Control
- Septage Receiving Facilities
- Administration/Process Building
- Residuals Processing and Storage
- Infiltration Basins for Recharge

Figure 12-5 presents a schematic diagram of the oxidation ditch process.

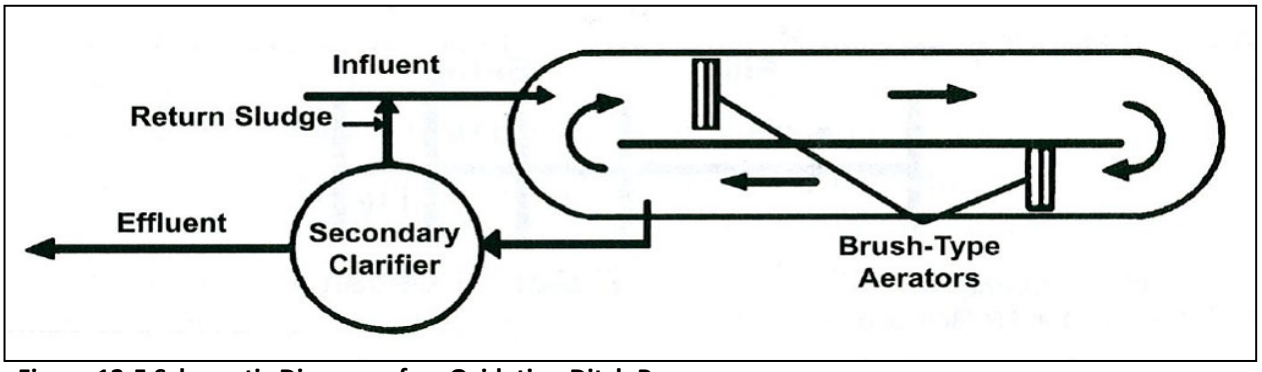


Figure 12-5 Schematic Diagram of an Oxidation Ditch Process

The wastewater treatment facilities for Chatham and the Massachusetts Military Reservation (MMR) in Bourne utilize oxidation ditch technology.

Membrane Bioreactor (MBR)

A membrane bioreactor used for nitrogen removal is an activated sludge reactor with membrane filtration downstream of anoxic and aerobic bioreactors. Influent enters the headworks and flows into the pre-anoxic zone, then to the aerobic zone, then the post-anoxic zone, and finally into the membrane tanks, where mixed liquor is re-aerated and solids separated from the process effluent. Effluent is then disinfected. Membrane tanks are aerated to provide final BOD removal and nitrification and to provide scour for prevention of membrane fouling. Membranes require fine screening down to less than 2 millimeters (mm) in addition to the coarse screening and grit removal. One hundred percent redundancy must be provided for screening and membrane tanks.

The membranes must be capable of physically passing the peak hour flow through the membrane modules, and therefore an influent equalization tank is recommended to dampen peak hour flow. Flow is recycled from the membrane tanks to the aerobic zone, and then back to the pre-anoxic zone in order to avoid recycling high quantities of dissolved oxygen to the anoxic zones. The treatment process requirements are similar to that of an oxidation ditch WWTF. Below is a list of major process components associated with an MBR WWTF.

- Headworks Building (Coarse Screening)
- Grit/Grease Removal
- Fine Screening
- Pre-Anoxic Tanks
- Aerobic Tanks
- Post-Anoxic Tanks
- Membrane Tanks with Influent Equalization
- Disinfection
- Odor Control
- Septage Receiving Facilities
- Administration/Process Building
- Residuals Processing and Storage
- Infiltration Basins for Discharge

Figure 12-6 presents a schematic diagram of the MBR process. The wastewater treatment facility for the town of Cohasset utilizes MBR technology.

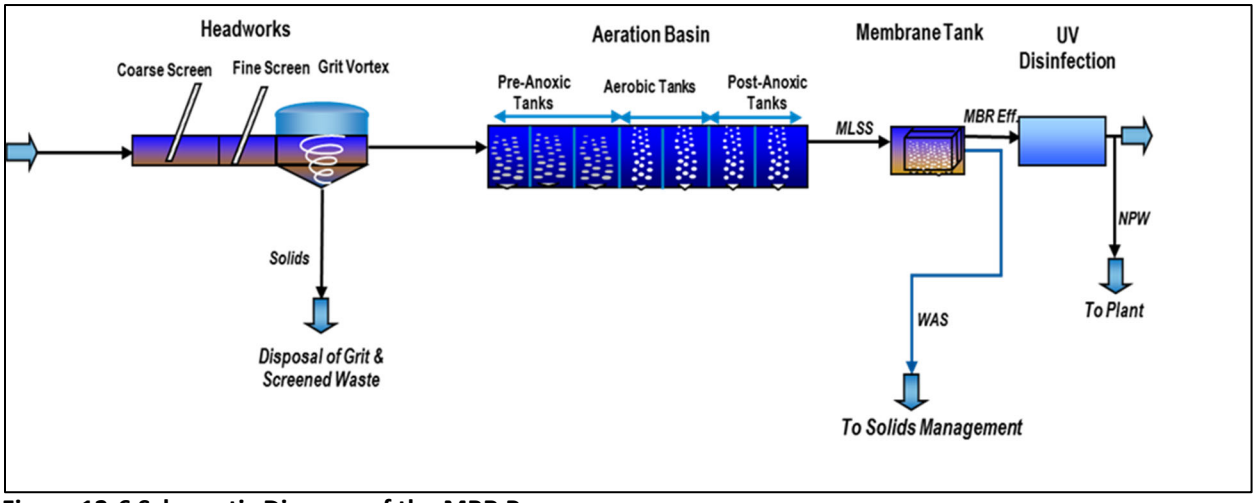


Figure 12-6 Schematic Diagram of the MBR Process

Trickling Filters (TF)

The tricking filter (TF) is a nonsubmerged fixed-film biological reactor using rock or plastic media over which wastewater is distributed continuously. Treatment occurs as the liquid flows over the attached biofilm (or slime layer), where microorganisms already in the water gradually attach themselves to the rock or plastic surface and form a film. The nitrogen (and other organic material) is then degraded by the aerobic microorganisms in the outer part of the slime layer.

Virtually all new trickling filter installations are constructed using plastic media. Other components of the TF include a wastewater dosing system, and underdrain, and a structure to contain the packing. The underdrain system is a porous structure through which air can circulate and to collect TF effluent liquid. The collected liquid is passed to a sedimentation tank where the solids are separated from the treated wastewater. As the biological film continues to grow, the microorganisms near the surface lose their ability to cling to the medium, and a portion of the slime layer falls off the filter. This phenomenon of losing the slime layer is called *sloughing* and is primarily a function of the organic and hydraulic loading onto the TF. The sloughed solids are picked up by the underdrain and transported to a clarifier for removal.

A portion of the liquid collected in the underdrain system (or the settled effluent) is recycled to the tricking filter feed flow, in order to dilute the strength of incoming wastewater and to maintain enough wetting to keep the biological slime layer moist. Major components required for a TF WWTF are listed below.

- Headworks Building (Coarse Screening)
- Grit/Grease Removal
- Primary Sedimentation Basin
- Trickling Filter
- Secondary Sedimentation
- Disinfection
- Odor Control

- Septage Receiving Facilities
- Administration/Process Building
- Residuals Processing and Storage
- Infiltration Basins for Recharge

Figure 12-7 presents a schematic diagram of the tricking filter process.

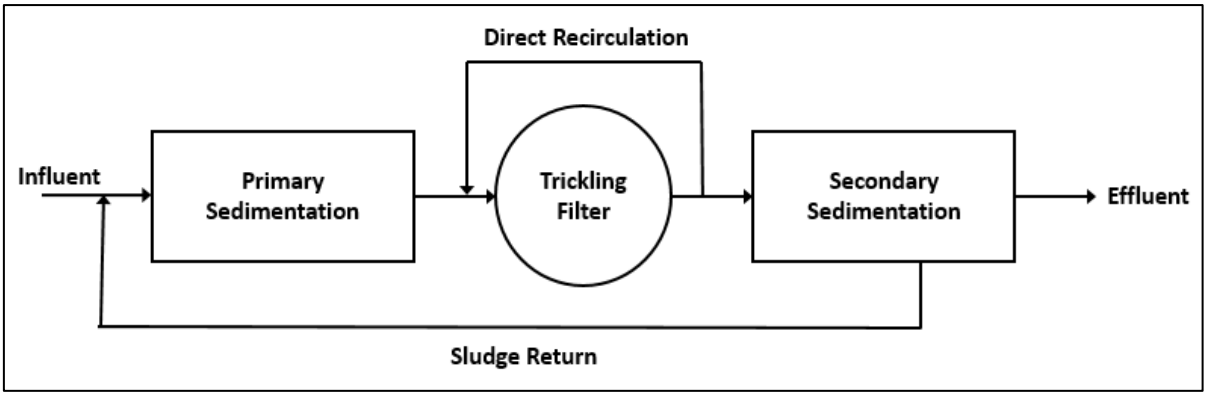


Figure 12-7 Schematic Diagram of a Single Stage TF Process

12.7.1.1 Disinfection

There are three typical disinfection methods for wastewater: ozone, UV (ultraviolet irradiation) and chlorination. The ozonation process is very energy intensive for small facilities and there are significant costs associated with chemicals and tankage for chlorination/dechlorination required for groundwater recharge. It is recommended that UV disinfection be utilized as the most appropriate option for disinfection.

12.7.1.2 Residuals Handling

Most wastewater treatment facilities today with flows under 5 mgd haul offsite the thickened solids created during the treatment process. Thus, any proposed treatment facility for Dennis which is well below that size facility will include solids thickening process equipment and storage tanks for unthickened and thickened residuals. It is recommended that thickened residuals be removed by establishment of a hauling/disposal contract with an approved off-site processing facility.

12.7.2 Biological Treatment Technology Comparison

All four technologies represent a feasible alternative for the new Dennis WWTF(s). Each technology has its own advantages and disadvantages based on the listed evaluation criteria. **Table 12-5** presents those advantages and disadvantages.

Table 12-5 Comparisons of Four Treatment Technologies: Advantages and Disadvantages

Technology	Advantages	Disadvantages
Sequencing Batch Reactor (SBR)	▪ Able to meet strict effluent criteria for groundwater discharge standards ▪ Operationally flexible with respect to seasonal variations in flow. Cycle times may be adjusted as required to meet permit limits. ▪ Easily expanded with common wall construction for additional SBRs	▪ Expansion will be expensive as new large SBRs are constructed to handle the increase in flow. ▪ Requires effluent equalization ▪ May require filtration for discharge limits
Oxidation Ditch (OD)	▪ Simple process to operate ▪ Able to meet strict effluent criteria for groundwater discharge ▪ Resilient process to varied loadings and seasonal flexibility	▪ Process requires a lot of space ▪ Additional expansion requires more tankage than other processes (anoxic tanks plus OD plus clarifier) ▪ Mechanical aerators result in higher O&M costs for aeration process
Membrane Bioreactor (MBR)	▪ Able to meet strict effluent criteria for reclaimed water standards ▪ No additional filtration required ▪ Modular system is easily expandable. Cassettes can be easily dropped into membrane tanks as flow increases. ▪ Higher quality effluent	▪ Requires fine screening of less than 2 mm ahead of the membranes ▪ Peak hour flow rates must pass through membranes, which will likely only occur during summer months due to seasonal flow (influent equalization) ▪ Membranes must be replaced every seven years and are expensive to replace
Trickling Filters (TF)	▪ Simple and reliable biological process ▪ Low power requirements ▪ Relatively small area required	▪ Additional treatment may be needed to meet more stringent discharge standards ▪ Requires regular operation attention ▪ Clogging can occur frequently ▪ Flexibility and control are limited (compared to activated-sludge processes)

In addition to the summary of advantages and disadvantages, a ranking system was developed to assist with technology screening that is based on the key evaluation criteria. Those criteria are listed below with associated rankings. These factors provide a qualitative method for ranking the treatment technologies and a means for making a recommendation. The following are the assessment criteria and rationale used in performing the comparison of technologies:

- ***Ease of Expandability*** – Assessment depends on the ability to allow for future expansion as potential phased expansion of collection system and needs areas arise. Technologies are ranked as follows:

  1 - Difficult to expand

  3 - Flexibility and expandability are likely to be average

  5 - Easily expandable

- ***Operational Flexibility*** – This step assesses the ability of the technology process to meet seasonal flow fluctuations anticipated for Dennis. Alternatives are ranked as follows:

1 - Difficult to meet flow variations (need additional tankage)

3 - Average flexibility

5 - Very flexible

- ***Operability*** – The difficulty of operating a process will be considered. Some processes are complex and require a lot of attention for proper operation. Some processes require special skills and extensive training for the operators. Technologies are ranked as follows:

  1 - Processes difficult to operate or requiring special skills

  3 - Processes require average attention and some additional staff and training

  5 - Less complex processes

- ***Capital Cost*** – Capital cost relates to the construction cost based on the facility needed for meeting build-out flows. Alternatives are ranked as follows:

  1 - High construction cost estimate

  3 - Medium cost when compared to other technologies

  5 - Low construction estimate

- ***O&M Costs*** – O&M cost includes general maintenance, labor, supplies and power requirements. Mechanical equipment with high horsepower demands results in high O&M costs, and the need for replacement of components is also evaluated here. Technologies are ranked as follows:

  1 - High O&M estimate

  3 - Medium O&M estimate when compared to other technologies

  5 - Low O&M estimate

- ***Space Requirements*** – This evaluates the footprint needed for the main components of the biological process.

  1 - A large quantity of space required for the suggested technology

  3 - Space required is likely to be average

  5 - Minimal space is required of the alternative

- ***Process Performance*** — All of these technologies would provide secondary effluent water quality that meets groundwater discharge standards. Some processes can more easily meet these performance standards than others. Technologies are ranked as follows:

  1 - Processes that need additional process steps to meet the discharge standards (i.e. additional filtration)

  3 - Average process performance

  5 - High process performance

Table 12-6 summarizes all criteria into a matrix for ease in comparing the different technologies. Each is graded for its response to the respective criteria. A ranking of 1, 3 and 5 is provided with 5 being the most desirable. The technology with the highest total score is the recommended technology for secondary wastewater treatment in Dennis.

Table 12-6 Matrix Assessment for Recommending Dennis WWTP Technology

Criteria	Sequencing Batch Reactor (SBR)	Oxidation Ditch (OD)	Membrane Bioreactor (MBR)	Trickling Filter (TF)
Ease of Expandability	5	1	5	3
Operational Flexibility	5	5	3	1
Operability	1	5	3	3
Capital Cost	5	3	3	3
O&M Cost	5	3	1	3
Space Requirements	3	1	5	5
Process Performance	5	5	5	3
Total Score	29	23	25	21

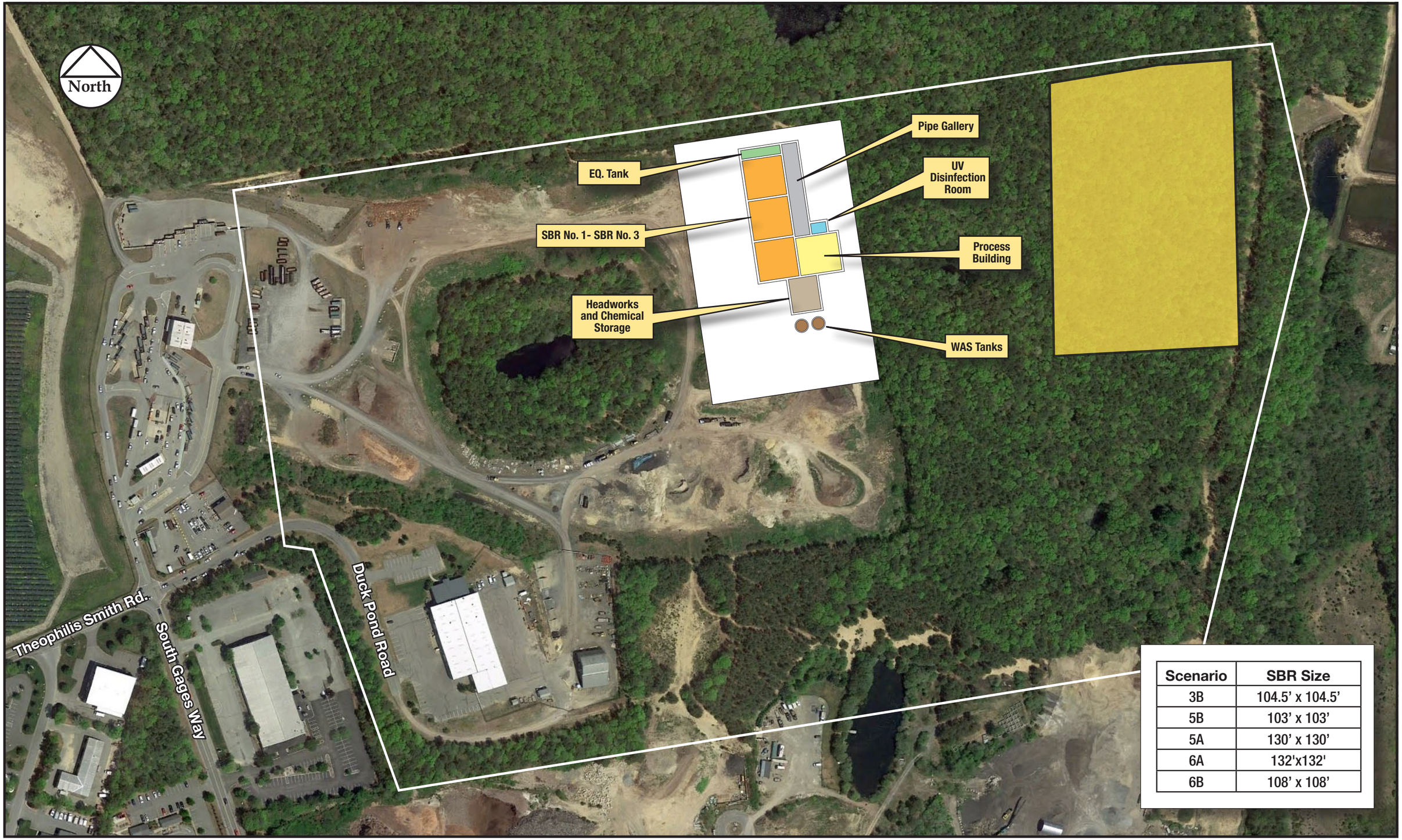
12.7.3 Recommended Treatment Technology

The recommended treatment technology for Dennis is an SBR process, with the construction to be phased in coordination with the collection system work. The key reasons for constructing the SBR process initially are to minimize capital costs for the town, to provide the best operational flexibility based on the anticipated plant flow variations, and to be easily expanded. Going forward, as the collection system grows and potential future permit regulations develop, the option to continue forward with SBR allows for maximum flexibility. **Figures 12-8 and 12-9** show the wastewater treatment facility layouts for each scenario.

Supplemental Carbon Addition and Denitrification Filters

Based on the results of the MEP reports for the Bass River and Swan Pond, the need for nitrogen removal within Dennis is greater than anticipated earlier in the CWMP process. Ultimately, the WWTF requirements for nitrogen removal will be an annual average nitrogen discharge concentration of 3 mg/L at ultimate build-out of the proposed collection system.

As the 3 mg/L concentration for discharge is based on the removal limits of technology, it is assumed for estimating purposes that an SBR treatment facility for Dennis will need additional denitrification. For the purposes of this evaluation, it is recommended that supplemental carbon addition and denitrification filters be used to meet these very stringent effluent total nitrogen concentrations.



Scenario	SBR Size
3B	104.5’ x 104.5’
5B	103’ x 103’
5A	130’ x 130’
6A	132'x132'
6B	108’ x 108’

0 100 200 300 400 500

Scale in Feet

Town of Dennis, Massachusetts

CDM Smith

Site 1 Location Scenarios

North

Old Bass River Road

Process Building

WAS Tanks

UV Disinfection Room

Headworks and Chemical Storage

Pipe Gallery

EQ. Tank

SBR No. 1- SBR No. 3

Bob Crowell Road

Scenario	SBR Size
3B	77.5’ x 77.5’
5B	77’ x 77’
5A	NA
6A	NA
6B	76’ x 76’

0 100 200 300 400 500

Scale in Feet

Town of Dennis, Massachusetts

CDM Smith

Site 2 Location Scenarios

Supplemental Carbon Addition

Supplemental carbon alternatives are recommended for use as part of any wastewater alternative for Dennis. The best form of carbon for denitrification is the soluble organic compounds that have low molecular weight and are readily degradable. More complex forms can also be relied upon for denitrification (after they have been broken down to more soluble forms), but denitrification occurs much more slowly because the break-down to more soluble forms of carbon is the rate-limiting step. Carbon can be added from an external sources as a supplement when there is insufficient endogenous carbon. Methanol has been the industry standard for supplemental carbon addition, but other sources are now being used which are safer and may be less expensive. These include proprietary products such as MicroC™, manufactured by Environmental Operating Solutions (EOS). Based on the flammability, safety, transportation, storage, and permitting issues associated with methanol it is not recommended for this application and a proprietary product (MicroC™) should be considered during preliminary and final design.

It is assumed that the biological treatment process selected would remove total nitrogen to 5 mg/L or less without the use of supplemental carbon addition. It should be noted that if the denitrification rates are less than typical values, it may be necessary to add supplemental carbon both during the biological treatment process and during the final denitrification step. Dosing controls will be provided that can modify dosage rates accordingly as additional carbon demand will vary based on seasonal temperature and flow variations associated with the annual population fluctuation in Dennis. In addition, since the effluent nitrogen concentration is based upon plant flows and nitrogen loadings, initial discharge concentrations from the phased sewer system may be 3 mg/L. This could result in savings and minimize carbon dosing during initial phases of operation.

Denitrification Filters

As described above, the low total nitrogen effluent requirements of 3 mg/L on an average annual basis at build-out will require treatment beyond a suspended growth biological nutrient removal process to ensure regular compliance. It is recommended that denitrification filters be provided as an additional nitrogen removal process as they provide both the biological nitrogen removal and solids removal necessary to achieve low effluent total nitrogen concentrations. Denitrification filters are media filters that can operate in either a downflow or upflow mode depending on the manufacturer. The filters need to be periodically backwashed and the waste backwash water returned to an earlier process step for treatment. It is recommended during preliminary design to evaluate the need and point during the phased construction of the system at which to implement denitrification filters. This again will be based on the allowable loading at the selected recharge site.

12.8 Estimated Wastewater Treatment Flows and Loads

12.8.1Flows

Section 8 determined flow factors to account for seasonal variation in flows that result from the population changes that Dennis undergoes annually. Because of the seasonal fluctuations inherent to Cape Cod, wastewater treatment plant design conditions need to be properly evaluated to account for the change in flows. Using the annual flows calculated from water use

data, the average annual wastewater flows for Scenarios 3B, 5A, 5B, 6A and 6B to the WWTF(s), including infiltration, are as follows:

- ***Scenario 3B – 1,507,000 gpd*** - This scenario would utilize two treatment facilities, located at Sites 1 and 2. Site 1 will receive flow from south of Route 6 and Site 2 will receive flows from north of Route 6.
- ***Scenario 5A – 1,491,000 gpd*** - This scenario would utilize one treatment facility, located at Site 1.
- ***Scenario 5B – 1,491,000 gpd*** - This scenario would utilize two treatment facilities, located at Sites 1 and 2. Site 1 will receive flow from south of Route 6 and Site 2 will receive flows from north of Route 6.
- ***Scenario 6A – 1,554,000 gpd***- This scenario would utilize one treatment facility, located at Site 1.
- ***Scenario 6B – 1,554,000 gpd***- This scenario would utilize two treatment facilities, located at Sites 1 and 2. Site 1 will receive flow from south of Route 6 and Site 2 will receive flows from north of Route 6.

Based on the data analyzed and reviewed in Section 8, the seasonal peaking factors identified are 2.02 for summer flows, and 0.43 for winter flows. Updated flows and loads for the final Recommended Plan are included in Section 14. **Table 12-7** summarizes the seasonal flows in million gallons per day (mgd) for Scenarios 3B, 5A, 5B, 6A, and 6B. Maximum day and peak hour flows are also included in this table.

Table 12-7 Build-out Seasonal Wastewater Flows and Peaking Factors

Scenario	Annual Average Flow (mgd)	Summer Average Flow (mgd)	Winter Average Flow (mgd)	Spring Average Flow (mgd)	Fall Average Flow (mgd))	Max. Day Flow (mgd)	Peak Hour Flow (mgd)
3B- Site 1	0.971	1.96	0.417	0.680	0.816	4.020	6.668
3B- Site 2	0.536	1.08	0.230	0.375	0.450	2.382	4.006
5A- Site 1	1.491	3.01	0.641	1.044	1.252	5.723	9.337
5B- Site 1	0.956	1.93	0.411	0.669	0.803	3.959	6.566
5B- Site 2	0.535	1.08	0.230	0.375	0.449	2.378	3.999
6A/8A/8B/8C- Site 1	1.554	3.14	0.668	1.088	1.305	5.965	9.732
6B- Site 1	1.042	2.11	0.448	0.730	0.875	4.210	6.947
6B- Site 2	0.512	1.03	0.220	0.358	0.430	2.275	3.826

Septage flows are considered to be minimal for each scenario evaluated. As described later in this section, the ability to receive limited hauled wastes will be incorporated into WWTF design but it is not anticipated to represent a significant volume of flow or constituent loading.

12.8.2 Loads

Design loads for wastewater flows are based on the constituent concentrations listed below. Depending on sewer construction phasing, initial loadings to the WWTF could represent a higher

concentration of constituents depending on the makeup of the area being sewered. For comparison purposes, the build-out scenarios used for this evaluation focus on a more "typical" domestic wastewater strength as the majority of sewered areas represent residential connections. The residential loading concentrations were developed using values from the industry accepted Metcalf & Eddy, *Wastewater Engineering* text. Going forward into preliminary design stages, a more detailed evaluation of waste strength should be estimated based on data collected from other seasonal Cape Cod communities. **Table 12-8** lists the estimated concentrations for the Dennis wastewater.

Table 12-8 Estimated Average Wastewater Concentrations

Criteria	Build-out Concentration
BOD (Biochemical Oxygen Demand)	245 mg/L
TSS (Total Suspended Solids)	260 mg/L
TKN (Total Kjehldahl Nitrogen)	45 mg/L

12.9 Wastewater Treatment Facility Costs

12.9.1Capital Costs

The capital costs of the wastewater treatment facility have been calculated for each scenario being considered in Dennis. The costs are calculated using the 208 plan's cost document cost curve. The cost curve uses the summer average flows to make construction cost estimates. The results in **Table 12-9** show that the scenarios with two treatment facilities, as expected, are more expensive. The community partnership scenarios are less expensive since towns are gaining economy of scale by constructing one larger facility instead of multiple smaller facilities.

Table 12-9 Wastewater Treatment Facility Capital Costs

	Scenarios							
	3B	5A	5B	6A	6B	8A	8B	8C
Treatment Facility Capital Cost	$53.3 M	$39.4 M	$52.7 M	$37.6 M	$52.4 M	$24.6 M	$35.2 M	$22.9 M

Notes: Refer to Appendix D for details on basis of cost estimate. Costs are based and methodology published in "Comparison of Costs for Wastewater Management Systems Applicable to Cape Cod, Guidance to Cape Cod Towns Undertaking Comprehensive Wastewater Management Planning," dated April 2014 (version 2). ENR = 9702.

12.9.2 O&M Costs

The O&M costs for the wastewater treatment facility have been calculated for each scenario being considered in Dennis. The costs are derived from the 208 Plan's cost document cost curve and cover the following items:

- Labor
- Electricity and chemicals
- Laboratory Analysis
- Repairs and equipment replacement
- Administrative costs including insurance

- Sludge disposal

Table 12-10 includes the O&M costs for each scenario on an annual basis. The community partnership scenarios (8A, 8B, and 8C) have significantly lower O&M costs for the treatment facility since costs are shared by other communities.

Table 12-10 Wastewater Treatment Facility O&M Costs

	3B	5A	5B	6A	6B	8A	8B	8C
Annual Treatment Facility O&M Cost	$5.3 M	$4.6 M	$5.3 M	$4.5 M	$5.4 M	$1.8 M	$3.2 M	$1.4 M

Notes: Refer to Appendix D for details on basis of cost estimate. Costs are based and methodology published in "Comparison of Costs for Wastewater Management Systems Applicable to Cape Cod, Guidance to Cape Cod Towns Undertaking Comprehensive Wastewater Management Planning," dated April 2014 (version 2). ENR = 9702.

12.10 Effluent Recharge and Reuse Technology Evaluation

Wastewater effluent disposal is a significant challenge in Dennis and other Cape Cod communities because of the environmental constraints of the sole source aquifer. Disposal options are also limited due to the number of available sites. In watersheds that require the removal of all existing nitrogen loads to meet a Total Maximum Daily Load (TMDL), it will likely be necessary to dispose of treated wastewater in a different watershed. Added costs associated with meeting a higher level of treatment than nitrogen reduction also discourages construction of new disposal facilities in wellhead protection areas. As with treatment and collection, effluent disposal or reuse alternatives must balance cost and feasibility. Within this context, a site screening analysis was completed in a previous phase of the CWMP process and identified the three best candidate sites for effluent recharge in Dennis. Now that specific recharge sites have been identified, it is appropriate to consider which recharge technology will provide the best, cost-effective long-term service.

The intent of this section is to present some of the more common types of recharge technologies and discuss the advantages and disadvantages of each type. In addition, effluent reuse is also discussed. This section provides a guide for implementing a component of the overall wastewater management system but final decisions on the type of technology and exact layout would not be made until the actual final design.

12.10.1 Effluent Recharge Technologies

Several land-based disposal technologies can be used in Massachusetts. Proven technologies include infiltration basins, subsurface leaching systems, wicks, drip irrigation, and deep well injection. These technologies are described below. The information is taken from the Cape Cod Commission's 208 Plan[2] and supplemented with additional industry literature, as well as first hand design and implementation of some of the technologies.

[2] http://www.capecodcommission.org/resources/RWMP/RWMP_ta_conventional.pdf and https://sp.barnstablecounty.org/ccc/public/default.aspx?RootFolder=%2Fccc%2Fpublic%2FDocuments%2F208%20Final%2FAppendices%2FChapter%204%20Appendices%2FAppendix%204B&FolderCTID=0x01200077CDF2B1F1A32247AC61B462B8770BB7&View=%7BA4406685-D679-4D71-8754-6778F9E523D9%7D

12.10.1.1 Infiltration Basins

Infiltration basins are open basins in which treated effluent percolates through the sand (or native material), the unsaturated zone of the soil, and then to groundwater. The infiltration basin is unlined and excavated at the ground surface. Compared to subsurface leaching systems (described next), infiltration basins have the smallest footprint, but the site cannot be used for other purposes. MassDEP generally allows hydraulic loading rates up to 5 gallons per day per square foot of basin area unless higher rates are proven for a specific site. Maintenance requirements are minimal. Typically, disinfection is required.

Advantages:

- Lower construction costs than subsurface leaching systems
- Easy access to soils underlying discharge
- Smallest land area requirement

Disadvantages:

- Requires periodic maintenance of the basins
- Requires dedicated area of open land
- If basins are not located at the wastewater treatment facility, will require construction of a pumping station and force main to transport the treated effluent

12.10.1.2 Subsurface Leaching Systems

Subsurface leaching systems or soil absorption systems (SAS) are the most common disposal method presently employed on Cape Cod, as they are used for on-site septic systems. Although larger wastewater treatment facilities require large disposal areas, SAS can be installed beneath recreational and paved land areas. Large-scale SAS typically have pumps and pipes to pressure dose the infiltration areas. Maintenance is more difficult because the infiltration area is below the surface of the ground and solids cannot be easily removed. MassDEP generally allows hydraulic loading rates of 1 to 2 gallons per day per square foot of bed area. Typically, disinfection is not required unless the SAS is in a Zone II.

Advantages:

- Virtually no above ground utilities
- Can be installed in public areas (fields, under gold course fairways, parks, etc.)

Disadvantages:

- Requires the most land area of discharge options
- Generally most expensive (Land and construction costs) of the land discharge options

12.10.1.3 Wicks

Once the wastewater has been collected and treated at a WWTF, the treated wastewater effluent is generally disposed to groundwater. Wicks are large diameter conduits of stone that allow for

the rapid infiltration of effluent to the underlying groundwater. The effluent is discharged into a wick (two to six feet in diameter) where it is infiltrated into the aquifer until it reaches the ocean. Wicks do not require a highly treated effluent like injection wells, but they still have the advantage of using only a fraction of the land area required for an equivalent discharge through infiltration basins and SAS systems. This technology has been used in only a few places in Massachusetts.

Advantages:

- Requires only a fraction of the land area needed for infiltration basins or soil absorption systems
- Can be installed on very small parcels or within easement areas
- Low capital and O&M costs compared to the other discharge options
- Can be installed through shallow layers of fine soils that may limit or prohibit the installation of infiltration basins or soil absorption systems
- Virtually no above ground utilities
- Easy access for monitoring

Disadvantages:

- Higher level of treatment than infiltration basins and soil absorption systems (SAS) discharges may be required
- May require a higher level of hydrogeologic investigation than infiltration basin and soil absorption systems (SAS)
- Higher level of permitting (MassDEP) may be required than infiltration basins or soil absorption systems (SAS)

12.10.1.4 Drip Irrigation

MassDEP has approved drip irrigation as an acceptable effluent-disposal method for flows that are less than 10,000 gallons per day and that meet required treatment levels for reclaimed water. Drip irrigation functions much like SAS except it utilizes pressurized flexible tubing installed at shallow depth where effluent can be absorbed by plant roots. Drip irrigation uses small diameter, porous tubing to discharge the effluent within a foot of the ground surface and within the root zone of vegetation. The plants uptake a portion of the discharge including nitrogen and phosphorus, lowering nitrogen and phosphorus concentration before reaching the water table. Benefits include ease and low cost of installation and minimal water table impacts. Drip irrigation systems may not operate in colder climates. This technology also requires that effluent be treated to a high level to prevent clogging of the emitters. A reserve standard SAS may be required due to the experimental nature of drip irrigation systems in Massachusetts.

Advantages:

- Can be used in adverse terrain conditions
- Ease of construction
- Low human exposure to wastewater

- Low delivery rate to minimize water table impacts

Disadvantages:

- Effluent must be highly treated to minimize plugging
- Periodic back flushing is required
- May not operate in very cold conditions
- There is limited long-term performance data

12.10.1.5 Deep Well Injection

Deep well injection involves pumping treated effluent into the groundwater below the land surface. The recharge is accomplished by pumping the treated water through wells that extend into permeable, saturated, and unsaturated geologic strata. A potential concern of well injection is the mounding of groundwater in low elevation areas. As a result, well injection requires extensive testing prior to design and construction. This would include hydraulic conductivity tests, hydrogeologic surveys, and pilot testing.

Well injection of treated wastewater has been implemented on a limited basis throughout the United States, as there are limited regulatory standards on the siting, design, construction, and operation of the wells. A pilot test conducted at the Hyannis Water Pollution Control Facility indicated injection wells can become plugged with biological growth if the effluent is not chlorinated. MassDEP has not supported this technology as chlorination can create secondary impacts to the groundwater.

Advantages:

- Land area required would be much less than the area required for infiltration basins, subsurface infiltration, and spray irrigation
- Recharge would occur below the surface, and the surface would have minimal disruption
- Discharge points could be spread over a large area to minimize groundwater monitoring

Disadvantages:

- Effluent filtration is needed to provide a high level of nutrient and solids removal to minimize plugging of the wells
- Relatively unproven technology in Massachusetts
- Limited performance data is available
- Chlorination is needed, which conflicts with guidance from MassDEP

12.10.1.6 Effluent Reuse - Spray Irrigation

Spray irrigation facilities are typically comprised of pumps, distribution piping and a spraying system consisting of risers and spray nozzles. Treated wastewater is pumped through various distribution lines and discharged via spray nozzles to the surrounding area. Spray irrigation

systems discharge treated effluent to large areas such as fields, woods, and golf courses. Spray irrigation allows for a secondary use of land, provides inexpensive irrigation, promotes evapo-transpiration, and, in the case of golf courses, can reduce the need for fertilizers. The potential for freezing temperatures may require a secondary method of effluent disposal during winter months. MassDEP has stringent requirements for the use of reclaimed water, including a requirement for disinfection.

Advantages:

- Allows for secondary use of land (i.e. golf courses) as regulated by MassDEP
- Provide inexpensive means of irrigation, reducing clean water demands
- Provides nitrogen uptake by plant life and also reduced nitrogen application at the golf courses

Disadvantages:

- Difficult to find locations suitable or willing to use spray irrigation
- Limited cold weather use due to potential freezing problems (redundancy required)
- Spray nozzles may be subject to clogging
- Requires secondary means of treated wastewater effluent recharge or storage during winter months (redundancy required)
- Must meet more stringent MassDEP requirements for reclaimed water use
- Large areas are typically needed
- Applied at an agronomic rate; not disposal.

12.10.2 Recharge and Reuse Sites and Total Organic Carbon

Due to the revision of MassDEP regulations in 2009, disposing of treated water in Zone II areas could be prohibitively expensive. Effluent discharge into Zone II areas are required to meet MassDEP's "Interim Guidelines on Reclaimed Water" (January 2000). The 2009 proposed revision to the guidelines made the limit on total organic carbon more stringent and prompted the Cape Cod Water Protection Collaborative to submit a comment indicating that the literal application of the total organic carbon requirement would seriously impede wastewater planning on Cape Cod. In response, MassDEP modified its regulations (314 CMR 5.10) to include some accommodation for extenuating circumstances and requirements varying treatment limits based on time of travel to a municipal drilling water well.

12.10.3 Recommended Effluent Recharge Technology

As discussed in Section 11, initial hydrogeologic evaluations of effluent recharge sites has begun at Sites 1 and 2. The sites must undergo a detailed hydrogeological evaluation as the first step in obtaining a groundwater discharge permit from the Massachusetts Department of Environmental Protection.

Based on the information obtained thus far at Sites 1 and 2, infiltration basins appear to be the most viable effluent recharge technology. It is likely that the basins at Site 1 will be open, while the basins at Site 2 will be covered in some fashion. Infiltration basins have lower construction costs and typically require less land than subsurface leaching systems Infiltration basins also require a lower level of treatment, hydrogeologic investigation, and permitting than wicks, drip irrigation, or deep well injection. Infiltration basins have also been successfully used in other Massachusetts communities like Plymouth and Falmouth, and in Norton as part of the MFN Regional Wastewater District's wastewater treatment plant expansion and upgrade project. And, compared to other technologies like spray irrigation and drip irrigation, infiltration basins are a proven success in the cold New England climate. While infiltration basins do require a dedicated area of open land and are visible above ground, Sites 1 and 2 are adjacent to Dennis' current and former DPW facilities, respectively, and other flexible layout options ideally located away from residential abutters or other public spaces.

12.11 Effluent Recharge Costs

12.11.1 Effluent Recharge Capital Costs

The capital costs for effluent recharge were calculated using the 208 plan's cost document's costs for infiltration basins. The costs increase as the sewer area and flow increase, as shown in **Table 12-11.**

Table 12-11 Effluent Recharge Capital Costs

	3B	5A	5B	6A	6B	8A	8B	8C
Effluent Recharge Capital Cost	$3.14 M	$3.11 M	$3.11 M	$3.3 M	$3.3 M	$3.3 M	$3.3 M	$3.3 M

Notes: Refer to Appendix D for details on basis of cost estimate. Costs are based and methodology published in "Comparison of Costs for Wastewater Management Systems Applicable to Cape Cod, Guidance to Cape Cod Towns Undertaking Comprehensive Wastewater Management Planning," dated April 2014 (version 2). ENR = 9702.

12.11.2 Effluent Recharge O&M Costs

The O&M costs for effluent recharge were calculated using the 208 plan's cost document. The costs increase as the sewer area and flow increase, as shown in **Table 12-12**.

Table 12-12 Effluent Recharge O&M Costs

	3B	5A	5B	6A	6B	8A	8B	8C
Effluent Recharge Capital Cost	$93 K	$92 K	$92 K	$95 K	$95 K	$95 K	$95 K	$95 K

Notes: Refer to Appendix D for details on basis of cost estimate. Costs are based and methodology published in "Comparison of Costs for Wastewater Management Systems Applicable to Cape Cod, Guidance to Cape Cod Towns Undertaking Comprehensive Wastewater Management Planning," dated April 2014 (version 2). ENR = 9702.

Section 13

Cost Results and Comparison of Final Scenarios

13.1 Purpose and Scope

This section compares and ranks the scenarios recommended for further analysis in the Water Quality Evaluation and Mitigation Alternative Study completed in August 2015. A final recommended scenario is identified based on the cost and non-cost factors. Costs presented in this section are for comparative purposes only and updated costs for the final Recommended Plan are included in Section 14.

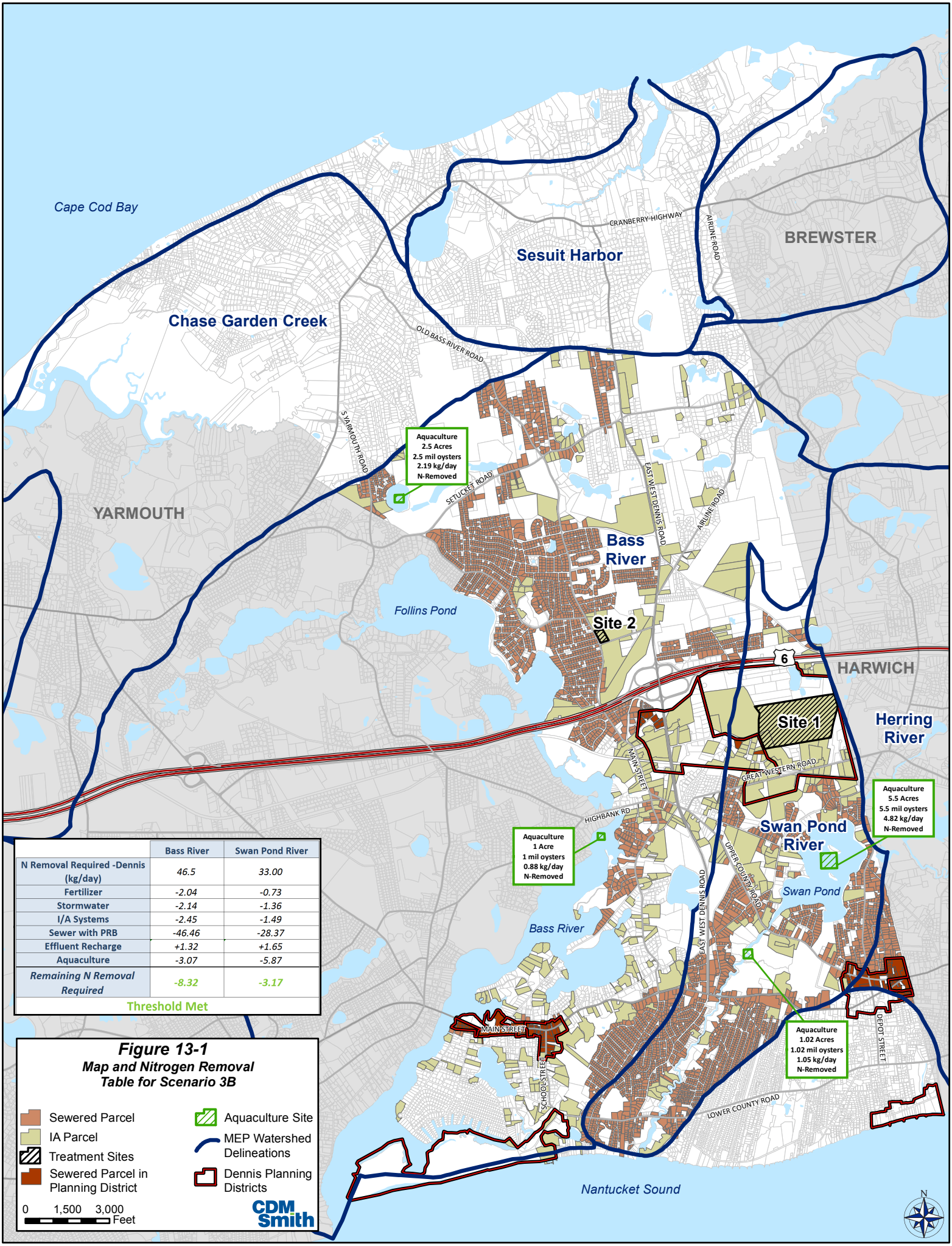
13.2 Water Quality Management Scenarios

The town developed fourteen water quality management scenarios to evaluate in the previous study phase completed in August 2015 that meet the MEP nitrogen removal requirements. The fourteen scenarios included combinations of traditional sewering methods, both centralized and decentralized, as well as non-traditional nitrogen management options including aquaculture, innovative/alternative (I/A) septic systems, and permeable reactive barriers (PRB). Furthermore, the baseline of each scenario is the assumption that the town will implement fertilizer and stormwater management programs. This accounts for a 25% nitrogen reduction of the stormwater and fertilizer nitrogen contributions to each watershed, as suggested by the Cape Cod Commission (CCC) as a credit to be provided to towns that implement such programs. To achieve 25% nitrogen reduction, 50% of the total roads in the Bass River and Swan Pond River watersheds are assumed to require stormwater Best Management Practices (BMPs). The town plans to achieve 25% nitrogen reduction in fertilizers by implementing a town-wide fertilizer education program.

Based on that evaluation, five scenarios – 3B, 5A, 5B, 6A, and 6B – have been brought forward for further analysis. In addition, since the initial scenario evaluation, Dennis has been participating in ongoing discussions with neighboring towns about possible community partnership scenarios. As a result, three additional scenarios – 8A, 8B, and 8C – evaluate various partnership scenarios with Yarmouth and/or Harwich. It was the Comprehensive Wastewater Management Task Forces (CWMTF's), now the Wastewater Implementation Committee (WIC) belief that these scenarios will provide the town with the best variety of viable options to reduce nitrogen in the town's watersheds to meet MEP and other community goals. The scenarios are described below and a map for each follows in **Figures 13-1 through 13-3**.

Scenario 3B

Scenario 3B addresses the majority of existing developed parcels in the Swan Pond River and Bass River watersheds and assumes that the town would reduce its stormwater and fertilizer nitrogen contributions by 25% by implementing a stormwater control plan, as well as a fertilizer education plan. Scenario 3B includes a combination of advanced I/A systems on parcels over 1 acre in size, and sewering as many parcels as required to meet MEP goals, with a perimeter PRB



	Bass River	Swan Pond River
N Removal Required -Dennis (kg/day)	46.5	33.00
Fertilizer	-2.04	-0.73
Stormwater	-2.14	-1.36
I/A Systems	-2.45	-1.49
Sewer with PRB	-46.46	-28.37
Effluent Recharge	+1.32	+1.65
Aquaculture	-3.07	-5.87
Remaining N Removal Required	*-8.32*	*-3.17*
Threshold Met		

Figure 13-1
Map and Nitrogen Removal Table for Scenario 3B

- Sewered Parcel
- IA Parcel
- Treatment Sites
- Sewered Parcel in Planning District
- Aquaculture Site
- MEP Watershed Delineations
- Dennis Planning Districts

around the effluent recharge sites. The sewering areas were chosen for smaller parcels in high density neighborhoods where an I/A system may not otherwise be practical, and sewers in the West Dennis Planning District. Scenario 3B includes decentralized treatment, meaning there are two smaller treatment facilities at Sites #1 and #2, with recharge on each facility's site. Scenario 3B also includes two PRBs for the two recharge areas. Figure 13-1 shows the scenario map and nitrogen removal table for Scenario 3B.

Scenario 5A

Scenario 5 includes fertilizer and stormwater credits, aquaculture, and sewering without PRBs. The sewer footprint includes sewering as many existing developed parcels as necessary in the Bass River and Swan Pond River watersheds in order to meet the nitrogen removal requirements. The sewered area includes multiple planning district areas. Aquaculture is included in both the Bass River and Swan Pond River watersheds to compensate for the lost nitrogen reduction provided by PRBs, which have been eliminated from Scenario 5A. Scenario 5A includes centralized treatment at Site #1 and recharge at Sites #1 and #2. **Figure 13-2** shows the scenario map and nitrogen removal table for Scenario 5A.

Scenario 5B

Scenario 5B includes the same fertilizer and stormwater credits, aquaculture, and sewering without PRBs as Scenario 5A, but includes decentralized treatment and recharge at Site #1 and Site #2. Figure 13-2 shows the scenario map and nitrogen removal table for Scenario 5B.

Scenario 6A

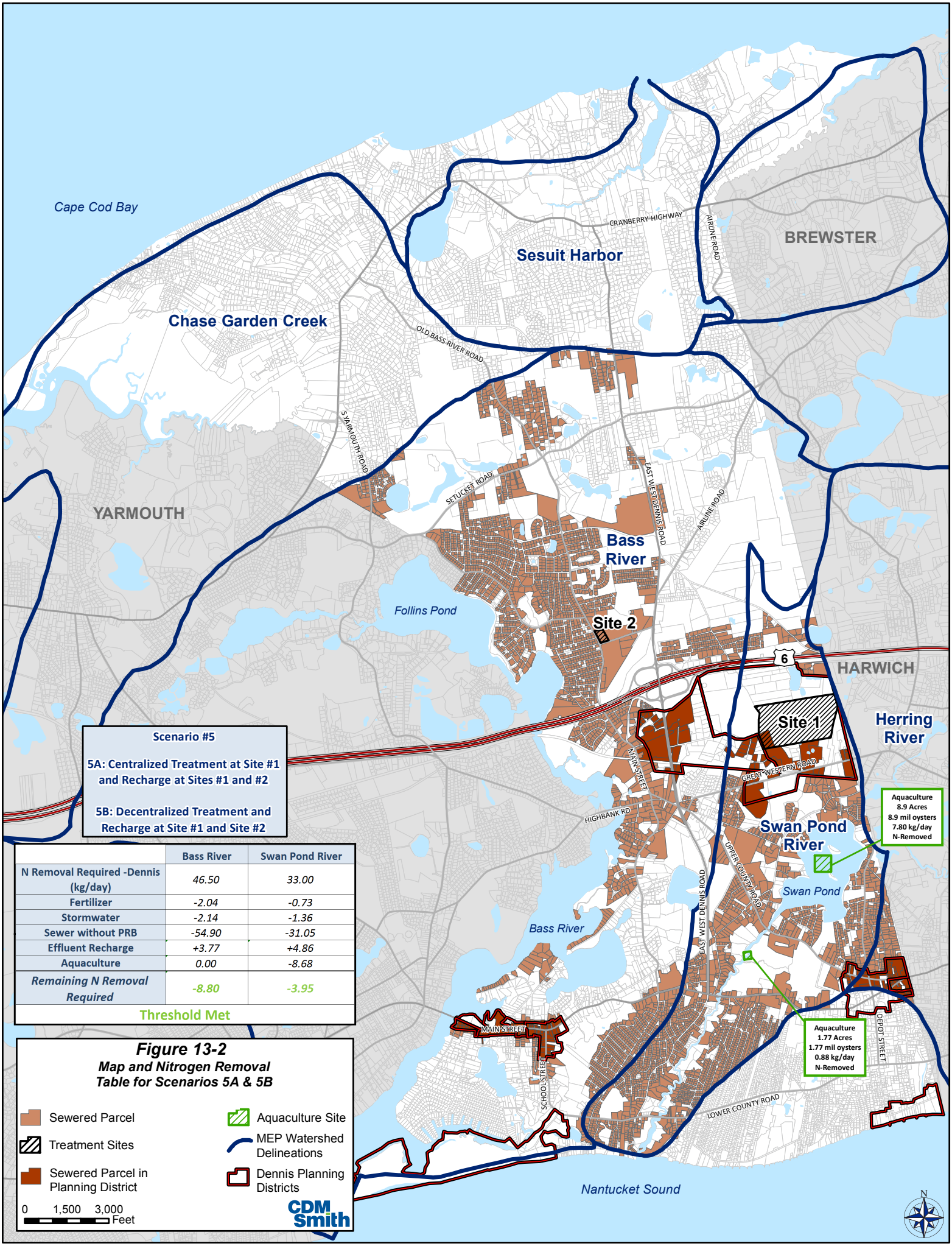
Scenario 6A includes fertilizer and stormwater credits, aquaculture, and sewering with PRBs and the recharge sites. The sewering plan in Scenario 6A includes a similar footprint of sewers as Scenarios 5A and 5B, including a portion of existing developed parcels, plus all of the planning districts and the entire southern coast of town. While this scenario exceeds the nitrogen removal requirements of the MEP, it has been laid out to meet the infrastructure needs of other town goals such as economic growth and Title 5 issues. Scenario 6A includes centralized treatment at Site #1 and recharge at Sites #1 and #2. **Figure 13-3** shows the scenario map and nitrogen removal table for Scenario 6A. This scenario is utilized in the community partnership scenarios (8A, 8B, and 8C).

Scenario 6B

Scenario 6B includes the same fertilizer and stormwater credits, aquaculture, and sewering with PRBs as Scenario 6A, but includes decentralized treatment and recharge at each of Site #1 and Site #2. Figure 13-3 shows the scenario map and nitrogen removal table for Scenario 6B.

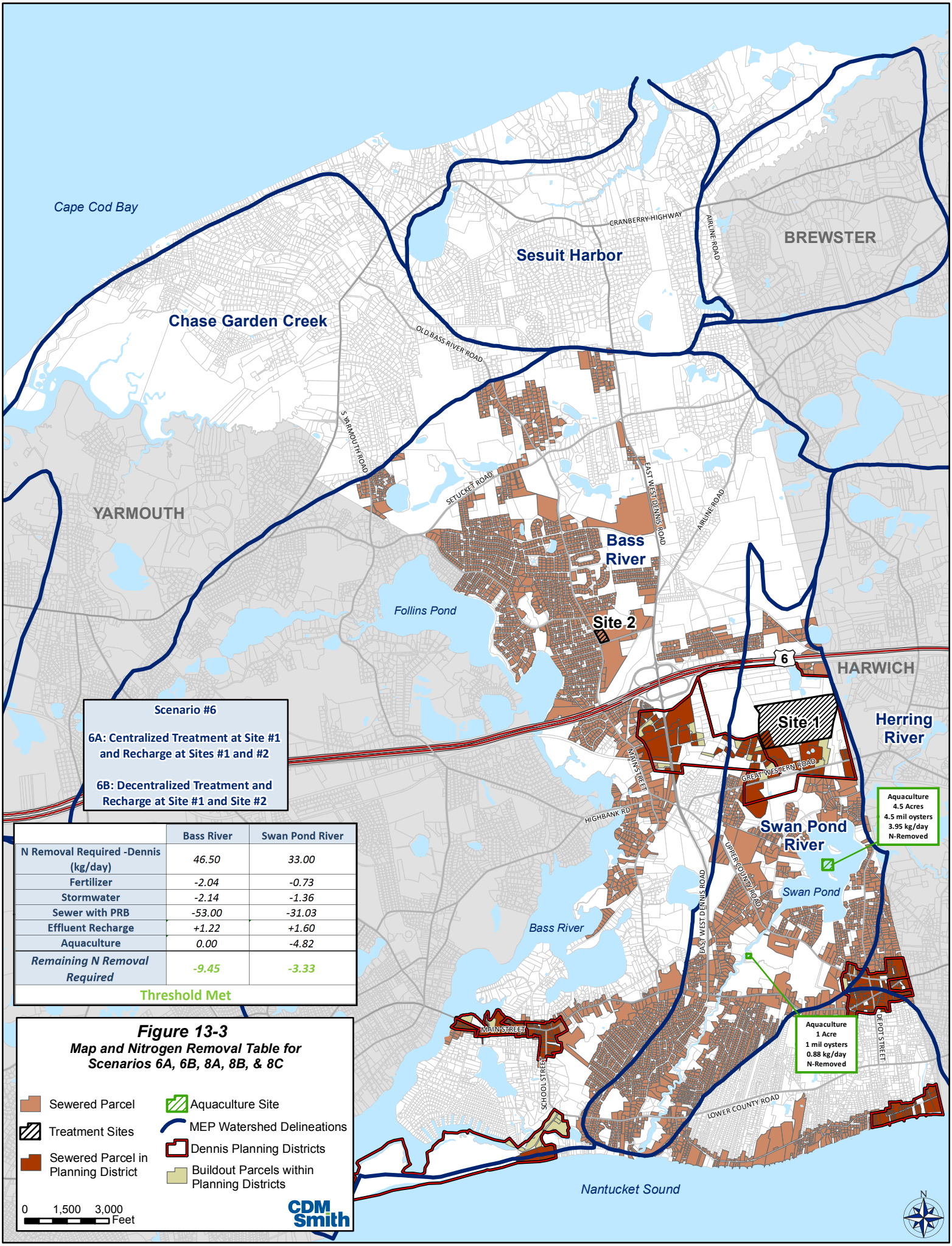
Scenario 8A

Scenario 8A includes the same fertilizer and stormwater credits, aquaculture, and sewering with PRBs as Scenario 6A, but includes a centralized treatment plant that is shared with Yarmouth. Under this community partnership scenario, Dennis would pump their wastewater to the Community Wastewater Treatment Facility at Yarmouth's Buck Island Road Site, and recharge would take place in both Dennis and Yarmouth. Figure 13-3 shows the scenario map and nitrogen removal table for Scenario 8A.



	Bass River	Swan Pond River
N Removal Required -Dennis (kg/day)	46.50	33.00
Fertilizer	-2.04	-0.73
Stormwater	-2.14	-1.36
Sewer without PRB	-54.90	-31.05
Effluent Recharge	+3.77	+4.86
Aquaculture	0.00	-8.68
Remaining N Removal Required	*-8.80*	*-3.95*
Threshold Met		

Figure 13-2
Map and Nitrogen Removal Table for Scenarios 5A & 5B



	Bass River	Swan Pond River
N Removal Required -Dennis (kg/day)	46.50	33.00
Fertilizer	-2.04	-0.73
Stormwater	-2.14	-1.36
Sewer with PRB	-53.00	-31.03
Effluent Recharge	+1.22	+1.60
Aquaculture	0.00	-4.82
Remaining N Removal Required	*-9.45*	*-3.33*
Threshold Met		

Figure 13-3
Map and Nitrogen Removal Table for Scenarios 6A, 6B, 8A, 8B, & 8C

Scenario 8B

Scenario 8A includes the same fertilizer and stormwater credits, aquaculture, and sewering with PRBs as Scenario 6A, but includes a centralized treatment plant that is shared with Harwich. Under this community partnership scenario, Harwich would pump their wastewater to the Community Wastewater Treatment Facility at Dennis's Site #1, and recharge would take place in both Dennis and Harwich. Figure 13-3 shows the scenario map and nitrogen removal table for Scenario 8B.

Scenario 8C

Scenario 8C includes the same fertilizer and stormwater credits, aquaculture, and sewering with PRBs as Scenario 6A, but includes a centralized treatment plant that is shared with Harwich and Yarmouth. Under this community partnership scenario, both Harwich and Yarmouth would pump their wastewater to the Community Wastewater Treatment Facility at Dennis's Site #1, and recharge would take place in Dennis, Harwich, and Yarmouth. Figure 13-3 shows the scenario map and nitrogen removal table for Scenario 8C.

The eight scenarios are summarized below in **Table 13-1**.

13.3 Comparative Assessment of Final Scenarios

A comparative analysis was performed to screen the eight scenarios and identify the scenario deemed most favorable to the town. The intent of the screening process was to gather enough data to perform fair comparisons between the scenarios. The first step of the comparative analysis was to build on the costs developed in Section 12 and establish planning-level cost estimates for each scenario, considering both short-term and long-term costs.

13.3.1Cost Analysis

The comparative costs were developed using the tools presented in the Barnstable County Wastewater Cost Task Force's report entitled, "Comparison of Costs for Wastewater Management Systems Applicable to Cape Cod, Guidance to Cape Cod Towns Undertaking Comprehensive Wastewater Management Planning" dated April 2010, and updated April 2014 (v2), referred to herein as the 208 Plan cost document. Capital Costs were supplemented by CDM Smith for unit costs not readily available in the 208 Plan cost document.

Since the initial cost estimate performed in the August 2015 study, a number of quantities and unit costs have been further refined. A preliminary sewer layout was performed for each scenario in Section 12, providing a refined linear footage of pipe and number of pumping stations. Additionally, an evaluation was performed on the town's expected wastewater flows under build-out conditions. The revised cost estimates are based on the build-out wastewater flows. CDM Smith supplemented unit costs based on past experiences on similar projects for pumping stations, gravity sewer pipe by size, force main by pipe size, and pipe costs when working in a state road. In addition, costs were provided by pressure sewer and vacuum sewer vendors to further supplement the 208 Plan costs. The information presented in this subsection is supplemented by the cost estimate details and assumptions provided in Appendix D.

Capital costs developed include collection, conveyance, treatment, and effluent recharge. These capital costs include design and permitting costs as well. Collection and transport costs are .

Table 13-1 Scenario Comparison Summary (ENR: 10181)

	3B	5A	5B	6A	6B	8A	8B	8C
Description	**Aquaculture , I/A &Sewer with PRB**	**Aquaculture & Sewer without PRB**	**Aquaculture & Sewer without PRB**	**Aquaculture & Sewer with PRB**	**Aquaculture & Sewer with PRB**	**Centralized Scenario 6 + Community Partnership with Yarmouth**	**Centralized Scenario 6 + Community Partnership with Harwich**	**Centralized Scenario 6 + Community Partnership with Harwich & Yarmouth**
Fertilizer/Stormwater Credits	X	X	X	X	X	X	X	X
Number of Parcels with I/A Systems	395							
Acres of Aquaculture	10.02	10.67	10.67	5.50	5.50	5.50	5.50	5.50
Number of Parcels Sewered	5,815	6,114	6,114	6,276	6,276	6,276	6,276	6,276
Planning Districts Included	West Dennis	Multiple	Multiple	All	All	All	All	All
Areas of Concerns (AOC's) Included	Some	Some	Some	Some	Some	Some	Some	Some
Route 6 Crossing		X		X		X	X	X
Miles of Sewer Collection Pipes	72	80	80	88	88	88	88	88
Number of Pumping Stations	18	18	18	22	22	22	22	22
Linear Feet of Force Main	4,468	4,105	4,105	9,430	9,430	9,430	9,430	9,430
Number of WWTPs	2	1	2	1	2	1	1	1
Number of Effluent Recharge Sites	2	2	2	2	2	2	2	7
PRB at Recharge Site	X			X	X	X	X	X
Number of Non-traditional Technologies	3	1	1	2	2	2	2	2
Average Daily Flow to WWTP #1 (from Dennis)	971,000	1,491,000	956,000	1,555,000	1,043,000	1,555,000	1,555,000	1,555,000
Average Daily Flow to WWTP #2	536,000		535,000		512,000			
Collection and Conveyance Capital Cost	$98 M	$108 M	$107 M	$119 M	$118 M	$129 M	$119 M	$122 M
Treatment Capital Cost	$53 M	$39 M	$53 M	$38 M	$52 M	$25 M	$35 M	$24 M
Conveyance to Recharge Cost	$1 M	$4 M	$1 M	$4 M	$1 M	$13 M	$4 M	$6 M
Effluent Recharge with PRB Cost	$17 M	$3 M	$3 M	$19 M	$17 M	$16 M	$16 M	$10 M
Non-Traditional Cost	$20 M	$9 M	$9 M	$9 M	$9 M	$9 M	$9 M	$9 M
Total Capital Cost	$189 M	$164 M	$173 M	$188 M	$197 M	$191 M	$183 M	$170 M
Total Capital Cost with Engineering & Contingency	$208 M	$180 M	$190 M	$207 M	$217 M	$210 M	$202 M	$170 M
Total Annual O&M	$9.0 M	$6.7 M	$7.3 M	$7.0 M	$7.9 M	$4.5 M	$5.8 M	$4.0 M
Equivalent Annual Cost (EAC)	$21.7 M	$17.7 M	$19.0 M	$19.7 M	$21.2 M	$17.3 M	$18.0 M	$12.0 M
Nitrogen Removed (lbs/yr)	73,231	74,245	74,245	74,269	74,269	74,269	74,269	74,269
Annual cost per Pound Removed	$300	$240	$260	$270	$290	$230	$240	$162

determined based on the linear footage of sewers within the proposed sewer collection areas for each scenario. Conveyance costs for pumping stations are based on the pumping stations required in the preliminary sewer layout, as well as pumping stations and related force mains to pump to a community wastewater treatment facility in one town and then a return pumping station to effluent recharge sites. Treatment costs were determined using a cost curve in the 208 Plan cost document based on flows under build-out conditions at the proposed wastewater treatment facilities. A peaking factor of 2.2 was used to account for short term peak flows. The average daily flow (ADF) for each treatment facility is included in Table 13-1. Effluent recharge costs are based on the acreage of the recharge sites and an assumed recharge rate per acre.

In addition to these capital costs, costs were estimated for the non-traditional technology components of each scenario using the 208 Plan cost document as well. These included advanced I/A system costs calculated per parcel, PRB costs per linear foot, aquaculture per acre, and stormwater BMPs per curb mile. Fertilizer education was assumed to have no capital costs associated. PRB costs were also supplemented using information developed in CDM Smith's pilot study for the town of Falmouth, Massachusetts. The amount of aquaculture required to meet nitrogen reduction loadings was based on Scott Lindell's "Introduction to Shellfish Bioremediation Case Studies of Relevance to Town of Dennis."

Operations and maintenance (O&M) costs were also developed using the 208 Plan cost document. These costs include labor, chemicals, electricity, laboratory analysis, repairs, administrative costs, and sludge removal for wastewater treatment facilities. The O&M costs are determined separately for each proposed treatment facility based on a cost curve in the 208 Plan cost document which provides the annual cost per gallon treated. Similar to the capital costs, the peaking factor of 2.2 was applied to the average daily flows taken directly from the MEP water usage (or CCC water usage for parcels outside of the MEP watersheds with completed reports) for each area tributary to each treatment facility. These flows will be adjusted in the next study phase to account for infiltration and inflow components of various sewer collection systems. The O&M costs for pressure sewer and vacuum sewer were developed with input from vendors.

Equivalent annual costs (EAC) were developed using the capital and O&M costs together, as presented in Section 13.3.2 below. Cost efficiency was then developed by dividing the equivalent annual cost by the pounds of nitrogen removed by each scenario, to arrive at an annual cost per pound of nitrogen removed.

13.3.2 Cost Results

All of the costs described above were tabulated into a detailed spreadsheet that shows each component of the proposed wastewater system for each scenario including collection, conveyance, treatment, and effluent recharge, along with each applicable non-traditional technology including aquaculture, advanced I/A systems, PRBs, stormwater BMPs, and fertilizer education. The spreadsheet is provided in Appendix D, along with additional details regarding the calculations included therein. A summary of this information for each scenario is presented in Table 13-1.

The estimated total capital cost of each option is presented along with the estimated total O&M cost for each option. For comparison of costs on an annualized basis, an EAC is calculated. The

EAC is calculated on the basis that the entire capital cost is borrowed in Year 1 and paid back over a 20-year period at an interest rate of 2 percent, consistent with the typical lending rate of the Clean Water State Revolving Fund (SRF). This annualized capital cost is then added to the estimated annual O&M cost, to arrive at a total EAC for each scenario. While this mechanism and schedule of borrowing is not a realistic financing plan since implementation would be phased in over many years, it allows for a fair comparison of scenarios using a methodology that combines capital with O&M costs.
From the summary table, the equivalent annual cost of Scenario 5A is the lowest among the Dennis-only scenarios. Scenario 3B is the most costly EAC because of the large number of individual advanced I/A systems required, which carry both expensive capital and annual O&M costs. The scenarios with two smaller treatment facilities (5B and 6B) are more costly than having one larger treatment facility due to economies of scale (5A and 6A). Scenario 6A has a higher cost than Scenario 5A as it sewers a larger area in the economic district in Dennis.

From a community partnership perspective, Scenario 8C has the lowest cost while Scenario 8A has the highest cost. This is expected because Scenario 8C spreads costs among three communities, capitalizing on the economy of scale at the wastewater treatment plant from both a capital and O&M perspective. In Scenario 8A, Dennis is only partnering with one community, Yarmouth, reducing overall flows to the treatment plant as compared to Scenario 8C. Scenario 8A costs more than 8B because Dennis must pump and convey their wastewater to a treatment facility in Yarmouth

13.3.3 Evaluation Criteria

To distinguish between the eight scenarios, a detailed evaluation matrix was developed. The following evaluation criteria were selected for analysis and divided into four major categories:

- Relative Costs
  - Capital Costs
  - O&M Costs
  - Equivalent Annual Cost (EAC)
  - Cost per Pound of Nitrogen Removed
- Design Requirements and Technology Reliability
  - Design Requirements
  - Technology Reliability
- Implementation Concerns
  - Regulatory Acceptance and Permitting Requirements
  - Available Resources
  - Governance Structure

- Public Acceptance
- Other Community and Environmental Needs

- Construction Impacts

Each individual criterion was weighted individually by the CWMTF to reflect preferences in Dennis. The relative costs category is weighted at 40 percent in this analysis since project costs are often times the deciding factor in whether a project is implemented. Capital costs have been the greatest obstacle to the advancement of other Cape Cod wastewater projects in recent years.

All criteria were ranked on a scale of 1 to 5, with 1 being the least favorable and 5 being the most favorable. Thus, the scenario with the highest total score would rank most favorable. The definition and ranking approach for each criterion is described below.

Relative Costs (40 Percent Weight)

Capital Costs (5%): The planning-level capital cost were ranked as follows:

Rating	Range
1	>$215 M
2	$205 M - $215 M
3	$195 M - $205 M
4	$190 M - $195 M
5	<$190 M

Operations and Maintenance Costs (5%): The O&M costs are shown on an average annual basis at 2016 dollars and were ranked as follows:

Rating	Range
1	>$8.5 M
2	$7 M - $8.5 M
3	$5.5 M - $6.9 M
4	$4.1 M - $5.5 M
5	≤$4 M

Equivalent Annual Cost (20%): The Equivalent Annual Cost (EAC) of the system is calculated using the 20-year life cycle at an interest payment rate of two percent plus the annual O&M cost. This gives a good comparative estimate of the annual cost for the system by accounting for loan payments and O&M costs. Note, however, that this method presumes all capital costs are accrued at once, therefore it is useful for comparative purposes only. The EAC was ranked as follows:

Rating	Range
1	>$21.5M
2	$19.1 M-$21.5 M
3	$18.1 M-$19 M
4	$17.1 M- $18 M
5	≤$17 M

Cost per Pound of Nitrogen Removed (10%): The capital cost of each scenario was divided by the amount of nitrogen removed to develop a cost per pound of nitrogen removed to determine the scenario's effectiveness in removing nitrogen inputs from Dennis' waterways:

Rating	Range
1	>$299/lb N
2	$270/lb N - $299/lb N
3	$255/lb N - $269/lb N
4	$230/lb N - $255/lb N
5	<$229/lb N

Design Requirements and Technology Reliability (14 Percent Weight)

Design Requirements (4%): The various scenarios involve collecting wastewater from sewer service areas and conveying the collected wastewater via pumping stations and force mains to treatment facilities and effluent recharge areas. The design complexities increase with the number of houses on sewer, increasing the number of major pumping stations required to convey collected wastewater to the treatment facilities and effluent recharge sites. The complexity of each scenario's transport system was evaluated by considering the total length of force mains required to convey wastewater to the treatment facility sites and effluent to the recharge sites (including outfall pipes) to arrive at the following rankings:

Rating	Range
1	Requires greater than 10,000 lf of force mains
2	Requires greater than 8,000 lf up to 10,000 lf of force mains
3	Requires greater than 6,000 lf up to 8,000 lf of force mains
4	Requires greater than 4,200 lf up to 6,000 lf of force mains
5	Requires 4,200 lf or less of force mains

Technology Reliability (10%): Reliability issues explore the likelihood of a technology's success. Technologies considered tried and true are ranked with a higher score. Newer technologies that have not been widely used in the industry are ranked with a lower score. Thus, scenarios with more non-traditional technologies receive a lower score. These criteria are used in the following rankings:

Rating	Range
1	Includes 4 or more non-traditional technologies
2	Includes 3 non-traditional technologies
3	Includes 2 non-traditional technologies
4	Includes 1 non-traditional technology
5	Includes no non-traditional technologies

Implementation Concerns (38 Percent Weight)

Regulatory Acceptance and Permitting Requirements (10%): Regulatory considerations include the permitting required to both construct and operate the proposed facilities, which can depend on their locations, the number of facilities and technologies proposed, and the proximity to areas requiring additional regulatory review such as coastal zones, flood plains, sensitive habitats, etc. Regulatory considerations were ranked as follows:

Rating	Range
1	Many regulatory hurdles anticipated for PRB, aquaculture, I/A systems, two treatment facilities and two effluent recharge locations
2	Many regulatory hurdles anticipated for PRB, aquaculture, two treatment facilities and two effluent recharge locations
3	Many regulatory hurdles anticipated for PRB, aquaculture, one treatment facility and two or more effluent recharge locations
4	Some regulatory hurdles anticipated for aquaculture and two treatment facilities and two effluent recharge locations
5	Few regulatory hurdles anticipated for aquaculture and one treatment facility and two effluent recharge locations

Available Resources (4%): Implementation of a management program for I/A systems may require some additional BOH staffing to oversee the installation and proper operation of the systems, monitoring of the systems, and implementation of a continuous public education program.

From five to almost 11 acres is proposed for aquaculture projects in the scenarios. As aquaculture acreage increases, the need for multiple aquaculture locations may be necessary. This could necessitate different installation and maintenance methods depending on site conditions and increasing labor needs.

PRBs are an added treatment process. However, once installed, regular maintenance is relatively minimal when compared to other non-traditional treatment approaches like I/A and aquaculture.

All treatment facility options have similar resource needs. Construction of multiple treatment facilities will require an increase in labor force. Available resources to operate and maintain each scenario were compared and ranked as follows:

Rating	Range
1	Labor needed to implement I/A management plan, operate and maintain aquaculture greater than 10 acres, and operate and maintain two treatment facilities
2	Labor needed to operate and maintain aquaculture greater than 10 acres and operate and maintain two treatment facilities
3	Labor needed to operate and maintain approximately 5 acres of aquaculture, operate and maintain a PRB, and operate and maintain two treatment facilities
4	Labor needed to operate and maintain aquaculture greater than 10 acres and operate and maintain one treatment facility

5	Labor needed to operate and maintain approximately 5 acres of aquaculture, operate and maintain a PRB, and operate and maintain one treatment facility

Governance Structure (10%): The various scenarios have a mix of technologies that would be owned and operated by individual property owners, the town of Dennis, or the town of Dennis in cooperation with neighboring town(s). Scenarios with Dennis or multiple town oversight are expected to result in more reliable nitrogen removal performance as compared to I/A systems and were given more points. Scenarios with Dennis-only oversight were given the most points and ranked as follows:

Rating	Range
1	Includes I/As and two treatment facilities
2	Includes two treatment facilities managed jointly by Dennis and other towns
3	Includes one treatment facility managed jointly by Dennis and other towns
4	Includes two treatment facilities managed by Dennis only
5	Includes one treatment facility managed by Dennis only

Public Acceptance (4%): On-site I/A systems will contain complex nutrient removal equipment requiring special skills to operate and maintain. Property owners may be reluctant to bear the responsibility for operating and maintaining such systems. Conversely, the proximity of resident's homes to wastewater treatment facilities can be a barrier to public acceptance. Thus, proposing multiple treatment facilities could prove difficult in garnering public support. Lastly, the installation of large aquaculture projects could be aesthetically displeasing to some members of the public. Public acceptance of the various scenarios is ranked as follows:

Rating	Range
1	Individual homeowner responsible for I/A systems, two treatment facilities
2	Greater than 10 acres of aquaculture and two treatment facilities
3	Approximately 5 acres of aquaculture and two treatment facilities
4	Greater than 10 acres of aquaculture but only one treatment facility
5	Approximately 5 acres of aquaculture and one treatment facility

Other Community and Environmental Needs (10%): Some scenarios address wastewater needs in other parts of town beyond meeting the watershed goals, including planning districts and areas of concern (AOCs). The opportunity for addressing other community needs associated with each scenario is ranked as follows:

Rating	Range
1	No planning districts or AOCs included

2	West Dennis planning district included and some AOCs included
3	Multiple planning districts included and some AOCs included
4	All planning districts and some AOCs included
5	Sewer in all planning districts and all AOCs included

Construction Impacts (8 Percent Weight)

Construction Impacts (8%): Each scenario will involve some level of construction impacts. Scenarios anticipated to require deeper construction, more time-consuming construction, more challenging construction methods (e.g., trenchless technologies or complex dewatering systems), or work in more challenging areas (e.g., major roads, wetland areas, etc.) are ranked less favorably due to the higher likelihood of impacts to surrounding areas than those for which construction is anticipated to be straightforward. The construction impacts were ranked as follows:

Rating	Range
1	Construction is anticipated to be very complex with I/A systems, two treatment facilities, and two effluent recharge sites
2	Construction is anticipated to be complex by utilizing two treatment facilities and two effluent recharge sites with no Route 6 crossings, no I/A systems
3	Construction is anticipated to be complex, requiring construction and coordination in multiple communities, utilizing one treatment facility and two effluent recharge sites, and including Route 6 crossings, no I/A systems
4	Construction is anticipated to be somewhat complex by utilizing one treatment facility and two effluent recharge sites, and including Route 6 crossings, no I/A systems
5	Construction is anticipated to be straightforward, with no I/A systems, Route 6 crossings, or WWTPs

13.3.4Matrix Scoring and Results

All of the factors described above were tabulated below into a matrix which show the ranking for each evaluation criterion and respective assigned weight. Each criterion is ranked from 1 to 5 (higher ranking equals most favorable) and each criterion was weighted by the CWMTF based on preference for that particular category. The relative costs are weighed at 40 percent because the CWMTF believes that the cost of the system will be a significant deciding factor in the outcome of the final recommended program. The end result is a matrix that ranks each of the options with a low score of 137 and a high score of 414. In this matrix, the low score of 137 is given to Scenario 3B, and the high score is given to Scenario 5A. Scenario 3B was ranked low due to the high cost of constructing and maintaining I/A systems. Scenarios 5B and 6B had lower matrix scores due to the high cost of building and maintaining two smaller treatment plants, versus one larger plant. Scenario 5A received the highest score because of the combined factors of only one treatment plant and a smaller sewer collection system footprint to only meet the MEP criteria as compared to Scenario 6A. The community partnership scenarios, especially Scenarios 8C, were generally ranked high due to the economy of scale gained with one large plant and shared costs among two or more communities.

13.4 Recommended Scenario

The Dennis CWMTF discussed in April 2016, the evaluation results and recommended that Scenario 6A be brought forward to be evaluated in more detail and ultimately be implemented. While this was not the highest scoring scenario in the matrix evaluation, the CWMTF selected this scenario because it, as compared to Scenario 5A, provides for greater wastewater collection from all of the town's economic development planning districts. Some CWMTF members felt it would only be a matter of time before scenario 5A would be expanded into Scenario 6A and so it should be planned for from the start. The economic development areas can also be addressed as the spine of the sewer system is constructed in the initial phases. In summary, the Dennis WIC believes that Scenario 6A will provide the town with a viable option to reduce nitrogen in the town's watersheds to meet MEP goals, while also meeting other important town goals for economic and community development.

The WIC in subsequent meetings wanted to modify the recommendation to implement Scenario 6A as the full recommended program phasing is developed. They voted to adopt a recommendation that incorporates implementation of Scenario 7A in the long-term since those additional Areas of Concern (AOCs) included in that option are characterized by high

groundwater and very small lots even though groundwater flow from those areas discharges directly to Nantucket Sound. So while current cost projections only reflect Scenario 6A, future costs account for allowances in future flow increases (larger pipe sizes, increased capacity in a pumping station, etc.) to accommodate the Scenario 7A areas. Additional effluent recharge areas will also be identified to account for the increased flow in future phases.

Table 13-2 **Scenario Evaluation**

Scenarios									
Evaluation Criteria	***Criteria Weight***	***3B***	***5A***	***5B***	***6A***	***6B***	***8A***	***8B***	***8C***
Relative Costs	**40%**								
Capital Costs	5%	10	25	20	10	5	10	15	25
O&M Costs	5%	5	15	10	10	10	20	15	25
Equivalent Annual Cost (EAC)	20%	20	80	60	40	40	80	60	100
Cost per lb of N Removed	10%	10	40	30	20	20	40	40	50
Subtotal Relative Costs		45	160	120	80	75	150	130	200
Design Requirements and Technology Reliability	**14%**								
Design Requirements	4%	16	20	20	8	8	8	8	8
Technology Reliability	10%	20	40	40	30	30	30	30	30
Subtotal Design and Technology		36	60	60	38	38	38	38	38
Implementation Concerns	**38%**								
Regulatory Acceptance and Permitting Requirements	10%	10	50	40	30	20	30	30	30
Available Resources	4%	4	16	8	20	12	20	20	20
Governance Structure	10%	10	50	40	50	40	30	30	30
Public Acceptance	4%	4	16	8	20	12	20	20	20
Other Community and Environmental Needs	10%	20	30	30	40	40	40	40	40
Subtotal Implementation Concerns		48	162	126	160	124	140	140	140
Construction Impacts	**8%**								
Construction Impacts	8%	8	32	16	32	16	24	24	24
Subtotal Construction Impacts		8	32	16	32	16	24	24	24
Total With Weighting	**100%**	137	414	322	310	253	352	332	402

Section 14

Recommended Program

14.1 Introduction

The recommended wastewater program for the Town of Dennis includes a collection system utilizing one centralized treatment facility. Each of these components would be phased in over 40 years. The implementation of such a program will allow Dennis to meet its water resource management needs as defined throughout this report, including consistency with the Massachusetts Estuaries Project (MEP) and subsequent Total Maximum Daily Load (TMDL) nitrogen reduction goals as well as the protection of freshwater resources including ponds and drinking water resources. This section describes the recommended program components for the collection system, wastewater treatment, and effluent recharge. It also presents a wastewater phasing plan for implementation. The recommended non-infrastructure program components which include fertilizer and stormwater management programs, potential land use changes, open space acquisition, and several community involved conservation and pollution reduction programs.

This section summarizes the final Comprehensive Wastewater Management Plan (CWMP)/Single Environmental Impact Review (SEIR) recommended program, includes a plan for an adaptive management strategy to meet and adjust to MEP goals, and provides a description of alternatives to this plan that were evaluated. The sections which follow describe the proposed cost recovery strategy and environmental impacts and mitigation specific to this proposed recommended program.

Since the Draft CWMP/ Expanded Environmental Notification Form (EENF) was approved in 2017, the Town has been working to further develop their Final CWMP while also coordinating with neighboring Harwich and Yarmouth on a potential community partnership for shared wastewater infrastructure including a regional wastewater treatment facility. Dennis wanted to make sure all feasible options were evaluated before finalizing the CWMP for the next submittal to MEPA. As such, the submittal of the Final CWMP was delayed. At this time Dennis has determined that a Dennis only in-town solution is the best path forward. The town-only solution is discussed in more detail in this Section.

14.2 CWMP Recommended Program to Meet TMDL Requirements, Traditional Resource Management Needs, Other Town Needs, and 208 Plan Requirements

The CWMP Recommended Program is a comprehensive plan designed to address nitrogen loading to the local embayments, drinking water supply protection, growth management, and support of local planning and development initiatives. This program is proposed for implementation over a 40 year period due to the significant costs of the program.

In Section 10, seven collection and treatment scenarios (1A to 7D) were evaluated for their applicability in Dennis based on the current and future community development and the TMDLs for nitrogen that have been defined for each of the four embayments, not currently including Sesuit Harbor. TMDLs were identified for the Chase Garden Creek (Bass Hole) watershed in the recently published Barnstable Great Marshes-Bass Hole MEP Report. It was determined that this watershed could accept access nitrogen. These evaluations considered a broad range of scenarios and were screened down to five scenarios (3B, 5A, 5B, 6A, and 6B) for further detailed evaluation. Section 13 further analyzes these scenarios, and Scenario 6A was ultimately recommended as the preferred scenario because it provides for cost effective wastewater collection from all of the town's economic development planning districts. The sewer collection area in Scenario 6A includes sewering as many existing developed parcels as necessary in the Bass River and Swan Pond River watersheds in order to meet the nitrogen removal requirements. The collection system area includes multiple planning district areas, as well as some Areas of Concern (AOCs). Aquaculture is included in both the Bass River and Swan Pond River watersheds to provide additional nitrogen removal.

Highlights of Scenario 6A:

- Meets MEP and TMDL nitrogen reduction thresholds;
- Allows for effluent recharge sites in multiple watersheds (Bass River and Swan Pond);
- Provides a phasing plan that provides for implementation flexibility;
- Allows for potential future regional solutions between Dennis, Harwich, and Yarmouth; and
- Supports desired smart economic development.

The WIC also voted to adopt a recommendation that incorporates implementation of Scenario 7A in the long-term after the completion of Scenario 6A. The additional Areas of Concern (AOCs) included in Scenario 7A are characterized not for nitrogen loading, but for high groundwater and very small lots. Groundwater flow from those areas discharges directly to Nantucket Sound.

14.2.1 Recommended Sewer System Master Plan

The recommended collection system master plan for the Town of Dennis is shown on **Figure 14-1**. The recommended plan and the preliminary sewer layout shown meets or exceeds the amount of septic system nitrogen required to be removed to meet the proposed TMDL in each watershed, as shown in Figure 2-17. **Figure 14-2** shows the phasing plan recommended for implementing the overall Dennis program.

The recommended plan provides collection and conveyance, treatment, and effluent recharge for about 2.07 mgd of annual average daily flow of wastewater from the MEP watersheds and other selected portions of Dennis. This is a future flow projection developed from the buildout analysis in the MEP models with assistance and updates from the Dennis Planning Department as well as Cape Cod Commission (CCC). The buildout flow is projected to be about a 45 percent increase over the current wastewater flow.

Cape Cod Bay

CRANBERRY HIGHWAY

AIRLINE ROAD

OLD BASS RIVER ROAD

Site 3

Site 4

Site 5

S YARMOUTH ROAD

SETUCKET ROAD

EAST WEST DENNIS ROAD

AIRLINE ROAD

BREWSTER

Follins Pond

Site 2

6

Site 1

MAIN STREET

GREAT WESTERN ROAD

YARMOUTH

HIGHBANK RD

UPPER COUNTY ROAD

EAST WEST DENNIS ROAD

Swan Pond

HARWICH

Bass River

MAIN STREET

SCHOOL STREET

DEPOT STREET

LOWER COUNTY ROAD

Nantucket Sound

Legend

- Vacuum Main
- Pressure Main
- Force Main
- Gravity Main
- Vacuum Station
- Pump Station
- Treatment Sites
- Sewered Parcels

Town of Dennis, MA

Comprehensive Wastewater Management Plan
September 2021

N

1 in = 3,000 ft

0 0.5 1

Miles

Recommended Areas to be Sewered

Figure 14-1

CDM Smith

NEWELLJD F:\Dennis\DATA\MXD\Dennis_Figure_14-1_Recommended_Sewered_Areas_20210927.mxd 9/27/2021

Cape Cod Bay

CRANBERRY HIGHWAY

AIRLINE ROAD

OLD BASS RIVER ROAD

Site 4

Site 3

Site 5

S YARMOUTH ROAD

SETUCKET ROAD

EAST WEST DENNIS ROAD

BREWSTER

Follins Pond

Site 2

6

Site 1

MAIN STREET

GREAT WESTERN ROAD

YARMOUTH

HIGHBANK RD

UPPER COUNTY ROAD

Swan Pond

HARWICH

Bass River

SCHOOL STREET

DEPOT STREET

LOWER COUNTY ROAD

Nantucket Sound

Legend

- Vacuum Main
- Pressure Main
- Force Main
- Gravity Main
- Vacuum Station
- Pump Station
- Treatment Sites

Sewer Phasing

- Phase 1
- Phase 2
- Phase 3
- Phase 4
- Phase 5
- Phase 6
- Phase 7
- Phase 8

Town of Dennis, MA

Comprehensive Wastewater Management Plan

September 2021

N

1 in = 3,000 ft

0 0.5 1

Miles

Recommended Phasing Plan

Figure 14-2

CDM Smith

NEWELLJD F:\Dennis\DATA\MXD\Dennis_Figure_14-2_Recommended_Phasing_Plan_20210927.mxd 9/27/2021

14.2.1.1 Scenario 6A with Additional Wastewater Collection Areas

The recommended plan utilizes Scenario 6A which includes sewer collection areas in the MEP watersheds of Bass River, Herring River, and Swan Pond River plus it includes some other wastewater needs areas located outside of MEP studied watersheds. Thus, this plan modifies the Scenario 6A plan evaluated in Section 12 by including updates to the existing CCC buildout estimates for the direct discharge areas. Parcel specific data was not previously available for CCC buildout estimate for the direct discharge area within the GIS model and as such wastewater flows were estimated for this area in the past. The direct discharge flow at buildout has been refined within the GIS model and is included in this section.

14.2.2 Neighboring Towns with Shared MEP Watersheds

Dennis shares MEP watersheds with the Towns of Brewster, Harwich, and Yarmouth. Because of this, nitrogen management must be shared by all parties who contribute to the problem. In many cases it is considered inefficient for each town to separately manage its individual contribution of nitrogen to the impaired embayment. Typically, it is more efficient for the communities to work regionally to address the nitrogen issue within a given watershed. Brewster, as an example, shares the Swan Pond River watershed with Dennis and is responsible for approximately 1% of the buildout septic nitrogen load in that watershed. Since Brewster's contribution to the Swan Pond watershed is so minimal at this time, the CCC has determined that nitrogen reductions aren't necessary, but should be reevaluated every five years with the update to the Regional Policy Plan. Should conditions change in the future, the Town of Brewster may want to partner with Dennis on the operation of their collection and treatment facilities to determine a solution that will benefit both towns and achieve regulatory compliance. Several solutions should be evaluated that may include nitrogen trading (if possible), one time infrastructure payments, long term nitrogen management payments, or possible inter-municipal connections that convey wastewater and treated effluent across town lines for treatment and recharge at different locations.

The list below details how the Towns of Dennis, Brewster, Harwich, and Yarmouth have been addressed within the context of the Dennis recommended plan and how it relates to the overall program. It is important to note that Dennis has already initiated conversations with its neighboring communities to discuss wastewater management, but no formal agreements have been established at this time. While the recommended plan presented in this section addresses how to achieve the TMDL limits in the embayments of the Bass River, Herring River, and Swan Pond River, it does not completely address how each town will address its share of the responsibility. Those issues will be formalized at a later date.

Brewster

Brewster shares a portion of the Swan Pond River and Bass River watersheds with Dennis. The recommended wastewater plan presented herein assumes that the Town of Brewster will not initiate any wastewater infrastructure management in either watershed. It also assumes that should Brewster be required to address their own nitrogen load contribution to Swan Pond River and Bass River via a wastewater infrastructure management plan, it will occur within their town boundaries. Since Brewster is currently developing their wastewater management strategy, these

assumptions may change and will be verified as their recommended CWMP program is further developed.

Harwich

Dennis shares a small portion of the Herring River watershed with the Town of Harwich. The recommended plan presented herein is in line with the recently approved Final Harwich CWMP/SEIR. The Town of Dennis will collect wastewater in their densely developed area of Dennis Port and will recharge the treated effluent in a watershed outside of the Herring River watershed.

Harwich was involved in past DHY Clean Water Community Partnership discussions about a potential regional wastewater solution. However, at this time, the communities involved have elected to pursue Town-only solutions. The option for regional solutions remains a potential alternative for the future.

Yarmouth

Yarmouth shares a significant portion of the Bass River watershed with the Town of Dennis. The recommended program presented herein aligns with the Town of Yarmouth's update to their CWMP. Yarmouth will initiate wastewater collection and treatment for their share of the septic nitrogen load that is generated within the Bass River watershed.

Similar to Harwich, Yarmouth was involved in discussions about a regional solution with Dennis but has also elected to pursue a Town-only solution at this time.

14.2.3 Recommended Collection System Technology

As discussed in detail in Section 12, the recommended wastewater collection system for the Town is a hybrid system. In this system, gravity collection would be utilized as much as possible to decrease the overall cost of conveyance and to best handle the large swing in seasonal and commercial/residential annual flows. The gravity system will be supplemented with pumping stations, low pressure sewers, and vacuum sewers in the areas where appropriate to help minimize costs. Typically, if an area with low pressure sewers exceeded more than 20 to 25 homes, a gravity system with a small pumping station would instead be utilized. In smaller neighborhoods, with fewer than 20 homes, or at the end of streets where topography drops down, low pressure sewers will be utilized to collect the flow and then discharge into a gravity pipeline. For vacuum sewers, typical service areas range from 500 to 1,200 homes per vacuum station and they are utilized in relatively flat topographic areas that are densely developed and experience high groundwater. Decisions on the type of sewer to be utilized can be confirmed by the Town as each phase is implemented.

The recommended collection system plan includes 24 pumping stations, twenty-two of which are fed by gravity sewers and two of which are fed by vacuum sewers. The approximate locations of the pumping stations are shown in Figure 14-2. These located will be refined during the design and implementation of each phase of the master plan.

The rated capacity of a wastewater pumping station is based upon the estimated peak hour flow to avoid surcharges and overflows of the collection system. Peak hour flow is determined utilizing peaking factors applied to the average day flow plus an estimate for infiltration/inflow. The peak

hour flow rates tend to range from 5 to 10 times the average day flow rate. The smaller stations have the greatest range of flow from average day to peak hour.

The topography of Dennis is relatively flat, providing little grade for the slope of lengthy reaches of gravity sewer without the need for deep excavation. Deep excavation is complicated by the sandy soils and high water table and should be avoided if possible. Thus, pumping stations in the collection areas are spaced relatively close together.

Submersible pump type pumping stations are the least costly option for handling wastewater and are recommended for this project. Submersible pumping systems are particularly adaptable to the range and variability of flows that are anticipated for this project. The submersible station will consist of a pre-cast concrete vault, either cylindrical or rectangular, to house two or more submersible pumps. Submersible type pumping stations provide good flexibility to select design pump capacity and head and are not limited to allowable station depth. Submersible stations are a good compromise between cost of construction, accessibility, and maintenance.

The pumps engage a special receiver mounted near the bottom of the wet well that makes a pipe connection to the pump. The pump engages and disengages by raising/lowering the pump on a guide. An adjacent shallow underground structure houses pump discharge piping, valves, and a flow meter. Electrical equipment is typically installed in an above grade cabinet adjacent to the pump wet well and valve vault but can be housed in a building to provide more pleasing architectural appearance. The station will typically be equipped with a standby generator to provide power to the pumping station in case of utility power failure. The generator is housed in an outdoor enclosure or in the same building with the electrical equipment. Odor control equipment such as filters for air vented from the wet well and/or chemical injection may be required and may be housed in the building.

The vacuum stations would be combination vacuum/pumping stations and would be above-ground, each housed in a small building.

14.2.4 Recommended Treatment Technology

The recommended treatment technology for the Dennis treatment facility to be built at Site 1 is a sequencing batch reactor (SBR) process as discussed in detail in Section 12. The SBR option is cost-effective, easily expandable, able to treat to stringent permit limits, and can handle seasonal fluctuations in flows and loads. As the collection system expands and potential future regulations are revised, the option to continue forward with the SBR process maximizes flexibility. This process allows for the addition of more SBRs to accommodate increased flows and loads, as well as the addition of downstream denitrification filters will allow the facility to achieve stringent effluent nitrogen requirements, as required. This would allow the facility to operate utilizing only SBRs or the combination of SBRs and denitrification filters to achieve seasonal nutrient requirements. The advanced level of treatment afforded with tertiary denitrification filters following a conventional activated sludge process (SBRs) can produce an effluent with a total nitrogen level of 3 mg/L and consider reuse options in the future, if desired.

It is also recommended that when the initial phase treatment facility is built at Site 1, a pilot demonstration project be conducted utilizing a permeable reactive barrier (PRB) around one or

more of the infiltration basins at the effluent recharge site. PRBs provide a carbon source for denitrification to take place in the recharged effluent, resulting in further nitrogen reduction.

Figure 14-3 includes a conceptual level site plan of a treatment facility at site 1. This concept includes liquids treatment and solids treatment processes. The liquids process treatment train consists of an influent pumping station, headworks, grit removal, SBRs, equalization basins, denitrification filters, UV disinfection, and an effluent pumping station. Caustic soda storage and feed provisions are provided for pH adjustment to maintain year-round nitrification and supplemental carbon storage and feed provisions are included to drive denitrification to achieve seasonal effluent total nitrogen goals. A blower room will house aeration blowers integral to the successful operation of the activated sludge/biological nutrient removal process.

Waste activated sludge (WAS) collected from the SBRs will be pumped to WAS storage tanks. From the WAS storage tanks, WAS will be thickened and stored in subsurface tanks. Thickened sludge will be regularly collected by regional sludge haulers and trucked offsite for disposal.

To support the operation of the treatment facility, the layout also includes an operations building that includes a SCADA/control room, an analytical laboratory, offices for facility staff, a conference room, lunch space, locker rooms, a training room, a mechanical shop room, and a building HVAC system.

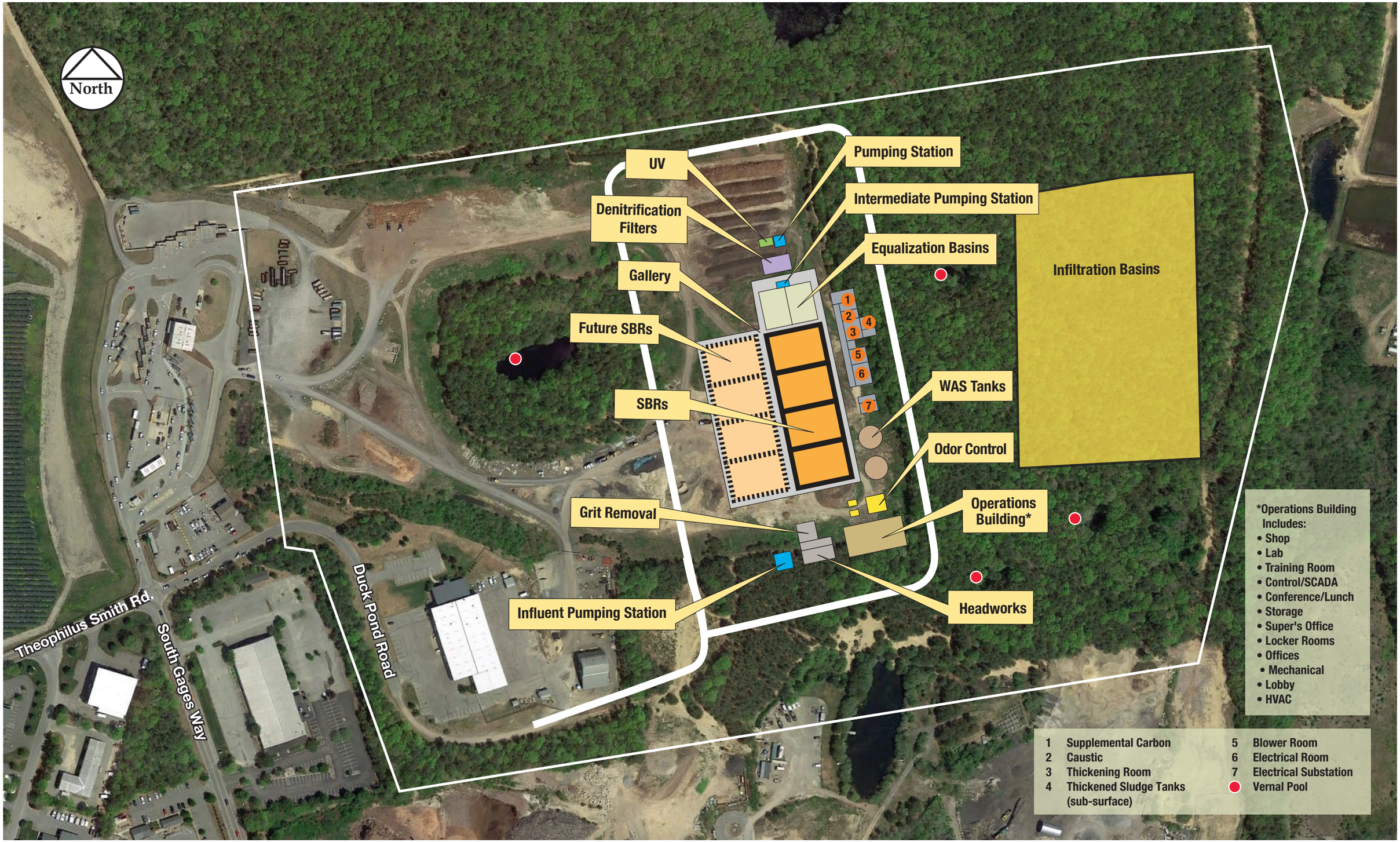
This conceptual level site plan and treatment facility layout have been developed on a conceptual level, and as such will need to be revisited and refined during subsequent design phases to ensure that all of the Town's treatment and operability goals are met.

14.2.5 Revised System-wide Flows

Buildout wastewater flows were calculated using the MEP model which contains water use records from the Town. The MEP, working with Dennis planning staff, developed a buildout estimate for the town as part of its nitrogen loading model. The buildout estimate took into account the town's planning data, as well as zoning and land use classifications. In areas such as the direct discharge areas, Dennis Port Growth District, Exit 78 (formerly Exit 9) Growth District, Hotel Report District (Dennis Port), Hotel Report District (West Dennis), and the West Dennis Village Center, the Town updated the buildout estimates as discussed earlier in Section 13.2.1.

When the MEP developed buildout projections, it estimated future flows for each parcel. The associated flows and loads have been accounted for in the MEP buildout flow and load totals. If there are future subdivision lots created from existing parcels, the total number of parcels in the buildout service areas may increase.

In the summer of 2018, the Town's Wastewater Implementation Committee, in conjunction with the Town Planner, recommended allocating additional flow from Planning Districts within the Town of Dennis as a result of the economic analysis performed by the University of Massachusetts Donohue Institute in early 2018. **Table 14-1** below presents the increase in buildout wastewater flows that were agreed upon during the WIC meeting held on May 14, 2018. The increase in wastewater flow to be collected in the town's sewer system is approximately 219,100 gallons per day at buildout. This increases the town's buildout wastewater flow of the sewer system from 1.85 MGD to 2.07 MGD.



Town of Dennis, Massachusetts

Figure 14-3
Site 1 WWTF and Effluent Recharge Conceptual Layout

CDM Smith

Table 14-1 Increased Buildout Wastewater Flow in Planning Districts

Planning District	Revised % Increase from Existing CCC Water Use	Revised Buildout Water Use (gpd)	Difference from Revised Buildout to CCC Buildout Water Use (gpd)	Average CCC Buildout Water Use (gpd/parcel)	Additional Units from Existing
Dennis Port Growth District	50%	77,250	12,050	750	35
Exit 78 Growth District	570%	394,500	185,000	185	1,000
Hotel Resort District (Dennis Port)	50%	62,550	13,450	1,455	15
Hotel Resort District (West Dennis)	50%	10,350	2,150	1,035	4
West Dennis Village Center	50%	48,150	6,450	517	32
Total		**592,800**	**219,100**		**1,086**

14.2.6 Updated Treatment Facility Flows, Loads and Nitrogen Limits

The flows for the Dennis treatment facility were calculated by applying peaking factors to the anticipated annual average daily wastewater flows. The ratio of summer (June, July, and August) to annual average daily flow was determined to be 2.02 from monthly well pumping records. To evaluate low flows, the ratio of winter to annual average daily flow was determined to be 0.43. **Table 14-2** shows the design flows for the Dennis wastewater treatment facility at buildout. The buildout annual average daily flow to be treated is approximately 2.07 mgd.

Table 14-2 Dennis Facility Estimated Design Flows

Flow Scenario	Dennis WWTF Interim Flows Phases 1-4	Dennis WWTF Buildout Flows Phases 1-8
Average Day Total Wastewater (MGD)	1.00	2.07
Maximum Month Flow (MGD)	1.57	3.25
Maximum Day Flow (MGD)	2.59	5.36
Summer Average Flow (MGD)	2.02	4.18
Winter Average Flow (MGD)	0.429	0.888

The Dennis wastewater treatment facility will be constructed in two phases as discussed in Section 4.4. The first phase of the facility will be designed to accommodate about half of the buildout flow and will require an expansion to accommodate the full buildout flow.

The initial Dennis treatment facility will be constructed in Phase 1 and will allow the Town to construct phases 1 through 4 of the wastewater collection system. An expansion will be needed at the Dennis facility to bring Phases 5 through 8 online. The annual average flow to the fully expanded Dennis treatment facility is approximately 2.07 mgd and will serve about 6,300 parcels or approximately 44 percent of the non-vacant parcels in Town (see Figure 14-1). Design loads

for wastewater flows are based on the constituent concentrations shown in Table 12-8. The conceptual sizing is based on the average estimated wastewater concentrations of the constituents listed in the table and facility specific data should be collected in preliminary design.

As discussed earlier, the MEP reports and the recommended program indicate that the effluent recharge for the Swan Pond River and Bass River watersheds must be treated to a total nitrogen concentration of 3 mg/l to minimize the extent of the wastewater collection system. As a result, the final treatment facilities will be designed with a 3 mg/l limit for total nitrogen. The addition of a PRB will help to further reduce the nitrogen load at this site, with the treatment level designed for 1 mg/L. Should the use of a PRB not be able to reduce the concentration of nitrogen in the recharged effluent down to 1 mg/L, alternative PRB locations will be assessed, as discussed in Section 11.

The Dennis treatment facility will remove approximately 109,076 lb/yr of nitrogen resulting in an ultimate discharge of 18,904 lb/yr. Hydrogeologic modeling results indicate that Site 1 in the Swan Pond watershed will be able to recharge approximately 0.336 MGD. Therefore, with a PRB at this site, the total nitrogen to be discharged will be 1,023 lb/yr (0.336 MGD x 1 mg/L x 8.34 = 2.8 lb/day). Site 2 in the Bass River watershed will be able to recharge approximately 0.410 MGD. Therefore, with a PRB at this site, the total nitrogen to be discharged will be 1,248 lb/yr (0.410 MGD x 1 mg/L x 8.34 = 3.42 lb/day). The remaining future flow of 1.32 MGD equating to 12,055 lb/yr (1.32 MGD x 3 mg/L x 8.34 = 33.03 lb/d) of nitrogen will be discharged at separate location(s) to be selected by the Town in the future. As of fall 2021, the Town is currently

assessing additional effluent recharge sites for the remaining flow, with a focus on sites located outside of Zone IIs.

14.2.7 Ability of Recommended Program to Meet CCC 208 Plan Intent

As discussed in Section 1, The Town of Dennis has reviewed the work performed by the Cape Cod Commission since the final 208 Plan was approved in 2015. Dennis's plan is in line with the 208 Plan since Dennis's approach is based on the MEP nitrogen loading models with the goal of achieving the most efficient sewershed footprint while keeping costs to a minimum. The town of Dennis's wastewater scenarios utilized a hybrid approach. As suggested in the 208 Plan, Dennis has combined both traditional and non-traditional technologies with an iterative process to develop the most cost effective recommended program. This CWMP/SEIR also incorporates an adaptive management strategy, whereby ongoing monitoring and analysis will result in continually revisiting and updating the plan accordingly. Regional solutions are also highly recommended in the 208 Plan. As noted earlier, Dennis has worked with neighboring communities throughout the CWMP develop process and although now currently included in the plan, the option for future community partnerships with some combination of Harwich and Yarmouth remains a possibility in the future.

14.3 Updated Capital and O&M Costs

Cost estimates were developed for the final recommended collection and treatment systems. The cost estimates, as described in Section 10 and Section 13, are derived from the 208 Plan cost document, and supplemented by CDM Smith for unit costs not readily available in the 208 Plan cost document. The capital cost estimates include an allowance for design, permitting, land

acquisition, and construction costs. Note, costs have been updated in this Section to further reflect a more accurate depiction of the proposed Scenario 6A. Although costs presented herein may have changed, this would not change the matrix analysis performed in Section 10 or Section 13. Additionally, some changes to the Recommended Plan have been made since completion of the last cost update; however, those changes are anticipated to have minimal impact on the overall cost of the Recommended Plan. Construction cost estimates will be updated again in the preliminary design phase.

The recommended plan cost was updated in the summer of 2018 and again in 2021. The cost update considered additional flow and collection from planning districts, additional treatment and effluent recharge capacity needed and overall increases in updated construction costs for collection and conveyance. Additionally, unit costs that were first shown in 2016 dollars were increased to 2021 using the Engineering New Record (ENR) construction cost index. Updated total project costs were then escalated to the midpoint of the anticipated first phase of construction in 2024. A summary of the updates by each cost category are described below:

- Updated aquaculture program costs to reflect more recent actual project costs of similar type and scale;
- Updated collection system construction costs (including full width paving) based on recent Harwich construction cost estimate and other recent bids;
- Increased length and size of gravity sewer system with addition of parcels in planning districts to include additional wastewater flow;
- Updated costs for pressure sewer and vacuum sewer from vendors (AIRVAC and E-One);
- Updated pumping station and force main costs based on recent construction cost estimates and bid prices;
- Increased size of wastewater treatment facility (WWTF) due to additional flow from planning districts and updated WWTF costs;
- Reduced cost of permeable reactive barriers (PRBs) by removing alternative that included caisson PRBs from the average cost per linear foot calculation as this construction technique is unlikely to be used;
- Added an additional effluent recharge site to accommodate increased flow, and updated effluent recharge costs;
- Added conveyance (force main and pumping station) to additional effluent recharge site at the Dennis Pines Golf Course.

14.3.1 Non-Traditional Technology Capital Costs

Cost estimates for the non-traditional technology components including stormwater BMPs, fertilizer education program, and aquaculture are shown in **Table 14-3**.

Table 14-3 Estimated Non-Traditional Technology Capital Costs (Year 2024 ENR: 13,060)

Non-Traditional Technology Capital Costs	Recommended Plan
Stormwater BMPs Cost	$9.93 Million
Fertilizer Education Program Cost	$25,000
Aquaculture Program Cost	$496,650
Total Non-Traditional Technology Costs (Rounded)	**$ 10.4 Million**

14.3.2 Collection and Conveyance System Capital Costs

Cost estimates for the hybrid sewer collection system including gravity sewer, pressure sewer, vacuum sewer systems, pumping stations, and force mains are shown in **Table 14-4**.

Table 14-4 Estimated Collection and Conveyance System Capital Costs (Year 2024 ENR: 13,060)

Collection and Conveyance System Capital Costs	Recommended Plan
Number of Parcels Served	5,707
Collection System Cost	$189.3 Million
Pumping Station Cost	$35.3 Million
Total Collection and Conveyance to WWTF Cost	**$224.6 Million**

The cost for gravity piping includes pipe, manholes, wye connections for each parcel, 6-inch service connections extending an average of 20 feet for each lot (from centerline of the street to the property line), excavation support, state highway construction considerations where applicable (flowable fill, etc.), paving, police details, and some allowances for drainage and mobilization. Paving is assumed to include a 2-inch trench patch and a 1.5-inch full width overlay on all currently paved roads. The cost for individual homeowner hookups (gravity, pressure, and vacuum) will be paid for by the property owner and are not included in the costs presented in Table 14-4.

14.3.3 Treatment Facility and Effluent Recharge Capital Costs

The treatment facility and effluent recharge costs are presented below in **Table 14-5**. Those costs are based on annual average flows but increased to account for the large seasonal flow swings characteristic of a Cape community like Dennis. A cost for effluent recharge facilities was included and assumed that open infiltration basins will be utilized for effluent recharge at Site 1, Site 2, and any future recharge sites. A cost for a PRB downstream of the recharge sites is also included.

Table 14-5 Estimated Treatment Facility Capital Costs (Year 2024 ENR: 13,060)

	Recommended Plan
Dennis Wastewater Treatment Facility Cost[1]	$70.7 Million
Conveyance to Recharge Cost	$15.2 Million
Effluent Recharge Cost	$14.6 Million
PRB Cost	$8.8 Million
Total (Rounded)	**$109.3 Million**

1. Includes cost for OPM services (estimated at $1.1 Million in 2024 dollars).

14.3.4 Capital Cost Summary

Table 14-6 summarizes the estimated total capital cost for Dennis' wastewater program. The total construction costs were updated to 2018 costs. These costs were escalated ahead at about three (3) percent per year to the projected midpoint of construction for the first phase. The capital costs are summarized in the table below for the anticipated midpoint of construction, June 2024 (2024 Estimated ENR: 13,060).

Table 14-6 Estimated Collection and Treatment System Capital Costs[1] Scenario 6A

Option	2016	2018	2024
ENR	10,379	11,068	13,060 (projected approx. 3% per year)
Total Non-Traditional Technology Cost	$8.6 Million	$8.6 Million	$10.4 Million
Total Collection and Conveyance System Cost	$116.6 Million	$190.5 Million	$224.6 Million
Total Treatment System Cost	$37.6 Million	$58.0 Million	$70.7 Million
Total Effluent Recharge Cost with Conveyance and PRB	$22.6 Million	$22.9 Million	$38.7 Million
Total Capital Cost with Engineering, Contingency, Permitting & Planning[3] (Rounded)	**$205 Million[2]**	**$280 Million**	**$344 Million**

[1]Capital costs include 15% for planning, design, and engineering and include 25% for construction contingency.
[2] Year 2016 costs included an additional 10% contingency on top of capital costs. For Years 2018 and 2024, all contingencies are included in the unit costs.
[3] Costs do not include the homeowner connection costs.

14.3.5 Dennis Non-Traditional Technology O&M Costs

Estimated annual operation and maintenance cost for Dennis' non-traditional technology components is shown in **Table 14-7**. These costs were developed from the 208 Plan Cost Document. O&M costs for stormwater BMPs include street sweeping, maintenance of stormwater utilities, education and public outreach programs, land use planning, and impervious cover reduction and control. Fertilizer O&M costs include an education and public outreach program. Aquaculture O&M costs include the cost of shellfish, beds, and one staff member to oversee the aquaculture program.

Table 14-7 Annual Operation and Maintenance Cost Summary for Non-Traditional Technologies
(Year 2024 ENR: 13,060)

Cost Category	Recommended Plan
Stormwater BMPs O&M	$8,800
Fertilizer Education Program O&M	$6,900
Aquaculture Program O&M	$103,000
Total Non-Traditional Technology O&M (Rounded)	**$118,700**

14.3.6 Dennis Collection and Conveyance System O&M Costs

Annual operation and maintenance collection systems costs for the recommended plan under buildout conditions are shown below in **Table 14-8**. These costs are for operation of the collection system in Dennis only and do not include operation and maintenance costs associated with the Town's proposed wastewater treatment facilities. The costs are developed from the Cape Cod Commissions' 208 Plan Cost Document. Costs include regular maintenance by staff, and include 10-year cycle servicing/inspections. Daily pumping station inspections are also included in addition to regular pumping station and force main maintenance by staff, including force main and siphon flushing annually.

Table 14-8 Annual Operation and Maintenance Cost Summary for Buildout Conditions
(Year 2024 ENR: 13,060)

Cost Category	Recommended Plan
Gravity Sewer O&M	$517,000
Pressure Sewer O&M	$523,000
Vacuum Sewer O&M	$413,000
Force Main O&M	$91,000
Pumping Station O&M	$1,237,000
Total Collection and Conveyance System Wide O&M (Rounded)	**$2.78 Million**

14.3.7 Dennis Treatment Facility O&M Costs

Estimated annual operation and maintenance costs for the Dennis treatment facility is shown below in **Table 14-9**. These costs were developed from the 208 Plan Cost Document and include labor, electricity and chemicals, laboratory analysis, repairs and equipment replacement, administrative costs including insurance, and sludge disposal.

Table 14-9 Estimated Annual Dennis Treatment Facility O&M Costs (Year 2024 ENR: 13,060)

Item	O&M Cost
Wastewater Treatment Facility O&M	$4.7 Million
Effluent Recharge O&M	$142,000
PRB O&M	$110,000
Total Treatment and Recharge O&M (Rounded)	**$5.0 Million**

14.3.8 Total Annual O&M Costs Summary

A summary of annual operation and maintenance costs for the recommended plan is shown below in **Table 14-10**. These costs are for operation and maintenance of both the collection and treatment systems associated with the Town's proposed wastewater treatment facility. These costs represent the estimated annual costs to collect wastewater, operate the town's treatment facility at 2.07 mgd of annual average daily buildout flow, and to recharge the effluent.

Table 14-10 Estimated Collection and Treatment System Annual O&M Costs (Year 2024 ENR: 13,060)

Option	Scenario 6A
Non-Traditional O&M (Rounded)	$118,700
Collection and Conveyance O&M (Rounded)	$2.78 Million
Treatment and Recharge O&M (Rounded)	$5.0 Million
Total Town O&M Costs (Rounded)	**$7.9 Million**

A number of factors can affect these budget numbers such as specific town requirements or preferences, outsourcing to private operators, sharing of regional facilities, variations in wastewater quality, and specific treatment goals and guidelines for each individual facility.

14.3.9 Recommended Program Cost Summary

In **Table 14-11**, the estimated total capital cost is presented along with the estimated total O&M costs. In addition, an Equivalent Annual Cost (EAC) is presented. The equivalent annual cost assumes that the capital cost is based on a 20 year loan with a 2% interest rate that assumes the standard State Revolving Fund (SRF) is the funding mechanism for the project. Some SRF loans are now being done up to 30 year loans, and zero-percent interest financing may also be available for some components of the project.

Table 14-11 Estimated Collection and Treatment System and O&M Annual Costs

Option	Scenario 6A
Collection and Treatment Capital Costs (Rounded) (Year 2024 ENR: 13,060)	$344 Million
Collection and Treatment O&M Cost (Year 202**4** ENR: 1**3,06**0)	$7.9 Million
Total Equivalent Annual Cost	**$23.3 Million**

Note that this annualized cost implies the entire project is constructed at once, under the same 20-year loan. This, however, is not actually the case, as presented in the phasing plan below.

14.4 Wastewater Phasing Plan

Since the overall wastewater plan in the CWMP cannot be constructed as one project and will take several years to construct, a phasing plan is required. This will ensure that the wastewater plan (which is a combination of several smaller projects) progresses efficiently while meeting the needs of the Town including economic development of town centers, dealing with financial impacts, minimizing traffic impacts, and addressing environmental protection.

14.4.1 Wastewater Phasing Plan Issues

There are several issues that need to be considered in developing the phasing plan for implementing the recommended wastewater program in the Town. The CWMP addresses many of these issues but conditions and priorities will change over the next 40 years that will impact current day decisions. Thus, the phasing plan will need to be constantly monitored and periodically modified as it is implemented via a process known as adaptive management.

Current issues that need to be considered in developing the phasing plan include:

1. Title 5 septic system issues;
2. Freshwater ponds water quality;
3. Future growth and economic development potential;
4. Regionalization opportunities;
5. TMDL (MEP) issues; and
6. Program costs.

Title 5 Septic System Issues

As discussed in earlier sections (Sections 3 and 8), the Town has relatively good soils throughout for Title 5 subsurface disposal septic systems. With almost all parcels in Town on municipal water, the majority of septic system waivers are for setback requirements due to small lots in specific areas. Although Title 5 septic system issues are not a main driver for sewering in town, these areas should be planned for sewering when adjacent areas are to be sewered.

Freshwater Ponds Water Quality

As discussed in Section 3, there are 29 freshwater ponds and lakes in Dennis. Based on known data there are some areas that should be sewered to remove the phosphorus source coming from septic systems that is entering the nearby freshwater resource. These areas include Fresh Pond and Run Pond, both of which are impaired and in MEP nitrogen sensitive watersheds. Potential pond projects should also be considered for areas around Cedar Pond, Coles Pond, Hiram Pond, and Scargo Lake which all have impaired water quality (eutrophic or meso-eutrophic) due to phosphorus loading. As data becomes available on other ponds, they may be added to this list. These areas should be considered for sewering when adjacent areas are being addressed. Local solutions may also be considered for higher priority ponds, including stormwater improvement projects.

Future Growth and Economic Development Potential

As discussed in Section 7.4 and Section 14.2.5, the Town has developed several areas where growth and economic development or redevelopment are desired. All five of these development areas have been included in the town's recommended sewer plan and were included in the MEP Reports. The areas include Dennis Port Growth District, Exit 78 (formerly Exit 9) Growth District, two Hotel Resort Districts, and the West Dennis Village Center Growth District. This type of planning concept requires higher density development that may not be able to be supported by typical Title 5 septic systems. Appropriate infrastructure needs to be installed to support the change, along with appropriate changes to zoning and other utilities (traffic, water, etc.). Therefore, it would appear that the timing of when the infrastructure is needed in these areas in order to support the desired development along with when sewers are to be installed in adjacent areas will be the driving forces for when these areas are to be addressed in the phasing plan.

Regionalization Opportunities

As mentioned in earlier sections, the Town of Dennis has discussed the potential future partnership opportunity with the Towns of Harwich and Yarmouth by forming a community partnership for the treatment and recharge of collected wastewater from all three towns. Although the communities spent several years in discussions, working out the details of the potential combined plans, at this time each community has elected to pursue a Town-only solution. Should the Towns choose to enter into some form of regional partnership with neighboring communities, this will have minimal impact on the areas of need in Dennis that will be addressed through the recommended plan.

Total Maximum Daily Loads (TMDLs) from the Massachusetts Estuaries Project (MEP) Issues

The MEP reports for the watersheds defined in Dennis established the basis for how much nitrogen can be safely discharged to the estuaries and still maintain a healthy environment. The newly issued TMDLs require significant nitrogen removal in order to be attained. Ultimately, those TMDLs will become watershed permits enforced by appropriate regulatory agencies in which the Town will need to take action to meet those load limits. This phasing plan will need to take that into account even though at this time there is no mandatory timeline that has been issued. Therefore, it is in the Town's best interest to propose a timeline that meets their various needs but also focuses on meeting the nitrogen removal requirements within the watersheds. Thus, meeting the TMDLs is a significant driver in defining the phasing plan. The Swan Pond and Bass River watersheds require the highest percentage of nitrogen removal within their watersheds. Proposed effluent recharge, which has some nitrogen loading attached to it, needs to be addressed as well. Therefore, an appropriate amount of sewering needs to take place in any watershed where recharge is to occur in order to maintain a no net increase in nitrogen balance within that watershed.

Program Costs

The wastewater program capital cost is a significant issue for the Town to undertake. Thus, the program needs to be implemented over many years so that as other municipally bonded projects are paid off, this program can move forward in a way that tries to minimize the financial impact and make it affordable. The number of phases proposed to implement the program must be weighed versus the need to meet the TMDLs. Initially an eight phase program for implementation is proposed with each phase being approximately five years in duration, for a total program duration of approximately 40 years. The cost per phase will vary depending on the specific infrastructure being built. The ultimate number of phases and timeline is likely to vary as well, as adaptive management will likely result in adjustments to the later phases of the overall program.

In summary, the program costs and attaining the TMDLs are considered to be the most important factors in developing the phasing plan for the wastewater program. Figure 2-17 shows the amount of septic system nitrogen required to be removed from each of the MEP watersheds. To receive regulatory approval the CWMP must present a wastewater program that conforms to the TMDLs. To receive local community approval the program costs must be deemed to be affordable. Providing infrastructure to assist with desired development and acting in a timely and

coordinated manner to take advantage of regionalization are next in importance. Addressing Title 5 issues and freshwater pond issues are important but are not key drivers in developing the overall phasing plan.

14.4.2 Wastewater Phasing Program by Phase

Figure 14-1 shows the areas to be sewered by phase while Figure 14-2 shows the phasing plan. Details of the proposed phasing program are described below:

Dennis' phasing plan proposes a 40-year, 8-phase approach to implement its recommended wastewater management plan. The preliminary 5-year phases in general include:

- Phase 1: Construction of its WWTF and a recharge facility at the same location and potentially other site(s) with a PRB at the recharge facility or another location in Town; construction of a sewer "spine" from the WWTF to the commercial planning district along Route 28; sewering in residential areas adjacent to Bass River and East-West Dennis (Route 134); construction of the town's WWTF and an effluent recharge facility with a PRB; Potential beginning of aquaculture program, stormwater BMPs implementation, and fertilizer education program;
- Phase 2: Sewering in WWTF-adjacent developed areas and commercial planning districts, and sewering in areas north and west of Swan Pond; Potential continuation of aquaculture program, stormwater BMPs, and fertilizer education program;
- Phase 3: Sewering in commercial planning districts on the southeast coast (i.e. hotel area) and in Dennis Port; Potential continuation of aquaculture program, stormwater BMPs, and fertilizer education program;
- Phase 4: Expansion of the Town's WWTF and construction of an additional recharge facility at Site 2 and/or other site(s) with a PRB at the recharge facilities or other locations in Town; sewering in areas adjacent to Route 6; Potential continuation of aquaculture program, stormwater BMPs, and fertilizer education program;
- Phase 5: Sewering the areas south of Swan Pond; stormwater BMPs, and fertilizer education program;
- Phase 6: Sewering the area north of Route 6 and west of Old Bass River Road; stormwater BMPs, and fertilizer education program;
- Phase 7: Sewering the area northwest of Route 6 adjacent to Follins Pond; stormwater BMPs, and fertilizer education program; and
- Phase 8: Sewering the area north of Site 2; stormwater BMPs, and fertilizer education program.

In subsequent meetings, Dennis has discussed modifying its recommended plan to address additional Areas of Concern (AOC) that are characterized by high groundwater and very small lots, even though groundwater flow from those areas discharges directly to Nantucket Sound. So while current cost projections discussed below only reflect Scenario 6A (i.e. the town's recommended plan), future costs should account for allowances in future flow increases (larger

pipe sizes, increased capacity in a pumping station, etc.) to accommodate the Scenario 7A areas and additional effluent recharge areas should also be identified to account for the increased flow.

Sewer service areas in Phases 5, 6, 7, and 8 can be adjusted as needed to meet local needs and based on feedback from water quality monitoring. The order in which these phases are implemented is also flexible and can be adjusted to meet those same needs.

Table 14-12 presents each phase of the wastewater plan, the estimated number of parcels served and the estimated buildout annual average daily flow (wastewater and I/I) for each phase.

Table 14-12 Wastewater Flows by Phase

Phase	Built-out Annual Average Wastewater Use (gpd)	Buildout Average Estimated I/I Flow (gpd)	Buildout Annual Average Wastewater Use With I/I (gpd) (Rounded)
1	479,600	34,700	514,300
2	497,200	20,100	517,300
3	187,000	24,300	211,300
4	60,200	13,800	74,000
Subtotal			***1,316,900***
5	352,500	0	352,500
6	98,900	2,500	101,300
7	129,900	0	129,900
8	133,900	33,800	167,800
Total	**1,939,200**	**129,200**	**2,068,400**

14.4.3 Wastewater Phasing Plan Costs by Phase

Based on the information provided in this CWMP/SEIR, preliminary project costs have been updated for the recommended plan by phase and are summarized below in **Table 14-13**.

Table 14-13 Details of Phasing Plan Costs by Phases 1-8 (Year 2024 ENR: 13,060)

Phase	Collection and Conveyance System	Treatment Facility	OPM	Effluent Recharge with Conveyance and PRB	Non-Traditional Technologies	Total
1	$49.0 Mil	$52.7 Mil	$0.9 Mil	$20.7 Mil	$1.3 Mil	$124.4 Mil
2	$30.9 Mil				$1.3 Mil	$32.3 Mil
3	$21.0 Mil				$1.3 Mil	$22.3 Mil
4	$15.3 Mil	$16.9 Mil	$0.3 Mil	$18.0 Mil	$1.3 Mil	$51.7 Mil
5	$34.7 Mil				$1.3 Mil	$36.0 Mil
6	$21.3 Mil				$1.3 Mil	$22.6 Mil
7	$26.9 Mil				$1.3 Mil	$28.2 Mil
8	$25.6 Mil				$1.3 Mil	$26.9 Mil
Total (Rounded)	**$224.6 Mil**	**$69.5 Mil**	**$1.1 Mil**	**$38.7 Mil**	**$10.4 Mil**	**$344.3 Mil**

These project costs include 25% construction contingency and 15% allocation for planning, permitting, and engineering. Home connection costs are not included in this total. Costs also include 19.5% escalation to mid-point of construction in June, 2024 (ENR 13,060).

The cost per phase for this program ranges from $22.3 - $124.4 million. The total program cost is $344.3 M. The Dennis treatment facility, which will treat approximately 2.07 MGD at buildout, will be built in Phase 1, about 1 MGD initial capacity and is proportionally more costly in the initial phase as it includes all the supporting buildings and common processes. It is proposed that this facility will be expanded to accommodate the additional wastewater flow and increased treatment capacity in Phase 4. The expansion is mainly for treatment processes and supporting tankage. The existing wastewater flow from Phases 4 to 6 will need to be verified to be within the initial treatment facility capacity and that buildout flows have not occurred. The adaptive management approach will allow the treatment facility expansion requirements and sewer service areas to be further evaluated and modified as needed between Phases 4 and 8.

14.4.4 MEP Issues Related to Wastewater Phasing

As described in Section 2, the MEP reports for the Bass River, Herring River, and Swan Pond watersheds describe the development of target nitrogen loads to meet the goals established for restoration of eelgrass and/or infaunal habitats in each embayment. Figure 2-17 shows the septic system nitrogen loads needing to be eliminated in order to meet the water quality goals in the five watersheds, if only focusing on nitrogen reduction from septic system loads. The reports note that these are attenuated loads, accounting for travel through the watershed prior to reaching the embayment. Figure 10-9 presents the estimated load change for the nitrogen sensitive watersheds.

14.4.5 Effluent Recharge Related to Wastewater Phasing

Phases 1-3

The effluent recharge for the initial phases of Dennis' wastewater program will utilize infiltration basins at Site 1, the Dennis WWTF site, located in the Swan Pond River watershed. These phases address most of the service area south of Route 6 and include nitrogen sensitive watersheds Bass River, Herring River, and Swan Pond River, in addition to direct discharge areas. A permeable reactive barrier (PRB) program will be conducted at Site 1 in order to reduce the nitrogen treatment level to 1 ppm. Should this technology prove not to be able to reduce an already low concentration of nitrogen at 3 ppm further down to 1 ppm, the plan allows for alternate locations of a PRB at different sites in town where concentrated streams of nitrogen may be present, such as the Town owned landfill or other sites that are suspected of contributing high concentrations of nitrogen to surrounding watershed. Additional nitrogen removal methods (i.e. aquaculture, stormwater BMPs, fertilizer education, etc.) will be used to reduce any additional nitrogen from effluent recharge in the Swan Pond River watershed. In more recent modeling, the recharge capacity at Site 1 is estimated to be able to accommodate the average annual flow of 336,000 gpd. Since this flow is lower than initially estimated and less than the suspected initial capacity of the WWTF, it's likely that Site 2, described below, or another effluent recharge location will be needed. The Town is currently investigating additional effluent recharge needs for the full buildout design flow.

Phases 4-8

After the infiltration basins at Site 1 have reached capacity, the town of Dennis will construct and utilize Site 2 and other recharge sites for additional effluent recharge. Site 2 is located off of Bob Crowell Road north of Route 6 and is in the Bass River watershed. It is anticipated that this additional recharge capacity will need to be constructed around Phase 4, but the Town will determine the exact timing based on the actual wastewater flows. As mentioned above, Site 2 may be needed in an earlier phase should the initial capacity of the WWTF be built as planed at approximately 1 MGD. Similar to phases 1-3, a permeable reactive barrier (PRB) program will be conducted at either Site 2 or another location in the watershed in order to reduce the nitrogen treatment level to 1 ppm. Additional nitrogen removal methods (i.e., aquaculture, stormwater BMPs, fertilizer education, etc.) will be used to reduce any additional nitrogen from effluent recharge in the Bass River watershed.

As the phasing plan progresses, the net nitrogen load in these watersheds will gradually decrease until the recommended plan is complete. At that time, all of the nitrogen sensitive watersheds will be in compliance with the TMDLs.

14.5 Route 6 Bridge Widening

One potential solution evaluated to help improve the Bass River water quality conditions includes the removal of the flow restrictions resulting from the former railroad bridge south of Route 6 and from the Route 6 east and west bound bridges. The Bass River watershed MEP report and the August 2013 *Hydrodynamic Tidal Study of Bass River, Dennis and Yarmouth, Massachusetts, Final Report* evaluated options for widening those two restrictions. The studies concluded that widening each restriction to pre-bridge conditions would have a positive impact on this tidally influenced portion of the river. The average tidal prism upstream of Route 6 would increase by 35 percent resulting in a 25 percent reduction in total time required to exchange water in that area. That results in a significant reduction in the amount of nitrogen needing to be removed from the watershed since the residence time is reduced. This solution offers the best potential for long-term restoration of salt marsh and benthic habitat in the upper reaches of the Bass River system. Both are indicators of a healthy aquatic ecosystem.

The widening of the former railroad bridge has been implemented as part of the MassDOT funded Dennis-Yarmouth Multi-use Path Bridge over the Bass River. Construction of Phase 1 began in October of 2015 and was completed in 2017. Phase 2 began in 2017, which included the widening of the Bass River Bridge from 60 feet to 160 feet, improving the ecosystem of the upper Bass River. Phase II was completed in the Summer of 2018.

The larger restriction located at the two Route 6 bridges is not included in any formal plan at this time. Those bridges are over 50 years old now and are likely in need of repair in the next few years. The documented water quality improvements resulting from this opening will greatly enhance the valuable water resources of Dennis and Yarmouth and result in significant cost saving to the water resources management plans in each community. In April 2016, both the Towns of Dennis and Yarmouth have written to the MassDOT requesting consideration for widening the bridges during future replacement of the bridges. In separate responses from MassDOT, it was stated that there are currently no plans to replace these bridges in the near future but if future conditions warrant full replacement, MassDOT will consider widening to the

greatest extent possible. In March 2018, the communities of Dennis, Harwich and Yarmouth, as part of the collaborative effort of the DHY Clean Water Community Partnership sent a joint letter to MassDOT requesting a meeting to discuss the widening of the bridge and the documented environmental benefits. In April 2018, MassDOT responded that the bridge is neither functionally obsolete or structurally deficient and therefore will not be considered for widening at this time. Further discussions between the entities are required as this bridge widening would save the communities several million dollars.

14.6 Recommended Program Costs

Each phase of the plan is between $22.3 to $124.4 million for a total program cost of $344.3 million. The initial Dennis treatment facility will be built in Phase 1 and is proportionally more costly in its initial phase as it includes all the supporting buildings and common processes. It is proposed that this facility will be expanded to accommodate the additional wastewater flow and increased treatment capacity in Phase 4. The adaptive management approach will allow the treatment facility expansion requirements and sewer service areas to be further evaluated and modified as needed between Phases 4 and 8. Operation and maintenance costs at buildout are projected to about $7.0 million annually.

Dennis's Wastewater Implementation Committee, in discussions with Dennis staff and other Boards and Committees, created a subcommittee to further evaluate potential cost recovery models and develop a recommendation. The models evaluated are discussed in detail in Section 15.

Table 14-14 presents anticipated costs by calendar year based on the phasing plan discussed earlier in this section.

Table 14-14 Details of Phasing Plan Costs by Phases 1-8 (Year 2024 ENR: 13,060)

Funding Request Year	Fiscal Year	Annual	Cumulative	Funding For	Total Annual Funding Request
Phase 1					
2022	2023	$3.6 Mil	$3.6 Mil	Phase 1 Collection System - Design	$10.9 Mil
		$5.33 Mil	$8.9 Mil	WWTF - Design	
		$2.1 Mil	$10.9 Mil	Effluent Recharge - Design	
2024	2025	$45.4 Mil	$56.3 Mil	Phase 1 Collection System - Construction	$113.5 Mil
		$48.2 Mil	$104.5 Mil	WWTF - Construction	
		$18.6 Mil	$123.1 Mil	Effluent Recharge - Construction	
		$1.3 Mil	$124.4 Mil	Non-Traditional Technologies	
Phase 2					
2027	2028	$3.1 Mil	$127.5 Mil	Phase 2 Collection System - Design	$3.1 Mil
2029	2030	$27.9 Mil	$155.4 Mil	Phase 2 Collection System - Construction	$29.2 Mil
		$1.3 Mil	$156.7 Mil	Non-Traditional Technologies	
Phase 3					
2032	2033	$2.1 Mil	$158.8 Mil	Phase 3 Collection System - Design	$2.1 Mil
2034	2035	$18.9 Mil	$177.7 Mil	Phase 3 Collection System - Construction	$20.2 Mil
		$1.3 Mil	$179.0 Mil	Non-Traditional Technologies	
Phase 4					
2037	2038	$1.5 Mil	$180.5 Mil	Phase 4 Collection System - Design	$3.2 Mil
		$1.7 Mil	$182.2 Mil	WWTF Upgrade - Design	
2039	2040	$13.7 Mil	$195.9 Mil	Phase 5 Collection System - Construction	$48.5 Mil
		$15.5 Mil	$211.4 Mil	WWTF Upgrade - Construction	
		$18.0 Mil	$229.4 Mil	Effluent Recharge - Design & Construction	
		$1.3 Mil	$230.7 Mil	Non-Traditional Technologies	
Phase 5					
2042	2043	$3.5 Mil	$234.2 Mil	Phase 5 Collection System - Design	$3.5 Mil
2044	2045	$31.2 Mil	$265.4 Mil	Phase 5 Collection System - Construction	$32.5 Mil
		$1.3 Mil	$266.7 Mil	Non-Traditional Technologies	
Phase 6					
2047	2048	$2.1 Mil	$268.8 Mil	Phase 6 Collection System - Design	$2.1 Mil
2049	2050	$19.1 Mil	$288.0 Mil	Phase 6 Collection System - Construction	$20.4 Mil
		$1.3 Mil	$289.3 Mil	Non-Traditional Technologies	
Phase 7					
2052	2053	$2.7 Mil	$292.0 Mil	Phase 7 Collection System - Design	$2.7 Mil
2054	2055	$24.2 Mil	$316.1 Mil	Phase 7 Collection System - Construction	$25.5 Mil
		$1.3 Mil	$317.4 Mil	Non-Traditional Technologies	
Phase 8					
2057	2058	$2.6 Mil	$320.0 Mil	Phase 8 Collection System - Design	$2.6 Mil
2059	2060	$23.0 Mil	$343.0 Mil	Phase 8 Collection System - Construction	$24.3 Mil
		$1.3 Mil	$344.3 Mil	Non-Traditional Technologies	

Based on discussions with Dennis representatives, the 40 year implementation has been divided into the timeline as shown in Table 14-15. The town will need to further evaluate and potentially adjust this timeline to help coordinate financing of other large capital projects in town in order to minimize financing impacts. Section 15 discusses detailed cost recovery options for Dennis.

Table 14-15 Timeline for Phasing Plan Costs by Phases 1-8 (Year 2024 ENR: 13,060)

Phase	Calendar Year	Duration (years)	Amount
1	2022 to 2026	5	$124.4 Mil
2	2027 to 2031	5	$32.3 Mil
3	2032 to 2036	5	$22.3 Mil
4	2037 to 2041	5	$51.7 Mil
5	2042 to 2046	5	$36.0 Mil
6	2047 to 2051	5	$22.6 Mil
7	2052 to 2056	5	$28.2 Mil
8	2057 to 2061	5	$26.9 Mil
Total Program	**2022 to 2061**	**40**	**$344.3 Mil**

The overall program to meet the nitrogen TMDLs and the other defined town needs are estimated to be $344 Million. However, the recommended program includes a buildout growth which is a prudent projection but may not occur. It also does not take credit for any other non-infrastructure nitrogen reduction aspects of the program such as fertilizer reduction, improved stormwater controls and land use changes. Thus, if only half the growth occurred and up to half of the nitrogen contributions from fertilizer and stormwater were achieved, then it is conceivable that a reduction in the recommended infrastructure cost can be realized.

14.7 Non-Infrastructure Components

The subsections above describe mainly infrastructure related components of the recommended wastewater management program. However, there are several non-infrastructure related components that need to be implemented as well. Each component which will help to reduce the overall program costs are described below.

14.7.1 Public Outreach

Public participation and outreach has been a priority during the CWMP/SEIR process, starting in 2005 when informational public outreach efforts under the Phase I Needs Assessment were initiated to gain participation and feedback from residents and business owners. Developing positive public relations – defined as an ongoing, informative conversation between the Town and various stakeholders – during the planning phase translates to enhanced public acceptance during the implementation of any project. Ultimately, buy-in from involved citizens, stakeholders like business and community groups, and the public at large will be required to gain acceptance of proposals to fund this water quality effort. According to the Massachusetts Executive Office of Energy and Environmental Affairs (EEA) Environmental Justice (EJ) Map Viewer, there are three areas of Dennis that are classified as being EJ communities due to income and minority populations, including South Dennis, Dennis Port and West Dennis. The Town and WIC worked to

keep all communities within Dennis informed and engaged on this significant future project. Documentation of public outreach can be found in **Appendix G**.

In 2018, a public outreach subcommittee was formed from several members of the WIC. This smaller group was tasked with identifying the best avenues for the Town of Dennis to reach its residents. It is likely that a subgroup will will continue to meet throughout implementation of the CWMP and adapt to changing conditions so that their message will continue to reach the residents of Dennis.

Avenues of public outreach that the WIC has used and will continue throughout the CWMP development and implementation are listed below. More detail is provided for each:

- Branding
- Website
- Publications
- Mailings
- Information Displays and Booths
- Social Media
- Committee Meetings

Branding

An identifiable logo for the project has been created that will carry through the entire effort and all forms of outreach and delivery. Since our approach to the public will constantly stress that the Town benefits most from proactively undertaking its own unique approach to the Cape-wide water quality concern, the logo emphasized that message as well as Dennis iconography.

Website

The previous CWMTF's webpage showcased all the technical documents and reports relating to the project. Simply put, if anyone is interested in really diving into this project, the website is the clearinghouse that contains all the information there is to know. The new WIC webpage will be updated to include the content developed, both technical and public participation related.

The WIC website will serve as a resource to the committee members and Town staff who work on this project on a constant basis, provide further information to potential evangelists, and serve to neutralize potential objections by conveying both education and project transparency.

Publications

The WIC could perform outreach through a variety of media channels, both traditional and online: The Cape Cod Times, The Register, local and Town blogs and websites, and local radio and television. These publications would provide useful, actionable information to these outlets to drive informative stories, publicize meetings and our other forms of outreach, and convey our message to the public at large.

Mailings

To date, the former CWMTF sent out an informational flyer in tax bills during November 2015. This outreach was performed to convey the reasons for the project, the importance of the project, and the latest details on upcoming events.

Additionally, an email address was created specifically for this initiative, so that the public has a consistent address to use to submit input or ask questions. Currently, the e-mail address is monitored by CDM Smith but the long-term goal is to have the address be monitored by town staff, to ensure timely responses and longevity for the duration of both the planning and implementation phases of the town's water quality initiatives.

Information Displays and Booths

Informational displays could be created at various Town venues where opportunities exist to educate and involve the public including the Town Hall, the Senior Center, the Town Annex, and the Dennis Water District. These kiosk locations reportedly were deemed successful during the prior phase of water quality planning.

Routine engagement that citizens and stakeholders have with the Town provides the WIC with an opportunity to reach out with information about the project. For instance, over 60% of the 12,994 beach stickers in FY2013 were purchased in person at Town offices. An informational poster was created in early 2015 to display at Town offices. This poster could be updated as the CWMP development continues and through implementation.

Social Media

Social media tools like Facebook and Twitter are free to use, and will help the WIC get the word out about events. These channels could also be used to engage local media and hopefully leverage existing Town accounts to spread the word. In 2021, the Town initiated "Wastewater Wednesday" which aims at educating the community on the water quality issue from the presence of nitrogen in the estuaries and what the Town is doing to address it. Content from the Wastewater Wednesday profile will be made accessible across mainstream social media channels, including Facebook, Instagram, Youtube, and Twitter.

Committee Meeting

The committee meetings are televised and available online, providing an opportunity for those most interested to stay up-to-date on the latest project developments. In 2021, virtual meetings were initiated, which allowed anyone from the public to join in on the meetings in real time and pose questions.

Community Meetings

There have been several community meetings to explain the project to the public. In September 2015 and in July 2015, the committee and CDM Smith presented to the Dennis Board of Selectmen on wastewater solution plan options. In November 2015, the chair of the WIC presented to the Rotary Club in Dennis to discuss the wastewater problem in Town and the work the then CWMTF has been doing to find a solution. Also in November 2015, the committee held a Wastewater Summit. Attendees included the Dennis Board of Selectmen, Planning Board, Finance Committee, Wastewater Task Force, Capital Outlay Committee, Board of Health, Water Quality Advisory

Committee, Economic Development Committee and Conservation Committee. The intent of the summit was to discuss the status of Dennis' efforts on wastewater and to gain a better general understanding of what progress can be made dealing with Dennis' wastewater management challenges and to begin to develop an understanding as to the level of "leadership" commitment that will be required to manage wastewater in Dennis and to educate Dennis citizens as to its importance. The Summit was facilitated by Brian Dudley, Regional Director for Cape Cod of the State Department of Environmental Protection. Additionally, a Public Information Session was held in June 2016 about the status of the Water Quality Evaluation and Mitigation Study which was nearly completed at the time. The committee will continue to consider additional meetings or events to educate the public and solicit feedback on the plan.

Ultimately valuable input from all of these events was utilized to develop the recommended wastewater program described herein.

At the annual residents meetings, CDM Smith, in collaboration with the Town, provided information and updated on the development and status of the CWMP. Dennis will continue to offer public outreach and educational opportunities through these collaborations during the implementation of the CWMP/SEIR recommendations. This will be particularly important during construction phases so that residents and business owners understand what is happening and when it will happen. Additional outreach efforts will include information about proper fertilizer application, low impact landscaping techniques, and water conservation practices. Programs will be designed to complement the needs of the community and will prioritize total nitrogen reduction through proven best management practices. Additional consideration will be given to developing nutrient management website resources on the Dennis website, printed educational materials, and participation in community events.

14.7.2 Fertilizer Education

Fertilizer applied to golf courses, agriculture, town properties, and residential lawns are estimated to account for approximately 7 to 8 percent of the total controllable nitrogen load to the town's estuaries. While the recommended wastewater management plan focuses on reduction of septic system nitrogen, which is the largest component of the controllable nitrogen load in a watershed (80 to 85 percent), fertilizers will continue to affect local estuaries until steps are taken by residents, landscapers, golf course operators, and cranberry bog owners to reduce overall fertilizer use.

The fertilizer education program will focus on ideal application types and rates of fertilizer and on awareness of the negative effects of over-fertilization or inappropriate use. The program will also target portions of Dennis located upstream from the most sensitive water sources and may include website resources, handout materials, collaboration with local landscaping companies, and other regional and County initiatives for the benefit of the community.

The Town could partner with local garden shops to hand out fertilizer education brochures created as part of the public outreach program and help in educating the public on proper fertilization practices. Additionally, the Garden Club could undertake fertilizer education as a special project and work within their community to disseminate the fertilizer education materials generated by the WIC and potentially showcase areas of town where proper fertilization

techniques are being used so that citizens can see the real potential. The Garden Club could potentially help to showcase a small visible patch of land that has been applied with a low maintenance grass seed (i.e. Harmony by Colonial Seed) to demonstrate the potential of low maintenance grass seeds. The Colonial Seed Harmony mix claims that no fertilization or watering, other than rain is required and it only needs to be mowed once per year.

Similar to the public outreach efforts, a fertilizer education subcommittee was formed in 2018 from several members of the WIC. A fertilizer educational brochure was created in 2019 and is posted on the WICs webpage. Additionally, an educational PowerPoint was also drafted which can be used by local community groups to educate the public when desired. The WIC will continue to develop local outreach programs and/or practices, as needed, to address fertilizer contributions in sensitive watershed areas. The Town elected to utilize this approach to achieve nutrient reduction instead of adopting a fertilizer bylaw.

14.7.3 Stormwater BMPs

Stormwater from runoff and impervious surfaces is similar to fertilizer in terms of the amount of total controllable nitrogen load to the estuaries. It accounts for about 8 to 13 percent of the controllable nitrogen. It can also be a source of nutrients to the fresh water resources in Dennis. While wastewater planning will reduce pollutants, stormwater will continue to affect local water bodies. In 2010, The Town of Dennis adopted the Stormwater Management Rules and Regulations, to be enforced by the Building Commissioner. The Town continues to enforce these rules and regulations which include stormwater best management practices (BMPs) that help reduce the turbidity from stormwater and reduce the total pollutant (phosphorus, nitrogen and pathogens) load to both the fresh and salt water resources in Dennis.

All three of the above non-infrastructure components should be addressed on a continuing basis, however, combined they do not achieve the required nitrogen reduction to meet the estuary TMDLs. It is also difficult to monitor the long-term benefits of each component. Improved fertilizer management and stormwater management will result in improved water quality which will be observed via long-term water quality monitoring. That benefit will allow the Town to implement the wastewater program closer to the lower end cost range.

The stormwater BMP program will focus on ideal application of BMPs at drain features throughout Dennis. The program will target those portions of town located upstream from the most sensitive water sources in subwatersheds with the highest nitrogen loads from stormwater and will include several stormwater controls and/or practices on all new work. As the program is developed, the town will decide which types of controls are most appropriate.

Listed below are five common BMP strategies to reduce pollutant input to the local water resources:

1. **Deep Sump Catch Basins**

   Deep sump catch basins are modified versions of the inlet structures typically installed in a piped stormwater conveyance system. They provide capacity for sediment accumulation which is then periodically clean-out from the basin.

2. Detention Pond Infiltration Basins

Detention pond infiltration basins are used to manage stormwater runoff and improve water quality in adjacent water bodies. These are shallow artificial ponds designed to infiltrate stormwater into the ground versus direct discharge to a water body.

3. Porous Pavement

Porous pavement is a permeable pavement surface with a stone reservoir underneath. Runoff from porous pavement infiltrates directly into the soil and receives some level of filtration. Porous pavement looks the same as traditional asphalt or concrete but is manufactured without "fine" materials, and instead incorporates void spaces that allow for infiltration versus run-off.

4. Bioretention and Vegetated Basins

Bioretention basins utilize structures to physically remove contaminants and sediment from stormwater runoff. Stormwater is collected into the treatment area which consists of a ponding area. Runoff passes first over or through the ponding area which slows the runoff's velocity and distributes it evenly along the length of the basin. The vegetated basins allow pollutants to settle and filter out, and also provide the opportunity for the uptake of nutrients. A vegetated infiltration basin can also help fulfill site landscaping requirements.

5. Catch Basin Cleaning

According to the USEPA, catch basin cleaning is an efficient and cost effective method for preventing the transport of sediment and pollutants to receiving water bodies. This improves both the aesthetics and the quality of the receiving water body. Catch basins should be inspected regularly to determine if they need to be cleaned.

Dennis has consider these strategies and others in the development of an appropriate town-wide stormwater strategy to initially implement in the most sensitive watershed areas, and eventually throughout the entire town. The initial stormwater initiatives developed by the Town and the status of each are shown in **Table 14-16**.

Table **14-16 Stormwater Initiatives**

Watershed	Location	Mitigation Project	
Bass River	Old Fish House Road	Barnstable county is performing a study to determine how well the existing rain garden is performing (Approximately 8 years old)	Current
		Install/Reconstruct BMP's at landing and add upstream drainage	Future
	Follins Pond Road	Reconstruct landing and add/upgrade BMP's-CCCD Grant for redesign	Future
	Pond Street	Replace culvert and install upstream BMP's	Future
	Cover Road Landing	Reconstruct landing and install BMP's	Future
	Center Street	Install BMP to reduce flow to wetland area	Future

Watershed	Location	Mitigation Project	
	Kelley's Pond Road	Upgrade BMP at discharge	Future
	Lower County Road	Replace culvert at Weir Creek	Future
	Country Circle	Create drainage easement	Complete
	Peter Oliver Road	Rehabilitation of existing drainage	Complete
	Aunt Julia Ann Road	Install stone drainage swale, rehab town landing and beach grass	Complete
	Bass River Park	Rehabilitation of existing drainage	Complete
	West Dennis Beach Rotary	Install porous pavement	Complete
	Fisk Street	Replace culvert and eliminate direct discharge with BMP	Complete
	Trotting Park	Install porous pavement at low point in area of flooding	Complete
	Swan Pond Road at Lower County Road	Construct wetland basins	Complete
	Highbank Road Landing	Resurfaced road with berm to redirect discharge to drainage system	Complete
	School Street and Marsh Street	Various drainage improvements	Complete
Quivett Creek	Sea Street	Install drainage at a parking area at intersection of Sea Street and South Street	Future
	South Street	Add drainage systems to replace direct discharge to wetland area (existing discharge now overflow)	Complete
Cape Cod Bay	Corporation Beach Parking Lot	Install leaching field underneath parking lot	Complete
Nantucket Sound	Chase Road	Replace culvert from Seaview Park to Nantucket Sound (with Back Flow Valve)	Partially Complete
	Sea View Park	MVP Grant to design stormwater improvements including dredging and expansion of Pound Pond	Current
Cedar Pond	Airline Road Pond Parking Area	Install leaching system at the direct discharge location in the parking lot	Future
	Greenland Circle	Convert outfall to leaching basin	Complete
	Cedar Hill Road/Quivet Drive	Convert outfall to leaching basin	Complete
Chase Garden Creek	Hope Lane	Install MPB's upstream of culvert crossing	Future

Watershed	Location	Mitigation Project	
Scargo Lake	Route 6A	Stormwater improvements at the Scargo Lake Landing (off Route 6A)	Future
	Beach Parking Lot	Reconstruct parking lot and incorporate BMP's	Future
	Princess Beach	Improve existing stormwater infrastructure (end of Dr. Lord's Road)	Complete
Swan Pond	Swan Pond Town Landing	Improve direct discharge at Town landing	Future
	Center Street at Hydaway Lane	Remove direct discharge at culvert crossing	Future
Swan Pond River	Route 28 Bridge at Swan Pond River	Divert drainage to Baxter Street wetland	Complete
	Lower County Road	Redirect drainage to town owned parcel to eliminate direct discharge	Complete
	Upper County Road at Swan River	Direct drainage to detention basin located within town owned parking lot	Complete
Flax Pond	Madison Road	Install BMP at stub road access	Future
Various	Town-wide	Culvert Assessment and Prioritization	Future

14.7.4 Freshwater Ponds Evaluation, Sampling and Restoration

In Section 3 of this CWMP, the health of the Dennis freshwater ponds was evaluated and summarized. According to the Cape Cod Pond and Lake Atlas (CCC, 2003), the Town has 29 ponds with a total area of 749 acres. The Cape Cod Pond and Lake Stewardship (PALS) program has consistently sampled up to seventeen locations annually in eleven of Dennis's ponds, typically in August, and/or September. Data from the PALS sampling program for 2004-2015 were reviewed for that analysis. In addition, PALS summary data from the 2001-2002 Cape Cod Pond and Lake Atlas were considered, herein referred to as the Pond and Lake Atlas.

The eleven Dennis ponds in the pond health assessment included herein are quite diverse in both physical and water quality characteristics. Dennis's ponds provide important habitat for aquatic life and are important natural resources for the community. The growing number of pond restoration actions on Cape Cod suggests that many ponds are reaching their tipping points, where further alterations to the environment will result in sometimes dramatic changes in water quality. Cedar Pond was observed as having macrophytes, aquatic plants, along the northern shoreline; current orthophotos show this growth in the southeastern area of the pond as well. Generally, historical orthophotos show multiple instances of algal growth. Below are some preliminary steps that should be taken to protect or restore Dennis's ponds.

1. Continue sampling

It is recommended that all current sampling of ponds continue. It is also recommended to expand the PALS program to collect at least one sample annually from other Dennis ponds without historic water quality data so that a baseline can be established.

2. Perform an inventory of all stormwater pipes draining to ponds

Road runoff was identified in at least thirteen ponds as a potential source of contamination. Create an inventory incrementally with focus on ponds with water quality data. If found, divert or disconnect stormwater systems that directly discharge to ponds.

3. Investigate other potential contaminant sources

Phosphorus loads from the following sources should be considered: abandoned or active cranberry bogs, sediment dumping locations, farms, private impervious surface runoff, private landscape and fertilizer applications, and waterfowl. Decreasing phosphorus loads to ponds that are currently affected by high phosphorus concentrations would improve pond health. For ponds that have evidence of phosphorus regeneration, expansion of monitoring points allows for a more accurate understanding of phosphorus regeneration.

4. Determine uses and ponds to support

Fostering stakeholder and public participation is a key component in determining which ponds and which uses for each individual pond should be prioritized to keep or meet a high quality designation. An example would be to prioritize the protection of Bakers, Cedar, Coles, Eagle, Flax, Fresh, Hiram, Northern Simmons Pond, Run, Scargo, and White Pond to prevent water quality degradation from affecting fish populations, if that is a priority for the community. **Table 14-17** summarizes the analysis and recommendations for each of the ponds currently sampled and examined.

5. Establish Long-term datasets

It is recommended to establish long-term data sets to evaluate the types of management (in-lake, BMP, sewering, etc.) that will be most beneficial for specific ponds. These long-term data sets help to understand whether poor water quality observed in one year is typical, caused by extreme conditions or is indicative of a long-term trend. It also helps to understand interannual variability in temperature and dissolved oxygen as well as nutrient concentrations. In the event that of active management is being is being considered in the future, the relatively low cost of ongoing monitoring can help better identify the best technique and can inform the design.

Table 14-17 Dennis Ponds Health Assessment Summary and Recommendations

Name	Pond Trophic Status	Monitor	Investigate Road Runoff Contribution	Investigate Potential Contaminant Sources	Shoreline Development
Aunt Pattys Pond	*	X	X		Low-Medium
Bakers Pond	Oligotrophic	X	X		Low
Cash Pond	*	X			Low
Cedar Pond	Eutrophic	X	X	X	Medium-High
Clay Pond		X		X	Low-Medium
Coles Pond	Eutrophic	X			Low-Medium
Duck Pond	*	X	X	X	Medium-High
Eagle Pond	Mesotrophic	X	X	X	Low
Flax Pond	Mesotrophic	X	X	X	Low-Medium
Follins Pond	*	X	X	X	High
Fresh Pond	Eutrophic	X		X	Low
Funn Pond**	*	X		X	Medium
Grassy Pond	*	X			Low
Great Pond Plash	*	X			Low
Hiram Pond	Eutrophic	X	X	X	Medium
Jonathans Pond	*	X		X	Low-Medium
Kelleys Pond	*	X		X	Medium-High
Little Coles Pond	*	X			Low
Northern Simmons Pond	Oligo-mesotrophic	X			Low
Pine Pond	*	X	X	X	Medium
Run Pond	Meso-eutrophic	X		X	Low
Scargo Lake	Meso-eutrophic	X	X	X	Medium
Southern Simmons Pond	*	X		X	Low
Swan Pond	*	X	X	X	High
The Plashes	*	X			Low
Uncle Stephens Pond	*	X		X	Medium
Weir Creek	*	X	X	X	Low-Medium
White Pond	Oligo-mesotrophic	X		X	Low
Whittemores Pond	*	X	X	X	Medium-High

Note: (*) Data not provided
(**) Also known as Fund Pond in historical USGS maps and the Pond and Lake Atlas.
Red Fields indicate impaired water quality.
Gray Fields indicate recommendation to explore alternative wastewater management due to shoreline density.

The Town will continue to investigate the need for adding more ponds to the list shown in Table 14-17. It is recommended to target ponds that have public access where algae blooms could pose a public health concern or impair recreation. Within this category, it's recommended to target ponds that are most likely to be nutrient impaired, these include ponds located within more densely developed areas, in unsewered areas, and those which incur significant stormwater inputs. It is recommended that the Town establish a priority list using these criteria which will be used for consideration going forward.

14.7.5 Continued Salt Water Sampling

Now that the MEP water quality monitoring program is complete, the Town via the WIC oversight will continue monitoring water quality at the defined sentinel and check stations. Monitoring of each sentinel and check station within Dennis is proposed seasonally for the duration of the implementation phase. At this time, it is anticipated that regular sampling required by the future

groundwater discharge permits will ensure that the health of the local estuaries improves as the program moves forward. As the program nears completion and is in the final phases, the sampling will become more important because the results may indicate, through adaptive management, that the extent of the sewer service areas can be reduced. The result could be a significant cost savings to the Town.

14.7.6 Low Impact Landscaping

As part of the nutrient management programs, the Town will encourage low impact landscaping, as mentioned above in the fertilizer education section. Low impact landscaping encourages the use of plantings that minimize the need for watering as well as the use of fertilizers. By utilizing these low impact plantings and reducing lawn areas, maintenance can be reduced while minimizing environmental impacts to the watershed.

14.7.7 Water Conservation Programs

Increased water use introduces a pathway for nitrogen to enter sensitive estuaries. Water conservation is a cost effective and environmentally sound way to reduce the demand for water, which is particularly important during warm weather months when overall water use increases by about 50 percent. The Dennis Water District has a bylaw which may declare a State of Water Conservation upon which restrictions to water uses such as lawn watering, filling of swimming pools, and automatic lawn sprinkler use may be enacted. Further reductions in water use may be found through an education and outreach program which focuses on the benefits of water efficiencies.

Examples of residential and commercial water efficiencies include incorporating low flow plumbing fixtures such as faucets, shower heads, hoses, and toilets. Efficiencies can also be found in landscaping by utilizing native plants and grasses whenever possible, watering lawns and landscaping as-needed and for limited amounts of time, installing rain sensors into irrigation systems, maintaining pools to eliminate leaking, mulching around plants to insulate from evaporation, repairing leaky faucets and drains, and planning landscaped areas according to sun and water demand.

In addition to reducing nitrogen pathways, saving water also saves energy. Residents of Dennis receive water from 22 groundwater wells located throughout the Town. Reducing overall water consumption will also reduce the amount of energy necessary to pump, filter, and treat water and that reduction will save costs.

The Dennis Water District currently has a Drought Management Plan but no comprehensive list of resources related to water conservation. Through implementation of this CWMP/SEIR, the water conservation efforts could be expanded to include participation in community events, K-12 educational presentations, developing and/or distributing paper materials and fliers in a general campaign, and a focused effort that targets the highest nitrogen-producing areas of the community.

14.7.8 Inflow Prevention Programs

An inflow prevention program will be implemented as soon as the first wastewater customers are tied into the new sewer system. Inflow prevention programs seek to ensure that water from

street drains, roof gutters, sump pumps, driveway drains, or any other clean water sources do not make their way into the wastewater collection system. When inflow sources are introduced into the wastewater collection system, the wastewater treatment facility is burdened with treating this extra flow. Unfortunately, these sources of inflow do not need to be treated at the wastewater facility. The result is an unnecessary burden on the collection system, pumping stations, and effluent recharge facilities. This burden costs additional dollars in the form of maintenance and the cost of pumping and treating this extra flow. By implementing an inflow prevention program from the very beginning, the Town can educate the public, monitor its system, and minimize the amount of inflow to the collection system.

14.7.9 On-site System Support

The staff at the Dennis Health Department has several resources dedicated to the maintenance of septic systems. The Towns website: (http://www.town.dennis.ma.us/Pages/DennisMA_Health/sep) lists several resources that a homeowner can utilize when selling their property or siting a new septic system. The website also gives guidelines on how to best maintain an existing septic system.

Even after the wastewater program is fully implemented, there will still be a significant number of Title 5 septic systems functioning in Dennis (approximately 60% of the town). The Health Department will continue its efforts in supporting owners of these systems and will continue to oversee their compliance.

Several resources listed on the Town's website include:

- Septic System Regulations
- Septic System Permit Application and Checklist
- Septic System As-Built Card
- 2016 Septic System Installers
- Septic Installer License Application
- Trench Permit Application
- Emergency Repairs to Cesspools
- Licensed IA Operation and Maintenance Operations
- Variance Forms
- Septic System Engineers and Surveyors
- Septage Haulers
- Title 5 Inspectors
- Consumer Guides

As part of the wastewater program, the Town will continue to regularly notify the property owners who remain on conventional septic systems of the importance of regular maintenance including pumping solids from the septic tank once every three years.

New technologies should also continue to be evaluated. The passive nitrogen reduction systems (PNRS) have shown some promise in warmer climate areas and may prove to be beneficial in some instances here in New England. These are being tested at the Massachusetts Alternative Septic System Test Center (MMASSTC) located in Barnstable County.

14.7.10 School Education Programs

The Town will initiate a school education program for primary and secondary age school children geared toward better understanding the recommended wastewater program. The program will introduce the concept that water is a precious resource that must be protected and will be dedicated to educating both students and the community about the environmental and economic benefits of using water efficiently. Understanding the full water cycle (water, wastewater, stormwater, etc.) and that water is a valuable resource is an important concept for all to understand.

14.7.11 Land Use and Open Space

The Town should continue to review land use planning tools for applicability to this recommended program and for meeting other town needs. Continued efforts, such as those ongoing in the Dennis Port area should occur as they may result in changes to this program. Land use planning tools such as up-sizing of lots via zoning revisions, open space acquisitions, and the like would result in lower nitrogen loadings in a given watershed requiring less sewering. Similarly, higher density development or expansion of commercial areas may result in higher nitrogen loadings potentially requiring more sewering. The percentage of growth currently included in each watershed varies significantly. There are several factors involved in this analysis (economics, open space, growth/no net growth, utilities, traffic, etc.), but clearly the Bass River and Swan Pond River watersheds are the ones where any land use revisions and acquisition of land for open space will have the most impact and can help reduce the overall program cost. Recently, the Town purchased a 13-acre parcel located in the Bass River Watershed and will continue to evaluate acquisition of other potential parcels in sensitive watersheds as phases of the recommended plan are implemented.

14.7.12 Innovative and Alternative Technologies Committee

Because of the high costs today of providing proven nitrogen removal treatment technology to the very stringent standards required to meet the proposed TMDLs, there are several innovative and alternative (I/A) technologies being tested. As described earlier, the available I/A technologies do not meet the nitrogen removal requirements or their use was not cost effective. However, development of new technologies should always be monitored and evaluated for incorporation into this recommended wastewater program. The Dennis program has been designed with significant flexibility such that it would allow potential technology improvements to be incorporated as appropriate. Dennis should develop a committee that monitors these systems going forward.

13.7.13 Boat Pump Out in Dennis Marinas

Currently the Sesuit Harbor, Bass River Marina, Swan River along with the entire Nantucket Sound and Cape Cod Bay, are federally designated no-discharge areas. This designation prohibits the dumping of boat wastewater into the harbors and their tributaries. The Dennis Harbormaster and the Marine Water Quality Committee have worked extensively with Massachusetts Coastal Zone Management (CZM) and EPA officials to enhance a holding tank discharge system that is already available to boaters in Dennis. The Town provides this service and it is considered to be valuable and proactive program that protects the town's valuable coastal resources. To continue its effectiveness, the Town should regularly review its ability to effectively provide this service in the marinas throughout Dennis.

14.7.14 Dennis Shellfish Program

The Town of Dennis Wastewater Implementation Committee and Shellfish Advisory Committee agreed to conduct a pilot study of oyster aquaculture as a nitrogen remediation strategy for the Town's wastewater mitigation planning in the Swan Pond Watershed. The two year project started in July of 2018 in the northwest section of Swan Pond. A total of 150 floating oyster bags with approximately 950 oysters in each comprised the original floating array. In July 2019, an additional 140,000 seed were stocked at approximately 1,000 per floating oyster bag.

In September each bag was divided into two to allow for optimal growth of the oysters. The oysters originally weighed approximately one gram and grew to about 14.5 grams by the end of October with a mortality rate of 11 percent. The floating cages employed during the growing season (April to November) were sunk to the bottom in the winter. Water quality and oyster biomass monitoring was also conducted as part of the pilot study. With the floating bag array covering such a small portion of Swan Pond, it was not expected that water quality improvements would be measurable across the whole pond. Therefore, samples were taken within the array and just outside of it to act as a control site. Samples of 24 oysters representing twelve 2-year old and twelve sub-year old oysters were collected in October 2019 and delivered to Boston University's Stable Isotope Laboratory for nitrogen and carbon analysis in the oyster meats and shells. Using the nitrogen analyses conducted by Boston University on these two size-classes of oysters, the total nitrogen contained was approximately 5.1 kg N in shells, and 10.8 kg N in tissue, for a total sequestered N of 15.9 kg. This amounts to about 0.15g of N removed per oysters as opposed to 0.32g used in previous projections.

While the scale of the project was not sufficient to demonstrate that it could make a significant difference in the water quality of the pond, it did demonstrate the nitrogen removal potential of a given area of oyster culture in the pond, and a measurable way of removing nitrogen to partially meet watershed TMDL limits. The project scale showed the feasibility of culturing up to 1 million oysters per acre and removing about 150 kg of N per acre at costs less than or equivalent to conventional means of treatment. Given the data collected in the pilot study, aquaculture may be a viable technology for additional nitrogen reduction in the Swan pond watershed or other impacted waterbodies in Town.

14.8 Adaptive Management Plan (AMP)

One benefit of a phased sewering approach is the ability to modify the recommended wastewater program as needed during the implementation phases. This "adaptive management" strategy allows for modification to the phasing, timing, or exact areas to be sewered depending on the

results of the earlier implementation phases. The proposed phasing plan discussed earlier allows for adaptive management to be fully utilized if the total sewer service area changes or if new technologies arise that provide better or more cost-effective treatment than those presently proposed. The Town plans to continue revisiting the recommended program throughout its implementation to re-evaluate each phase prior to design and construction. The proposed Adaptive Management Plan (AMP) scope is described below.

14.8.1 Adaptive Management Plan Scope

The AMP associated with Dennis's recommended program will have several components to allow for systematic review of the implementation phase and the resulting changes to water quality, community growth, and economic viability. Specifically, the following items are proposed to comprise the AMP:

1. ***Wastewater Implementation Committee:*** A WIC will continue to function to review the progress of implementing the CWMP recommended program and the potential need to modify the plan during the implementation phase. The WIC may modify its' membership from time to time to include representatives from the Town, MassDEP, and the CCC. Representatives from other towns may also be involved if they participate in regional solutions with Harwich and Yarmouth. The WIC will meet as needed during the implementation phase, but not less than quarterly. The ultimate make-up and authority of the WIC will be determined by the town but the main purpose is to coordinate and monitor the various aspects of the recommended program.

2. ***Water Quality Monitoring:*** Now that the MEP water quality monitoring program is complete for Bass River and Swan Pond Watershed, the Town plans to continue monitoring water quality at the sentinel and check stations. Monitoring will move from the detailed sampling program required for the MEP modeling to periodic monitoring to track the progress of the program's implementation. Monitoring of each sentinel and check station within Dennis is proposed seasonally for the duration of the implementation phase. Once the MEP water quality monitoring program is complete for Sesuit Harbor and Chase Garden Creek, periodic monitoring may also be carried out on these watersheds as well. Monitoring of freshwater ponds is also anticipated. The water quality monitoring plan will be formalized as a written document provided to the WIC for review and comment. This water quality monitoring, or a portion thereof, may also be required by the groundwater discharge permit for the effluent recharge site(s). The results of water quality monitoring will be reported to the WIC annually in writing.

3. ***Habitat Monitoring:*** The Town anticipates that MassDEP will continue eelgrass mapping to assess the results of the recommended program's implementation. Benthic habitat monitoring may also be beneficial to evaluate the effects of the program's implementation. The feasibility and responsibility for such monitoring will be determined through discussion between the Town, CCC, and MassDEP.

4. ***Wastewater Treatment Plant/Groundwater Discharge Reporting:*** The Town of Dennis will be required through their groundwater discharge permit from MassDEP to develop regular compliance reports. These reports, typically developed monthly, will be submitted to

MassDEP. Information contained in these discharge monitoring reports will include monthly WWTF flow rates (average daily and monthly) and influent and effluent quality (including, at a minimum, biochemical oxygen demand, total suspended solids, and total nitrogen). In addition, the groundwater discharge permit will require monitoring at specific groundwater wells and possibly also surface water bodies downstream of the discharge. These requirements will be specified by MassDEP during development of the permit and are anticipated to include both water quality parameters and groundwater elevations. Groundwater and surface water monitoring reports, as well as monthly WWTF discharge reports from the previous calendar year, will be submitted annually to the CCC and the WIC. In addition, a baseline report will be submitted to the CCC and the WIC containing monitoring data prior to bringing the new WWTF online.

5. ***CWMP Implementation and Funding Status:*** The WIC will be provided an annual implementation progress report following each calendar year containing an update regarding the implementation of the recommended program and the status of the project's funding. This report will include the following items:

   - The total length of sewer main pipeline installed to date and the length installed during the reporting year;
   - The total number of parcels with sewer available and the increase during the reporting year;
   - The total number of parcels connected to the sewer system and the increase during the reporting year;
   - The number of parcels connected to the sewer system broken down by watershed, and the increase by watershed during the reporting year;
   - The average daily influent flow to the WWTF during the reporting year, and the long-term trend of average daily flow from the first year of operation of the WWTF through the reporting year;
   - The estimated nitrogen removal by watershed, based on the number of parcels sewered, the influent flow to the WWTF, and the effluent flow and nitrogen concentration to the recharge site(s);
   - A description and status update regarding any other infrastructure-related improvements undertaken during the reporting year, such as widening of the Route 6 bridge and structural stormwater controls, and an estimate of the associated nitrogen removal;
   - A description and status update of any non-infrastructure components of the recommended program implemented in the reporting year, such as public education, fertilizer use reduction, and stormwater management, and an estimate of the associated nitrogen removal;

- Comparison of the estimated nitrogen removed to the results of water quality monitoring (with the understanding that due to groundwater travel times, results will not be immediate);
- The total dollar value of any funding approved during the reporting year for items associated with the recommended program;
- The approximate total dollar value of expenditures during the reporting year for items associated with the recommended program;
- An update regarding any regional initiatives; and
- The projects planned for the next two calendar years.

The previous year's Implementation Progress Report will be included with any Project Evaluation Forms submitted to MassDEP for CWSRF funding consideration.

6. ***Community Growth Status:*** Each year, concurrent with preparation of the implementation progress report, a written update will be prepared and submitted to the WIC describing community growth both in the community at-large and within the sewered areas. This report will list permitted renovations (building additions, redevelopment, etc.) both within and outside of the sewered areas, to assess if growth control strategies for the newly sewered areas are effective. Actual growth will be compared to the community buildout analysis. The report will also describe any changes to growth-management by-laws or regulations during the reporting year. This report will be used to determine if additional growth control or targeted growth strategies may be necessary.

7. ***CWMP Recommended Program Modifications:*** Based on the information provided, the WIC may recommend updates or modifications to the CWMP recommended program over the course of the implementation phase. This is the intent of the AMP, to assist the Town in evaluating compliance with TMDLs and identify the need for adjustments or mid-course corrections to subsequent phases of the structural or non-structural components of the recommended program. The proposed scope allows the recommendations to be periodically reviewed and updated to reflect the actual program results. This approach will result in the most efficient, cost-effective and successful implementation to achieve the necessary water quality results.

Note that the implementation of the 208 Plan and associated non-traditional technology piloting throughout Cape Cod may result in additional opportunities to reduce sewering through non-structural technologies, as discussed previously. Further consideration of such technologies will also be addressed via the adaptive management plan.

14.9 Resiliency and Adaptation Planning

The Town is committed to a long term, resilient wastewater solution that allows for the incorporation of features to address climate change. Resilient design of the wastewater collection and treatment systems will be an integral component of the next phase of work, following submission of the Final CWMP. The Water Utility Resilience Program (WURP), part of MassDEP,

will be a resource to the Town during preliminary and final design of future wastewater infrastructure. Collaboration with the WURP will offer help in identifying practical resiliency resources, opportunities for local and regional partnerships, infrastructure mapping and adaptation planning assistance and training opportunities.

During preliminary design, the Town will perform a detailed assessment of pump station locations, making all efforts to locate pump station outside of coastal AE and VE flood zones. Pump station locations currently shown in the recommended plan are for planning purposes only, showing approximate locations of stations based on system needs. Should pump stations or other wastewater infrastructure components be located within coastal flood zones, the design of these features will comply with 750 CMR. Per 750 CMR State Board of Building Regulations and Standards, new structures erected within coastal high hazard areas shall be elevated so that the lowest portion of all structural members supporting the lowest floor, with the exception of mat or raft foundations, piling, pile caps, grade beams and bracing, to be located at or above design flood elevation plus two three feet. Critical assets such as electrical equipment and standby generators will also be located above the flood elevation. New sewers within the coastal AE and VE flood zones will be ductile iron and waterproof manholes will be used to protect from damage in the event of sea level rise and hurricane surge. Other resilient design features will be considered in the final design stage, which will aim to address impacts from future sea level rise conditions.

14.10 Alternative Technologies

The Town supports the use of newer alternative technologies. That concept has been incorporated into this program. The collection systems will utilize high efficiency motors and will be optimized for the expected wastewater flows. In addition, the wastewater treatment facility is proposed to use SBR and MBR technologies, which are newer technologies and provide advanced nitrogen removal compared to conventional activated sludge treatment facilities. In 2009, the Town began the process of bringing a solar farm installation to the Dennis Transfer Station. The 6 Megwatt (23,000 photovoltaic panels) installation was completed in June 2014 and was connected to the grid in September 2014. The installation is one of the largest community hosted photovoltaic projects in Massachusetts and satisfies the current municipal load. Although it is not anticipated at this time that a future wastewater treatment facility would be served by the installation, revenue from the solar farm may be allocated towards the future funding of the CWMP as a partial means of paying for the implementation.

14.11 Alternatives to the Recommended Program

Over the course of the CWMP development, the Town considered many alternatives to the system layouts and locations, to the selection of appropriate technologies for wastewater conveyance and treatment, to effluent recharge sites and uses, and to cost recovery approaches. Each of these alternatives is discussed in detail in the pertinent sections of this report. This section focuses on the large-scale alternatives to the recommended program. Specifically, the No-Build Alternative, regional alternatives, and options to sewering either more or less of the Town are discussed.

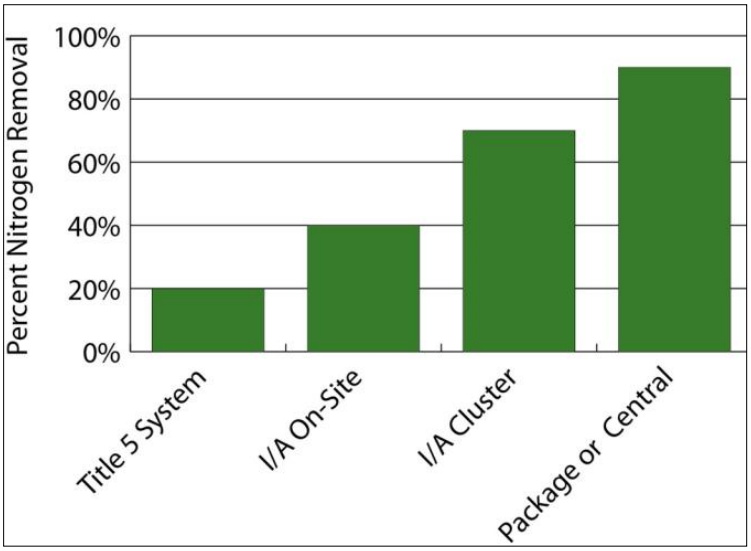
14.11.1 No-Build Alternative

The No-Build alternative involves the continued use of onsite Title 5 septic systems and innovative and alternative (I/A) systems where needed to meet the wastewater needs of the

community. MassDEP indicates that the baseline, or No-Build alternative, which focuses on optimization of existing facilities, should be evaluated "with respect to potential effects on surface water quality; groundwater quality (if applicable); land use limitations; and socio-economic factors (e.g., residential, industrial, and health hazards)." None of these factors can reach an acceptable level of service under the No-Build alternative.

As shown in **Figure 14-4**, on-site treatment technologies cannot reliably meet the stringent nitrogen reduction standards on thousands of individual lots that are possible with more centralized, municipally-run treatment systems. While some I/A systems exist which provide better nutrient reduction than a typical Title 5 system, they still fall short of the requirements since they do not remove the 50 to 90 percent of the septic nitrogen load that is required in the MEP reports for Dennis. In Section 10, it was demonstrated in Scenario 1 that I/A systems could be utilized in both the Bass River and Swan Pond watersheds. The analysis of Scenario 1 demonstrated that, while possible, I/A systems would still need to be supplemented with conventional wastewater treatment in order to achieve the TMDL. In that scenario, the use of I/A systems was maximized by installing an I/A system on all possible parcels within the two watersheds. After reviewing that scenario, the Town decided not to pursue the I/A scenario because the cost was the highest among all options considered and still did not meet minimum nitrogen removal requirements.

Figure 14-4 Percent Nitrogen Removal For Several Treatment Technologies



As such, continued use of on-site systems town-wide would not be cost effective to achieve the nitrogen levels required to restore the local embayments to the highest and best use water quality goals described in the MEP documents. Based on this data, surface water quality cannot be adequately maintained using the No-Build alternative. The drinking water in Dennis demonstrates excellent quality and as such it is important to note that the need to protect drinking water quality is not a significant driver for sewering at this time although a few wells do show nitrogen levels above expected background concentrations for nitrogen.

The No-Build alternative also presents land use limitations, specifically in the South Dennis and other areas of desired growth throughout town. Without off-site wastewater management options, desired land uses are expected to be severely restricted by Title 5.

The Town relies on tourism for jobs and revenue which is the direct result of the high quality natural resources on Cape Cod. Furthermore, many residents choose to reside in Dennis due to its natural beauty and the recreational opportunities afforded by its beaches, ponds, and scenic waterways. Protection of these resources is critical to the health and well-being of the Town. While the No-Build Alternative is obviously the least expensive option when only considering capital costs, the long-term impact on the economic viability of the Town must also be considered, along with the many qualitative factors related to aesthetics, quality-of-life, and environmental preservation. The No-Build Alternative would not adequately preserve these valuable resources, would be in violation of the TMDL requirements for the Town's three embayment's that have TMDLs, and is not considered a viable option by state, county, and local officials.

The Cape Cod Commission notes in a 2015 Three Bays Study that a one percent decline in water quality leads to an average loss in home value of 0.61 percent. This impacts all property owners on the Cape.

14.11.2 Regional Solutions

Dennis has explored regional opportunities with Yarmouth since the Bass River watershed is split primarily amongst Yarmouth and Dennis. The regional opportunities assessment was also extended to include Harwich since the Herring River watershed is split between Dennis and Harwich. Yarmouth and Harwich are in similar stages of their wastewater management programs as Dennis as none of the three towns currently have a wastewater treatment facility. The wastewater collected by the newly installed collection system in the Pleasant Bay watershed of Harwich is conveyed to Chatham's WWTF for treatment through an Intermunicipal Agreement.

In the Spring of 2017, the Towns of Dennis, Harwich and Yarmouth began working together to evaluate the development of a shared centralized wastewater treatment facility and multiple effluent recharge sites. This scenario is known as the DHY Clean Waters Community Partnership. In October 2019 an Act establishing the DHY Clean Waters Community Partnership for the towns of Dennis, Harwich and Yarmouth was passed in the State Legislation as Chapter 88 from the Acts of 2019.

In the previously proposed DYH Clean Water Community Partnership, the DHY WWTF would be located in Dennis at the same site identified for the Town's recommended plan, 120 Theophilus Smith Road. A series of force mains, pumping stations, and recharge sites would also be shared between the three towns. The costs associated with the shared facilities would mainly be distributed based on the wastewater flow capacity owned at the DHY WWTF by each town. Through a cost analysis, it was demonstrated that Dennis could save over $20 million in WWTF capital costs. Additionally, the Town could save approximately $2 Million in WWTF O&M costs. In general, the Regional Plan was projected to save the town of Dennis approximately $3.2 million dollars annually or approximately 15 percent of the cost for the Town-only recommended plan included herein. As mentioned above, at this time each of the three communities has elected to

pursue induvial Town-only solutions but Dennis leaves the opportunity for some form of partnership in the future.

14.11.3 Construct a Smaller or Larger Sewer Service Area

Over the course of the CWMP process, the Town explored many alternatives to the wastewater treatment facility program ultimately recommended. Decentralized service areas with smaller treatment facilities were explored in detail in Section 10, where the Town looked at the scenario of having three different wastewater treatment facilities and three different effluent recharge sites. An option with one centralized facility with an ocean outfall was also explored. In Scenarios 1, 2A, and 2B, thousands of treatment and effluent recharge locations were considered under the highly decentralized on-site I/A scenario. The cost for these decentralized approaches to wastewater management was higher than scenarios 3A/B, 4A/B, 5A/B, 6A/B and 7A/B which utilized no more than two centralized treatment facilities and no more than two effluent recharge sites.

The benefit of decentralized treatment of promoting local recharge to groundwater is not inherently consistent with the MEP goal of reducing nitrogen inputs in specific locations. By providing centralized treatment and effluent recharge in only two sites, nitrogen loading to local waterways can be closely monitored and controlled. It also allows for future treatment of personal care products (PCPs) or contaminants of emerging concern (CECs) should that be required.

On the other end of the spectrum is the remote possibility of sewering the entire town. Based on the analyses performed as part of this CWMP/SEIR, there are no documented reasons at this time with respect to environmental protection or public health to sewer areas beyond those currently proposed. Sewering areas beyond those necessary to protect the local embayments, to allow for additional growth in South Dennis and Dennis Port and to address limited Title 5 or pond water quality issues, is considered cost-prohibitive and would provide no apparent benefit at this time to the Town. The Town is confident that, based on several years of analysis, the CWMP recommended program strikes the proper balance between providing sewers in the areas where they are needed and promoting continued septic system use in the areas where lower cost and lower technology strategies remain appropriate.

Section 15

Cost Recovery Plan

15.1 Introduction

The Town of Dennis's recommended program for nitrogen management, as described in Section 14, is a costly town-wide program which includes sewer installation, wastewater treatment and effluent recharge, as well as a number of non-infrastructure solutions such as public education and aquaculture. To evaluate the range of cost recovery options available to the Town, a Cost Recovery Subgroup was formed to develop a preliminary recommended approach to the Wastewater Implementation Committee (WIC). This section summarizes the cost recovery Subgroup discussions, the preliminary recommended approach to the WIC, feedback from the WIC and public, and the final recommended cost recovery approach for implementation of the Final CWMP recommended plan.

The Cost Recovery Subgroup (Subgroup) consisted of Diane Chamberlain, Chair of the WIC; MaryAnne Gibbs, Town Accountant; Bob Prall, Vice Chair of the Finance Committee; Elizabeth Sullivan, Town Administrator; and David Young, CDM Smith. The Subgroup began meeting in May 2017 and met more than 10 times to develop a preliminary recommended approach to present to the WIC in November, 2017. The WIC reviewed and presented it to the Select Board, Finance Committee and general public in December, 2017. Comments were evaluated and the final cost recovery approach is as presented in this section.

As detailed in Section 14.3 the costs for the recommended plan were updated in August 2018. The Town's Wastewater Implementation Committee, in conjunction with the Town Planner, recommended allocating additional flow from Planning Districts within the Town of Dennis as a result of the economic analysis performed by the University of Massachusetts Donohue Institute in 2018. The cost update considered additional flow and collection from planning districts, additional treatment and effluent recharge capacity needed, and overall increases in updated construction costs for collection and conveyance. Updated total project costs were then escalated to the midpoint of the anticipated first phase of construction in 2022 (Engineering News Record index 12,400 estimated assuming approximately 3% increase per year).

The costs for the recommended plan were updated again in February 2021. The costs were revised to reflect estimated linear footage of each pipe size in the collection system, recent pumping station bid prices from local projects, recent effluent recharge site costs based on other local projects, and the addition of typical OPM services during construction. Updated total project costs were then escalated to the midpoint of the anticipated first phase of construction in 2024 (Engineering News Record index 13,060 estimated assuming approximately 3% increase per year).

15.2 Strategy for Establishing a Cost Recovery Plan

During development of the Draft CWMP the Wastewater Implementation Committee conducted many discussions regarding methods available to recover costs as the wastewater program is

implemented. During these discussions, three tenets developed as various members expressed their visions of the future of the community. First, the WIC felt that everyone in the Dennis community will receive benefits from restored water quality and that everyone contributes in some manner to the biggest problem – nitrogen coming from onsite septic systems. That is true if you visit a restaurant in Dennis, live in a home on the water, or live three miles inland. Thus, the overwhelming feeling throughout the committee was that everyone in town shares responsibility and should pay for a large part of the program's implementation costs. Second, the committee agreed that a dedicated funding source should be established to help pay for wastewater program components. It was important that this source of funding could not be utilized for other town programs but could be used to offset some costs for the larger infrastructure components as well as some of the later phases of the program. Third, the committee felt there should be a component that reflected the amount of water used and/or the amount of nitrogen contributed by a specific home or business owner. This water or nitrogen use component would help address the fact that smaller contributors should pay less while larger contributors should pay more. However, the WIC felt that more detailed discussions above specific cost impacts were needed prior to developing an overall program.

The Subgroup considered the above input but elected to review all options again as the clear message being received from local committees and residents was not to rely solely on the tax rate as the main funding source. That resulted in a philosophy of building up some annual revenue sources to create a base payment and then supplementing the remainder of a program payment with the town-wide property tax.

15.3 Dennis's Preferred Cost Recovery Methods

After careful consideration of several potential cost recovery methods, the Subgroup recommended a revenue-generating mechanism presented herein that the town will use to fund the wastewater program net costs (total costs less grants or other subsidies).

The following cost recovery options are preferred by the Subgroup and listed below based on the tenets mentioned above and the methods available to the town. These methods would be used to repay capital funds borrowed to implement the recommended program, which are typically borrowed via the Clean Water State Revolving Fund (SRF) loans for a 20 or 30 year period at up to 2.4 percent interest.

- **Landfill Solar Fund Revenues –** The Town installed a large solar field on their capped landfill and they intend to utilize about half of the revenues received for a dedicated wastewater account. Legislation was passed through Spring 2018 Town Meeting to transfer money from the Solar Special Revenue fund to the Wastewater Stabilization fund.

- **Increase Local Rooms Tax Fund** – Legislation was passed through Fall 2019 Town Meeting to increase rooms tax from 4 percent to 6 percent with the additional 2 percent to be appropriated in future fiscal years to the Wastewater Stabilization fund. This rooms tax includes local home rentals and AirBnB type rentals.

- **Water Infrastructure Investment Fund** - A real estate tax surcharge of up to 3 percent can be set aside into a Municipal Water Infrastructure Investment Fund, outside of

Proposition 2½, as allowed through recent state legislation. (2014 legislation M.G.L. Chapter 40, Section 39M). The Town has elected to implement a 1 percent tax surcharge at this time.

- **Town-wide Property Tax Fund** – Costs can be recovered from all property owners within the town through the general tax fund.

15.3.1 Landfill Solar Fund Revenues

The Town constructed a solar field on their capped landfill and a portion of the revenues received from that power source could be utilized for implementing the wastewater program by placing a percentage of the annual revenues into a dedicated wastewater program account. Legislation was passed through Spring 2018 Town Meeting to transfer money from the Solar Special Revenue fund to the Wastewater Stabilization fund. However the lease agreement with Eversource is for 20 years and so the revenue to be placed in that account has been limited to that timeframe to be conservative.

Pros:

- Annual revenue source that would help build a stabilization account;
- Dedicated fund for wastewater;
- Does not come from the residents.

Cons:

- Takes money from other potential town infrastructure needs and dedicates it to wastewater.

Recommendation: Annually place about half the solar revenue into the wastewater fund. Estimated currently to be about $300,000 annually.

15.3.2 Increase Local Rooms Tax

Massachusetts offers a local option tax on meals and a local option tax on room occupancy. Like all towns on the Cape, Dennis is at the state limit on meals tax (0.75%). However, Dennis adopted a 4.0 percent room occupancy tax in 1987 which is below the state limit of 6.0 percent. The state also collects a 5.0 percent rooms tax. Legislation was passed through Fall 2019 Town Meeting to increase rooms tax from 4 percent to 6 percent with the additional 2 percent to be appropriated in future fiscal years to the Wastewater Stabilization fund. The total state and local rooms tax is 11.0 percent.

Pros:

- Tourist based funding source dedicated to wastewater program;
- Does not increase property taxes;
- Can be used to pay both capital costs and operation and maintenance costs;

Cons:

- Required special legislation to dedicate revenue to dedicated fund;

Recommendation: Dennis should raise the local rooms tax by 2.0 percent to the state limit of 6.0 percent and dedicate that increase to a wastewater infrastructure fund. Estimated currently to be about $238,000 annually.

15.3.3 Water Infrastructure Investment Fund

This new Massachusetts legislation, approved in August 2014, allows towns to impose a real estate tax surcharge of up to 3% to be set aside into a Municipal Water Infrastructure Investment Fund (WIIF), outside of Proposition 2½. This program would operate similarly to Community Preservation Act (CPA) funding but would be available to the town exclusively for "maintenance, improvements and investments to municipal drinking, wastewater and stormwater infrastructure assets." The municipal treasurer would be the custodian of the fund. The Town voted to approve the establishment of a special “Municipal Water Infrastructure Investment Fund” during the Annual Town Election on June 30, 2020 to be effective for Fiscal Year 2021. The funding source is a 1% surcharge on real property taxes that may be spent on maintenance, improvements and investments to municipal drinking, wastewater and stormwater infrastructure assets.

Pros:

- Town-wide program;
- Creates an additional funding source;
- Attractive if state participates as it does in CPA;
- Progressive, as it is tied to assessed property values;
- Does not count against Proposition 2½ cap;
- Could shift some of the existing CPA percentage over to the infrastructure percentage to help offset the increase (i.e., could set up to not exceed a combined 3 percent total);
- Cost would be tax deductible.

Cons:

- In essence, an additional property tax (if CPA percentage is not reduced by similar amount).

Recommendation: Lower CPA from 3 percent to 1.5 percent and implement 1.5 percent to a dedicated wastewater infrastructure fund. Estimated currently to be about $580,000 annually.

15.3.4 Town-wide Property Tax Fund

A tax based on property value is the simplest method of cost recovery and is widely used to recover a municipality's capital costs. All wastewater system costs not recovered elsewhere can be added to the municipality's total expenditures for all other purposes, thus factoring into the overall property tax rate for the town.

In Massachusetts, tax increases have become more difficult due to the constraints imposed by Proposition 2½. Therefore, the Town needs to consider the likelihood of requiring a tax override petition and/or a debt exclusion vote to raise taxes, depending on other concurrent initiatives in town. From a property owner's perspective, property taxes are deductible from federal income taxes, compared with user charges or betterment fees, which cannot be deducted.

The rationale for such a widespread sharing of the burden is premised on the public health and environmental benefits received by the whole community, the improvement to the quality of life, continued viability of tourism via a natural and healthy seaside community, the maintenance of property values by preserving the town's natural resources, and equity concerns. Pros and cons of this methodology are listed below.

Pros:

- Town-wide funding source which is consistent with the goal of the CWMP to implement a plan to protect the town's water resources (estuaries, embayments, ponds, and drinking water) for the benefit of all residents;
- Distributes expenses across all property owners, as all property owners contribute to the water quality degradation (and solution);
- Is fair since approximately half the town could potentially be sewered; only the required number of properties will be connected to a treatment plant to reach sufficient nitrogen removal required to meet TMDL requirements;
- Simple to implement, as it is not tied to specific wastewater project sites, programs or implementation phases;
- Collected tax would go to a dedicated CWMP Implementation Fund, not the Dennis General Fund;
- Cost recovery is not contingent upon the total number of properties receiving sewers, which could change over time via adaptive management;
- Property tax is progressive which helps align each property owner's ability to pay their fair share of the project cost;
- Cost would be tax deductible;
- Avoids penalizing "first adopters," i.e., those first on the sewer system due to location within the town or a particular watershed;
- Provides a funding mechanism not tied to construction so that non-infrastructure components of the CWMP recommendations can be implemented as well; this is relevant for Dennis as the initial phases include conducting mitigation studies to determine the best way of moving forward and to minimize long-term costs;
- Can be used for paying operation and maintenance costs as well.

Cons:

- Increases property taxes;
- All town property owners will help pay program costs whether connected or not connected to a sewer system;
- Proposition 2½ capital exclusion vote is required (town-meeting vote and ballot approval);
- Those connecting to a sewer will pay additional costs to connect the sewer main to their houses/businesses and annual sewer operating and maintenance costs;
- Those not connecting to a sewer will be responsible for future onsite system replacement costs;
- Nitrogen contribution from a home is not directly proportional to a home's assessed (tax) value.

15.3.5 Estimated Costs Based on Recommendations

The town financial staff worked with their financial advisor Hilltop Securities Inc. to develop a debt schedule reflecting existing and proposed town debt during the implementation of the wastewater program. The debt schedule reflects existing tax-supported debt inside and outside of Proposition 2 ½ and adds in new debt for approved town facilities and for the wastewater program implemented over eight phases as presented in Section 14 herein. The wastewater program is assumed to start in Year 2022 and be implemented over 40 years using 30 year bond payments from the State Revolving Fund (SRF) Loan program at 2.4 percent interest (to Year 2092). A debt service growth rate of 3.5 percent was utilized and the tax impact for a $350,000 single family home was estimated.

Based on the recommended cost recovery methods presented above the following scenarios were prepared to estimate the tax impact:

- Scenario A: Tax Impact using $300,000 Solar Revenue Annually (20 yrs); Year 2016 ENR: 10,379
- Scenario B: Tax Impact using $238,000 2% Rooms Tax Increase Annually; Year 2016 ENR: 10,379
- Scenario C: Tax Impact using $588,000 1.5% Water Infrastructure Investment Fund (WIIF) Annually; Year 2016 ENR: 10,379
- Scenario D: Tax impact using $1,126,000 Solar, Rooms Tax and WIIF Annually; Year 2016 ENR: 10,379

Table **15-1A** presents the cost summary for the recommended scenarios when the plan was first adopted prior to the cost update presented in Section 14.3 for increased flow and escalation ahead to 2024.

Table 15-1A Summary of Previously Accepted Cost Recovery Methods (2016 ENR 10,379)

Revenue Source	Annual Revenue $	Average Tax Impact $/yr[3]	Maximum Tax Impact $/yr[4]
Scenario A - Solar	300,000[1]	275	491
Scenario B - Rooms Tax	238,000	270	478
Scenario C - WIIF	588,000	250	459
Scenario D - All	1,126,000[2]	240	447

[1]Solar revenue included first 20 years only.

[2]Revenue drops to $826,000 in year 21.

[3]Tax Impact over 70 years for $350,000 assessed home value.

[4]Maximum tax year is year 2048.

Upon evaluating the tax impact for each of the four scenarios, the Town decided to move forward with the Scenario D which uses the Solar, Rooms Tax and Water Infrastructure Investment Fund cost recovery methods. Working with the town's financial advisor, the cost recovery methods were revised to reflect the cost update presented in Section 14.3. Updated costs are summarized in **Table 15-1B**. The resultant average tax increase over the 70-year period for a $350,000 assessed home is $224 using all three cost recovery methods (Solar, Rooms Tax, and WIIF).

Table 15-1B Summary of Updated Cost Recovery Methods (2024 ENR: 13,060)

Revenue Source[1]	Annual Revenue $	Average Tax Impact $/yr[3]	Maximum Tax Impact $/yr[4]
Scenario D - All	1,126,000[2]	224	407

1 Solar revenue included first 20 years only.
2 Revenue drops to $826,000 in year 21.
3 Tax Impact over 70 years for $350,000 assessed home value.
4 Maximum tax year is year 2053.

Figure 15-1 presents the tax impact for Scenario D based on the most recent Dennis only recommended wastewater program capital costs as presented in Table 14-14 over the eight phase 40-year implementation. Operation and maintenance (O&M) costs will also be incurred and it is recommended the Board of Sewer Commissioners determine the amount to be recovered from users in the initial years and the amount to be recovered using the means presented above. The initial phases of implementation will not have sufficient sewer system users to support full recovery even though long-term that would be the recommended goal.

It should also be noted that if the town decides to enter into some form of community partnership for wastewater treatment and effluent recharge with Harwich and/or Yarmouth, each community would still need to construct and operate their own sewer collection system which is the bulk of the program costs. However, should Dennis decide to join in a partnership, the capital costs presented and the resultant tax impact estimated would be less than shown in this Section.

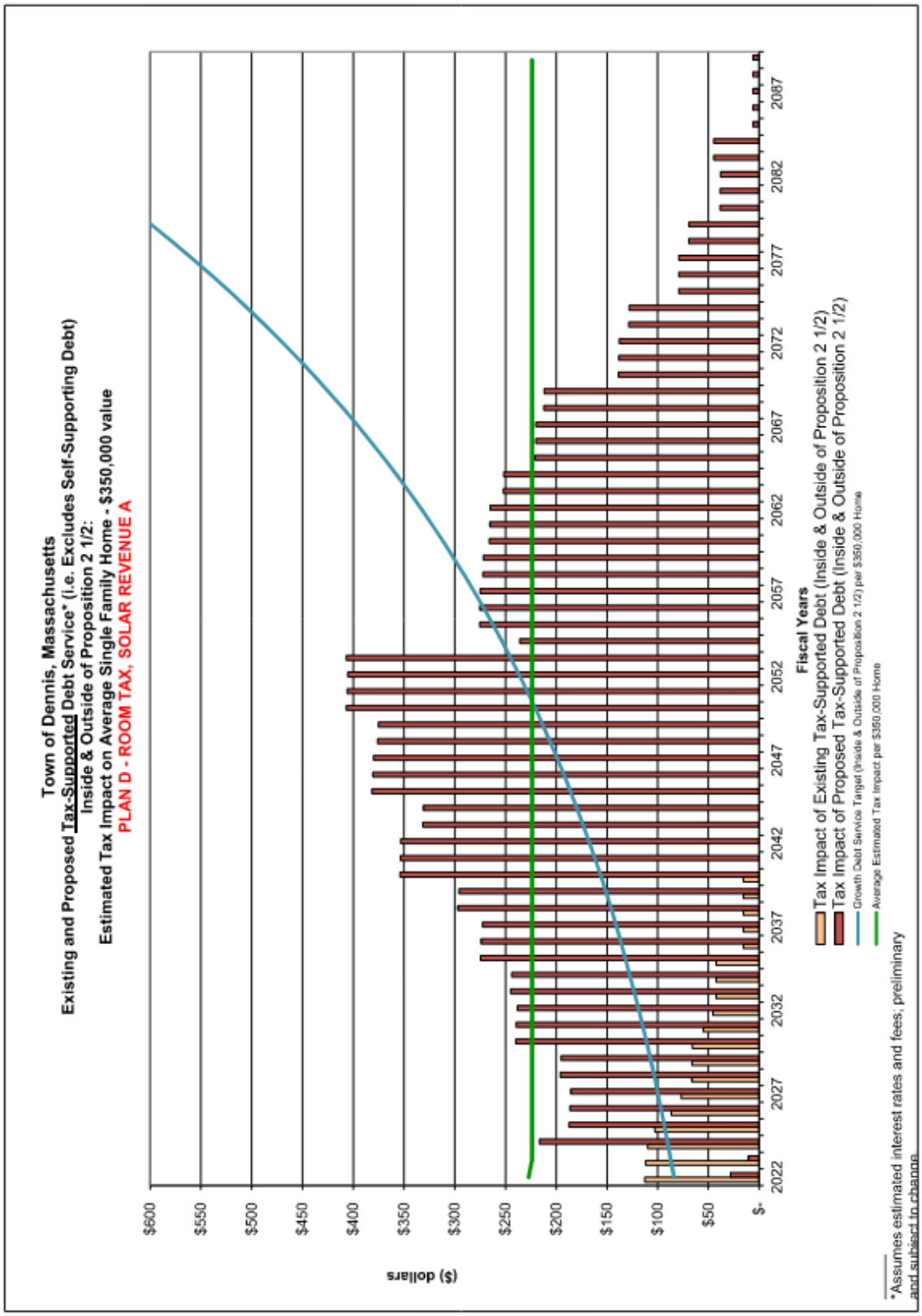


Figure 15-1 - Tax Impact for Cost Recovery

15.4 Other Possible Revenue Sources

Other revenue sources discussed by the Subgroup but dismissed or left for consideration in the future are briefly described below:

A. Cape Cod Water Protection Trust (Legislation Pending – S.2163 and H.3902)

This proposed legislation has been filed by representatives on Cape Cod to assist Barnstable County communities with funding their wastewater programs. It would place an additional 2.75 percent tax on the current rooms tax (includes expansion to local rentals and Air BnB) which would be deposited into a regional trust fund dedicated to funding wastewater projects. This fund would also be available to potentially receive funds from other federal, state and foundation sources.

This additional tax would be on top of the current 5 percent collected by the state and the 6 percent collected by the town (see Section 15.3.2 above) for a total of 13.75 percent.

Pros:

- If passed this would add an additional 2.75 percent to the rooms tax;
- Tourist based funding source dedicated to wastewater program;
- Does not increase property taxes;
- Can be used to pay both capital costs and operation and maintenance costs;

Cons:

- Requires legislation to be enacted;
- Collected revenue goes into a dedicated regional trust fund overseen by the Clean Water Trust that administers the State Revolving Fund loans;
- Town would need to apply to Trust for its' project funding;

B. Increase Beach Parking

Concept is to have the Town investigate potential town owned off-site parking facilities where buses/ trolleys could transport beach goers to various beaches around town. Fees would be collected using kiosks to minimize staffing. This additional revenue would be dedicated to wastewater funding as it is directly related to a water quality program.

Pros:

- Maximizes use of town assets;
- Tourist based funding source dedicated to wastewater program;
- Does not increase property taxes;
- Can be used to pay both capital costs and operation and maintenance costs;

Cons:

- Requires some infrastructure to implement (kiosks, etc.);
- Requires coordination with bus/trolley company to get to beaches;

C. Betterments (Charged to those Receiving Sewer Service Only)

There are specific requirements for establishing a betterment policy but essentially those homes and businesses directly connected to the wastewater program (sewer) would be charge a fee for bettering their property. A formal definition follows:

Betterments are assessments charged to property owners for public improvements that provide a benefit to their property. The Massachusetts Department of Revenue (DOR) offers a more precise definition: "A betterment or special assessment is a special property tax that is permitted where real property within a limited and determinable area receives a special benefit or advantage, other than the general advantage to the community, from the construction of a public improvement." Ability to issue falls under M.G.L Chapter 80.

Pros:

- The town may lien property and thus has a reasonable chance of insuring payment;
- Appearance of fairness as the properties that get direct benefit from sewers would pay;
- Low interest loans are available to property owners;
- History of use for capital improvements (however not as much use in recent years);
- Can be invoiced on town tax bills (though not tax deductible).

Cons:

- Nitrogen pollution is a town-wide problem;
- Narrow base of funding for wastewater program that is applicable to the entire town;
- Mismatch between benefits and those obligated to pay (i.e., few pay for benefit of everyone);
- Sewered areas selected based on least cost to town and higher density areas, not based on basic need or specific nitrogen contributions;
- Must be based on uniform unit method (e.g., number of bedrooms, water use, frontage, equivalent dwelling units (EDUs), etc.);
- Sewer betterment assessments may be inequitable if based on phasing of each watershed sewering project;
- Not tax deductible;
- Perception that property has been "bettered" is open to debate (Town assessors do not increase the value of a home if it is on a sewer).

D. Water Bill Surcharges/Sewer Enterprise Account Charges

This option involves adding a surcharge to water bills to help pay for the wastewater program capital and operating costs. Since the passage of tax limitation measures, user fees to recover capital costs have become more widespread in Massachusetts. User charges can be flat fees, charged periodically on a regular basis, or consumption fees, charged according to water or sewer use.

Since a town-wide public water supply system is already in place, existing users can be required to pay a portion of the capital cost based on their water use, which is directly tied to the amount of nitrogen discharged by each household or business. Would need to coordinate this process with the Dennis Water District who owns and operates the water system in Dennis.

Pros:

- Town-wide funding source dedicated to wastewater program;
- Does not increase property taxes;
- Can be used to pay both capital costs and operation and maintenance costs;
- Relates fee to water use/sewer demand;
- Water use is essentially proportional to the amount of nitrogen being contributed;
- Can easily implement, track and bill users;
- Can create and fund sewer enterprise funds with a dedicated funding source;
- Could initiate collection before funds are needed to build a sewer reserve account;
- A block rate structure could be used to shift more of this burden to seasonal users and offset low volume year-round users.

Cons:

- May require special legislation or formation of a sewer district for all fees to apply to all water users, not just those connected to sewers;
- Will require creation of a Wastewater/Sewer Enterprise Account;
- Dennis Water District is a separate legal entity from the Town of Dennis;
- Need to develop a means to capture the fee from residences on private wells in Dennis.

E. Impact Fees - New Construction

Pros:

- Extracts fees from new growth and new developments;
- Town-wide fee.

Cons:

- Discourages economic development (supports a no growth policy) and thus can have a negative impact on new construction. Typical fees in other communities have been in the following range:
  - $6K to 18K/home
  - $2K to 6K/addition
  - $2K to 6K/condo
  - $1K to 3K/commercial
- Must pass "Nexus" test set by Scotus in Koontz, Nolan & Dolan (i.e., the fee must be proportional to the cost; one can't shift costs to new construction as costs should be proportionally borne by all property owners);
- Must pass Emerson College test (i.e., one can't charge more than the expected benefit; the fee must be roughly equal to the cost of providing service);
- Not tax deductible.

F. Flat Fee on all Parcels

Pros:

- Town-wide fee.

Cons:

- Probably a tax as not specifically related to service (and thus contributes to Proposition 2½ cap);
- Must pass Emerson College test (see above);
- Special legislation needed;
- Not tax deductible;
- Requires designating a wastewater district.

G. Increase in Beach Stickers/ Parking Fees

Pros:

- Paid for mainly by tourists;
- Directly related to those using the Town's water resources and improving/restoring water quality;
- Current fees are modest.

Cons

- Relatively small overall revenue source.
- Ultimately, the Town is striving to arrive at a cost recovery approach that is equitable and justifiable to taxpayers, residents, business owners, and visitors. The approaches described in this section will form the basis for future cost recovery strategies, with each funding phase requiring applicable approvals from town meeting or ballot initiatives. Any number of these approaches may be combined to form the Cost Recovery Plan that best suites the Town. The cost recovery method is likely to change during the 40 year implementation period in order to adjust to town needs and as potential new funding sources become available.

Section 16

Environmental Impact Analysis and Mitigation

16.1 Introduction

The Town of Dennis ("the Town") is submitting this Comprehensive Wastewater Management Plan (CWMP) and SEIR concurrently, to coordinate review by Massachusetts Department of Environmental Protection (MassDEP), the Executive Office of Energy and Environmental Affairs Massachusetts Environmental Policy Act Office (MEPA) Unit, and the Cape Cod Commission (CCC). These documents were prepared based on the scope defined by MEPA in the July 14, 2017 Certificate on the Draft CWMP/Expanded Environmental Notification Form submitted in June 2017.

In 2014, the Town contracted with CDM Smith and began developing the CWMP to guide the decisions pertaining to wastewater management over the next 40 years, with a focus on mitigating nitrogen discharges to coastal waters. This work has been driven mostly by the significant population growth on Cape Cod and resulting development that has occurred since 1950. The population of Dennis increased 540 percent from 1950 to 1999; as of 2020, the number of year-round residents is about 14,674 with an estimated seasonal increase to 63,000.

With the exception of a few small package wastewater treatment facilities, the Town does not have a municipal wastewater collection and treatment system and instead relies on traditional Title 5 on-site septic systems for wastewater management. Nitrogen leaching from those on-site systems into the groundwater has resulted in negative impacts to the Town's saltwater estuaries and embayments; these negative impacts, in turn, affect the quality of life of residents and are beginning to impact the tourist economy. There have also been early signs of impacts to freshwater ponds. Also of concern are Title 5 septic system compliance issues and the ability to provide appropriate wastewater management for desired economic development.

A major driver of this wastewater planning process is the Massachusetts Estuaries Project (MEP) that MassDEP and School for Marine Science & Technology (SMAST) are conducting on 89 estuaries in southeastern Massachusetts. The goal of this program is to evaluate the pollutant status and sensitivity of the estuaries through comprehensive water quality testing and quantitative modeling, with the main focus on nitrogen. The results of the MEP assessments will require municipalities to remediate excessive nutrient inputs to restore water quality in estuaries, largely through expanded wastewater management. Upon review by MassDEP, thresholds for nitrogen loadings and reduction percentages needed for each watershed will be incorporated into Total Maximum Daily Load (TMDL) permits that municipalities will be required to meet.

MEP reports for three watersheds in Dennis are complete and the fourth is in draft form. The recommended reductions in septic system nitrogen are as follows: Bass River, 60 percent; Swan Pond River, 100 percent; Herring River, 39 percent; and Chase Garden Creek (Draft), +53 percent. The last remaining watershed in Dennis that will undergo modeling by MEP is Sesuit Harbor; however, draft results have not been published yet. The Quivett Creek watershed which is

predominately in Brewster but crosses into Dennis along the town's northeast border is not included in the MEP modeling effort. .

Other drivers for the CWMP include protecting drinking water supplies, improving and protecting freshwater pond water quality, and Title 5 compliance. All of Dennis's residents rely on groundwater supplies for drinking water, with the majority relying on municipal supply wells. A reduction in onsite septic system inputs into the groundwater will result in a beneficial reduction of all of the compounds and contaminants contained in wastewater effluent including nitrogen, phosphorus, bacterial and viral constituents, and contaminants of emerging concern (CEC's) such as pharmaceuticals and personal care products and per- and polyfluoroalkyl substances (PFAS).

16.2 Existing Environment

The Town of Dennis is located in the center of Cape Cod and is bordered by Nantucket Sound to the south, the Town of Yarmouth to the west, and the Town of Harwich to the east. The town consists of 21 square miles and has approximately 11 miles of tidal shoreline, four harbors, 22 freshwater ponds, two reservoirs, and two scenic river corridors (Herring River and Muddy Creek).

According to the 2020 U.S. Census, the Town has a population of 14,674 people, which is 3 percent more than the 2010 Census. The 2020 census data indiciates 15,799 housing units, 48 percent occupied and 52 percent vacant. The vacant housing units most likely reflect seasonal homes considering that the total population of Dennis increases to approximately 63,000 people in the summer months. The median household income in 2019 was $65,616. Dennis is primarily residential, with a seasonal tourist population that accounts for a large portion of the local economy.

Based on data in the Town's Geographic Information System (GIS), there were approximately 13,779 developed parcels out of 15,114 in Dennis. This constitutes the Town's best estimate of the number of on-site wastewater treatment and disposal systems in town. At the present time, there are only four facilities in Dennis that have groundwater discharge permits: a 31,020 gpd permitted camp and cottage resort on Old Warf Road in Dennis Port, a 44,000 gpd resort also on Old Warf Road in Dennis Port, another resort on Old Warf Road permitted for 19,360 gpd, and a 17,000 gpd permitted wastewater discharge from the Patriot Square shopping center on Route 134, just south of Route 6.

The landscape of Dennis, like most of Cape Cod, was formed by the last continental glacier and the rise in sea level that followed glaciations. The moving ice scraped the ground and picked up the bedrock of southern New England as glacial and postglacial drift. Natural Resources Conservation Service (NRCS) mapping indicates that the majority of Dennis consists of Carver type soils. These soils are nearly level to steep, very deep, excessively drained, sandy soils formed in glacial outwash and ice contact deposits, on outwash plains and kames. The NRCS soil description for Carver soils includes limitations for septic tank absorption fields due to rapid permeability which can result in bacterial pollution of groundwater.

Dennis contains both freshwater and coastal wetlands. Wetlands are concentrated in the northern and southern portions of the town, where there are large freshwater marshes, salt marshes, and wooded marsh complexes. Smaller areas of wetlands are present in other areas of

town as well, as are areas of cranberry bogs. Beaches and dunes occur along Nantucket Sound as well as Cape Cod Bay. Many ponds are present in Dennis as well.

16.3 Project Summary and Alternatives

This CWMP in its entirety consists of centralized wastewater collection and treatment, natural attenuation improvements, pond restoration/protection, improved stormwater management, public outreach, and continued on-site septic system support. The various components of the CWMP will be implemented in an eight phase approach over a minimum of 40 years, allowing for tailoring of these components using an adaptive management strategy. Below is a summary of the preferred alternative. A summary of the phasing of all of the components of the CWMP is presented in the Executive Summary; details of the phasing for each component are contained within the individual sections.

The recommended plan provides collection and conveyance, treatment, and effluent recharge for about 2.1 mgd of annual average daily flow of wastewater from the MEP watersheds and other selected portions of Dennis. This is a future flow projection developed from the buildout analysis in the MEP models with assistance and updates from the Dennis Planning Department as well as CCC. The buildout flow is projected to be about a 35 percent increase over the current wastewater flow. The recommended collection system master plan for the Town of Dennis is shown on Figure 14-1. The recommended plan and the preliminary sewer layout shown meets or exceeds the amount of septic system nitrogen required to be removed to meet the proposed TMDL in each watershed, as shown in Figure 2-17. Figure 14-2 shows the phasing plan recommended for implementing the overall Dennis program. As discussed in detail in Section 12, the recommended wastewater collection system for the Town is a hybrid system consisting of gravity, pressure and vacuum sewers. The recommended treatment technology for the Dennis treatment plant to be built at Site 1 is a sequencing batch reactor (SBR) process.

Freshwater pond restoration/protection is included in the CWMP. This program will include continuing water quality sampling, developing an inventory of stormwater pipes draining to ponds, investigating other potential contaminant sources, and determining which uses and ponds should be supported by the program. Programs would then be implemented to restore water quality in the ponds studied.

The CWMP includes improving stormwater management by using BMPs. The Stormwater BMP program will focus on the best application of BMPs at the drain features throughout Dennis and will target those portions of town located upstream from the most sensitive water sources. Several stormwater controls and/or practices will be used on all new work. The Town will decide which types of BMPs are most appropriate, but they may include deep sump drainage basins, detention pond infiltration basins, porous pavement, bio-retention and vegetated basins, and cleaning catch basins. These potential BMPs are further discussed in Section 14.7.

The public outreach component of the CWMP includes educating the public on the need to address nutrient pollution and the role that the wastewater program will play in reducing nutrients in the watersheds of Dennis. Fertilizer education is also a component aimed at reducing over-fertilization and fertilizer runoff. Other elements include low impact landscaping and water conservation. The public outreach and fertilizer education programs are further discussed in Section 14.7.

On-site septic system support by the Dennis Health Department will continue for the Title 5 septic systems that will remain after the wastewater program is fully implemented. This support will include guidelines for existing septic system maintenance and information on Title 5 inspections.

Throughout the CWMP initiative, the Town considered many alternatives to the system layouts and locations, appropriate technologies for wastewater conveyance and treatment, effluent recharge sites and types, and cost-recovery approaches. Each alternative is discussed in detail in the pertinent section of this report. Section 14.10 focuses on the large-scale alternatives to the Recommended Program. Specifically, the No-Build Alternative, regional alternatives, and options of sewering either more or less of the town are discussed.

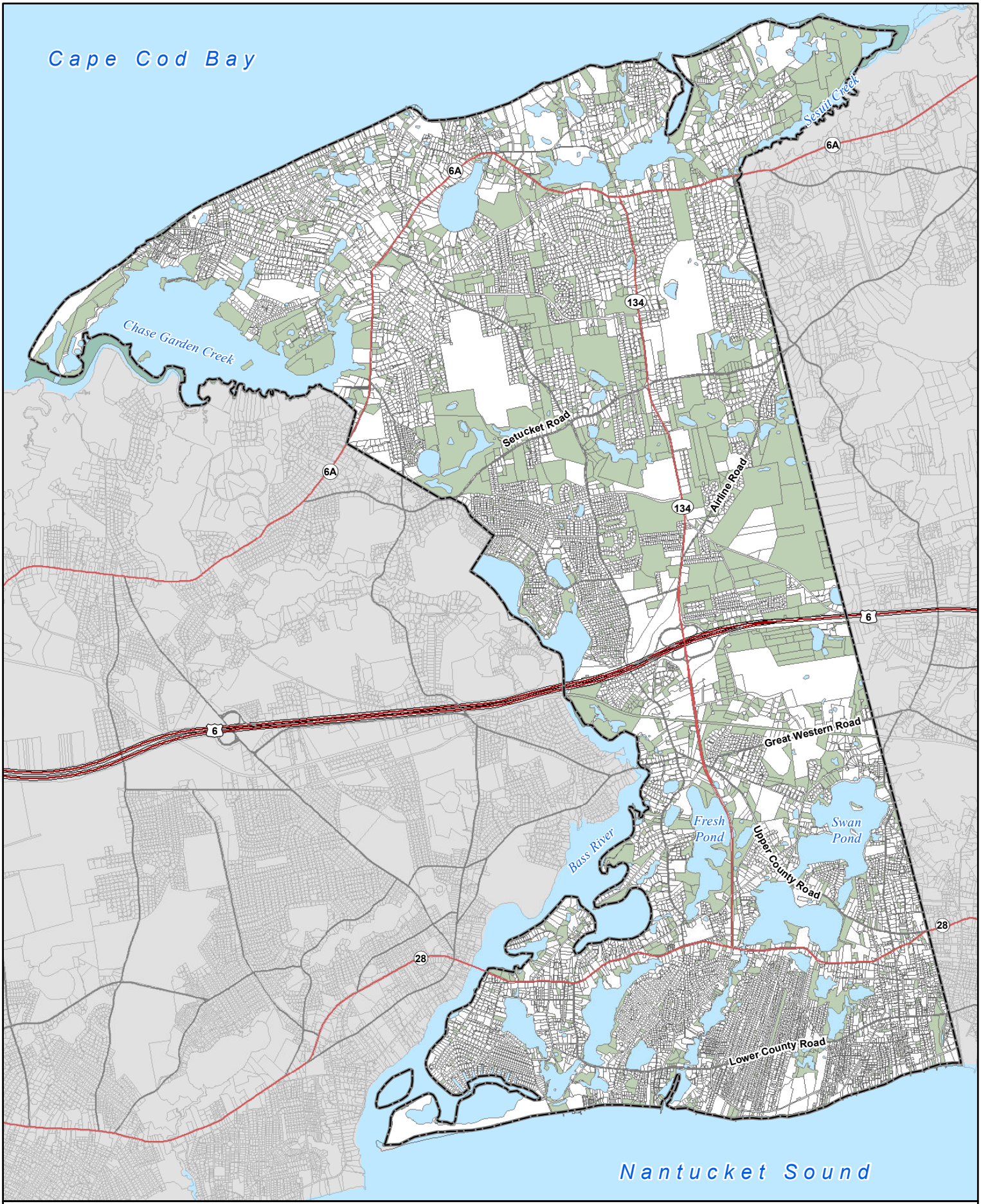
16.4 Land Use

The population of Dennis has grown substantially since 1950, from 2,500 full-time residents to 14,674, representing an increase of over 500 percent. In 1951, residential areas were primarily clustered along the southern and northern portions of the town, with other areas consisting of large tracts of forest. Today, areas of residential development are present over large portions of the Town. Economic centers are currently located in Dennis Port and West Dennis, the older hotel areas in Dennis Port, the Route 28 commercial strip, and the area around Exit 78 (formerly Exit 9). Current land use patterns are shown in Figure 7-6, and lot development density is shown in **Figure 16-1**. About 26%% (3,644 acres) of the land in Dennis is protected open space for either wellfields, conservation land, or beaches (2020 Open Space and Recreation Plan). The majority of the protected open space and conservation land is owned by the Town or by the Dennis Water District. The locations of conservation lands are shown in **Figure 16-2.**

This CWMP was developed to be consistent with the Town of Dennis Local Comprehensive Plan. Facility sites were selected in part to be in keeping with the plan, and the proposed areas to be sewered will support existing land uses or areas targeted by the local comprehensive plan for additional development.

The proposed new WWTF to be located on Site 1 is currently occupied by the Town Department of Public Works (DPW) which uses it for a variety of activities including composting. Development of a WWTF and associated groundwater recharge facility at Site 1 is not anticipated to result in negative impacts on surrounding land uses. It would be consistent with the nearby industrial development and the adjacent transfer station. The small areas of commercial uses to the south on Great Western Road would be buffered from the WWTF by forest. It is estimated that the proposed effluent recharge facility at Site 1 would be approximately 20 acres.

The proposed effluent recharge facility for Site 2 would be situated on land that was the former DPW site. The land immediately surrounding this facility is largely forested. A residential community is located to the north, northwest and one small development to the east. A recreational area is located to the south of Site 2 off Bob Crowell Road. Development of an effluent recharge parcel at Site 2 is not anticipated to result in a negative impact on surrounding land uses. A forested buffer would remain between the effluent recharge facility and surrounding land uses.



Legend

- Parcel Meeting Criteria (+1 Point)
- Developed Parcel

N

Town of Dennis, MA

Site Screening Criterion 7
Favorable Developement Status

1 inch = 4,500 feet

0 1,000 2,000 4,000 Feet

Figure 16-1

CDM Smith

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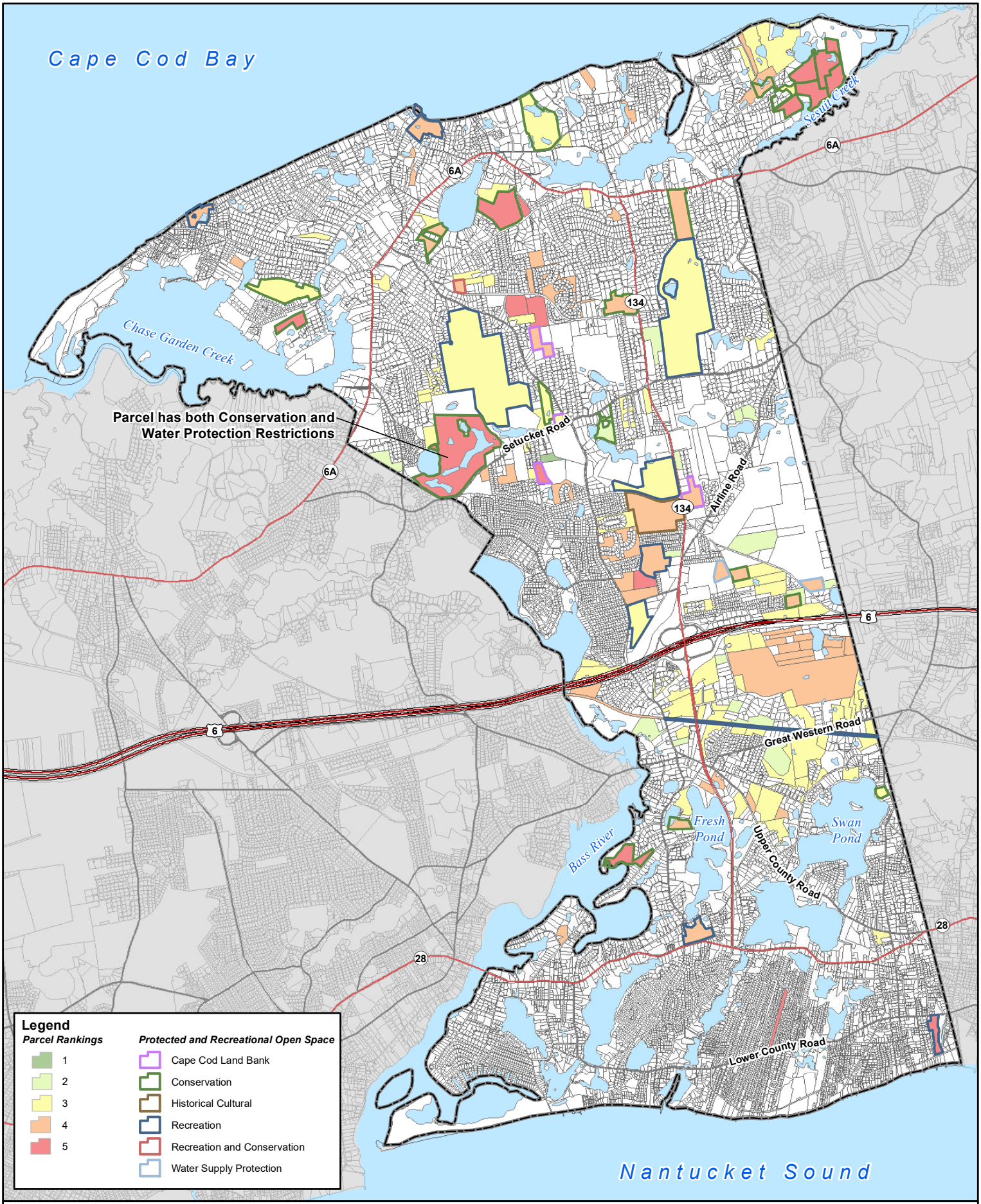

Town of Dennis, MA

N

1 inch = 4,500 feet

0 1,000 2,000 4,000 Feet

Site Screening Results
Protected and Recreational Open Space

Figure 16-2

CDM Smith

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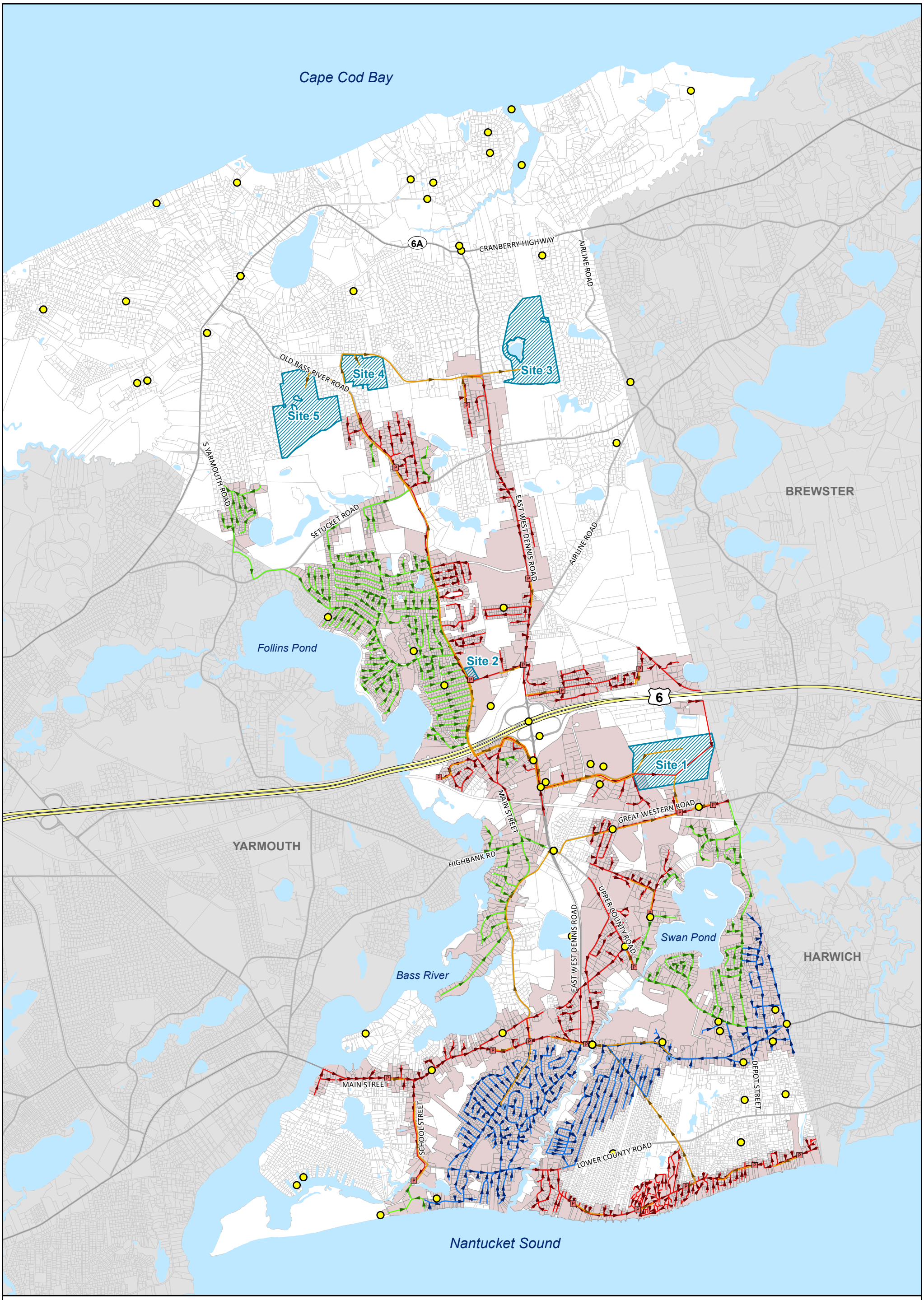
The proposed sewer lines will run through areas that are primarily residential. Since the sewer lines themselves will be located within the existing roads, they will not create a negative visual impact in these neighborhoods after construction is complete. The majority of the sewered areas in residential neighborhoods are near buildout condition, so the availability of sewers will not greatly affect land uses. The economic centers of Dennis represent an exception to this, however. Dennis Port and West Dennis, the older hotel areas in Dennis Port, the Route 28 commercial strip, and the area around Exit 78 (formerly Exit 9) are areas designated by the Town for planned growth and economic development in a manner that enhances pedestrian culture and a positive experience for residents, business owners, and visitors. The availability of sewers in these areas is consistent with supporting the type of growth desired by the Town.

The pumping stations planned within the areas to be sewered will generally be built within the road right-of-way. These stations will be small; many will be located underground. A large pumping station could be approximately 625 square feet in size.

16.4.1 Known Hazardous Waste Sites in Dennis

The Town considered the potential for encountering contamination during construction of the wastewater collection and treatment systems. The town has identified known hazardous waste sites governed by the Massachusetts Oil and Hazardous Material Release Prevention and Response Act (M.G.L. c. 21E) in the vicinity of the project areas. **Figure 16-3** shows the location of the hazardous waste sites. **Table 16-1** outlines hazardous waste sites in Dennis by number and includes a listing of each site's regulatory compliance status and Remedial Action Outcome (RAO) status, including an indication as to which sites are within the project area.



Legend

- Vacuum Main
- Pressure Main
- Force Main
- Gravity Main
- Vacuum Station
- Pump Station
- Recharge Sites
- Sewered Parcels
- Waste Sites and Reportable Releases (21E)

Town of Dennis, MA

Hazardous Waste Points

Figure 16-3

N

1 in = 3,000 ft

0 0.5 1

Miles

CDM Smith

NEWELLJD F:\Dennis\DATA\MXD\Dennis_Figure_16-5_Hazardous_Waste_Points.mxd 10/18/2021

Table 16-1 MGL 21E – Hazardous Waste Site Listing Dennis

Within Project Area	Release Tracking Number	Address	Site Name Location Aid	Compliance Status	Phase	RAO Class	Chemical Type
x	4-0027524	OFF SESUIT HARBOR	M/V CABRILLO	UNCLASSIFIED			
x	4-0027468	IVO 99 CHAPIN BEACH ROAD	HYDRAULIC OIL RELEASE	PSNC		PN	
x	4-0027222	505 MAIN STREET	SPEEDWAY STORE #2436	RTN CLOSED			
x	4-0027119	RTE 132 & THEOPOLIS SMITH RD	BEHIND BURGER KING	PSNC		PN	
x	4-0026976	15 FROG TREE LN	RESIDENTIAL RELEASE	PSNC		PN	
x	4-0026620	12 BERTRAN AVENUE	ROADWAY	PSNC		PN	
x	4-0026471	460 ROUTE 134	CUMBERLAND FARMS	PSNC		PN	
	4-0026267	12 SUNKEN RIVER ROAD	SINGLE FAMILY RESIDENCE	PSNC		PN	
x	4-0026218	515 MAIN STREET	SPEEDWAY GAS STATION STORE #2436	PSNC	PHASE II	PN	
x	4-0026066	IFO 1 CEDAR LANE	INTERSECTION CEDAR LN + CENTER STREET	PSNC		PN	
	4-0025978	34 FEDERAL LANE	PANTOS RESIDENCE	PSNC		PN	
x	4-0025769	234 MAIN ST	CONGREGATIONAL CHURCH OF SOUTH DENNIS	PSNC		PN	
x	4-0025517	260 UPPER COUNTY RD/714 MAIN	260 UPPER COUNTY RD/714 MAIN	DPS			Hazardous Material
x	4-0024439	305 MAIN STREET	HESS STATION	RTN CLOSED			
x	4-0023847	RT. 134 ON RAMP TO RT. 6 WES	ROADWAY	RAO		A1	Oil
x	4-0023701	UTLTY POLE ON CANDLEWOOD LANE	ROADWAY	RAO		A1	
x	4-0023626	20 CANDLEWOOD LANE	PARKING LOT	RAO		A2	Oil
	4-0023235	44 SUMMER STREET	HOWARD RESIDENCE	RAO		A2	Oil
x	4-0023134	773 MAIN STREET	FORMER MOBIL STATION	RTN CLOSED			Oil
x	4-0022941	13 HALL STREET	DENNISPORT COIN LAUNDRY	RAO		B1	Oil
x	4-0022431	342 MAIN ST	MILL STORES	TIER 2	PHASE IV		
x	4-0022312	305 MAIN ST	HESS GAS STATION # 21242	URAM			Oil
x	4-0022203	773 RTE 6A	MOBIL STATION 01 708	RTN CLOSED			Hazardous Material
	4-0022169	1098 RTE 6A	DURHAM SERVICE CENTER	REMOPS	PHASE V		Oil

Within Project Area	Release Tracking Number	Address	Site Name Location Aid	Compliance Status	Phase	RAO Class	Chemical Type
	4-0022168	140 MAIN ST	BASS RIVER MARINA	RAO		A2	Oil
x	4-0021894	305 MAIN ST	HESS GASOLINE STATION #21242	RTN CLOSED	PHASE II		Hazardous Material
x	4-0021865	305 MAIN ST	HESS GASOLINE STATION 21242	TMPS	PHASE IV	TF	Oil
x	4-0021432	248 MAIN ST	POSKITT RESIDENCE	RAO		A2	Oil
x	4-0021216	5 POPLAR LN	RESIDENCE	RAO		B1	Oil
	4-0020970	7 CAPTAIN KEAVY WAY	RESIDENCE	RAO	PHASE II	A2	
x	4-0020837	RTE 134	SHELL STATION	RTN CLOSED			Oil
x	4-0020706	WEST DENNIS BCH	NO LOCATION AID	ADEQUATE REG			Oil
	4-0020226	52 PADDOCKS PATH	FORMER PRUE FOUNDRY	RAO		A2	Hazardous Material
x	4-0020205	11 RTE 28	REMAX REAL ESTATE	RAO		A1	Oil
	4-0020128	1551 MAIN ST	FORMER CUMBERLAND FARMS, INC	REMOPS	PHASE V		Hazardous Material
x	4-0020094	RTE 134 @ RTE 6A	SPEEDWAY GASOLINE STATION	RAO		A1	Oil
x	4-0019965	72 UPPER COUNTY RD	NO LOCATION AID	RAO		A2	Oil
x	4-0019845	613 MAIN ST	NO LOCATION AID	TIER 2	PHASE II		Oil and Hazardous Material
x	4-0019581	UPPER COUNTY RD AND CTR ST	POLE 33/381/2	RAO		A1	Oil
	4-0019511	17 OLIVER RD	RESIDENCE	RAO		A2	
x	4-0019136	773 RTE 6A	NO LOCATION AID	RTN CLOSED			Oil
x	4-0019053	773 MAIN ST (RTE 6A)	MOBIL SERVICE STATION NO. 14099 (01-708)	RTN CLOSED			
x	4-0019045	84 OLD MAIN ST	DAILEY RESIDENCE	RAO		A2	Oil
	4-0018952	BLACK FLATS RD	POWER POLE 708/4	RAO		A1	Oil
x	4-0018838	24 CANDLEWOOD LN	FIRST STUDENT	RAO		A1	
x	4-0018662	OLD BASS RIVER RD	NEAR # 80	RAO		A1	Oil
x	4-0018609	305 MAIN ST	NO LOCATION AID	RAO		A1	Oil
x	4-0018436	FRESH POND CONVERSATION AREA	NO LOCATION AID	RAO		A2	Oil
x	4-0018326	41 HORSE FOOT RD	NO LOCATION AID	RAO	PHASE II	A2	Oil
x	4-0018209	773 RTE 6A	MOBIL SERVICE STATION NO 14099	RTN CLOSED			Hazardous Material
	4-0018123	150 MAIN ST	BASS RIVER MARINA	RAO		B1	Oil and Hazardous Material
x	4-0018078	497 RTE 134	NO LOCATION AID	RAO	PHASE V	A2	Hazardous Material

Within Project Area	Release Tracking Number	Address	Site Name Location Aid	Compliance Status	Phase	RAO Class	Chemical Type
	4-0017341	61 NOBSCUSSET T RD	SEARS RESIDENCE	RAO	PHASE II	A2	Oil
	4-0017248	529 AIRLINE RD	NO LOCATION AID	RAO		A2	Oil
x	4-0016958	RTE 6 AND RTE 134	SHELL STATION	RAO		A1	Oil
	4-0016894	357 SESUIT NECK RD	NORTHSIDE MARINA	RAO		A2	
	4-0016546	SESUIT RD	SESUIT HARBOR	RAO		A1	Oil
	4-0015619	SESUIT HBR	SESUIT HARBOR	ADEQUATE REG			Oil
x	4-0015610	MEADOW SPRING DR	NEAR 43 MEADOW SPRING	RAO		A1	Oil
	4-0015474	53 OLD TOWN LN	EHL RESIDENCE	RAO		A2	Oil
x	4-0015353	UPPER COUNTY RD	POLE #3308	RAO		A1	Oil
x	4-0014645	773 RTE 6A	MOBIL STATION	RTN CLOSED			Oil
x	4-0014367	169 GREAT WESTERN RD	ROBERT CHILDS INC	RAO	PHASE II	A2	Oil
x	4-0013586	329 MAIN ST	SCHOOL ST	RAO		B1	Oil
x	4-0013519	CORP AND SEASIDE RDS	POLE #12	RAO		A2	Oil
	4-0013453	56 HALL ST	NO LOCATION AID	RAO		A2	Oil
	4-0013388	3 MEADOW LN	RESIDENCE	RAO		A2	Oil
X	4-0012832	13 HALL ST	DENNISPORT AUTO LAUNDRY INC	RAO	PHASE V	C1	Hazardous Material
	4-0012306	12 WEST ST	RTE 28	RAO	PHASE II	A2	Oil
	4-0012268	13 SUSAN WAY	NO LOCATION AID	RAO		A2	Oil
	4-0012204	71 SOUTH ST	NO LOCATION AID	RAO		A2	Oil
X	4-0012157	THEOPHILUS F SMITH RD	FACILITY NO 136	DPS			Oil and Hazardous Material
x	4-0012054	18 HALL ST	CRAFTSBURY RLTY TRUST	DPS			Hazardous Material
X	4-0011954	117 P0ND ST	NO LOCATION AID	RAO		A2	Oil
X	4-0011864	528 MAIN ST RTE 6A	ACROSS FROM SIGNAL HILL RD	RAO		A2	Oil
x	4-0011750	10 BABCOCK RD	NO LOCATION AID	RAO	PHASE II	A2	Oil
	4-0011143	52 HIRAM POND RD	NO LOCATION AID	RAO		A2	Oil
X	4-0011047	432 MAIN ST	RTE 28	RAO		A2	Oil
X	4-0010903	35 MILL ST	NO LOCATION AID	RAO		A1	Oil
	4-0010739	50 WEST ST	NO LOCATION AID	RAO		A2	Oil
x	4-0010715	305 MAIN ST	CHRISTIES MARKET	72 HR	RAO	PHASE II	A2
x	4-0010617	75 LOWER COUNTY RD	I/S EDWARDS RD	TWO HR	RAO		A2
	4-0010544	40 SHIVERICK RD	NO LOCATION AID	TWO HR	RAO		A2
	4-0010496	680 MAIN ST RTE 6A	CUMBERLAND FARMS FMR	72 HR	PSNC	PHASE V	PN

Within Project Area	Release Tracking Number	Address	Site Name Location Aid	Compliance Status	Phase	RAO Class	Chemical Type
	4-0010421	12 WING LN	OFF AIRLINE RD NEAR SETUCKET	TWO HR	RAO		A2
x	4-0010190	38 LEIF ERICKSON DR	NO LOCATION AID	TWO HR	RAO		A2
	4-0006067	1782 MAIN ST RTE 6A	PROPERTY	NONE	RAO	PHASE II	A2
	4-0006064	773 RTE 6A	MOBIL STATION 01 708	NONE	RAO	PHASE V	C2
	4-0006056	22 MONUMENT VIEW RD	PROPERTY	NONE	RAO		A2
	4-0001190	652 MAIN ST	GETTY STATION FMR	NONE	RAO	PHASE III	A2
x	4-0000933	RTE 28 UPPER COUNTY RD	MOBIL STATION 01-707	NONE	TMPS		TN
x	4-0000827	400-422 MAIN ST RTE 28	CAPE COD MERCHANTS MALL	NONE	WCSPRM		
	4-0000617	450 MAIN ST	PROPERTY	NONE	DPS	PHASE II	
	4-0000535	RTE 6A	HINKLEY HOME CTR	NONE	RAO		B1
x	4-0000508	174 LOWER COUNTY RD	TAFTS SERVICE CTR	NONE	RAO		A2
	4-0000387	RTE 6A BRIDGE ST	SHELL SERVICE STATION	NONE	RAO	PHASE V	C1
x	4-0000334	305 MAIN ST	CHRISTYS MARKET	NONE	RAO	PHASE II	A2
x	4-0000277	GREAT WESTERN RD	PROPERTY	NONE	DEPNDS		
x	4-0000270	577 MAIN ST	MURRAYS FUEL OIL	NONE	RAO	PHASE III	A3
	4-0000195	1551 MAIN ST	GULF SERVICE STATION	NONE	WCSPRM		
x	4-0000057	THEOPHILOS SMITH RD	DENNIS SANI LANDFILL	NONE	ADEQUATE REG		

Class A RAO = Remedial work was completed and a level of "no significant risk" has been achieved.
Class B RAO = Site assessment indicates that "no significant risk" exists. No remedial work was necessary.
Class C RAO = A temporary cleanup. Although the site does not present a "substantial hazard," it has not reached a level of no significant risk.

No hazardous waste sites are known to exist at the proposed locations for the WWTF or effluent recharge facilities at Sites 1 and 2. Siting of the pumping stations during each design phase will occur outside of parcels with active hazardous waste issues; the Town is not planning any hazardous waste remediation as part of the project. The Town understands that if oil and/or hazardous material (OHM) is encountered during project construction, notification pursuant to the MCP will be made to MassDEP when required. A Licensed Site Professional (LSP) will be retained to determine if notification is required and will be available during construction to render appropriate opinions as needed. Construction protocols and procedures will reflect the potential for discovery of OHM throughout the construction period. Other mitigation measures regarding the discovery and handling of hazardous materials are discussed as part of the Construction Management Plan (Section 17) and Section 61 Findings (Section 18).

16.5 Rare and Endangered Species, Natural Habitats, and Fisheries

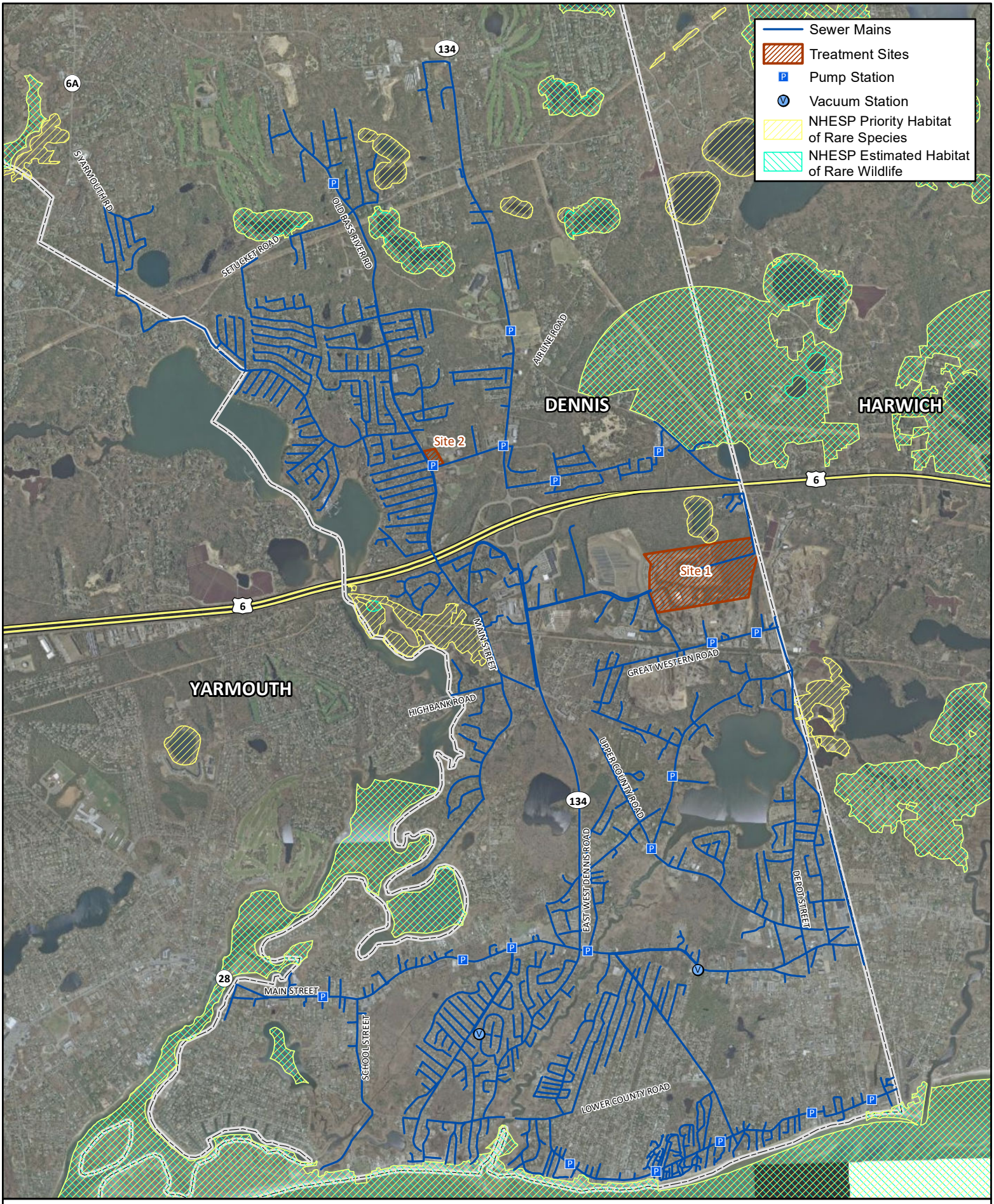
16.5.1 Rare and Endangered Species

In compliance with the Massachusetts Endangered Species Act (MESA), The Natural Heritage and Endangered Species Program (NHESP) was contacted and provided information about the proposed CWMP in September 2016 and July 2017. Relevant correspondence is included in Appendix L. NHESP identified whether the WWTF and the pump stations were located within Priority Habitats and Estimated Habitats, as well as which species were found in the vicinity. A Priority Habitat is the geographical extent of habitat for all state-listed plant and animal species as delineated by the Massachusetts Division of Fisheries and Wildlife. Estimated Habitats are subsets of Priority Habitats that include wetland-dependent wildlife. NHESP Estimated Habitats for rare wildlife are shown in **Figure 16-4**. **Table 16-2** outlines rare species that have been found in the vicinity of the project area.

Table 16-2 Rare Species in the Vicinity of the Proposed WWTF and Pump Stations

CWMP Component(s)	Species	Common Name	Taxonomic Group	State Status
Effluent Recharge Site 1	*Sabatia kennedyana*	Plymouth Gentian	Plant	Special Concern
	Rhynchospora scirpoides	Long-Beaked Bald-Sedge	Plant	Special Concern
	Terrapene carolina	Eastern box turtle	Reptile	Special Concern

The 2016 NHESP correspondence listed that effluent recharge Site 1 would be located within Priority Habitat (PH) 55 and 1424 and Estimated Habitat (EH) 19. Plymouth gentian (*Sabatia kennedyana*), long-beaked bald sedge (*Rhynchospora scirpoides*), and eastern box turtle (*Terrapene Carolina*), all three state listed species of special concern have been found in the vicinity of proposed Site 1 facilities. The NHESP comment letter on the EENF/Draft CWMP stated that, "*the estuarine waters, bays, ponds, streams and lakes of Dennis provide critical habitat for a suite of state-listed species*" and the implementation of the proposed CWMP and resulting improvements in water quality will benefit the wildlife in the area. Furthermore, NHESP stated that the projects that will occur within *Priority and Estimated Habitat* for state-listed species and require a filing with NHESP under the Massachusetts Endangered Species Act (MESA 321 CMR 10.00).



Town of Dennis, MA

NHESP Habitats Map
Figure 16-4

1 inch = 3,000 feet

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CDM Smith

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All sewer mains will be installed within town-owned roadways. Although portions of the phased sewer main installations within roadways are located near or within Priority Habitat and Estimated Habitat, these areas are exempt from MESA review for projects or activities in Priority Habitat pursuant to 321 CMR 10.18 through 10.23 (6), which reads, in part:

> *Installation, repair, replacement, and maintenance of utility lines (gas, water, sewer, phone, electrical) for which all associated work is within ten feet from the edge of existing paved roads.*

In its comments on the EENF, NHESP noted that additional guidance regarding rare species would be provided upon submission of more detailed site plans and NHESP consultation would be required during permitting for each phase. A joint streamlined 30-day Massachusetts Wetlands Protection Act (MWPA) and Massachusetts Endangered Species Act (MESA) review will be requested for activities within Priority Habitat and/or Estimated Habitat; the NOI will be sent to NHESP and the Dennis Conservation Commission/MassDEP for review. Furthermore, during the design of each phase of the project, detailed construction plans will be provided to NHESP to confirm the exemption status and/or determine the need for further review

16.5.2 Rare Species Descriptions and Potential Impacts

Information regarding the life cycle and preferred habitat for the rare species found in the vicinity of the CWMP components was obtained from NHESP fact sheets. This information is helpful in determining potential impacts from the construction and operation of the project components.

Eastern Box Turtle: The eastern box turtle is a terrestrial species that ranges from southeast Maine south to northern Florida, and west to Michigan, Illinois, and Tennessee. In Massachusetts, it is found in dry and moist woodlands, brushy fields, thickets, marsh edges, bogs, swales, fens, streambanks, and well-drained bottomland. In the northern part of its range it hibernates from late October or November until mid-March or April. It overwinters in upland forest, a few inches below the soil surface, typically covered by leaf litter or woody debris. In summer, adult Box Turtles are most active in the morning and evening, particularly after a rainfall. During the heat of the day they often seek shelter under rotting logs or masses of decaying leaves, in mammal burrows, or in mud. They often spend the night in a small scooped out space in leaf litter, grasses, ferns, or mosses. Eastern box turtles are omnivorous and feed on small animals such as slugs, insects, earthworms, and snails, as well as mushrooms, berries, and fruits. Females reach sexual maturity at approximately 13 years of age; they can store sperm and lay fertile eggs up to four years after mating. Females nest in June or early July and can travel up to one mile to find appropriate habitat such as early successional fields, meadows, utility right of ways, woodland openings, roadsides, cultivated gardens, residential lawns, mulch piles, beach dunes, and abandoned gravel pits.

The population of the eastern box turtle is threatened in Massachusetts due to habitat destruction, road mortality, collection for pets, mowing of fields and early successional habitat during the active season, unnaturally inflated rates of predation in suburban and urban areas, disturbance of nest sites by ATVs, and genetic degradation due to the release of non-native (pet store) turtles.

Potential impacts to eastern box turtle habitat are greatest at Site 1for the construction of the infiltration basins. During the design of this phase of the CWMP, NHESP will be consulted to minimize impacts to this species. Since eastern box turtle habitat includes early successional areas, utility right of ways, roadsides, gardens, and residential lawns, negative impacts will likely be restricted to building footprints, roads, and graveled areas. These may be able to be mitigated by discussing specific site design considerations with NHESP for maximizing or enhancing the habitat that will remain post-construction. Potential impacts from traffic and human interaction should be insignificant as the site will have minimal traffic. Likewise, potential impacts from the small footprint of the individual pumping stations and limited clearing of surrounding of vegetation should be minimal. NHESP will be consulted during the design of these ponds to help minimize such impacts.

Plymouth Gentian: The Plymouth gentian is a perennial herb that grows 12 to 28 inches tall, blooming between early July and mid-September. It grows in seasonally wet, sandy and peaty shorelines of low nutrient, acidic Coastal Plain ponds. It also prefers full sun and does not compete well with shrubs. Its range is limited to the coastal plain of Nova Scotia, Massachusetts, Rhode Island, North Carolina, South Carolina, and Virginia, and is locally rare. This species requires frequent water fluctuations, acidic, nutrient poor water and substrate, and an open, exposed shoreline.

Threats to the Plymouth gentian include any activity that alters the hydrologic regime, water quality, or soil integrity of the coastal plain pond. Protection of this species may require exclusion of new wells and septic systems as well as prohibitions on fertilizer use and recreational use at growing sites. Invasive exotic species also represent a threat to the Plymouth gentian as it is a poor competitor. The nutrient-poor conditions of its natural habitat tend to protect this species from competition.

Infiltration basins at Site 1 is the only CWMP component currently identified that would be near documented Plymouth gentian habitat. Impacts to downgradient areas including the vernal pools/kettle ponds were reviewed as part of the hydrogeologic evaluation (see Section 11) and the modeling indicates concerns in regard to elevated water table at the vernal pools at Site 1. Hydrographs for the vernal pool show that the water table regularly rises to the ground surface in May under average year conditions. The addition of recharge raises the water table five feet above the ground surface at the vernal pool. Mitigation options that the Town is considering include recharge of all effluent at Site 2 during the winter months and negotiating to allow the low elevation area to flood during wet periods. The transient modeling indicates that water levels at the vernal pools can be adjusted if effluent is discharged only at Site 2 for a few months. Model results must be verified with load testing, but initial results indicate that additional recharge capacity is needed for the peak usage months in the summer under current and build-out conditions. Additional mitigation measures to allow for seasonal flooding include enlarging the existing pond, construction of wetlands to reduce nitrogen and increase evapotranspiration or simply allowing the low-lying areas to flood.

A habitat evaluation for the Plymouth Gentian will be conducted by a qualified botanist approved by the NHESP. to determine if populations of the Plymouth gentian would be affected by increased pond water levels. Further coordination with NHESP during design will be required to develop appropriate mitigation measures to avoid impacts and a “take” of this protected species.

Overall, the CWMP has the potential to improve habitat for the Plymouth gentian in Dennis by removing many septic systems from service, thereby reducing nutrient inputs to waterways and helping to maintain and/or restore the low nutrient habitat that this species requires.

Long-Beaked Bald Sedge: This Long-beaked bald sedge is a cespitose annual in the sedge family (*Cyperaceae*) that grows 20 to 80 cm tall. It grows in wet, peaty sands of coastal pond shores and depressions with seasonal and annual water fluctuations; commonly found when pond water levels are drawn down and pond shore exposed. Here in New England, its range include the eastern coastal states from Massachusetts, Connecticut, and Rhode Island.

Threats to the Long-beaked bald sedge is similar to the listed threats above for the Plymouth gentian and include any activity that alters the hydrologic regime, water quality, or soil integrity of the coastal plain pond. Long-beaked sedge and Plymouth gentian is commonly seen growing together.

Infiltration basins at Site 1 is the only CWMP component currently identified that would be near documented Long-beaked sedge habitat. Similar to the approach described above for Plymouth Gentian, a habitat evaluation for the long-beaked bald sedge will be conducted by a qualified botanist approved by the NHESP to determine if populations of the long-beaked bald sedge would be affected by increased pond water levels. Further coordination with NHESP during design will be required to develop appropriate mitigation measures to avoid impacts and a "take" of this protected species.

a rare species habitat survey will be conducted to better determine any impacts to Long-beaked sedge habitat. Additional hydrologic studies will be conducted to ensure that the alteration to the hydrologic regime will not adversely impact the Long-beaked sedge by increasing pond water levels. Further coordination with NHESP during design will be required to develop mitigation measures to avoid impacts and a "take" of this protected species. Overall, the CWMP has the potential to improve habitat for the Long-beaked sedge in Dennis by removing a large number of septic systems from service, thereby reducing nutrient inputs to waterways and helping to maintain and/or restore the low nutrient habitat that this species requires.

16.5.3 Fisheries

In addition to coordination with the NHESP, the Town also received comments on the EENF/Draft CWMP from the Massachusetts Division of Marine Fisheries (Marine Fisheries). Marine Fisheries noted the proposed oyster aquaculture component in Swan Pond should follow the Marine Fisheries Shellfish Planting Guidelines (Hickey et al. 2015). The Cape Cod Commission noted in their comment letter on the EENF/Draft CWMP that they are in support of the Town's efforts to conduct an aquaculture program in Swan Pond and that the success of the ½ acre pilot program may result in expansion of the aquaculture program to other Town water bodies.

16.6 Wetlands, Waterways and Tidelands

The main purpose for recommending a new wastewater treatment and recharge program for the Town of Dennis is to reduce environmental degradation which is occurring in the Town's coastal waters. This degradation is caused largely by nitrogen inputs into coastal waters originating from on-site septic systems. The degree of degradation and the nitrogen load reductions required to ameliorate the problem are described in great detail in the MEP reports for the Allen, Wychmere,

and Saquatucket Harbor embayments (dated June 2010), the Herring River embayment (dated March 2013), the Pleasant Bay system (dated May 2006), and Stage Harbor, Sulphur Springs, Taylors Pond, Bassing Harbor, and Muddy Creek (dated December 2003).

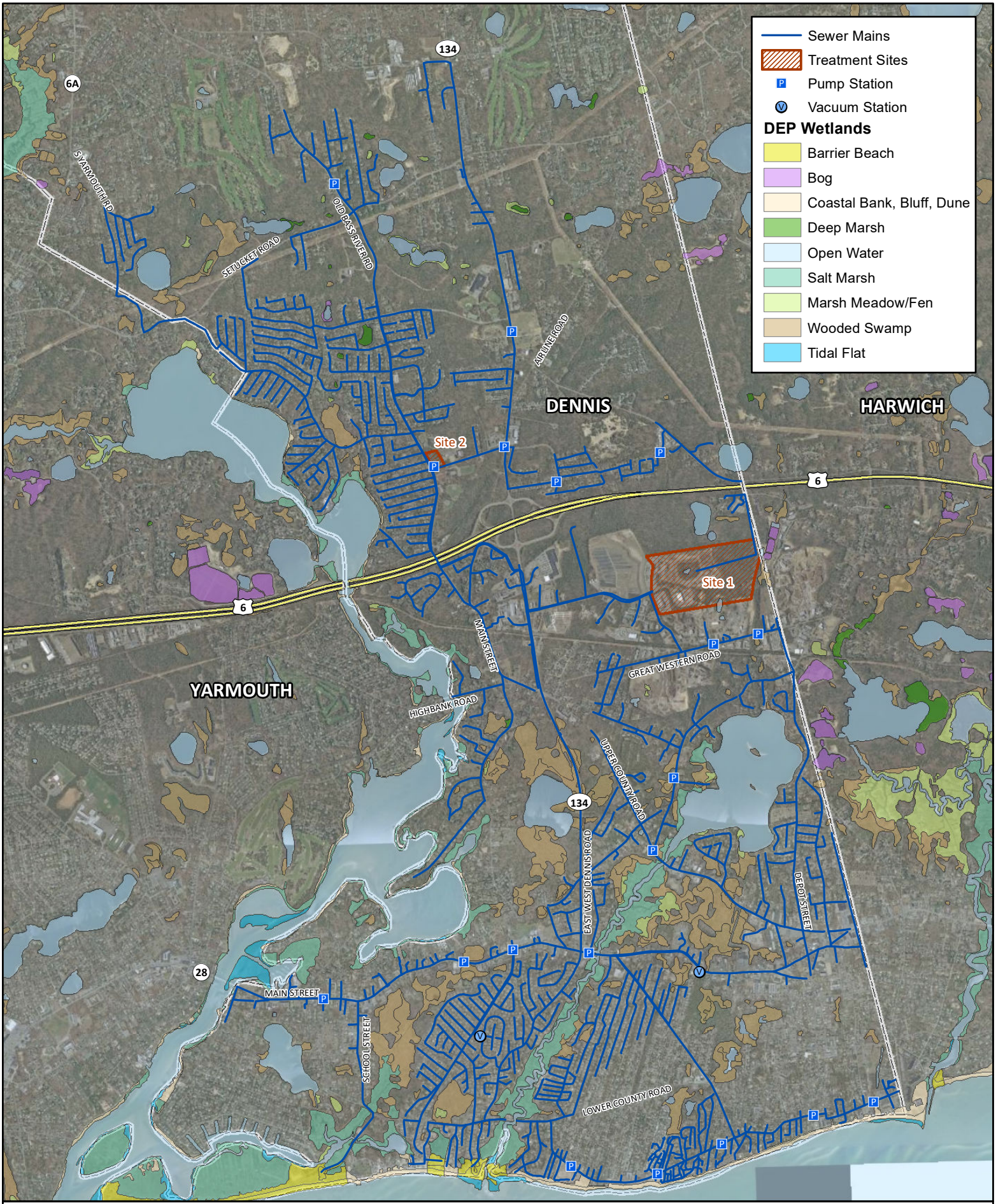
Wetland resource areas including floodplains in Dennis were identified using MassGIS and Federal Emergency Management Agency (FEMA) flood rate insurance maps (FIRM). Formal wetland delineations will not be done until topographical survey is required prior to each design phase. MassGIS wetland areas and the proposed WWTF, two effluent recharge facilities at Site 1 and 2, 92 linear miles of sewer lines, and 21 pumping stations are shown in **Figure 16-5** for wetlands and **Figure 16-6** for FEMA floodplains. MassGIS shows one pond on Site 1 in the center of a wooded area, however the WWTF is proposed to be located within an area previously disturbed from DPW activities and outside of the pond and its buffer zone. There are no wetlands near the proposed effluent recharge facility at Site 2.

There are a number of vernal pools on the western portion of Site 1 (see Figure 16-4). The MWPA does not protect the actual vernal pool it protects the wetland resource area within the vernal pool is located. The vernal pools within Site 1 are isolated and not connected to other wetlands and therefore is most likely regulated as Isolated Land Subject to Flooding (ILSF) under the MWPA. Dennis' Wetlands Protection Bylaw Rules and Regulations however protects the actual vernal pool as well as 100 feet from the mean annual boundary of the vernal pool.

Construction of the sewers within paved roadways and subsurface pumping stations will result in temporary impacts to approximately 508,290 square feet of Land Subject to Coastal Flowage and 25,710 square feet of Bordering Land Subject to Flooding. The proposed work will not result in a loss of flood storage as surface contours will be restored to preconstruction grades.

Section 14 of M.G.L. Chapter 258, Acts of 1996 (Riverfront Protection Act), exempts from review *"construction, expansion, repair, restoration, alteration, replacement, operation and maintenance of public or private local or regional wastewater treatment plants and their related structures, conveyance systems, and facilities, including utility lines"*. Wetland resource areas will be field delineated and impact areas further quantified during each phase as design and permitting under the MWPA and Dennis' Wetland Protection Bylaw occurs. While the construction of some of the sewer lines will be within floodplains, as well as a few pumping stations, implementation of the CWMP is not expected to promote additional development within flood zones because the majority of areas to be sewered are at near buildout condition. Additionally, development on the seaward side of primary dunes should not be promoted as the parcels to be sewered near these areas are essentially at full build out condition. The sewer lines and any pumping stations to be built within flood zones will be resilient and designed to withstand flood conditions and account for climate change.

The CWMP was designed to comply with the performance standards of 310 CMR 9.00 and 10.00. Wherever feasible, wetland resource areas and associated buffer zones were avoided when laying out the project. The proposed sewer main installation will occur within Town-owned roadways, and pumping stations will be located within Town-owned rights-of-way. Roads will be restored to pre-construction grades and paved after sewer construction. Any permanent structures constructed as part of the project in areas requiring review by the Dennis Conservation Commission will be designed to comply with MassDEP's Stormwater Management Standards.



Town of Dennis, MA

DEP Wetlands

Figure 16-5

N

1 inch = 3,000 feet

0 1,000 2,000 4,000 Feet

CDM Smith

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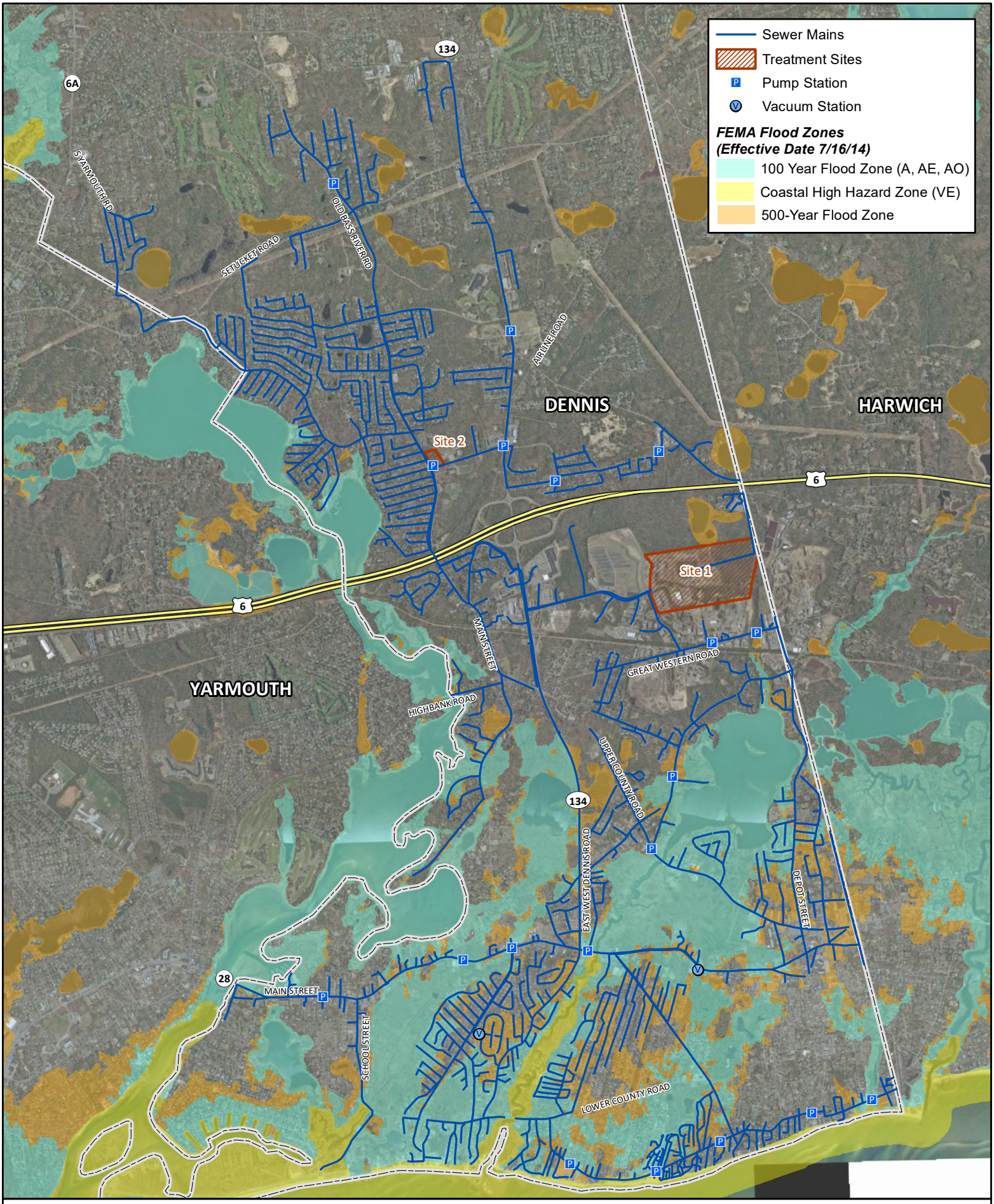

Town of Dennis, MA

Flood Insurance Rate Map
Figure 16-6

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1 inch = 3,000 feet
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CDM Smith

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Since design of the WWTF, effluent recharge facilities, and pumping stations has not yet begun, estimates of impervious areas to be created by the project is not available. Construction of the various components of the CWMP will require registration for the EPA Construction Stormwater General Permit and preparation of Stormwater Pollution Prevention Plans (SWPPPs) for each construction contract. Erosion and sediment controls during construction will be constructed in accordance with the Department of Environmental Protection Stormwater Guidance Manual.

Identification of the exact locations of wetland and surface water resources, including buffer zones, Riverfront Area, Land Subject to Coastal Flowage, and Bordering Land Subject to Flooding, will occur during the design stage of each phase of the CWMP. These will be shown on design plans and permitting for any impacts will occur during the design stage as outlined in Section 16.14. Wetland and related resource impacts have been avoided by locating the WWTF and effluent recharge facilities in upland locations, as well as locating sewers within paved roadways. The exact location of pumping stations will be determined during the design stage and will avoid wetlands as much as practicable. Mitigation for specific wetland impacts will also be determined at that time.

Long term monitoring of water resources will occur as part of the Adaptive Management Plan, outlined in Section 14.8. Implementation of the different phases of the CWMP is expected to be tailored in part based on the results of this monitoring. Overall, the implementation of the CWMP is expected to positively affect wetland resources in Dennis by reducing nitrogen loading from septic systems to the area waterways. Water quality restoration and future protection is the primary goal of this CWMP and all related project phases.

16.7 Massachusetts Coastal Zone Policies

Massachusetts Coastal Zone Management (CZM) in their comment letter on the EENF/Draft CWMP suggests that alternative locations for the proposed sewer collection system components outside of Coastal Zone A and Velocity Zones be evaluated and that the sewer system be designed to be protected from inundation by significant storm events including having utility connections capable of withstanding storm forces without damaging or contaminating nearby resources. CZM also recommends that an analysis of potential inundation be conducted, this analysis should include effects of sea level rise and hurricanes. CZMs StormSmart Coasts website has tools available to help assess vulnerability, sea level rise, and the hurricane inundation zones. Furthermore, CZM points out that the Coastal A Zone is considered a high hazard area by FEMA and differentiated from the rest of the A Zones by the Limit of Moderate Wave Action (LiMWA). Accurate floodplain mapping is only available on the FEMA Map Service Center and not from MassGIS.

Alternative locations for any pump stations located with Coastal Zone A or the Velocity Zone will be evaluated during the design/permitting of each phase. It is in the best interest of the Town to site pump stations outside of these areas. The Town cannot avoid temporary impacts to Coastal Zone A or the Velocity Zone for installation of the sewer mains within existing streets as the 100-year floodplain extends into and includes the existing roadway. However, this will not result in the loss of flood storage or result in downstream flooding as all disturbed areas will be returned to preconstruction grades.

The following is a review of the enforceable CZM policies, as outlined in the Massachusetts Office of Coastal Zone Management Policy Guide dated October 2011, relative to the CWMP Recommended Program for Dennis. Each enforceable CZM policy is presented in italics, and a description of how the proposed project complies with the policy follows in normal text. Enforceable CZM policies are those that are legally binding.

***Coastal Hazards Policy #1*:** *Preserve, protect, restore, and enhance the beneficial functions of storm damage prevention and flood control provided by natural coastal landforms, such as dunes, beaches, barrier beaches, coastal banks, land subject to coastal storm flowage, salt marshes, and land under the ocean.*

All components of the CWMP, when within the landforms identified by this policy, will be designed to preserve their storm damage prevention and flood control functions. The proposed WWTF and effluent recharge facilities at Sites 1 and 2 are outside these resources. Sewers will be installed within paved roadways which will be restored to existing preconstruction grades. Pumping stations (the majority being below ground) will be designed so as to not affect flood elevations or floodways.

***Coastal Hazards Policy #2*:** *Ensure that construction in water bodies and contiguous land areas will minimize interference with water circulation and sediment transport. Flood or erosion control projects must demonstrate no significant adverse effects on the project site or adjacent or downcoast areas.*

The proposed WWTF and effluent recharge facilities at Sites 1 and 2 are located outside of water bodies. Sewer lines will be constructed in existing paved roads and as such should not impact water circulation and sediment transport. Pumping stations will also be located outside of water bodies. The aquaculture restoration of Swan Pond is not expected to alter circulation patterns or sediment transport.

***Coastal Hazards Policy #3*:** *Ensure that state and federally funded public works projects proposed for location within the coastal zone will:*

- *Not exacerbate existing hazards or damage natural buffers or other natural resources.*
- *Be reasonably safe from flood and erosion-related damage.*
- *Not promote growth and development in hazard-prone or buffer areas, especially in velocity zones and Areas of Critical Environmental Concern.*
- *Not be used on Coastal Barrier Resource Units for new or substantial reconstruction of structures in a manner inconsistent with the Coastal Barrier Resource/Improvement Acts.*

The proposed WWTF and effluent recharge facilities at Sites 1 and 2 will not exacerbate existing hazards; these components of the CWMP are located outside of the coastal zone. Some areas to be sewered are within flood zones; however, the sewers will be constructed in existing paved roadways and would not exacerbate flooding.

Some of the parcels to be sewered are within flood zones; however, the majority of the areas to be sewered are near build-out condition. As such, the availability of sewers should not cause an increase of development in flood-prone areas.

Energy Policy #1**:** *For coastally dependent energy facilities, assess siting in alternative coastal locations. For non-coastally dependent energy facilities, assess siting in areas outside of the coastal zone. Weigh the environmental and safety impacts of locating proposed energy facilities at alternative sites.*

Not applicable; the project does not include any coastally dependent energy facilities.

Habitat Policy #1**:** *Protect coastal, estuarine, and marine habitats—including salt marshes, shellfish beds, submerged aquatic vegetation, dunes, beaches, barrier beaches, banks, salt ponds, eelgrass beds, tidal flats, rocky shores, bays, sounds, and other ocean habitats—and coastal freshwater streams, ponds, and wetlands to preserve critical wildlife habitat and other important functions and services including nutrient and sediment attenuation, wave and storm damage protection, and landform movement and processes.*

The goal of the CWMP is to reduce nutrient (especially nitrogen) loading of coastal habitats, and is expected to increase the ecological qualities of the resources downstream of the various components. The components of the CWMP will be also be designed to minimize direct impacts to these resources. Additional consultation with NHESP will occur during the design phase of each component to ensure the protection of rare species. Permitting of impacts to wetlands, waterways, and tidelands will also occur during the design process; such impacts will be minimized to the extent practicable.

Habitat Policy #2**:** *Advance the restoration of degraded or former habitats in coastal and marine areas.*

The goal of the CWMP is to reduce nutrient (especially nitrogen) loading of coastal habitats, and as such is expected to increase the ecological qualities of the resources downstream of the various components.

Ocean Resources Policy #1**:** *Support the development of sustainable aquaculture, both for commercial and enhancement (public shellfish stocking) purposes. Ensure that the review process regulating aquaculture facility sites (and access routes to those areas) protects significant ecological resources (salt marshes, dunes, beaches, barrier beaches, and salt ponds) and minimizes adverse effects on the coastal and marine environment and other water-dependent uses.*

The CWMP includes initiating a pilot oyster aquaculture program in Swan Pond to determine whether a healthy oyster population can be supported that results in water quality improvements. The CWMP's various components should indirectly support aquaculture by improving water quality within the Dennis embayments.

Ocean Resources Policy #2**:** *Except where such activity is prohibited by the Ocean Sanctuaries Act, the Massachusetts Ocean Management Plan, or other applicable provision of law, the extraction of oil, natural gas, or marine minerals (other than sand and gravel) in or affecting the coastal zone must protect marine resources, marine water quality, fisheries, and navigational, recreational and other uses.*

Not applicable; the CWMP does not propose the extraction of oil, natural gas, or marine minerals.

Ocean Resources Policy #3**:** *Accommodate offshore sand and gravel extraction needs in areas and in ways that will not adversely affect marine resources, navigation, or shoreline areas due to alteration of wave direction and dynamics. Extraction of sand and gravel, when and where permitted, will be primarily for the purpose of beach nourishment or shoreline stabilization.*

Not applicable; the CWMP does not propose offshore sand and gravel extraction.

Ports and Harbors Policy #1**:** *Ensure that dredging and disposal of dredged material minimize adverse effects on water quality, physical processes, marine productivity, and public health and take full advantage of opportunities for beneficial re-use.*

The CWMP does not propose any new dredging.

Ports and Harbors Policy #2**:** *Obtain the widest possible public benefit from channel dredging and ensure that Designated Port Areas and developed harbors are given highest priority in the allocation of resources.*

Not applicable; channel dredging is not proposed as part of this CWMP.

Ports and Harbors Policy #3**:** *Preserve and enhance the capacity of Designated Port Areas to accommodate water-dependent industrial uses and prevent the exclusion of such uses from tidelands and any other DPA lands over which an EEA agency exerts control by virtue of ownership or other legal authority.*

Not applicable, the CWMP components will not be within Designated Port Areas.

Ports and Harbors Policy #4**:** *For development on tidelands and other coastal waterways, preserve and enhance the immediate waterfront for vessel-related activities that require sufficient space and suitable facilities along the water's edge for operational purposes.*

Not applicable; the CWMP does not propose development that will affect the immediate waterfront.

Protected Areas Policy #1**:** *Preserve, restore, and enhance coastal Areas of Critical Environmental Concern, which are complexes of natural and cultural resources of regional or statewide significance.* Not applicable; there are no ACECs within or directly adjacent to Dennis..

Protected Areas Policy #2**:** *Protect state designated scenic rivers in the coastal zone.*

Not applicable; there are no state designated scenic rivers in Dennis.

Protected Areas Policy #3**:** *Ensure that proposed developments in or near designated or registered historic places respect the preservation intent of the designation and that potential adverse effects are minimized.*

Dennis and its consultants will continue to work with the Massachusetts Historical Commission (MHC) to identify cultural resources within the project areas and minimize potential adverse effects to cultural resources.

Public Access Policy #1**:** *Ensure that development (both water-dependent or nonwater-dependent) of coastal sites subject to state waterways regulation will promote general public use and enjoyment of the water's edge, to an extent commensurate with the Commonwealth's interests in flowed and filled tidelands under the Public Trust Doctrine.*

The components of the CWMP are intended to improve water quality within the embayments of Dennis, thereby improving the ecological functions and aesthetic values of these areas. As such, general public use and enjoyment is expected to be indirectly supported by the improved conditions of these waterways.

Water Quality Policy #1**:** *Ensure that point-source discharges and withdrawals in or affecting the coastal zone do not compromise water quality standards and protect designated uses and other interests.*

Not applicable; the CWMP does not propose point-source discharges or withdrawals within or affecting the coastal zone.

Water Quality Policy #2**:** *Ensure the implementation of nonpoint source pollution controls to promote the attainment of water quality standards and protect designated uses and other interests.*

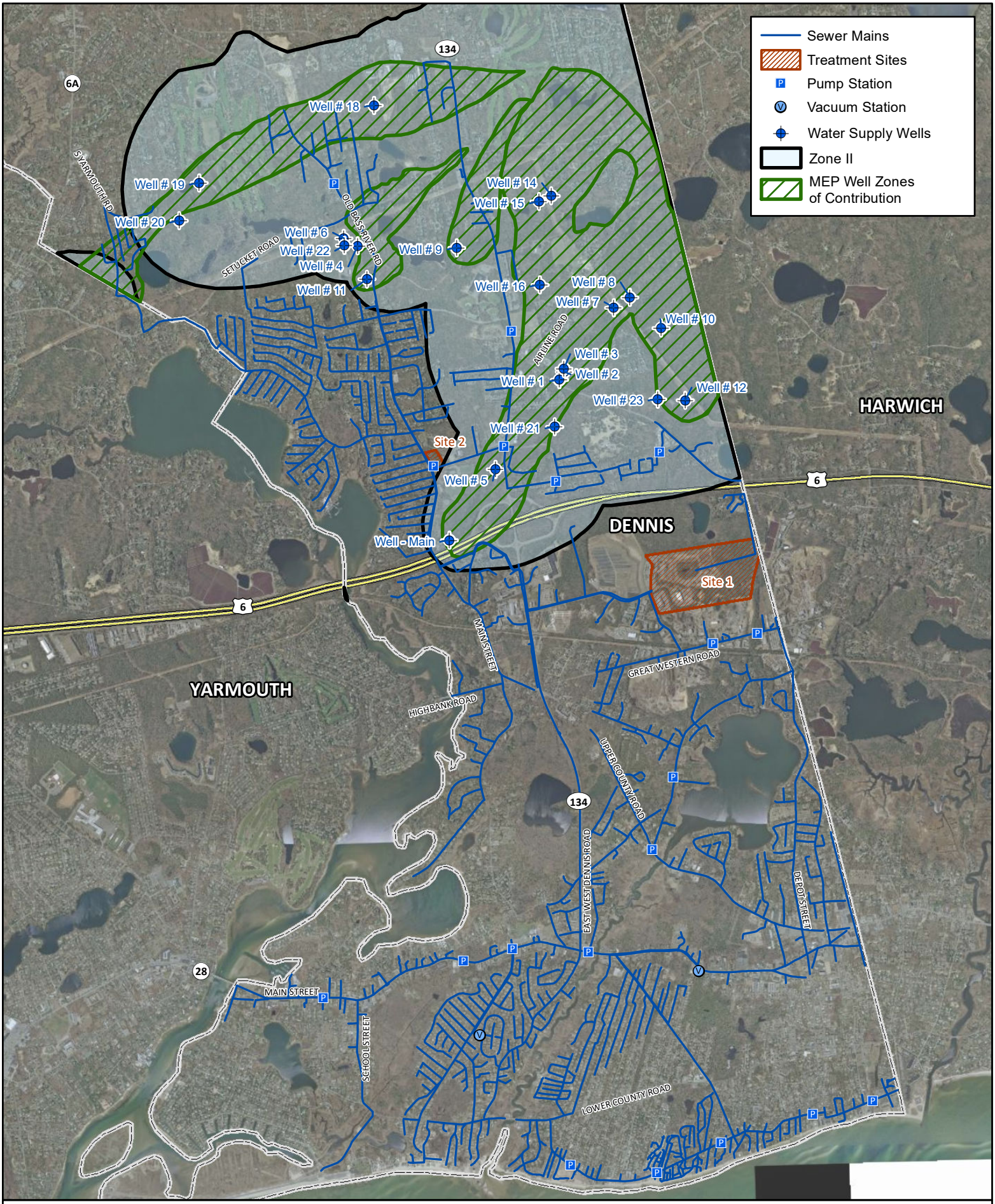
The goal of the CWMP is to improve water quality in the embayments of Dennis. The wastewater conveyance and treatment components, as well as public education components, are designed to reduce non-point sources of nutrients to Dennis waterways. Furthermore, Massachusetts Stormwater Management Standards will be met on properties containing new structures associated with this CWMP (WWTF and pumping stations), thereby further controlling non-point source pollution.

Water Quality Policy #3**:** *Ensure that subsurface waste discharges conform to applicable standards, including the siting, construction, and maintenance requirements for on-site wastewater disposal systems, water quality standards, established Total Maximum Daily Load limits, and prohibitions on facilities in high-hazard areas.*

The site screening process for the proposed effluent recharge facilities is explained in detail in Section 9. The CWMP does not propose subsurface discharge of untreated wastewater. The groundwater recharge facilities, using treated wastewater, will be designed to conform to all applicable standards and are intended to reduce nutrient loading to groundwater. These facilities will be subject to regulation under MassDEP Groundwater Discharge Permits.

16.8 Drinking Water Resources and Groundwater

Public water supply for the town of Dennis is provided by the Dennis Water District. The District supplies water via 22 wells, situated on more than 1,067 acres of land either owned or protected by the District. All of these wells are located north of Route 6, as shown on **Figure 16-7**, and draw from the Monomoy lens. This figure also shows the Zone II areas surrounding each well. Recorded 2020 nitrate concentrations in the Town's drinking water wells is relatively low with the highest concentration recorded at Well #15 at 2.10 mg/l . Overall, Dennis's drinking water is well below the 5 mg/l drinking water standard for nitrate.



Town of Dennis, MA

Drinking Water Resources

Figure 16-7

1 inch = 3,000 feet

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CDM Smith

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None of the proposed components of the CWMP are within the well contribution zones for Dennis's drinking water wells, except for sewer lines . Sewer lines are located within the Zone II recharge area.

The CWMP is not expected to result in adverse impacts to Dennis's drinking water quality or quantity. Wastewater effluent that will be recharged into groundwater will be treated as outlined in Section 11. Nitrate will be treated to between 1 and 3 mg/l. Overall, implementation of the CWMP is expected to positively affect groundwater quality by removing many septic systems from service. This will result in lowered inputs of nitrogen and phosphorus into the groundwater, as well as lowering the potential for contamination of groundwater from pathogens associated with wastewater. Additional information regarding Dennis's groundwater quality is provided in Section 4 and additional information regarding the selection of recharge sites is available in Sections 9, 10, and 11.

Groundwater quantity is not expected to be negatively impacted by the implementation of the CWMP. By constructing recharge facilities at the Site 1 and Site 2, groundwater recharge will be balanced between the Bass River and Swan Pond River watersheds. Each of these facilities will be subject to regulation and the associated monitoring requirements under the adaptive management plan and the Groundwater Discharge Permits issued by MassDEP.

Construction activities are not expected to impact groundwater quality or quantity. Construction activities will need to comply with current erosion and sedimentation standards, applicable Massachusetts stormwater management standards, as well as obtain a federal general permit for construction-related stormwater discharges.

Indirect impacts are not expected to negatively impact groundwater quality or quantity. Most of the areas to be sewered are near buildout condition, so sewering of these areas is not expected to place significant additional demand on groundwater supplies. Any new development is however also not expected to adversely impact groundwater quality or quantity since treated wastewater will be recharged into groundwater, and any additional water use should not result in a significant impact to groundwater supplies.

Long term monitoring of water resources will occur as part of the Adaptive Management Plan, outlined in Section 13.8. Implementation of the different phases of the CWMP is expected to be tailored in part based on the results of this monitoring, and improvement to groundwater quality over the long-term is expected as septic systems are removed from service.

16.9 Wastewater

Currently wastewater in Dennis is handled by Title 5 septic systems, except for a few small package wastewater treatment facilities. Since most of the areas to be sewered are near buildout condition, the construction of sewers is not expected to greatly increase wastewater generation. Some additional wastewater generation will occur as a result of the sewers allowing growth in the economic development areas. These areas are designated by the Town for planned growth and economic development; the design of sewerage facilities will take such growth into account.

As a project focused on wastewater solutions, this SEIR/CWMP extensively discusses the implications of wastewater handling. Specifically, estimated wastewater flows are described in

Section 8, wastewater needs are described in Section 7, wastewater scenarios in Section 10, collection and treatment system evaluations in Section 12, and treated effluent disposal/recharge in Sections 9 and 11.

16.10 Transportation and Traffic Generation

The CWMP proposes approximately 92 miles of new sewer mains to be installed within existing roadways. Roads will not be widened, and new roads will not be constructed as a part of this project, with the exception of access roads to the WWTF and effluent recharge facilities. The relationship between the proposed parcels to be sewered and MassDOT roadways is shown in **Figure 16-8**.

Construction of the WWTF and effluent recharge facilities at Sites 1 and 2 will require the addition of a small number of parking spaces. Estimated average traffic on roadways serving these new facilities are not expected to change.

The project requires installing sewer mains in state Routes 28 and 134. The Town understands that working in these roadways will present significant challenges for residents, businesses, and the construction crews tasked with the work. Such challenges include winter and summer construction restrictions, summer traffic from the tourist industry in Dennis, state highway construction requirements, and disruptions to local businesses and residents.

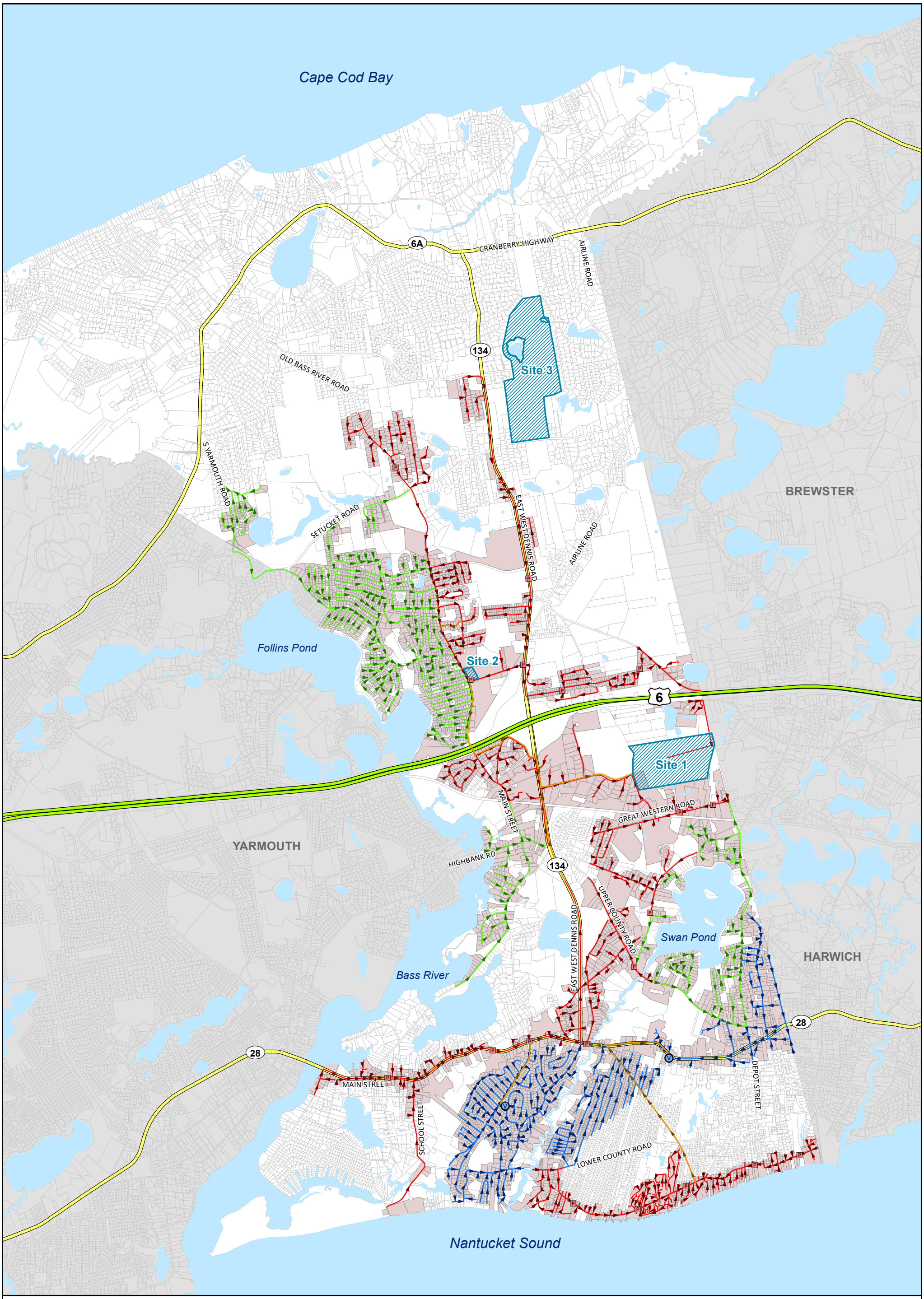
Proposed work on state-controlled roadways will occur outside of the summer months (Memorial Day to Labor Day) to minimize traffic impacts. Recent history indicates that MassDOT will prohibit construction in Routes 28 and 134 from Memorial Day to Labor Day. However, MassDOT does not allow any construction on state roads from November to April, so a special waiver would be needed to proceed with off-season construction. In addition, paving would have to be delayed until the hot mix asphalt plants reopen in the spring.

Temporary traffic disruptions during utility construction will be mitigated in consultation with Mass DOT. There will be temporary disruptions in the use of transit, pedestrian, and bicycle facilities during construction of the sewers and pump stations.

The Cape Cod Commission has recommended that potential impacts on the transportation network related to construction or expansion of any treatment facilities be considered by the Town at the appropriate stage in the design process. It also recommended that the Town coordinate sewer construction activities with planned roadway improvement projects to minimize traffic disruptions and reduce overall costs. As such, potential traffic impacts and mitigation methods will be looked at in greater detail during the design of the individual CWMP components, including coordinating other needed roadway improvements with the sewer project where such coordination is logical and cost-effective for the Town.

16.11 Air Quality

While emissions from the wastewater processes are not anticipated to require permits, combustion sources, specifically the new emergency generators that will combust either diesel or natural gas, will be required to comply with the Environmental Results Program (ERP). While this does not require a pre-construction permit, certification of the equipment will be required within 60 days of startup.



Legend

- Vacuum Main
- Pressure Main
- Force Main
- Gravity Main
- Vacuum Station
- Pump Station
- Recharge Sites
- Sewered Parcels
- U.S. Highway
- State Route

Town of Dennis, MA

MassDOT Roads

Figure 16-8

N

1 in = 3,000 ft

0 0.5 1

Miles

CDM Smith

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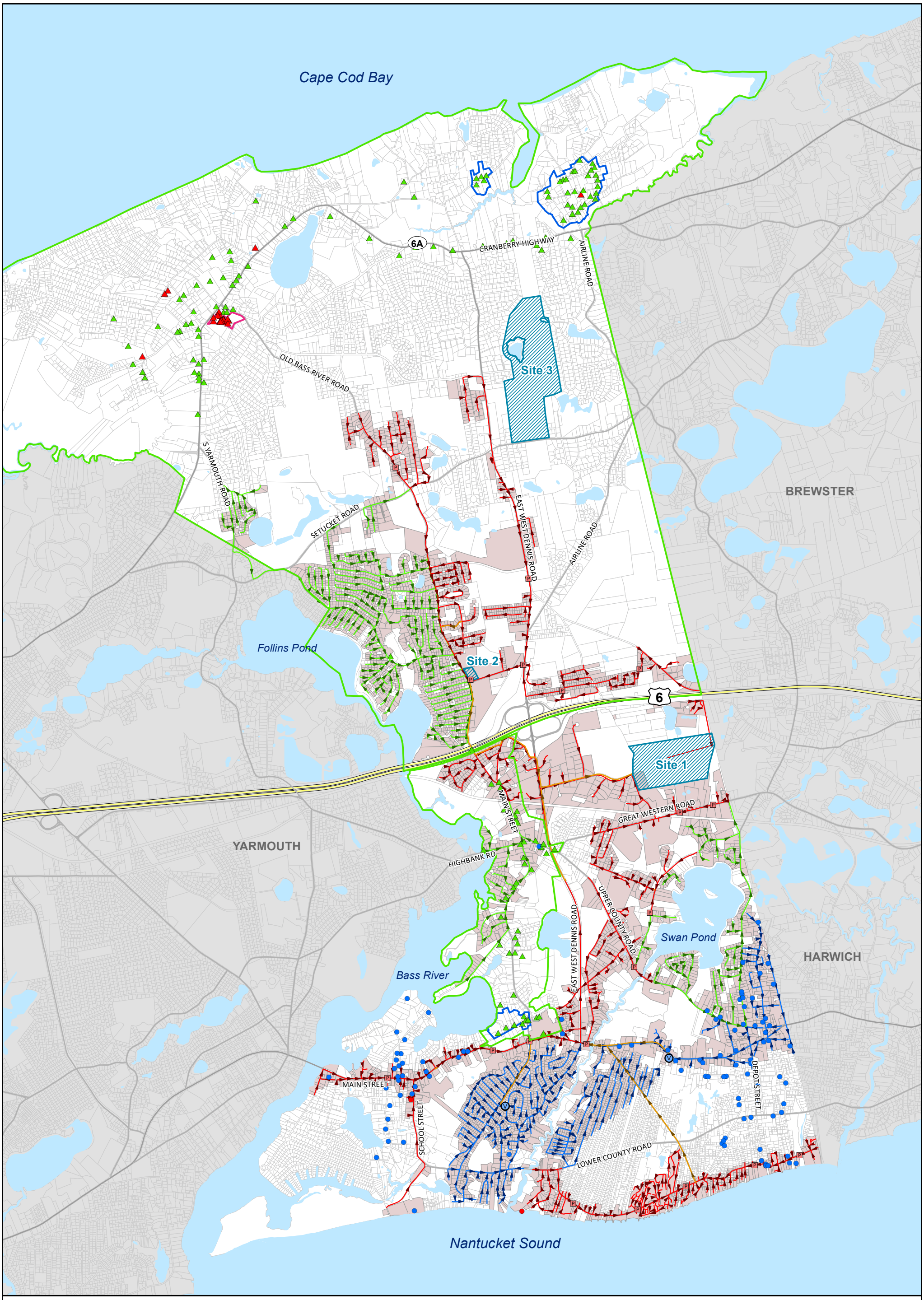
During the construction phase, the Town will require contractors to comply with MassDEP's Clean Air Construction Initiative and Diesel Retrofit Program, to mitigate diesel emissions to the maximum extent feasible. Project contractors will be required to use ultra-low sulfur diesel fuel in off-road engines. Specific requirements are included in the Construction Management Plan in Section 17.

16.12 Historical and Architectural Resources

The Massachusetts Cultural Resource Information System (MACRIS) from the MHC Web site was used to locate state listed historical and archeological sites within the project vicinity. Approximately 20 sites were listed on both the National Register of Historic Places and the Local Historic District sites. These sites were identified along the streets within the areas to be sewered, with many more properties having been inventoried. **Figure 16-9** shows the proposed work in relation to federal and state listed historical sites. Work near registered historic or archeological sites will occur within Town-owned rights-of-way. All work adjacent to any federal or state listed site will occur as quickly as possible. No impacts are anticipated because construction of sewer mains will occur in streets or rights-of-way. Pumping stations will be designed to be small and are generally away from listed or inventoried properties. MHC was consulted during the preparation of the EENF/Draft CWMP (associated correspondence is included in Appendix L). MHC indicated in their April 6, 2017 response to the PNF that an archaeological reconnaissance survey (950 CMR 70) be conducted for the project to provide a detailed archaeological sensitivity assessment and to provide recommendations for further archaeological testing, if any, that may be required to locate and identify any significant archaeological resources that could be affected by the Project in advance of project construction for each phase. Public Archaeology Laboratory (PAL) was contracted in the fall of 2018 to complete a cultural due diligence review and archaeological sensitivity assessment of the 72-acre Site 1, the preferred alternative for the proposed WWTF and a 7.2-acre effluent recharge site.

The due diligence review conducted by PAL showed that no cultural resources have been previously recorded within the Site 1 parcel. The western half of Site 1 which contains the DPW headquarters and the DPW solid waste yard was assigned as having low archaeological sensitivity and has little to no potential to contain significant cultural resources. PAL recommends no additional archaeological investigations for the western previously disturbed part of Site 1. The narrow ring surrounding the kettle pond in the middle of the DPW Yard and the forested eastern half of Site 1 (29.96 acres) were both assessed as having high/moderate sensitivity for significant cultural resources. PAL recommends that an intensive archaeological survey be conducted for 32.78 acres of this area (see Figure 4 in Appendix J). The applicant plans on having an intensive archaeological survey completed for the areas of Site 1 as recommended by PAL during final design.

The applicant will continue to consult with MHC for each phase of the project by submitting Project Notification Forms (PNFs) and scaled project plans for a review of potential impacts to historical and archaeological resources during detailed design of each phase of the project for the preferred alternative wastewater treatment plant location, recharge areas, pumping stations, equipment storage and materials staging areas In addition, as requested by MHC, the Inventory of Historic and Archaeological Assets of the Commonwealth will be consulted during each project



Legend

- Vacuum Main
- Pressure Main
- Force Main
- Gravity Main
- Vacuum Station
- Pump Station
- Recharge Sites
- Sewered Parcels
- Nat'l Register of Historic Places
- Local Historic District
- NRHP and LHD
- Inventoried Property
- Local Historic District
- NRHP and LHD
- Inventoried Area

Town of Dennis, MA

N

1 in = 3,000 ft

0 0.5 1

Miles

Federal and State Historical Resources

Figure 16-9

CDM Smith

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design phase to identify any resource areas that may be affected by the construction or operation of the CWMP components. The project designers will seek to minimize temporary or permanent impacts to such resources. Coordination with the MHC will continue throughout project planning and design.

The MHC requested that if above-ground pumping stations will be in historically significant areas that are significant for their setting, then considerations should be made for the structure design, materials, massing, landscaping, etc. to avoid or minimize adverse effects from the new construction. These considerations will be considered as the pump stations are designed.

16.13 Compliance with the MEPA Greenhouse Gas Policy

This project is subject to the MEPA Greenhouse Gas Emissions Policy and Protocol (the Policy). A meeting between CDM Smith, Inc. (CDM Smith) and the Massachusetts Environmental Policy Act (MEPA) Office was held on March 29, 2018, where the group discussed compliance with the MEPA Greenhouse Gas Policy (GHG). A draft section of the GHG compliance section of the CWMP was sent to MEPA for review on May 14, 2018. A follow up phone call was held on May 29, 2019 where MEPA discussed several comments with CDM Smith. From these discussions, is was determined that a more qualitative discussion of the GHG Emissions requirement will be presented in this Final CWMP/SEIR, as a formal GHG Assessment cannot be performed on the wastewater treatment facility and pumping stations at this conceptual stage.

16.13.1 Standard of Practice Energy Conservation Measures

The following subsections outline the mitigations measures which the town plans to implement as part of the future WWTF and pumping station designs. Since all facilities will be new, appropriate pump sizing will be of paramount importance. The efficient operation of pumps will be a key component in energy conservation measures, discussed in more detail below.

Premium Efficiency Motors and Variable Frequency Drives

National Electrical Manufacturers Association (NEMA) premium efficiency motors (PEM) and variable frequency drives (VFD) have proven to be reliable and cost effective. PEMs have an efficiency of 3 to 13 percent higher than older fixed speed motors. It is recommended that all motors, 1 hp or greater, installed as part of the future plant be premium efficiency motors. As the operation of pumps are typically the largest energy consumer in wastewater treatment facilities, the use of premium efficiency motors and VFDs could have a significant impact in reducing the overall energy demand of pumps used at the WWTF as well as the pump stations themselves.

Fine Bubble Aeration with Positive Displacement Blowers and Dissolved Oxygen Controls

It is recommended that fine bubble diffusers fed by positive displacement blowers be used as opposed to the mechanical aerators in the aeration tanks. The speed of the positive displacement blowers can be controlled by dissolved oxygen (DO) analyzers to optimize energy usage. Also, fine bubble systems use less power to transfer oxygen than mechanical aerators, and therefore is a more efficient system. The average energy savings of a fine bubble system as compared to surface aerators is 15% in the winter and 25% in the summer.

High Efficiency Lighting and Controls

It is anticipated that all new lighting systems will be outfitted with light-emitting diode (LED) type luminaires that comply with Mass Save guidance documents. Interior occupancy sensors should be installed in areas of the Process and Control Building that are frequently occupied and deemed safe for automatic light control systems. It is also recommended that exterior site lighting fixtures and exterior building mounted fixtures be controlled by photocells or astronomical time clocks, based on future operational requirements. Similar to photocells, astronomical time clocks have the ability to turn on the lights at dusk and off at dawn based on the programmed site coordinates. However, these lights also have the ability to be turned off at a certain time if the exterior lights do not need to be on until dawn.

High Efficiency HVAC System

It is recommended that heating boilers be high efficiency, gas fired, hot water, condensing type, boiler units. It is recommended that all air conditioning and ventilation units be high efficiency. Programmable thermostats can be installed to allow for automatic heating and cooling control.

Building Envelope

The following energy efficient features should be considered as part of the building envelope.

- High performance insulated glass windows – These save energy and associated cost.
- Passive Lighting – Skylights, light shelves or translucent walls should be incorporated into the design of the building to increase natural light, which improves worker comfort and productivity.
- Main Entrance – The entrance should have an energy efficient air lock: a small space with two air tight doors that do not open simultaneously. Air locks minimize heat gain/loss between the outside and inside.
- Insulation – High performance insulation can be installed.

16.3.2 Energy Conservation Measures

The following section discusses energy conservation measures (ECMs) which will be recommended to the town as part of their operations and maintenance plan for the future WWTF and pump stations. As defined the *Evaluation of Energy Conservation Measures for Wastewater Treatment Facilities* (USEPA 2010), ECMs should be planned for and implemented as part of a larger energy management program. The report defines the process of devising a formal energy management program in nine steps:

- Create an Energy Sustainability Team: This team could be formed from a combination of interested members of the WIC, department of public works (DPW) operation staff, town officials or interested community members.
- Gather Data
- Benchmark Performance: The USEPAs ENERGY STAR Portfolio Manager tool can be used at this juncture to set a baseline of energy performance, for all energy types including fuel sources, which will then be translated to an equivalent greenhouse gas emission. The

USEPA also identifies The Pumping System Assessment Tool (PSAT) and the MotorMaster+ as other tools that can be used to measure energy usage.

- Conduct and Energy Audit
- Develop Goals
- Devise a Plan: Once an energy audit is performed and preliminary energy reduction goals are set, ECMs can be devised that are specific to the facilities and a formal plan can be developed.
- Implement Improvements: WWTF and pump station operations staff will need to buy into the plan and understand the impacts so that it can be successfully implemented in the long term.
- Monitor and Measure Results
- Communicate Success: Throughout the CWMP process, the WIC and town officials have implemented a strong communications effort with local residents. The town will be able to build off of this effort to continue communications about the success of the energy management program.

16.3.3 Innovative and Emerging Technologies

The following section discusses some technologies that will be considered for implementation during final design of the WWTF and pump stations but may not necessarily be included due to financial considerations or technological challenges.

Motors

The USEPA report cited above identified two types of ultra efficient motors which were under development at the time of the report. An assessment on the payback for use of these pumps as an energy saving measure will be considered at the time of final design.

Aeration Process and Biological

There are several emerging technologies with regard to automation of aeration systems, other than through dissolved oxygen measurements, including respirometry, critical oxygen point control determination, and off-gas analysis. Additional innovative technologies for biological nitrogen removal include SybBio® and Biological Intelligent Optimization System (BIOS). CDM Smith understands that the town has the desire to keep operations of the future WWTF simple and use proven technologies. Should the use of these technologies significantly increase the level of complexity in operating the treatment plant, then it is likely they will not be implemented. A more in-depth review of these technologies can be completed during final design and recommendations can be made at that time.

16.3.4 Alternative Energy Systems

Energy Recovery from Sludge

Many technologies exist to recovery energy from municipal wastewater sludge; however, these processes require significant capital investment and ongoing costs for system operation and

maintenance. It is anticipated at this time that sludge from the new plant will be sent to existing energy recovery facilities within the state, such as the Upper Blackstone Water Pollution Abatement District.

Plant Water Source Heat Pumps

Heat pumps can take advantage of the heat in plant water, just as heat pumps can use source heat from the ground or the sewer (sewer heat recovery). Plant water heat pumps use the same principles of utilizing constant thermal temperatures in the plant water to efficiently produce building heating and/or cooling. Heat pumps can use the plant water side stream or be used in conjunction with a non-contact heat exchanger. If a heat exchanger is used, plant water does not circulate through the heat pump (instead a recycled heat exchange fluid is circulated), thereby reducing system maintenance. Heat exchangers are designed to be taken apart and cleaned, but heat pumps are not. Therefore, if the plant water side stream is in direct contact with the heat pump, a strainer should be used to avoid particulate matter in the heat pump.

The final design should also include a cost savings and return on investment analysis of heat pumps with non-contacting water versus water heat exchangers, with implementation of the most advantageous option.

Solar Photovoltaics (PV)

The solar energy on a site depends on the latitude of the location, which determines the angle of inclination of the sun. Additionally, the available solar energy depends on the time of day, time of year (due to changing inclination of the sun) and the weather. Solar insolation, a value used to consider the variability of the available solar energy, is typically measured as an average kWh/day/m^2 or kWh/day/ft^2. Near the proposed WWTP, the average annual solar insolation is 4.74 kWh/m2/day, according to the National Renewable Energy Laboratory (NREL) PV Watts Program. The Town will consider installation of solar at the facility which could tie into the existing infrastructure of the nearby Solar Farm at the Transfer Station, discussed in Section 15 of the CWMP. A feasibility assessment of a solar application at the future plant could be conducted in the future to determine type, layout and potential energy generation.

Solar Thermal

A solar thermal energy system harvests the sun's energy to provide domestic hot water, heating or cooling. Solar heating panels can be positioned on building roofs or walls. Solar thermal systems are a simple technology that is readily available in the United States. Solar domestic hot water systems include solar collectors, circulating pumps and controls, and storage tanks. The systems can either have direct or indirect circulation through the solar collectors. Solar hot water systems with direct circulation pump potable water through the solar collectors, whereas indirect circulation systems pump a non-freezing propylene-glycol fluid through the collectors and a heat exchanger which transfers heat to potable water. Indirect circulation systems are required in areas with freezing temperatures, such as Massachusetts.

A solar hot water system can usually meet 100% of the hot water requirements at a facility from April to September. In the winter, the solar hot water system can provide 85% to 65% of the hot water for a facility. Because solar hot water systems cannot meet all of the hot water requirements year round, a back-up heat source is needed. Systems can be designed to incorporate an existing conventional hot water heater for heating during the winter, if the

existing unit is in good condition. In this arrangement, solar heated water can be stored in an insulated tank before entering the conventional hot water heater. If the existing hot water unit is old or undersized, a one-tank solar hot water system can be installed that includes an insulated tank with gas or electric heating elements to provide additional heating during the winter.

Wind Turbines

Site wind speed is the most important factor in evaluating the feasibility of a wind turbine. Locations with annual average wind speeds around 6 m/s and greater at 70-m height are generally considered to have suitable wind resources for wind turbines. As final design of the future plant approaches, the option for a wind turbine application could be assessed as siting options will be better defined. The Massachusetts Clean Energy Center runs the Commonwealth Wind Program which will be reviewed prior to final design.

16.3.5 Economy of Scale

Discussions between the Towns of Dennis, Harwich and Yarmouth will continue to progress over the next year, through the aid of the recently awarded Efficiency and Regionalization Grant. Following Town Meeting vote in May 2018, all three towns approved filing of Special Legislation to potentially create the Dennis, Harwich, Yarmouth (DHY) Clean Waters Community Partnership. This formal partnership will allow the three communities to continue to work together to solve the towns' wastewater issues, and to draft an Agreement that would describe how they would govern the sharing of vital infrastructure (i.e., wastewater treatment facility and effluent reuse facilities). Approval at this time also allows the towns to collaborate, look for cost savings measures and develop the draft agreement. A partnership could potentially save each town millions of dollars annually for the construction and operation of shared infrastructure. Should the towns agree to authorize the formation of community wastewater district, a larger WWTP would be built within the Town of Dennis instead of three smaller and less efficient treatments in each community. This larger facility would be designed in the same way as the Dennis only solution but could have increased efficiency in several areas. Although wastewater flows will increase with the addition of Harwich and Yarmouth, the chosen treatment technology of sequencing batch reactors will still be the most viable technology for the combined plant as it still allows for the most flexibility in flow swings. Other biological processes are not as amenable to dramatic swings in process flows which can significantly impact the operation of the processes.

16.3.6 Mitigation Measures

The most viable GHG mitigation measures for the town for construction and operation of their new WWTP and pump stations have been presented above. CDM Smith has presented the options above, based on past experience with design of plants of similar size and nature to the proposed plant in Dennis. It is recommended that the town strongly consider the application of all measures presented particularly in the Standard of Practice Energy Conservation Measures Section when undergoing final design. Upon final design of the new plant and pump stations, an energy audit will be performed. This will serve as the benchmark from which future impacts can be compared against. The energy usage will be converted to a GHG emission equivalent though applying scientifically accepted equivalency factors. At the time of final design, the alternatives presented above will be assessed in greater detail and considered for application while weighing the life cycle cost of implementing these energy reducing measures. The use of supervisory control and data acquisition (SCADA) at the new plant will allow for easy tracking of energy usage and

refining the use of equipment to reduce energy consumption as much a possible, throughout the plant as well as the remote pump stations. At the time of final design, it is recommended that best management practices (BMPs) be developed and included in the Operations and Maintenance (O&M) plan to be followed by operations staff.

Table 16-3 Greenhouse Gas Emissions Policy and Protocol Mitigation Measures

Mitigation Measures to be Included	Related Equipment
Minimize energy use through proper building orientation and proper landscaping	LIGHTING
	HVAC
Minimize building footprint	LIGHTING
	HVAC
Increase roof insulation to at least 20% above the minimum required by the effective Mass Building Energy Code	HVAC
Increase boiler or furnace efficiency to at least 10% above the minimum required by code	HVAC
Include energy recovery ventilation for heated building areas	HVAC
Improve building envelope through higher R-value insulation in walls and, if appropriate, basement walls and ceiling	HVAC
Maximize the thermal mass of walls, roofs and floor to provide thermal damping	HVAC
Conduct inspection and comprehensive air sealing of building envelope to minimize air leakage	HVAC
Install lower U-value windows to improve envelope performance	HVAC
Incorporate window glazing to balance and optimize day lighting, heat loss and solar heat gain performance	HVAC
Evaluate use of high-albedo roofing materials to reduce heat absorption	HVAC
Prevent over-sizing of HVAC or other equipment by sizing only after efficiency measures have been incorporated to reduce HVAC, lighting and other electrical loads	HVAC
Install high-efficiency HVAC systems and premium efficiency motors	HVAC
Use demand control ventilation	HVAC
Use energy efficient boilers, heaters, furnaces, incinerators, or generators	HVAC
Seal and leak-check all supply air ductwork	HVAC
Incorporate motion sensors into lighting, day lighting, and climate controls where practicable as safety concerns and ventilation codes allow	HVAC
Provide automated energy management control system with the capacity to: ▪ Adjust and maintain set points and schedules ▪ Indicate alarms and problems ▪ Provide information on trends and operating history ▪ Operate mechanical and lighting systems to minimize overall energy usage	HVAC LIGHTING
Use efficient, directed exterior lighting, such as LED technology	LIGHTING
Install high efficiency lighting, including CFLs and LED technology as appropriate	LIGHTING
Reduce Lighting Power Density to at least 15% below maximum allowed by the code; include occupancy on/off controls	LIGHTING
Process optimization: Mitigate the negative impact on the life-cycle efficiency and emissions of the WWTF treatment process due to the impact of equipment operating for a large fraction of the life-cycle at partial loads through phasing and consideration of efficient turn-down capacity.	All WWTF related equipment
Size piping systems to minimize pressure loss	

Mitigation Measures to be Included	Related Equipment
Design pumping, blower, filtration and associated control systems to achieve overall efficiency	
Select high efficiency equipment including pumps, blowers, and motors	
Evaluate process alternatives and select the least energy intensive option practical	
Specify and procure efficient equipment	
Include sufficient metering and controls for real-time monitoring and optimization of the process operations	
Incorporate appropriate on-site renewable energy systems	All
Purchase Renewable Energy Credits	All
Other Mitigation Measures to be Considered	
Prepare a description of the business as usual case for the as-proposed pumping stations and projected annual MWH energy consumption and GHG emissions	
Prepare a description of the proposed mitigated pumping stations and projected annual MWH energy consumption and GHG emissions	
Demonstrate new tree planting	
Install efficient water fixtures that exceed building code requirements such as waterless urinals, dual flush toilets, low-flow faucets and showerheads, sensor faucets, or plant water reuse	
Plant only native species that need minimal watering and/or use xeriscaping	
Develop a water management plan	
Participate in EPA's WaterSense Program	
Use low volatile organic compound (VOC) adhesives, sealants, paints, carpets, and wood	
Track energy performance of the building and develop a strategy to maintain efficiency	
Provide energy information systems to promote energy awareness to occupants	
Conduct 3rd party building commissioning to ensure energy performance	
Design for waste reduction (i.e. provide for storage and collection of recyclables (including paper, corrugated cardboard, glass, plastic, and metals) in building design	
Reduce energy demand using peak shaving or load shifting strategies – if applicable, enroll in demand response program with the International Organization for Standardization (ISO)-New England	
Purchase or generate additional green power or purchase Renewable Energy Credits	
Specify and procure most efficient equipment	
Implement a construction waste management plan	
Implement and enforce no-idling policies	
Incentivize use of public transportation and car/vanpools, for construction workers to reduce vehicle trips	
Provide bicycle storage and showers/changing rooms	

The measures summarized above have been included in the Section 61 Findings in Section 18 of this CWMP/SEIR.

16.14 Regulatory Standards and Permit Requirements

In addition to the MEPA review, the following federal, state and local permits or reviews are anticipated to be needed at various stages of the CWMP's implementation, based on currently available site and design information:

- Cape Cod Commission 208 Consistency Plan Review;

- National Pollutant Discharge Elimination System (NPDES) Construction General Permit (CGP);
- US Army Corps of Engineers Section 10 and/or Section 404 Permits;
- Coastal Zone Federal Consistency Review (through Massachusetts Coastal Zone Management);
- Massachusetts Historical Commission Review;
- Coordination with the Natural Heritage and Endangered Species Program;
- DCR Construction Access Permit;
- Groundwater Discharge Permit from MassDEP;
- Orders of Conditions from the Dennis Conservation Commission;
- Massachusetts Highway (MassDOT) Permits; and
- Air Quality Permits/Compliance with the Environmental Results Program.

This section discusses the applicability of the permits and approvals listed above. Clean Water State Revolving Fund (SRF) Project Evaluation Form and Loan Application requirements are also discussed at the end of this section. Review times indicate the approximate duration for agency review from submittal of applications to the issuance of permits. Typically, permits obtained by the Town are initiated around the 30 percent design milestone for each construction contract. At this stage, sufficient detail is available to allow reviewing agencies to understand the project, and sufficient time is left in the design phase to incorporate any changes that result from the permit review process. Permits applied for by the contractor are initiated once construction contracts have been signed.

16.4.1 Federal Permits

NPDES General Permit for Construction

A NPDES General Permit for Construction is required from the EPA, pursuant to Section 402 of the Clean Water Act, to address stormwater controls during project construction. This permit is needed for any construction one acre or greater, that will involve a point source discharge to wetlands or water bodies. Since construction of the plant, preparation of the effluent recharge site, and installation of sewer mains will exceed one acre, this permit is applicable. A Storm Water Pollution Prevention Plan (SWPPP) addressing construction must be prepared, describing erosion and sedimentation controls and treatment and the ultimate discharge of storm water and uncontaminated groundwater during construction. Typically, this permit is to be completed and submitted by the contractor for each phase of construction. EPA review time is14 days.

US Army Corps of Engineers Section 10 and/or Section 404 Permits

Work in wetlands and waterways is regulated by the U.S. Army Corps of Engineers (the Corps) under the authority of Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act. In Massachusetts, the Corps has developed the Massachusetts General Permit (GP) to expedite their evaluation of permit applications and streamline the permitting process. There

are two categories associated with the GP, Self Verification (SV) and Pre-Construction Notification (PCN). SV activities are projects that impact less than 5,000 square feet of a federally defined wetland or waterbody. There is no formal approval or a permit from the Corps for a SV. If impacts to wetlands are 5,000 square feet or greater, but less than 1 acre, a PCN permit application must be filed. The Corps, along with other federal resource agencies (U.S. Fish and Wildlife Service, National Marine Fisheries Service, EPA and the Massachusetts CZM office), reviews this application and determines that either: 1) the project meets the criteria of the GP and can proceed with no changes and no additional Corps review is needed; 2) additional information is needed before making a permitting decision; or 3) the project does not meet GP criteria and an Individual Permit is required. An Individual Permit is generally reserved for large projects which exceed the established criteria for either SV or PCN activities. Note, however, that the Corps may act at any time to exercise its discretionary authority and require an Individual Permit and/or a NEPA documentation, even if GP criteria are met. Coordination with the Corps and MassDEP should take place on such projects prior to the submittal of a permit application so as to anticipate documentation, alternatives analysis, and mitigation requirements. Review times for Section 10 and Section 404 permits vary based on the size and complexity of the project, types of resources being impacted, and magnitude of the impacts.

16.4.2 State Permits

Section 401 Water Quality Certification

Section 401 Water Quality Certification is required of all projects requesting an individual Section 404 or Section 10 permit under the Clean Water Act. MassDEP administers the 401 Water Quality Certification program. Projects with a cumulative loss of more than 5,000 square feet of bordering and isolated vegetated wetlands and land under water must apply for a Major Fill/Excavation Project Certification. A Minor Fill/Excavation Project Certification must be obtained for projects with a cumulative loss of more than 5,000 square feet of bordering and isolated vegetated wetlands if the project consists of routine maintenance meeting the criteria of 314 CMR 9.04(5), or if the project is a subdivision with a cumulative loss of up to 5,000 square feet, or if the project involves an agricultural limited product meeting the criteria of 314 CMR 9.04(10). Projects with a cumulative loss of not more than 5,000 square feet that are not listed above and for which a Final Order of Conditions has been issued by the local Conservation Commission are excluded from Section 401 review. Additionally, 401 Water Quality Certification is not required of projects in isolated vegetated wetlands not subject to the Wetlands Protection Act so long as the cumulative impacts to bordering and isolated vegetated wetlands and land under water are less than 5,000 square feet and the fill/excavation will not take place in any habitat for rare or endangered species or Outstanding Resource Water.

It is not anticipated that any phase of the CWMP Program will require Section 401 authorization.

Coastal Zone Federal Consistency Review

The Massachusetts Office of Coastal Zone Management was established in accordance with the Federal Coastal Zone Management Act of 1972, as amended. The purpose of the Massachusetts CZM is to provide technical assistance to municipalities and state agencies with jurisdiction over coastal resources, ensure that responsibilities of the Executive Office of Energy and Environmental Affairs agencies are administered in a coordinated and consistent manner, and

review projects proposed within the Coastal Zone for compliance with the CZM Policies established in 301 CMR 20.00.

CZM Consistency Review is required for any project which needs a federal permit for activities in the Coastal Zone and/or when a project located in the Coastal Zone is subject to MEPA review. A federal permit which requires a Consistency Statement from CZM is not valid until the Statement is issued. A CZM Consistency Review is often prepared as part of MEPA documentation or can be prepared as a stand-alone document. Because all of Cape Cod is mapped within the Coastal Zone, a review of CZM policies is provided in Section 16.7 of this SEIR.

Orders of Conditions under the Massachusetts Wetlands Protection Act

Under the state Wetlands Protection Act (M.G.L. c.131s.40) and its regulations (310 CMR 10.00), alterations of wetland resource areas, and work adjacent to certain resource areas, require issuance of an Order of Conditions by the local Conservation Commission. Work within the 100-foot Buffer Zone to certain resource areas can be approved via a Determination of Applicability. An Order of Conditions is required for any work within a protected wetland resource area (including but not limited to Bordering Vegetated Wetlands, Bank, 200-foot Riverfront Areas and/or 100-year floodplains), or when the Conservation Commission determines that an Order of Conditions will be required for work in a 100-foot Buffer Zone area. The Conservation Commission holds a public hearing to review the proposed activities subject to jurisdiction of the Wetlands Protection Act and receives input from the public before issuing a permit decision. Abutters to the jurisdictional areas must be notified of the public hearing.

Orders of Conditions will likely be required from the Dennis Conservation Commission for work in jurisdictional areas during each phase of the project. The review time for a Notice of Intent is approximately 3 months. Dennis has a local Wetlands Protection Bylaw and Regulations that is applicable to the CWMP Program.

Historic Preservation Act, MHC Section 106 and Chapter 254 Compliance

The MHC identifies, evaluates, and protects the state's significant cultural resources under Section 106 of the National Historic Preservation Act and Chapter 254 of the Acts of 1988 (950 CMR 71.00). Any new construction projects or renovations to existing buildings that require state funds, licenses, or permits are subject to MHC review requirements. The state regulations set up a review process to identify historic properties, assess effects, and consult interested parties to avoid, minimize, or mitigate any adverse impacts.

Construction of the proposed WWTF and appurtenant structures will require state and federal permits for work within previously undisturbed areas. As such, consultation with the MHC is required to determine whether potentially sensitive archaeological/historical features could be affected by construction. As described in Section 16.12, MHC has been notified of the project and has provided the comments included in Appendix L. Further coordination will take place during each design phase of the CWMP's implementation.

Review by Massachusetts Division of Fisheries & Wildlife NHESP

A primary responsibility of the NHESP is the regulatory protection of rare species and their habitats as codified under the MESA (M.G.L. c 131A) and the Wetlands Protection Act (M.G.L.

c.131s.40). Projects affecting rare species and/or habitats, and triggering specified requirements or permits, are reviewed by the NHESP.

As described in Section 15.5, NHESP has been contacted and has provided the comments attached in Appendix L and Section 18. Follow-up required as a result of NHESP's review is described in Section 16.5 and will take place during each design phase of the CWMP's implementation.

Sewer Connection and Extension Permit

Under 314 CMR 7.00, new connections to sanitary sewers, increases in flow to existing sanitary sewers, and discharges from businesses that are not considered to be "industrial wastewater" are subject to state requirements based on their expected discharge volume.

Sewer extensions are subject to state requirements in 314 CMR 7.00 based on their length. Note that sewer extension projects that obtain a Project Approval Certificate from MassDEP's Clean Water State Revolving Fund Program are exempt from permitting requirements, due to MassDEP's detailed review before the certificate is issued. Design plans for all phases funded by the State Revolving Fund will undergo MassDEP review and comment prior to receiving approval to advertise for construction bids.

Groundwater Discharge Permit

Any facility that discharges 10,000 gallons per day (gpd) or more into the ground must have a valid groundwater discharge permit from MassDEP pursuant to 314 CMR 5.00. There may also be instances, particularly in nitrogen sensitive areas, where a groundwater discharge permit will be required for flows less than 10,000 gpd. Each proposed site for recharge of treatment plant effluent will require such a permit.

An application to build a new treatment plant must include an engineering report along with a statement by a registered professional engineer that the plans and specifications have been prepared in accordance with the regulations. Along with the report, applications must include hydrogeologic studies of the recharge site and its surroundings as well as a groundwater monitoring plan. The plans and specifications must describe in detail the collection, treatment and recharge components of the facility.

Review time by MassDEP is approximately 3 months.

MassDOT (State Highway Permit)

Any utility that encroaches on the state highway layout or requires significant modification to traffic patterns will require a state highway permit. The application includes a description of the property and/or facility for which access is sought, a description of the work to be performed in the vicinity of the state highway layout, and a set of construction drawings including traffic control measures for the project. All work along Routes 28 and 134 will require a MassDOT permit.

Review time is approximately 4 to 6 months.

Air Quality Permit/Compliance with the Environmental Results Program

A pre-construction permit is not required, but a certification of the pertinent equipment will be required within 60 days of startup under the Environmental Results Program.

16.4.3 Local Approval

Cape Cod Commission Section 208 Consistency Determination

The CCC is the regional planning and land use commission for Cape Cod. Municipal Comprehensive Wastewater Management Plans (CWMPs) are no longer reviewed as a Development of Regional Impact (DRI). Since September 2015, CWMPs are reviewed for consistency with the 208 Plan. This process provides a streamlined regulatory pathway for more efficiently and effectively achieving water quality goals through the development of targeted watershed management plans that address nutrient remediation through a variety of approaches.

16.4.4 Clean Water State Revolving Fund (CWSRF) Loans

The Clean Water State Revolving Fund for water pollution abatement projects offers low-interest loans (0 percent interest for nutrient removal projects meeting certain criteria and 2 percent for most other projects) to assist municipalities in complying with federal and state water quality requirements. The program is administered by MassDEP and the Massachusetts Water Pollution Abatement Trust. A major goal is to encourage communities to undertake projects with meaningful water quality and public health benefits and which address the needs of communities and watersheds. Further discussion of use of the State Revolving Fund program is provided in Section 15 of this CWMP/SEIR.

16.5 Compliance with Cape Cod Commission Regional Plan

The EENF and draft CWMP were submitted for joint review by MEPA and the Cape Cod Commission (CCC). The project will be subject to 208 Plan Consistency Review by the CCC, which will formally begin after the MEPA review process is complete. A MEPA scoping session/public hearing was held June 2017, and the CCC commented on the EENF and draft CWMP on July 7, 2017. The CCC determined that the EENF in general addresses many of the parameters of the 208 Plan Consistency Review Criteria. Comments made by the CCC are addressed in this document and summarized in the Response to Comments in Section 19.

Table 16-4, below reviews the applicable CCC 208 Plan Consistency Review provisions relative to water resources (drinking water quality and quantity, freshwater ponds and lakes, marine waters, water quality improvement areas, and stormwater quality).

Table 16-4 208 Plan Consistency Review Criteria

Performance Standards		Compliance
1	WMA assumes responsibility for controllable nitrogen for any part of the watershed within its jurisdiction	A WMA shall assume its nitrogen loading responsibility as set out in the 208 Plan Update, unless otherwise determined through the Process for WMAs to Revise Nitrogen Load Allocation outlined in the 208 Plan Update and discussed below. A WMA shall establish in its plan a nitrogen design load based on such nitrogen allocation, and any additional nitrogen load for planned or anticipated development, and other specific municipal needs or objectives identified in the plan.
2	Plan meets applicable nutrient reduction targets	All plans shall achieve the nitrogen load reduction required, either as allocated in the 208 Plan Update, or as agreed upon and approved via the allocation revision process outlined in section 1 herein.
3	Planning occurs at a watershed level with consideration of a hybrid approach	At least one hybrid watershed scenario shall be developed following the hybrid watershed scenario planning process outlined in the 208 Plan Update that integrates reduction, remediation and restoration technologies and approaches.
4	Public was engaged to gain plan consensus	The local planning process shall engage the public at the watershed level to gain consensus on proposed actions and those included shall represent a range of community stakeholders.
5	Plan includes proposed strategies to manage nitrogen loading from new growth	A WMA shall calculate its future nitrogen loading responsibility for the watershed(s) in question based on buildout, and based on unattenuated nitrogen loads (in contrast to existing loads which are calculated based on attenuated loads).
6	Plan includes adaptive management approach	As watershed plans will include numerous and alternative strategies and approaches proposed to achieve required nitrogen reduction and other goals, these plans shall also include an adaptive management plan to guide a WMAs future decision-making with respect to plan implementation. AMPs shall contain specific milestones and triggers for decision-making, undertaking actions, and reporting relative to plan implementation for the respective watershed
7	Plan includes pre- and post-implementation monitoring program	An ongoing monitoring program for technology performance shall be included in the plan. At a minimum, the monitoring program shall address nitrogen, but may include other compounds.
8	Plan includes a description and assessment of the town's proposed funding strategy	All plans shall include a fiscal analysis of the town's ability to pay for the projects proposed. Potential local revenue sources and outside sources of funding should be identified and schedules for financing over the life of the project(s) should be included.

Performance Standards		Compliance
9	WMA commits to regular 208 Plan Update Consistency reviews until water quality goals are achieved, generally reviewed at least every five years	The WMA shall commit to submitting all future plans and material changes to existing plans to the Cape Cod Commission for consistency review at least every five years.
10	In shared watersheds, WMA seeking 208 Consistency Review collaborates with neighboring WMA(s) on nitrogen allocation, shared solutions, and cost saving measures	In shared watersheds, and in circumstances where nitrogen management infrastructure or approaches may be shared, an effort shall be made to engage neighboring and other appropriate WMAs and cooperate on solutions.

Section 17

Construction Management Plan

17.1 Purpose

A draft construction management plan (CMP) was developed for the implementation of the Dennis Comprehensive Wastewater Management Plan (CWMP) Recommended Program. This plan describes anticipated construction activities, scheduling and sequencing, and best management practices (BMPs) that are proposed to avoid and minimize both temporary and permanent construction period impacts. This draft CMP will be further refined as individual construction contracts are brought to final design and as contractors are retained to perform the work of each construction phase.

17.2 Construction Scheduling and Sequencing

As described in Section 14, the Dennis CWMP Recommended Program has been divided into eight construction phases, with a scheduling plan spanning approximately forty years. The first phase, Phase 1, includes construction of the initial Dennis wastewater treatment facility (WWTF) and at least one effluent recharge area potentially with a permeable reactive barriers (PRB) which will allow the Town to construct phases 1 through 3 of the wastewater collection system. Phase 4 will include an expansion to the WWTF along with the additional effluent recharge areas potentially with PRBs to bring Phases 4 through 8 online. Each of the other phases includes a combination of sewer and pumping station installation, continued monitoring of the results from previous phases, and additional smaller projects to meet the ultimate water quality goals of the CWMP. Each subsequent phase will proceed approximately five years following the previous phase, for a total forty year implementation duration. The breakdown of individual construction contracts will be determined as each phase is designed and funded.

Requirements of the contractor to be included in the specifications that pertain to construction scheduling and sequencing include the following measures to mitigate construction period impacts:

- Normal working hours are defined as approximately 7:00 a.m. to 3:30 p.m. on weekdays.
- The Contractor will notify DIGSAFE and private utility mark-out companies at least 72 hours before digging, trenching, blasting, demolishing, boring, backfilling, grading, landscaping or other earth moving operations in any public ways, rights of way and easements.
- Trenches may not remain open overnight.
- Test pits will be backfilled immediately after their purpose is satisfied and the surface restored and maintained in a manner satisfactory to the Engineer.
- To minimize disruptions to residents, final paving of each street will occur within one year of pipe installation, and to facilitate resident connections to the new sewers, the Contractor

will be required to install mainline sewers, services, initial paving, invert construction, pipe testing, raising structures and cleanup of the site on individual streets within the contract before being allowed to commence construction in other streets of the contract. All pipe testing, including mandrel testing, will be completed within 120 days of pipe installation (mandrel testing will commence after a 90 day waiting period after pipe installation).

- Equipment will not be delivered to the site more than one month prior to installation without written authorization from the Engineer.
- Once the Contractor begins to install sewers and force mains within a street, the Contractor will complete the sewer and force main installation prior to moving to another street. Installing sewers, service connections and other work including paving can be performed on other streets by separate crews as approved by the Engineer.

17.3 Environmental Protection Requirements

Construction will be conducted in a manner to avoid, minimize, and mitigate impacts to the surrounding environment. The contract specifications will include extensive, detailed provisions for environmental protection to be followed by the Contractor, as listed below.

17.3.1 General Requirements

- The Contractor will be required to comply with all applicable federal, state and local laws and regulations concerning environmental pollution control and abatement.
- The Contractor will be notified in writing of any non-compliance of environmentally objectionable acts. After receipt of such notice, the Contractor will be required to take corrective action. If the Contractor fails or refuses to comply promptly, the Town may issue an order stopping all or part of the work until satisfactory corrective action has been taken.
- Prior to commencement of the work, the Contractor will meet with the Town to develop mutual understandings relative to compliance with these provisions and administration of the environmental pollution control programs.
- Throughout the performance of the work required, the Contractor will be subject to environmental inspections of his/her equipment, routine daily operations and environmental protection procedures.
- At the completion of the work, a joint final field inspection will be made by the Town and the Contractor.
- The Contractor will not be permitted to use procedures, activities, or operations that may adversely impact the natural environment to the extent practicable or the public health and safety.
- For the duration of each contract, facilities constructed for pollution control will be maintained as long as the operations creating the particular pollutant are being carried out or until the material concerned has become stabilized to the extent that pollution is no longer being created.

17.3.2 Land Disturbance

- The Contractor will not be permitted to enter or occupy private land outside of easements, except by written permission of the landowner and the Town.
- The Contractor will be responsible for the preservation of all public and private property and must use every precaution necessary to prevent damage thereto, to the extent practicable. If direct or indirect damage is done to public or private property by or on account of any act, omission, neglect, or misconduct in the execution of the work on the part of the Contractor, the Contractor will be required to restore such property to a condition similar or equal to that existing before the damage was done.
- No work will be permitted within permanent easements which may be required for pumping stations until written authorization is provided by the Town.
- Work areas will be restored to conditions that existed prior to construction. Land resources within the project boundaries and outside the limits of permanent work will be restored to a condition, after completion of construction that will appear to be natural and not detract from the appearance of the project. All construction activities will be confined to areas shown on the contract drawings.
- The locations of the Contractor's storage and temporary buildings will be cleared portions of the job site and will require written approval of the Engineer. These sites will not be within wetlands or floodplains. The preservation of the landscape will be a consideration in the selection of all such sites.
- All signs of temporary construction facilities such as haul roads, work areas, structures, stockpiles of excess or waste materials, or any other vestiges of construction will be removed by the Contractor.
- All areas disturbed by the installation and removal of groundwater control systems and observation wells will be restored to their original condition.
- The Contractor will assume full responsibility for the protection of all buildings, structures, pavement, sidewalks, curbing, driveway aprons, fencing, landscaping, and utilities, public or private, including poles, signs, services to buildings, utilities in the street, gas pipes, water pipes, hydrants, sewers, drains and electric and telephone cables, whether or not they are shown on the contract drawings. If necessary, curbing, driveway aprons and fencing will be removed and restored or replaced after backfilling. All existing facilities damaged by the construction will be promptly replaced with material equal to that existing prior to construction to the satisfaction of the Town.
- Topsoil will be stripped, stockpiled, and reused from grassed areas crossed by trenches. At the Contractor's option, topsoil may be otherwise disposed of and replaced, when required, with approved topsoil of equal quality.

17.3.3 Noise and Vibration

- The Contractor will be required to make every effort to minimize noises caused by the operations. Equipment will be equipped with silencers or mufflers designed to operate with the least possible noise level in compliance with state and federal regulations and Town of Dennis regulations, whichever are more stringent.
- During construction, the following measures will be used to control noise: 1) loud pieces of equipment will be substituted with quieter equipment, 2) effective intake and exhaust mufflers will be used on internal combustion engines, and 3) truck loading, unloading, and hauling operations will be conducted in a manner that keeps noise and vibration to a minimum.

17.3.4 Air Quality and Dust

- The Contractor will perform dust control operations, in an approved manner, whenever a nuisance or hazard occurs or when directed by the Engineer, even though other work on the project may be suspended.
- Methods of controlling dust will meet all air pollutant standards as set forth by federal and state regulatory agencies.
- All road surfaces will be broomed clean after backfilling.
- Paved streets adjacent to work areas will be swept regularly.
- Dump trucks will be covered with tarpaulins and have tightly fitting tailgates.
- The Contractor will be required to maintain all excavations, embankments, stockpiles, access roads, plant sites, waste areas, borrow areas, and all other work areas within or outside the project boundaries free from dust which could cause the standards for air pollution to be exceeded, and which would cause a hazard or nuisance to others.
- Dust control will be generally accomplished by the use of water. An approved method of stabilization consisting of sprinkling or other similar methods will be permitted. Calcium chloride may be used if permitted by the Engineer and the Town. The use of petroleum products is prohibited.
- Sprinkling will be repeated at such intervals as to keep all parts of the disturbed area at least damp, and the Contractor must have sufficient competent equipment on the job to accomplish this if sprinkling is used.

Vehicle Emissions

During construction, vehicles and equipment will generate emissions. The EENF Certificate recommends compliance with MassDEP's Clean Air Construction Initiative and the Massachusetts Diesel Retrofit Program (MDRP). The 2008 MDRP guidance document defines measures to mitigate construction vehicle impacts, with requirements specific to the SRF program and recommendations for those projects reviewed by MEPA. As stated in this guidance document, project construction contracts must:

- Require contractors to install an emission control device on each piece of diesel construction equipment to reduce emissions, including a diesel oxidation catalyst (DOC) or diesel particulate filter (DPF). MassDEP's SRF program specifically requires that a verified DOC be installed on the equipment, meaning the device is proven to reduce emissions via standardized testing consistent with an EPA or California Air Resources Board (CARB) program;

- As of January 2010, require the use of ultra-low sulfur diesel (ULSD) fuel [sulfur content less than 15 parts per million (ppm)] in all diesel-fired construction equipment used on MEPA reviewed projects; and

- Prohibit motor vehicle engines from idling more than five minutes (in compliance with the Massachusetts 5-minute idle law, 310 CMR 7.11), unless the engine is being used to operate a lift or refrigeration unit.

It should be noted that as of January 1, 2008, MDRP retrofit requirements for the SRF program are applicable only for construction engines 50 or more horsepower (hp) and that will be used at least 30 days on the project site; however, retrofit recommendations for projects reviewed by MEPA are not limited to engines of a particular size. The SRF program requires that contractors fill out and file with MassDEP a formal Certification of equipment retrofits.

Consistent with these requirements, the contract documents will require the Contractor to comply with the MDRP by having all of the Contractor's off-road (non-registered) diesel vehicles and equipment used during construction equipped, or retrofitted, with after-engine emission controls that are EPA certified or their equivalent. Additionally, the Contractor will be required to use ULSD fuel in all off-road construction equipment, and the anti-idling law will be enforced at the construction sites.

17.3.5 Vegetation

- Outside of areas requiring earthwork for the construction of new facilities, the Contractor will not deface, injure, or destroy trees or shrubs, nor remove or cut them without prior approval. No ropes, cables, or guys will be fastened or attached to any existing nearby trees for anchorage unless specifically authorized by the Engineer. Where such special emergency use is permitted, the trunk will first be wrapped with a sufficient thickness of burlap or rags over which softwood cleats can be tied before rope, cable, or wire is placed. The Contractor will be responsible for any damage resulting from such use.

- Trees will be protected by placing boards, planks, or poles around them where they may possibly be defaced, bruised, injured, or otherwise damaged by the Contractor's operations.

- Any trees or other landscape feature scarred or damaged by the Contractor's equipment or operations will be restored as nearly as possible to its original condition.

- All scars made on trees by equipment, construction operations, or by the removal of limbs larger than 1-in in diameter will be coated as soon as possible with an approved tree wound dressing. All trimming or pruning will be performed in an approved manner by experienced workmen with saws or pruning shears.

- Clearing operations shall be conducted in a manner to prevent falling trees from damaging trees designated to remain.
- Trees that are to remain that are subsequently damaged by the Contractor and are beyond saving in the opinion of the Engineer will be removed and replaced.
- Areas outside easements or limits of clearing will be protected from damage and no equipment or materials shall be stored in these areas.
- All tree trunks, limbs, roots, stumps, brush, foliage, other vegetation and objectionable material will be removed from the site and disposed of in an approved manner.
- The Contractor will be responsible for placing sod, topsoil, fertilizer, seed, and mulch, and maintaining all seeded and sodded areas. Seeding will be required where grass existed prior to construction including all areas disturbed by installing service connections.
- Loam will be fertile, natural soil, typical of the locality, free from large stones, roots, sticks, clay, peat, weeds and sod and obtained from naturally well drained areas. It will not be excessively acid or alkaline nor contain toxic material harmful to plant growth. Stockpiled topsoil may be used where available.
- Seed will be from the same or previous year's crop; each variety of seed will have a percentage of germination not less than 90, a percentage of purity of not less than 85, and will have not more than one percent weed content and contain no noxious weed seed.
- The seed will be furnished and delivered premixed in the proportions specified above. Seed shall be delivered in accordance with USDA Rules and Regulations under the Federal Seed Act and applicable state seed laws.
- Mulch will be a specially processed cellulose fiber containing no growth or germination-inhibiting factors.
- Sod will be as grown by an established sod grower, as approved by the Engineer and will consist of the following grasses:

Botanical Name	Common Name	Percent
Poa pratensis	Kentucky Bluegrass	40-60
Festuca rubra	Fine Fescue	20-30
Lolium perenne	Perennial Ryegrass	20-30

- Sod will be vigorous, well rooted, healthy turf, free from insect pests, disease, weeds, other grasses, stones, bare spots, burned spots and any other harmful or deleterious matter. Sod shall be machine stripped at a uniform soil thickness of approximately 1 in and not less than 3/4 in.
- Loam shall be placed to a minimum depth of 6 inches. Where loam exists prior to construction in depths greater than 6 inches, it will be replaced to the full depth.

- The Contractor will keep all seeded areas watered and in good condition, reseeding if and when necessary until a good, healthy, uniform growth is established over the entire area seeded.

- On slopes, the Contractor will provide against washouts by an approved method. Any washout which occurs will be regraded and reseeded until a good sod is established.

17.3.6 Traffic and Public Safety

Maintenance of traffic and pedestrian access, especially between Memorial Day and Labor Day, will be an essential component of construction management for all work in Dennis. The Town will work with MassDOT to develop a plan for working within Route 28 and other major state roadways that satisfies the needs of both residents and tourists while complying with, or seeking exemptions from, MassDOT standard requirements for work in state roadways where necessary to complete the work in a timely fashion and limit inconveniences. In addition to these special considerations for work on major roads, the following measures will be required by the Contractor under each construction contract:

- Adequately safeguard all open excavations by providing temporary barricades, caution signs, lights and other means to prevent accidents to persons and damage to property. Provide suitable and safe bridges and other crossings for accommodating travel by pedestrians and workmen. The length or size of excavation will be controlled by the particular surrounding conditions, but will always be confined to the limits prescribed by the Engineer. If the excavation becomes a hazard, or if it excessively restricts traffic at any point, the Engineer may require special construction procedures such as limiting the length of the open trench or prohibiting stacking excavated material in the street.

- Take precautions to prevent injury to the public. Provide adequate light at all trenches, excavated material, equipment, or other obstacles, which could be dangerous to the public at night. Night watchmen may be required where special hazards exist, or police protection provided for traffic while work is in progress.

- Unless permission to close a street is received in writing from the Dennis Police Department, place all excavated material so that vehicular and pedestrian traffic may be maintained at all times. If the Contractor's operations cause traffic hazards, repair the road surface, provide temporary ways, erect wheel guards or fences, or take other measures for safety satisfactory to the Engineer.

- Detours around construction will be subject to the approval of the Engineer, the Dennis Police Department and MassDOT (for work on state roadways). Where detours are permitted, provide all necessary barricades and signs as required to divert the flow of traffic.

- Under each construction contract, the Contractor will submit a traffic management plan for review and approval prior to any work commencing within the right of way. This plan will include phased plans showing the setup, number, and width of open lanes and a schedule for approval by the Engineer. Any detours will also be shown.

- Expedite construction operations while traffic is detoured. Periods when traffic is being detoured will be strictly controlled by the Town.
- All streets not subject to special restrictions may be closed between 7:00 AM and 4:00 PM subject to the approval of the Dennis Police Department.
- Affected property owners must be notified by the Contractor 48 hours prior to road closures or any work that will interfere with access to their residences or places of business. Residents will be provided access to their properties at all times.
- Work on roads in the immediate vicinity of schools must be performed either during school summer vacation or during restricted hours, subject to the approval of the Town.
- Emergency vehicles and school buses will be provided access to all streets at all times.
- All streets shall be plated, as necessary, every night. No open excavations will be allowed after working hours.
- All traffic control work performed by the Contractor must be in accordance with the Manual on Uniform Traffic Control Devices (MUTCD).

17.3.7 Water Quality and Wetlands

Measures to protect water quality and wetlands in the vicinity of the construction areas include using appropriate dewatering procedures and sedimentation and erosion control BMPs. The Contractor's responsibilities as defined in the specifications for each construction contract will include the following items, broken down into regulatory and pre-construction provisions and other water quality and sedimentation/erosion prevention provisions.

Regulatory and Pre-Construction Provisions

- Necessary permits required for proper execution of the project will be obtained prior to commencement of work. A copy of each permit will be submitted to the Engineer.
- The Contractor will apply for and obtain a Construction General Permit from EPA pursuant to the National Pollutant Discharge Elimination System (NPDES) program. The permit requires preparing and submitting a Notice of Intent (NOI) for Storm Water Discharges and Notice of Termination Form and preparation of a Storm Water Pollution Prevention Plan (SWPPP).
- The Contractor will prepare an Erosion and Sedimentation Control Plan and submit to the Engineer for review and approval. Once approved by the Engineer, the Contractor will incorporate the Erosion and Sedimentation Control Plan into the SWPPP.
- The Contractor will update the Erosion and Sedimentation Control Plan and the SWPPP as necessary so that the documents are always current in accordance with the NPDES regulations and describe erosion and sediment control and storm water pollution prevention at all locations of construction and for all activities of construction.

- The requirements of any applicable Dennis Conservation Commission Order of Conditions will be followed. A preconstruction meeting will be held with the Conservation Agent.
- The Contractor will submit a dewatering plan for review and approval by the Conservation Commission prior to the start of work. The plan will include the methods and discharge points proposed to be used by the Contractor. The Contractor will be required to retain the services of a Professional Engineer registered in Massachusetts to prepare dewatering and drainage system designs and submittals.
- The Contractor will submit the location of proposed stockpile areas to the Conservation Commission for approval prior to the start of work.
- The Contractor will have a copy of the Order of Conditions and the approved SWPPP and Erosion and Sedimentation Control Plan on-site at all times.

Other Water Quality and Sedimentation/Erosion Prevention Provisions

- The Contractor will take sufficient precautions during construction to minimize the run off of polluting substances such as silt, clay, fuels, oils, bitumens and calcium chloride into the supplies and surface waters of the state. Special precautions will be taken in the use of construction equipment to prevent operations which promote erosion.
- Disposal of drainage will be in an area approved by the Town. Drainage will not be disposed of until silt and other sedimentary materials have been removed. Particular care will be taken to prevent the discharge of unsuitable drainage to a water supply, surface water body, or other resource area.
- Staked bales of hay and/or silt fence will be provided at points where drainage from the work site leaves the site, to reduce the sediment content of the water. Sufficient bales of hay will be provided such that all flow will filter through the hay. Other methods which reduce the sediment content to an equal or greater degree may be used as approved by the Engineer.
- When excavating in wetlands or floodplain, where no temporary diversion structure is required, excavated material will be placed on the uphill side of the trench so that the trench serves as a barrier between the excavated material and the wetland or floodplain.
- Erosion and sedimentation control will be installed prior to site preparation activities. The Contractor will be required to contact the Dennis Conservation Agent to inspect siltation controls prior to excavation.
- All work will be scheduled and conducted in a manner that will minimize the erosion of soils in the area of the work. Erosion control measures will be provided as required to prevent silting and muddying of streams, rivers, impoundments, lakes, etc.
- Offsite surface water will be diverted around the site, to a downstream channel ahead of siltation barriers. Ditches around construction areas will also be used to carry away water resulting from dewatering of excavated areas. At the completion of the work, ditches will be backfilled and the ground surface restored to original condition.

- Water that has been used for washing or processing, or that contains oils or sediments that will reduce the quality of the water in a surface water body, will not be directly returned to the water body. Such waters will be diverted through a settling basin or filter before being directed into water bodies.
- The Contractor will not discharge water from dewatering operations directly into any live or intermittent stream, channel, wetlands, surface water or any storm water. Water from dewatering operations will be treated by filtration, settling basins, or other approved method to reduce the amount of sediment contained in the water to allowable levels. Dewatering hose intakes will be kept off the bottom of the trench to minimize the pumping of silt.
- The Contractor will repair any damage caused by dewatering and drainage system operations.
- Existing or new sanitary sewers will not be used to dispose of drainage unless written permission is obtained from the Town.
- Crushed stone for sediment filtration devices, access ways and staging areas will conform to Mass Highway Department "Standards and Specifications for Highways and Bridges" Section M2.01.3.
- Hay bales will be placed around catch basins that discharge into wetlands, water supply or surface water bodies.
- Straw mulch will be utilized on all newly graded areas to protect areas against washouts and erosion.
- Silt fences will be positioned as necessary to prevent off site movement of sediment.
- Staging areas and access ways, which in the opinion of the Engineer will erode due to truck traffic, will be surfaced with a minimum depth of 4 in of crushed stone.
- The Contractor will visually inspect all sedimentation control devices once per week and promptly after every rainstorm. If such inspection reveals that additional measures are needed to prevent movement of sediment to offsite areas, the Contractor will promptly install additional devices as needed. Sediment controls in need of maintenance will be repaired promptly.
- Where silt fence is used, accumulated sediment will be removed once it builds up to 1/2 of the height of the fabric. Damaged fabric will be replaced or patched with a 2 ft minimum overlap. Other repairs will be made as necessary to ensure that the fence is filtering all runoff directed to the fence.
- In cross country areas, if applicable, brush and stumps will not be removed and the ground surface will not be disturbed until no more than one week prior to the start of pipe laying in that area.

- Loaming and seeding or mulching of cross-country areas will take place as soon after laying the pipeline as practicable.
- Temporary mulch will be applied to areas where rough grading has been completed but final grading is not anticipated to begin within 30 days.
- Once the site has been fully stabilized against erosion, sediment control devices and all accumulated silt will be removed and disposed of in a proper manner.
- All preventative measures will be taken to avoid the spillage of petroleum products and other pollutants. Routine vehicle and equipment maintenance and refueling will only occur in designated areas located more than 100-feet from wetland resource areas. At each staging area, spill clean-up equipment (shovels, brooms, absorbent pads and materials) will be maintained for use in the event of an accidental spill.
- All fuel, oil, solvents, etc. will be stored in original containers or in containers manufactured for storing such material that are clearly labeled as to the contents of the container. Fuel, oil and other potentially hazardous materials will be kept secured in a locked storage locker designed and properly vented for storing such material. Copies of Safety Data Sheets (formerly "MSDSs") for all applicable materials will be maintained at the construction site and will be readily accessible for employees or inspection officials.
- The Contractor will immediately clean up any and all spills of fuel, oil, or other potentially hazardous materials. Any and all reportable spills will be reported to the proper authorities (Dennis Fire Department, Board of Health, MassDEP, and others as applicable).

17.3.8 Materials Management, Construction Debris, Solid Waste and Recycling

Since the proposed project primarily involves the construction of new pipelines and facilities, limited demolition will be involved. The following requirements will be included in the specifications with regards to materials handling, storage, cleanup, and disposal, to mitigate environmental impacts:

- Provide for the flow of sewers, drains and water courses interrupted during the progress of the work, and immediately cart away and remove all offensive matter.
- During the course of the work, keep the site of operations in as clean and neat a condition as possible. Dispose of all residue resulting from the construction work and, at the conclusion of the work, remove and haul away any surplus excavation, broken pavement, lumber, equipment, temporary structures and any other refuse remaining from the construction operations and leave the entire site of the work in a neat and orderly condition.
- Excavated material will be segregated for use in backfilling provided the material meets the requirements for its intended use.
- It is expressly understood that no excavated material will be removed from the site of the work or disposed of, except as directed by the Engineer. When removal of surplus materials

has been approved by the Engineer, dispose of such surplus material in approved designated areas.

- Should conditions make it impracticable or unsafe to stack material adjacent to the trench, the material will be hauled and stored at a location provided. When required, it will be re handled and used in backfilling the trench.
- All debris and excess material will be disposed of in an environmentally sound manner. Dumping or disposal of debris or excess material in any stream corridors, any wetlands, any surface waters, any floodplains or at unspecified locations is prohibited. Discharging of solid waste deleterious to any public or private property not specified for said purpose is prohibited.
- Storing construction equipment and vehicles and/or stockpiling construction materials at locations not previously specified and approved by the Town for said purposes is prohibited.
- Dumping, disposing, or stockpiling of any material at any location within the Town of Dennis without approval of the Conservation Agent is prohibited.
- Burning at the project site for the disposal of refuse and debris or cleared and grubbed materials will not be permitted.
- All pieces of ledge and boulders which are not suitable for use in other parts of the work will be removed and disposed of in an approved manner.
- Surplus imported fill will be removed and disposed off site.
- The Contractor will either be, or employ the services of a Subcontractor, who is licensed in the Commonwealth of Massachusetts to perform asbestos abatement where applicable. All work associated with the handling of asbestos cement pipe will be conducted only by the licensed party.

17.3.9 Management of Hazardous Materials

The following mitigation measures will be employed to address potential impacts associated with subsurface contamination throughout the project area and will be included in the contract specifications:

- Excavated materials will be managed in accordance with applicable Massachusetts Contingency Plan (MCP) requirements. These provisions include identification of contaminated materials, segregation, proper stockpiling or containment, and sampling and analysis to determine the appropriate facility for reuse, recycling, or disposal of these materials.
- Dewatering discharges will be managed in accordance with MCP requirements, including identification of contaminated groundwater, proper containment and pretreatment, and required sampling and analysis.

- The Contractor will submit a Hazardous Material Health and Safety Plan detailing procedures and protocols to protect workers and the general public from potential hazards during the construction work.
- The Contractor will submit an Emergency Response Plan detailing procedures to address the discovery of hazardous materials that could pose an imminent hazard to workers and the public, and procedures to address emergencies that involve fires and/or explosions.
- Hazardous materials management activities will be conducted under the supervision of a Licensed Site Professional (LSP) in accordance with MCP Utility-Related Abatement Measure or Immediate Response Action provisions, as appropriate.

17.4 Coordination with Local Agencies

Construction of the CWMP Recommended Program will include extensive coordination with local agencies throughout each construction contract. Each contractor will be required to supply the Dennis Police Department, Fire Department, School Department, Conservation Commission, Water Department, and Public Works Department with the following information:

1. A list of streets and intersections where work will be in progress to be supplied at intervals as required by the Engineer.
2. Areas where approved detours are in effect.
3. Immediate notification of any drain, gas, buried electric or water main breaks.
4. A list of after-hours telephone numbers by which appropriate Contractor personnel may be contacted in the event of emergencies.

Section 18

Draft Section 61 Findings

18.1 Introduction

These Section 61 Findings for the Dennis CWMP/SEIR were prepared to comply with the requirements of Massachusetts General Laws Chapter 30, Section 61. Pursuant to M.G.L. c.30 s.61, any determination made by an agency of the Commonwealth must include a finding describing the environmental impact, if any, of the project and a finding that all feasible measures have been taken to avoid or minimize said impact. Such environmental impacts include, but are not limited to*: "air pollution, water pollution, improper sewage disposal, pesticide pollution, excessive noise, improper operation of dumping grounds, reduction of groundwater levels, impairment of water quality, increases in flooding or stormwater flows, impairment and eutrophication of rivers, streams, flood plains, lakes, ponds, or other surface or subsurface water resources, destruction of seashores, dunes, marine resources, underwater archaeological resources, wetlands, open spaces, natural areas, parks, or historic districts or sites."*

These findings address the activities necessary to implement the Dennis CWMP Recommended Program, including both temporary (construction phase) and permanent impacts.

18.2 Project Schedule

The Recommended Program includes eight construction phases, to take place over the next 40 years. includes construction of the initial Dennis wastewater treatment facility (WWTF) and at least one effluent recharge area potentially with a permeable reactive barriers (PRB) which will allow the Town to construct phases 1 through 3 of the wastewater collection system. Phase 4 will include an expansion to the WWTF along with the additional effluent recharge areas potentially with PRBs to bring Phases 4 through 8 online. All other phases involve a combination of new sewer and pumping stations, continued monitoring of the results from previous phases, and additional smaller projects to meet the ultimate water quality goals of the CWMP. Each phase will commence approximately five years following the completion of the previous phase.

18.3 Summary of These Section 61 Findings

These Section 61 Findings provide an overview of the mitigation program for implementation of the CWMP, describing measures to avoid, minimize, and/or mitigate identified impacts to the maximum extent practicable. The Town is recommending a traditional wastewater program that includes approximately 92 miles of sewer pipes, 21 pumping stations and one centralized treatment facility. Other than the effluent recharge areas, most of the construction will occur within previously disturbed areas in existing roadways, some pumping stations will be outside of town and state roads. Careful layout of facilities was conducted to minimize impacts to the environment. Most impacts are construction-related and temporary. The most significant post-

construction impact is beneficial – reducing nitrogen loading to protect and restore the coastal environment by meeting Total Maximum Daily Load (TMDL) limit and protecting public health by providing sewer service and enhanced wastewater treatment.

- Mitigation measures for the project were developed and incorporated into the draft Construction Management Plan provided in Section 17. Additional mitigation measures are also described herein that pertain to the potential long-term impacts of the proposed facilities. The mitigation measures described in these findings are split into the following broad areas of concern:
- General Environmental Protection
  - Resiliency
  - Climate Change
- Land Disturbance
- Noise and Vibration
- Air Quality and Dust
  - Vehicle emissions
  - Greenhouse Gas Emissions
- Vegetation
- Traffic and Public Safety
- Water Quality, Wetlands and Vernal Pools
- Significant Historical or Archaeological Resources
- Materials Management, Construction Debris, Solid Waste and Recycling
- Management of Hazardous Materials

18.4 Mitigation Measures

18-1 Mitigation Measures

Mitigation Measure	Responsibility/Applicability
General Environmental Protection	
The Contractor will be required to comply with all applicable federal, state and local laws and regulations concerning environmental pollution control and abatement.	Town, Design Engineers, and Construction Contractors
The Contractor will be notified in writing of any non-compliance of environmentally objectionable acts. After receipt of such notice, the Contractor will be required to take corrective action. If the Contractor fails or refuses to comply promptly, the Town may issue an order stopping all or part of the work until satisfactory corrective action has been taken.	Construction Contractor
Prior to commencement of the work, the Contractor will meet with the Town to develop mutual understandings relative to compliance with these provisions and administration of the environmental pollution control programs.	Construction Contractor, Town
Throughout the performance of the work required, the Contractor will be subject to environmental inspections of his/her equipment, routine daily operations and environmental protection procedures.	Construction Contractors and Resident Engineers/ Inspectors
At the completion of the work, a joint final field inspection will be made by the Town and the Contractor.	Town, Construction Contractors and Resident Engineers
The Contractor will not be permitted to use procedures, activities, or operations that may adversely impact the natural environment to the extent practicable or the public health and safety.	Construction Contractors
For the duration of each contract, facilities constructed for pollution control will be maintained as long as the operations creating the particular pollutant are being carried out or until the material concerned has become stabilized to the extent that pollution is no longer being created.	Town
Structures and pipelines will be designed to minimize impacts to environmental resources wherever feasible.	Design Engineers
The town plans to adopt land use controls to limit growth by requiring a property to meet Title 5 requirements before it can be further developed, regardless of whether it is served by municipal sewer or an on-site septic system. This type of land use control will prevent existing unbuildable lots from becoming buildable as a result of new sewer service.	Town

Mitigation Measure	Responsibility/Applicability
Scaled project plans will be submitted to MHC for a review of potential impacts to historical and archaeological resources during design of each project phase for the "preferred alternative wastewater treatment plant location(s), recharge areas, pumping stations, equipment storage and materials staging areas and cross-country sewer right-of-ways." In addition, as requested by MHC, the Inventory of Historic and Archaeological Assets of the Commonwealth will be consulted during each project design phase to identify any cultural resources that may be affected by the construction or operation of the project.	Design Engineers
Resiliency	
Following the completion of project phases, such aspects as water quality, groundwater elevations and impacts to coastal embayments will be reviewed. At this time, adjustments to the CWMP will be made to address those aspects accordingly, while also working the Massachusetts Department of Environmental protection (MassDEP) and the Cape Code Commission (CCC).	Design Engineers, Town
Climate Change	
Develop comprehensive land use plans to address protection, preservation and restoration of local beaches and coastal wetlands, including the use of protective best management practices (BMPs) and engineering controls.	To be considered in final design
The following areas of environmental regulation and permitting could be strengthened or created to address protection of beaches and coastal wetlands: Ecological buffers; Protection of headwater streams and associated buffer areas by focusing on land use acquisition and conservation restrictions in applicable areas; Protect and maintain natural stream flow.	To be considered in final design
Continue with regular comprehensive beach and coastal monitoring to be able to track how the areas are changing and being impacted by natural and manmade conditions.	To be considered in final design
The following measures can be taken to protect against negative impacts to both shoreline residential and commercial infrastructure development: Similar to beach and wetland protection, devise land use planning BMPs and tools to account for sea level rise and climate change;	To be considered in final design

Mitigation Measure	Responsibility/Applicability
Prioritize protecting those locations that are the most susceptible to detrimental effect of climate change and potentially eliminate future development in those areas; Devise or revise building codes and require that coastal property insurance include provisions that account for climate change; Devise economic incentives for developers to use sustainable building practices when choosing sites to construct new developments in, which account for climate change including sea level rise.	
Land Disturbance	
The Contractor will not be permitted to enter or occupy private land outside of easements, except by written permission of the landowner and the Town.	Construction Contractors
The Contractor will be responsible for the preservation of all public and private property and must use every precaution necessary to prevent damage thereto, to the extent practicable. If direct or indirect damage is done to public or private property by or on account of any act, omission, neglect, or misconduct in the execution of the work on the part of the Contractor, the Contractor will be required to restore such property to a condition similar or equal to that existing before the damage was done.	Construction Contractors
No work will be permitted within permanent easements which may be required for pumping stations until written authorization is provided by the Town.	Construction Contractors
Work areas will be restored to conditions that existed prior to construction. Land resources within the project boundaries and outside the limits of permanent work will be restored to a condition, after completion of construction that will appear to be natural and not detract from the appearance of the project. All construction activities will be confined to areas shown on the contract drawings.	Construction Contractors
The locations of the Contractor's storage and temporary buildings will be cleared portions of the job site and will require written approval of the Engineer. These sites will not be within wetlands or floodplains. The preservation of the landscape will be a consideration in the selection of all such sites.	Construction Contractors
All signs of temporary construction facilities such as haul roads, work areas, structures, stockpiles of excess or waste materials, or any other	Construction Contractors

Mitigation Measure	Responsibility/Applicability
vestiges of construction will be removed by the Contractor.	
All areas disturbed by the installation and removal of groundwater control systems and observation wells will be restored to their original condition.	Construction Contractors
The Contractor will assume full responsibility for the protection of all buildings, structures, pavement, sidewalks, curbing, driveway aprons, fencing, landscaping, and utilities, public or private, including poles, signs, services to buildings, utilities in the street, gas pipes, water pipes, hydrants, sewers, drains and electric and telephone cables, whether or not they are shown on the contract drawings. If necessary, curbing, driveway aprons and fencing will be removed and restored or replaced after backfilling. All existing facilities damaged by the construction will be promptly replaced with material equal to that existing prior to construction to the satisfaction of the Town.	Construction Contractors
Topsoil will be stripped, stockpiled, and reused from grassed areas crossed by trenches. At the Contractor's option, topsoil may be otherwise disposed of and replaced, when required, with approved topsoil of equal quality.	Construction Contractors
When designing and laying out facilities, clearing and grading and alteration of natural topography will be minimized.	Design Engineers
During the design of each phase of the project, detailed construction plans will be provided to the Natural Heritage and Endangered Species Program to confirm the exemption status or indicate the need for further NHESP review.	Design Engineers
Noise and Vibration	
The Contractor will be required to make every effort to minimize noises caused by the operations. Equipment will be equipped with silencers or mufflers designed to operate with the least possible noise level in compliance with state and federal regulations and Town of Dennis regulations, whichever are more stringent.	Construction Contractors
During construction, the following measures will be used to control noise: 1) loud pieces of equipment will be substituted with quieter equipment, 2) effective intake and exhaust mufflers will be used on internal combustion engines, and 3) truck loading, unloading, and hauling operations will be conducted in a manner that keeps noise and vibration to a minimum.	Construction Contractors
Effective intake and exhaust mufflers must be used on internal combustion engines.	Construction Contractors

Mitigation Measure	Responsibility/Applicability
All equipment to be installed, unless specified otherwise in the Technical Specifications, will be designed to insure that the sound pressure level does not exceed 85 decibels over a frequency range of 37.8 to 9600 cycles per second at a distance of three feet from any portion of the equipment, under any load condition, when tested using standard equipment and methods. Noise levels will include the noise from the motor. Mufflers or external baffles will not be acceptable for the purpose of reducing post-construction noise. Outdoor equipment at the pumps stations is anticipated to be limited to odor control fans and the standby generator, which will be located within an enclosure.	Design Engineers
Air Quality and Dust	
The Contractor will perform dust control operations, in an approved manner, whenever a nuisance or hazard occurs or when directed by the Engineer, even though other work on the project may be suspended.	Construction Contractors
Methods of controlling dust will meet all air pollutant standards as set forth by federal and state regulatory agencies.	Construction Contractors
All road surfaces will be broomed clean after backfilling.	Construction Contractors
Paved streets adjacent to work areas will be swept regularly.	Construction Contractors
Dump trucks will be covered with tarpaulins and have tightly fitting tailgates.	Construction Contractors
The Contractor will be required to maintain all excavations, embankments, stockpiles, access roads, plant sites, waste areas, borrow areas, and all other work areas within or outside the project boundaries free from dust which could cause the standards for air pollution to be exceeded, and which would cause a hazard or nuisance to others.	Construction Contractors
Dust control will be generally accomplished by the use of water. An approved method of stabilization consisting of sprinkling or other similar methods will be permitted. Calcium chloride may be used if permitted by the Engineer and the Town. The use of petroleum products is prohibited.	Construction Contractors
Sprinkling will be repeated at such intervals as to keep all parts of the disturbed area at least damp, and the Contractor must have sufficient competent equipment on the job to accomplish this if sprinkling is used.	Construction Contractors

Mitigation Measure	Responsibility/Applicability
Where necessary, carbon filters will be installed at the pumping stations to control odors.	Design Engineers
Vehicle Emissions	
Install an emission control device on each piece of diesel construction equipment to reduce emissions, including a diesel oxidation catalyst (DOC) or diesel particulate filter (DPF). Requires that a verified DOC be installed on the equipment.	Construction Contractors
Ultra-low sulfur diesel (ULSD) fuel [sulfur content less than 15 parts per million (ppm)] in all diesel-fired construction equipment.	Construction Contractors
Prohibit motor vehicle engines from idling more than five minutes (in compliance with the Massachusetts 5-minute idle law, 310 CMR 7.11), unless the engine is being used to operate a lift or refrigeration unit.	Construction Contractors
Contractors will be required to comply with the Massachusetts Diesel Retrofit Program and the Clean Construction Initiative. These provisions will be included in construction specifications.	Design Engineers
Greenhouse Gas Emissions	
Demonstrate new tree planting	To be incorporated into pumping station design
Minimize building footprint	The pumping station building footprints will be minimized
Minimize energy use through proper building orientation and use of appropriate landscaping (e.g. trees for shading parking lots or southern facing facades)	To be incorporated into final design
Building Design, Construction, and Operation	
Building Envelope	
Improve building envelope through higher R-value insulation in walls, roof, and if appropriate, basement walls and ceiling	To be incorporated into final pumping station design
Maximize the thermal mass of walls, roofs and floor to provide thermal damping	To be incorporated into final pumping station design
Conduct inspection and comprehensive air sealing of building envelope to minimize air leakage	To be incorporated into final pumping station design
Install lower U-value windows to improve envelope performance	To be incorporated into final pumping station design
Incorporate window glazing to balance and optimize daylighting, heat loss and solar heat gain performance	To be incorporated into final pumping station design
Design roofs at a minimum to be solar-ready	To be considered during final design
Construct green roofs to reduce heat load on roof, further insulate, and retain/filter rainwater	To be considered during final design

Mitigation Measure	Responsibility/Applicability
Evaluate use of high-albedo roofing materials to reduce heat absorption	To be incorporated into final design
Maximize interior daylighting through floor plates, and use of skylights, celestories and light wells	To be considered during final design
Consider a Net Zero building design	To be considered during final design
Participate in Energy Star for New Homes or U.S. Green Building Council (USGBC) Leadership in Energy and Environmental Design (LEED) for Homes	Energy Star appliances will be used wherever possible
Building Mechanical Systems and Lighting	
Prevent over-sizing of HVAC or other equipment by sizing only after efficiency measures have been incorporated to reduce Heating, Ventilating, and Air Conditioning (HVAC), lighting and other electrical loads	To be incorporated into final pumping station design
Install high-efficiency HVAC systems and premium efficiency motors	To be incorporated into final pumping station design
Eliminate or reduce use of refrigerants in HVAC systems	To be considered during final design
Use demand control ventilation	To be incorporated into final pumping station design
Use energy efficient boilers, heaters, furnaces, incinerators, or generators	To be incorporated into final pumping station design
Seal and leak-check all supply air ductwork	To be incorporated into final pumping station design
Incorporate motion sensors into lighting, daylighting, and climate controls	To be incorporated into final pumping station design
Use efficient, directed exterior lighting, such as LED technology	To be incorporated into final pumping station design
Install high efficiency lighting, including compact fluorescent lamps (CFLs) and LED technology as appropriate	To be incorporated into final pumping station design
Provide automated energy management control system with the capacity to: Adjust and maintain set points and schedules Indicate alarms and problems Provide information on trends and operating history Operate mechanical and lighting systems to minimize overall energy usage	To be incorporated into final pumping station design
Distributed Generation (On-Site)	
Incorporate appropriate on-site renewable energy systems into project	Wind or solar energy to be utilized
Water Conservation	
Re-use gray water and/or collect and re-use rainwater for landscaping and other non-potable uses	To be considered during final design

Mitigation Measure	Responsibility/Applicability
Plant only native species that need minimal watering and/or use xeriscaping	To be incorporated into final pumping station design
Develop a water management plan	Plant water (treated effluent) will be used in place of potable water wherever feasible
Consider participation in EPA's WaterSense Program	WaterSense fixtures will be used wherever possible
Materials	
Use building materials with recycled content	To be considered during final design
Use building materials that are extracted and/or manufactured within the region	To be considered during final design
Use rapidly renewable building materials	To be considered during final design
Use wood that is certified in accordance with the Forestry Stewardship Council's Principles and Criteria	To be considered during final design
Use low volatile organic compound (VOC) adhesives, sealants, paints, carpets, and wood	To be incorporated into final pumping station design
Energy Information (Data Acquisition)	
Track energy performance of building and develop strategy to maintain efficiency	To be incorporated into final pumping station design
Install sub-meters on all floors and/or departments and/or for each specific tenant space	To be incorporated into final pumping station design
Provide energy information systems to promote energy awareness to occupants	To be incorporated into final pumping station design
Conduct 3rd party building commissioning to ensure energy performance	To be considered during final design
Ongoing Operations	
Purchase and install Energy Star-rated appliances that are the lowest energy rating	To be considered during final design. All appliances will be EnergyStar certified
Reduce energy demand using peak shaving or load shifting strategies – if applicable, enroll in demand response program with the International Organization for Standardization (ISO)-New England	To be incorporated into final pumping station design
Purchase green power	To be considered during final design
Other Industrial Process Systems and/or Facilities	
Evaluate process alternatives and select the least energy intensive option	To be incorporated into final pumping station design
Specify and procure most efficient equipment	To be incorporated into final pumping station design
Include sufficient metering and controls for real-time monitoring and optimization of the process operations	To be incorporated into final pumping station design
Construction Period Emissions	
Participate in MassDEP's Clean Air Construction Initiative	Incorporated into draft construction documents

Mitigation Measure	Responsibility/Applicability
Implement a construction waste management plan	To be incorporated into construction documents
Implement and enforce no-idling policies	Incorporated into draft construction documents
Incentivize use of public transportation, car/vanpools, for construction workers to reduce vehicle trips	To be incorporated into construction documents
Mobile Source Emissions	
Purchase alternative fuel and/or fuel efficient vehicles for fleet, including maintenance or operation vehicles on-site	To be considered during final design
Roadway Improvements to improve traffic flow and reduce vehicle congestion	Traffic improvements will be considered during sewer design
Make on- and off-site improvements to reduce vehicle miles traveled (VMT) including sidewalks, paths, traffic signals, bus shelters, lighting and landscaping	To be considered during final design
Implement idle reduction policies	To be incorporated in construction documents
Provide electric vehicle charging infrastructure	To be considered during final design
Vegetation	
Outside of areas requiring earthwork for the construction of new facilities, the Contractor will not deface, injure, or destroy trees or shrubs, nor remove or cut them without prior approval. No ropes, cables, or guys will be fastened or attached to any existing nearby trees for anchorage unless specifically authorized by the Engineer. Where such special emergency use is permitted, the trunk will first be wrapped with a sufficient thickness of burlap or rags over which softwood cleats can be tied before rope, cable, or wire is placed. The Contractor will be responsible for any damage resulting from such use.	Construction Contractors
Trees will be protected by placing boards, planks, or poles around them where they may possibly be defaced, bruised, injured, or otherwise damaged by the Contractor's operations.	Construction Contractors
Any trees or other landscape feature scarred or damaged by the Contractor's equipment or operations will be restored as nearly as possible to its original condition.	Construction Contractors
Any trees or other landscape feature scarred or damaged by the Contractor's equipment or operations will be restored as nearly as possible to its original condition.	Construction Contractors
All scars made on trees by equipment, construction operations, or by the removal of limbs larger than 1-in in diameter will be coated as soon as possible with an approved tree wound dressing. All trimming or pruning will be performed in an approved manner by	Construction Contractors

Mitigation Measure	Responsibility/Applicability
experienced workmen with saws or pruning shears.	
Clearing operations shall be conducted in a manner to prevent falling trees from damaging trees designated to remain.	Construction Contractors
Trees that are to remain that are subsequently damaged by the Contractor and are beyond saving in the opinion of the Engineer will be removed and replaced.	Construction Contractors, Resident Engineers
Areas outside easements or limits of clearing will be protected from damage and no equipment or materials shall be stored in these areas.	Construction Contractors
All tree trunks, limbs, roots, stumps, brush, foliage, other vegetation and objectionable material will be removed from the site and disposed of in an approved manner.	Construction Contractors
The Contractor will be responsible for placing sod, topsoil, fertilizer, seed, and mulch, and maintaining all seeded and sodded areas. Seeding will be required where grass existed prior to construction including all areas disturbed by installing service connections.	Construction Contractors
Loam will be fertile, natural soil, typical of the locality, free from large stones, roots, sticks, clay, peat, weeds and sod and obtained from naturally well drained areas. It will not be excessively acid or alkaline nor contain toxic material harmful to plant growth. Stockpiled topsoil may be used where available.	Construction Contractors
Seed will be from the same or previous year's crop; each variety of seed will have a percentage of germination not less than 90, a percentage of purity of not less than 85, and will have not more than one percent weed content and contain no noxious weed seed.	Construction Contractors
The seed will be furnished and delivered premixed in the proportions specified above. Seed shall be delivered in accordance with USDA Rules and Regulations under the Federal Seed Act and applicable state seed laws.	Construction Contractors
Mulch will be a specially processed cellulose fiber containing no growth or germination-inhibiting factors.	Construction Contractors
Sod will be as grown by an established sod grower, as approved by the Engineer and will consist of the following grasses:	Construction Contractors, Resident Engineers
Sod will be vigorous, well rooted, healthy turf, free from insect pests, disease, weeds, other grasses, stones, bare spots, burned spots and any other harmful or deleterious matter. Sod shall be	Construction Contractors

Mitigation Measure	Responsibility/Applicability
machine stripped at a uniform soil thickness of approximately 1 in and not less than 3/4 in.	
Loam shall be placed to a minimum depth of 6 inches. Where loam exists prior to construction in depths greater than 6 inches, it will be replaced to the full depth.	Construction Contractors
The Contractor will keep all seeded areas watered and in good condition, reseeding if and when necessary until a good, healthy, uniform growth is established over the entire area seeded.	Construction Contractors
On slopes, the Contractor will provide against washouts by an approved method. Any washout which occurs will be regraded and reseeded until a good sod is established.	Construction Contractors
Topsoil stripped from construction areas will be segregated from subsoils. Topsoil will be stockpiled in approved areas and reused onsite.	Construction Contractors
In sections where a pipeline passes through grassed areas, the disturbed area will be loamed and seeded.	Construction Contractors
Traffic and Public Safety	
Adequately safeguard all open excavations by providing temporary barricades, caution signs, lights and other means to prevent accidents to persons and damage to property. Provide suitable and safe bridges and other crossings for accommodating travel by pedestrians and workmen. The length or size of excavation will be controlled by the particular surrounding conditions, but will always be confined to the limits prescribed by the Engineer. If the excavation becomes a hazard, or if it excessively restricts traffic at any point, the Engineer may require special construction procedures such as limiting the length of the open trench or prohibiting stacking excavated material in the street.	Construction Contractors
Take precautions to prevent injury to the public. Provide adequate light at all trenches, excavated material, equipment, or other obstacles, which could be dangerous to the public at night. Night watchmen may be required where special hazards exist, or police protection provided for traffic while work is in progress.	Construction Contractors
Unless permission to close a street is received in writing from the Dennis Police Department, place all excavated material so that vehicular and pedestrian traffic may be maintained at all times. If the Contractor's operations cause traffic hazards, repair the road surface, provide temporary ways, erect wheel guards or fences, or	Construction Contractors

Mitigation Measure	Responsibility/Applicability
take other measures for safety satisfactory to the Engineer.	
Detours around construction will be subject to the approval of the Engineer, the Dennis Police Department and MassDOT (for work on state roadways). Where detours are permitted, provide all necessary barricades and signs as required to divert the flow of traffic.	Town, Design Engineers
Under each construction contract, the Contractor will submit a traffic management plan for review and approval prior to any work commencing within the right of way. This plan will include phased plans showing the setup, number, and width of open lanes and a schedule for approval by the Engineer. Any detours will also be shown.	Construction Contractors
Expedite construction operations while traffic is detoured. Periods when traffic is being detoured will be strictly controlled by the Town.	Construction Contractors, Town
All streets not subject to special restrictions may be closed between 7:00 AM and 4:00 PM subject to the approval of the Dennis Police Department.	Construction Contractors
Affected property owners must be notified by the Contractor 48 hours prior to road closures or any work that will interfere with access to their residences or places of business. Residents will be provided access to their properties at all times.	Construction Contractors
Work on roads in the immediate vicinity of schools must be performed either during school summer vacation or during restricted hours, subject to the approval of the Town.	Construction Contractors
Emergency vehicles and school buses will be provided access to all streets at all times.	Construction Contractors
All streets shall be plated, as necessary, every night. No open excavations will be allowed after working hours.	Construction Contractors
All traffic control work performed by the Contractor must be in accordance with the Manual on Uniform Traffic Control Devices (MUTCD).	Construction Contractors
Traffic and pedestrian access will be maintained on Route 28 during construction between Memorial Day and Labor Day.	Design Engineers and Construction Contractors
The Town will work with MassDOT to develop a plan for working within Route 28 that satisfies the needs of both residents and tourists while complying with, or seeking exemptions from, MassDOT standard requirements for work in state roadways.	Town, Design Engineers
No open excavations on roadways will be allowed after working hours.	Construction Contractors

Mitigation Measure	Responsibility/Applicability
Water Quality, Wetlands and Vernal Pools	
Necessary permits required for proper execution of the project will be obtained prior to commencement of work. A copy of each permit will be submitted to the Engineer.	Town, Design Engineers, Construction Contractors
The Contractor will apply for and obtain a Construction General Permit from EPA pursuant to the National Pollutant Discharge Elimination System (NPDES) program. The permit requires preparing and submitting a Notice of Intent (NOI) for Storm Water Discharges and Notice of Termination Form and preparation of a Storm Water Pollution Prevention Plan (SWPPP).	Construction Contractors
The Contractor will prepare an Erosion and Sedimentation Control Plan and submit to the Engineer for review and approval. Once approved by the Engineer, the Contractor will incorporate the Erosion and Sedimentation Control Plan into the SWPPP.	Construction Contractors
The Contractor will update the Erosion and Sedimentation Control Plan and the SWPPP as necessary so that the documents are always current in accordance with the NPDES regulations and describe erosion and sediment control and storm water pollution prevention at all locations of construction and for all activities of construction.	Construction Contractors
The requirements of any applicable Dennis Conservation Commission Order of Conditions will be followed. A preconstruction meeting will be held with the Conservation Agent.	Town, Design Engineers, Construction Contractors
The Contractor will submit a dewatering plan for review and approval by the Conservation Commission prior to the start of work. The plan will include the methods and discharge points proposed to be used by the Contractor. The Contractor will be required to retain the services of a Professional Engineer registered in Massachusetts to prepare dewatering and drainage system designs and submittals.	Construction Contractors
The Contractor will submit the location of proposed stockpile areas to the Conservation Commission for approval prior to the start of work.	Construction Contractors
The Contractor will have a copy of the Order of Conditions and the approved SWPPP and Erosion and Sedimentation Control Plan on-site at all times.	Construction Contractors
The Contractor will take sufficient precautions during construction to minimize the run off of polluting substances such as silt, clay, fuels, oils, bitumens and calcium chloride into the supplies	Construction Contractors

Mitigation Measure	Responsibility/Applicability
and surface waters of the state. Special precautions will be taken in the use of construction equipment to prevent operations which promote erosion.	
Disposal of drainage will be in an area approved by the Town. Drainage will not be disposed of until silt and other sedimentary materials have been removed. Particular care will be taken to prevent the discharge of unsuitable drainage to a water supply, surface water body, or other resource area.	Construction Contractors
Staked compost logs will be provided at points where drainage from the work site leaves the site, to reduce the sediment content of the water. Sufficient compost logs will be provided such that all flow will filter through the hay. Other methods which reduce the sediment content to an equal or greater degree may be used as approved by the Engineer.	Construction Contractors
When excavating in wetlands or floodplain, where no temporary diversion structure is required, excavated material will be placed on the uphill side of the trench so that the trench serves as a barrier between the excavated material and the wetland or floodplain.	Construction Contractors
Erosion and sedimentation control will be installed prior to site preparation activities. The Contractor will be required to contact the Dennis Conservation Agent to inspect siltation controls prior to excavation.	Construction Contractors
All work will be scheduled and conducted in a manner that will minimize the erosion of soils in the area of the work. Erosion control measures will be provided as required to prevent silting and muddying of streams, rivers, impoundments, lakes, etc.	Construction Contractors
Offsite surface water will be diverted around the site, to a downstream channel ahead of siltation barriers. Ditches around construction areas will also be used to carry away water resulting from dewatering of excavated areas. At the completion of the work, ditches will be backfilled and the ground surface restored to original condition.	Construction Contractors
Water that has been used for washing or processing, or that contains oils or sediments that will reduce the quality of the water in a surface water body, will not be directly returned to the water body. Such waters will be diverted through a settling basin or filter before being directed into water bodies.	Construction Contractors
The Contractor will not discharge water from dewatering operations directly into any live or intermittent stream, channel, wetlands, surface	Construction Contractors

Mitigation Measure	Responsibility/Applicability
water or any storm water. Water from dewatering operations will be treated by filtration, settling basins, or other approved method to reduce the amount of sediment contained in the water to allowable levels. Dewatering hose intakes will be kept off the bottom of the trench to minimize the pumping of silt.	
The Contractor will repair any damage caused by dewatering and drainage system operations.	Construction Contractors
Existing or new sanitary sewers will not be used to dispose of drainage unless written permission is obtained from the Town.	Construction Contractors
Crushed stone for sediment filtration devices, access ways and staging areas will conform to Mass Highway Department "Standards and Specifications for Highways and Bridges" Section M2.01.3.	Construction Contractors
Filter bags will be placed in catch basins that discharge into wetlands, water supply or surface water bodies.	Construction Contractors
Straw mulch will be utilized on all newly graded areas to protect areas against washouts and erosion.	Construction Contractors
Silt fences will be positioned as necessary to prevent off site movement of sediment.	Construction Contractors
Staging areas and access ways, which in the opinion of the Engineer will erode due to truck traffic, will be surfaced with a minimum depth of 4 in of crushed stone.	Construction Contractors, Resident Engineers
The Contractor will visually inspect all sedimentation control devices once per week and promptly after every rainstorm. If such inspection reveals that additional measures are needed to prevent movement of sediment to offsite areas, the Contractor will promptly install additional devices as needed. Sediment controls in need of maintenance will be repaired promptly.	Construction Contractors
Where silt fence is used, accumulated sediment will be removed once it builds up to 1/2 of the height of the fabric. Damaged fabric will be replaced or patched with a 2 ft minimum overlap. Other repairs will be made as necessary to ensure that the fence is filtering all runoff directed to the fence.	Construction Contractors
In cross country areas, if applicable, brush and stumps will not be removed and the ground surface will not be disturbed until no more than one week prior to the start of pipe laying in that area.	Construction Contractors

Mitigation Measure	Responsibility/Applicability
Loaming and seeding or mulching of cross-country areas will take place as soon after laying the pipeline as practicable.	Construction Contractors
Temporary mulch will be applied to areas where rough grading has been completed but final grading is not anticipated to begin within 30 days.	Construction Contractors
Once the site has been fully stabilized against erosion, sediment control devices and all accumulated silt will be removed and disposed of in a proper manner.	Construction Contractors
All preventative measures will be taken to avoid the spillage of petroleum products and other pollutants. Routine vehicle and equipment maintenance and refueling will only occur in designated areas located more than 100-feet from wetland resource areas. At each staging area, spill clean-up equipment (shovels, brooms, absorbent pads and materials) will be maintained for use in the event of an accidental spill.	Construction Contractors
All fuel, oil, solvents, etc. will be stored in original containers or in containers manufactured for storing such material that are clearly labeled as to the contents of the container. Fuel, oil and other potentially hazardous materials will be kept secured in a locked storage locker designed and properly vented for storing such material. Copies of Safety Data Sheets (formerly "MSDSs") for all applicable materials will be maintained at the construction site and will be readily accessible for employees or inspection officials.	Construction Contractors
The Contractor will immediately clean up any and all spills of fuel, oil, or other potentially hazardous materials. Any and all reportable spills will be reported to the proper authorities (Dennis Fire Department, Board of Health, MassDEP, and others as applicable).	Construction Contractors
Wherever feasible, wetland resource areas and associated buffer zones were avoided when laying out the project. The majority of work will take place within roadways.	Design Engineers
The criteria for pumping station siting included avoiding floodplain areas wherever possible. During the design of each construction phase, pumping station siting will be refined, and avoiding LSCSF to the maximum extent feasible will continue to be a primary goal.	Design Engineers
Any permanent structures constructed as part of the project in areas requiring review of the Dennis Conservation Commission, including the proposed wastewater treatment plant, will be designed to comply with MassDEP's Stormwater Management Standards.	Design Engineers

Mitigation Measure	Responsibility/Applicability
Stormwater BMPs are not permissible within 100 feet of vernal pool habitat	Design Engineers
Design the effluent recharge basins to avoid permanent impacts to certified vernal pools	Design Engineers
Cultural Resources	
Conduct detailed site investigations and/or data recovery where impacts to archaeological resources are unavoidable	Design Engineers
Materials Management, Construction Debris, Solid Waste and Recycling	
Provide for the flow of sewers, drains and water courses interrupted during the progress of the work, and immediately cart away and remove all offensive matter.	Construction Contractors
During the course of the work, keep the site of operations in as clean and neat a condition as possible. Dispose of all residue resulting from the construction work and, at the conclusion of the work, remove and haul away any surplus excavation, broken pavement, lumber, equipment, temporary structures and any other refuse remaining from the construction operations and leave the entire site of the work in a neat and orderly condition.	Construction Contractors
Excavated material will be segregated for use in backfilling provided the material meets the requirements for its intended use.	Construction Contractors
It is expressly understood that no excavated material will be removed from the site of the work or disposed of, except as directed by the Engineer. When removal of surplus materials has been approved by the Engineer, dispose of such surplus material in approved designated areas.	Construction Contractors, Resident Engineer
Should conditions make it impracticable or unsafe to stack material adjacent to the trench, the material will be hauled and stored at a location provided. When required, it will be re handled and used in backfilling the trench.	Construction Contractors
All debris and excess material will be disposed of in an environmentally sound manner. Dumping or disposal of debris or excess material in any stream corridors, any wetlands, any surface waters, any floodplains or at unspecified locations is prohibited. Discharging of solid waste deleterious to any public or private property not specified for said purpose is prohibited.	Construction Contractors
Storing construction equipment and vehicles and/or stockpiling construction materials at locations not previously specified and approved by the Town for said purposes is prohibited.	Construction Contractors
Dumping, disposing, or stockpiling of any material at any location within the Town of Dennis	Construction Contractors

Mitigation Measure	Responsibility/Applicability
without approval of the Conservation Agent is prohibited.	
Burning at the project site for the disposal of refuse and debris or cleared and grubbed materials will not be permitted.	Construction Contractors
All pieces of ledge and boulders which are not suitable for use in other parts of the work will be removed and disposed of in an approved manner.	Construction Contractors
Surplus imported fill will be removed and disposed off site.	Construction Contractors
The Contractor will either be, or employ the services of a Subcontractor, who is licensed in the Commonwealth of Massachusetts to perform asbestos abatement where applicable. All work associated with the handling of asbestos cement pipe will be conducted only by the licensed party.	Construction Contractors
Management of Hazardous Materials	
Excavated materials will be managed in accordance with applicable Massachusetts Contingency Plan (MCP) requirements. These provisions include identification of contaminated materials, segregation, proper stockpiling or containment, and sampling and analysis to determine the appropriate facility for reuse, recycling, or disposal of these materials.	Construction Contractors
Dewatering discharges will be managed in accordance with MCP requirements, including identification of contaminated groundwater, proper containment and pretreatment, and required sampling and analysis.	Construction Contractors
The Contractor will submit a Hazardous Material Health and Safety Plan detailing procedures and protocols to protect workers and the general public from potential hazards during the construction work.	Construction Contractors
The Contractor will submit an Emergency Response Plan detailing procedures to address the discovery of hazardous materials that could pose an imminent hazard to workers and the public, and procedures to address emergencies that involve fires and/or explosions.	Construction Contractors
Hazardous materials management activities will be conducted under the supervision of a Licensed Site Professional (LSP) in accordance with MCP Utility-Related Abatement Measure or Immediate Response Action provisions, as appropriate.	Construction Contractors

18.5 Self-Certification

The mitigation measures in the table above will be implemented as described herein, to minimize, to the maximum extent feasible, the environmental impacts of the Recommended Program. Applicable federal, state, and local permits will be obtained during design and construction of each phase of the project.

Section 19

Response to Comments

This section addresses comments on the June 2017 Dennis Draft Comprehensive Wastewater Management Plan/Expanded Environmental Notification Form (CWMP/EENF). The first comments addressed are those provided in the July 14, 2017 Certificate issued by the Massachusetts Environmental Policy Act (MEPA) Office. The subsections that follow include comments provided in the comment letters received by MEPA during the Expanded ENF review period.

Each comment is presented below in italics and is a direct quote from the applicable letter. Responses are provided below each comment in normal type font. Most comments or concerns are addressed in the body of this Final CWMP/SEIR in more detail, and reference is made below to the applicable sections where supplemental information can be found.

19.1 MEPA EENF Certificate- 07/14/2017

Comment 1-1:

The project is undergoing MEPA review and is subject to preparation of a mandatory EIR pursuant to 301 CMR 11.03(3)(a)(1)(b) and 301 CMR 11.03(5)(a)(3) of the MEPA regulations because it requires State Agency Actions and involves the alternation of ten or more acres of LSCSF and BLSF and the construction of one or more new sewer mains of ten or more miles in length, respectively. The project also exceeds the ENF threshold at 301 CMR 11.03(5)(b)(1) because it involves the construction of a new wastewater treatment and/or disposal facility with a capacity of 100,000 gpd or more. It requires a groundwater Discharge Permit from MassDEP and Construction Access Permit from MassDOT and/or DCR. The project may require a Conservation and Management Permit (CMP) from the Division of Fisheries & Wildlife's NHESP. It is subject to review under the May 2010 MEPA Greenhouse Gas (GHG) Emissions Policy and Protocol ("the Policy").

Pursuant to the MEPA Certificate, the document herein constitutes the Single EIR, meeting the scope included in the Certificate.

Comment 1-2:

The project will require an Order of Conditions (OC) from the Dennis Conservation Commission (or in the case of an appeal, a Superseding Order of Conditions (SOC) from MassDEP. It may require review by the Massachusetts Historical Commission (MHC) under Section 106 of the National Historical Preservation Act 1996 and M.G.L. Section 9, sections 26-27C (950 CMR 70-71).

Section 16, Environmental Impacts and Mitigation, includes a description of permits anticipated to be sought with regards to the work proposed in this Final CWMP/SEIR over the course of the eight phases of design and construction. Several of these permits will be required with the implementation of each phase, and others will only be required for particular phases where applicable thresholds are triggered. Permitting requirements can be found in Section 16.14, and related draft Section 61 Findings can be found in Section 18.

Comment 1-3:

The Town will receive Financial Assistant from the Commonwealth through the State Revolving Fund (SRF). Therefore, MEPA jurisdiction is broad and extends to all aspects of the project that are likely, directly, or indirectly, to cause Damage to the Environment, as defined in the MEPA regulations.

All aspects of the environmental review as outlined by MEPA are addressed in this Final CWMP/SEIR. Please see Sections 15 and 16 for a detailed discussion of the financial and environmental impacts and benefits of the Final CWMP recommended program, including both short- and long-term considerations.

Comment 1-4:

The project is intended to improve aquatic health and water quality by providing more effective wastewater treatment. Measures to avoid minimize, and mitigate project impacts include the use of erosion and sediment control measures during construction, limiting areas of disturbance by locating work within previously disturbed areas where possible, and designing the system to limit extraneous infiltration and inflow (I/I). Additional mitigation commitments should be identified in the Single EIR.

A construction management plan is discussed in Section 17. Additional environmental impact mitigation measures are also defined in Section 16.

Comment 1-5:

The Proponent submitted an EENF to satisfy the requirements for a Single EIR and, as required, the EENF was subject to an extended comment period. It provided a detailed project description, a baseline for evaluating environmental impacts and a comprehensive alternatives analysis. The EENF identified how the project is designed to achieve consistency with regulatory standards, including water quality standards and measures to avoid, minimize and mitigate project impacts. Comments from MassDEP, the Massachusetts Office of Coastal Zone Management (CZM) and the Cape Cod Commission (CCC) identify issues that can be addressed in the Single EIR.

All comments from State agencies have been addressed in this SEIR and are summarized in this section.

Comment 1-6:

The Single EIR should include an executive summary, it should identify significant environmental benefits and impacts, and measures that will be taken to avoid, minimize and mitigate adverse impacts. The Single EIR should describe the planning process that has occurred to date, and the proposed schedule for the remaining phases of planning, design, environmental permitting and review, and construction. Detailed information should be provided for each area where construction is proposed, including maps that show where sewer lines, cross-country easements, pumping stations, and other facilities will be located.

The Single EIR should discuss the state permitting process and describe how it will meet all applicable performance standards. I encourage early coordination with MassDEP during preparation of the Single EIR/CWMP as requested in the agency's comments.

A detailed executive summary is provided at the front of this Final CWMP/SEIR document. Section 16 of the SEIR addresses the environmental impacts and benefits of the recommended program, as well as measures proposed to be taken to minimize and mitigate adverse impacts. Sections 16 and 17 also include information about the anticipated timing of planning, design, and environmental permitting through the eight phases of construction. The figures in Section 16 show the recommended sewering plan, including gravity, vacuum, and low pressure sewer mains, pumping stations, force mains, and treatment and recharge sites, overlaid with a variety of town-wide environmental data to show the proximity of specific sensitive receptors to the proposed work. Note that there are no cross-country sewer easements proposed at this time, although detailed design could result in changes to the preliminary sewer main layout. Figures 14-1 and 14-2 show the recommended sewering plan and phasing plans. In addition, Section 17 presents a construction management plan including proposed mitigation measures, and Section 18 includes the draft Section 61 Findings for this project which apply to the state permitting process and related performance standards.

Comment 1-7:

Executive Order #385 requires that State and local agencies engage in protective and coordinated planning oriented towards resource protection and sustainable economic development. For reasons of both environmental protection and fiscal prudence, investments in public infrastructure should be carefully targeted toward those areas for which clear existing needs have been established and for those areas where denser development is appropriate, thereby relieving development pressures on open space, agricultural lands, and other valuable natural resources. The Single EIR should identify parcels located within the proposed sewer service areas that are undeveloped or that have development constraints due to lack of sewer, and compare potential secondary growth impact that may be induced by public sewers with local and regional growth management policies and zoning.

Figure 7-6 shows the undeveloped parcels located in Dennis. Development of buildable parcels is included in buildout flow estimates (based on current or proposed revisions to zoning). Planning districts are shown in Figure 7-8. The Town will also develop land use controls to meet SRF requirements. These land use controls are described in more detail in Section 14.7. Additionally, the Town completed an Economic Development Impact Assessment to understand the economic impact of constructing sewers in areas of town versus not providing sewers. An economic development model was created to present those findings. The economic development model assessed two scenarios, the relevant impacts to the town with the construction of sewers and without the construction of sewers. These findings are presented in more detail in Section 7.4 and in Section 14.

Comment 1-8:

The CWMP provided a summary of wastewater planning that has occurred to date, described existing conditions and land uses in the project area, identified future needs, and evaluated system alternatives to meet identified wastewater treatment demand and water quality objectives. The Single EIR should address the comments of MassDEP, CZM and the CCC and incorporate the requested data and analysis.

All state agency comments are included in Appendix H and summarized herein.

Comment 1-9:

….the Single EIR should include analysis of an additional alternative consisting of a sewer/treatment-only scenario with effluent recharge outside nitrogen-sensitive watersheds within Dennis and in neighboring communities as part of the regional wastewater system.

As part of a regional approach, the communities of Yarmouth, Dennis and Harwich evaluated the impact of recharging treated wastewater effluent in each of their communities. At this time, the Town's have chosen to pursue individual collection and treatment solutions, but partnerships may be considered again in the future.

Following completion of the Draft Barnstable Harbor Massachusetts Estuaries Project (MEP) report, findings indicate that the Chase Garden Creek or Bass Hole watershed has the ability to take on additional nitrogen loading, as the threshold limits set by the study are higher than present day loadings. With this finding, treated wastewater effluent from a community or Town only treatment facility could potentially be discharged in North Dennis at the Highlands Golf Course, which discharges to Chase Garden Creek. Additional analysis of effluent recharge capacity at this location will need to be performed in the future. Initial studies performed in 2016 through a Cape Cod Commission grant, discussed in more detail in Section 11.5, indicate that portions of the golf course may be capable of accepting effluent in the range of 0.25 to 1.25 MGD. The Town is in the process of reviewing additional effluent recharge sites as well.

Comment 1-10:

According to the EENF, the use of PRBs will reduce effluent nitrogen concentrations] to 1.0 mg/L. The Single EIR should confirm that 1.0 mg/L is an achievable treatment level. MassDEP and CZM note that the calculations regarding nitrogen loading to the Swan Pond and Bass River watersheds may be incorrect. The Single EIR should provide revised calculations and summarize any changes to nitrogen treatment and loading levels. As, recommended by MassDEP, the Single EIR should evaluate the potential for disposal of effluent outside of the Swan Pond River watershed using drip irrigation in open space areas such as golf courses.

Section 9.6.1 includes an expanded discussion of achievable treatment levels with an application of a PRB. The results of the mathematical errors have been corrected in Section 14. As stated in the CCC 208 plan, treatment of wastewater through a PRB can result in a 75% to 95% reduction in the concentration of nitrogen in the effluent. The treatment technologies chosen for application at the WWTP are capable of achieving an effluent nitrogen concentration of 3 mg/L, which is required by the TMDL set in the MEP reports for the Bass River and Swan Pond watersheds. Assuming that the application of a PRB around effluent recharge basins will result in an effluent nitrogen concentration of 1 mg/L is a conservative approach, as this would indicate that the PRB was capable of reducing nitrogen by 67%. Section 9 also discusses the use of PRBs downgradient of other nitrogen sources such as landfills located in Town as a means of lowering the total nitrogen load in the Swan Pond River and Bass River watersheds should PRBs around effluent recharge sites prove to be less effective once this alternative has been further vetted in final design, following site specific investigations.

An updated effluent recharge analysis was completed as part of additional field investigations conducted in late 2017 and early 2018. Results of this additional investigation are included in

Section 11.The Town is currently planning to conduct additional effluent recharge investigations, to include at least one additional location outside of Swan Pond Watershed, including Site 5 the Dennis Highland Golf Course which discharges to Chase Garden Creek Watershed.

Comment 1-11:

The Single EIR should provide additional information on how the Town will administer the fertilizer and stormwater management programs to the extent necessary to achieve reduction goals. It should provide more detail about the monitoring program including the general approach to be used, how it will be implemented, monitoring locations, and water quality parameters to be measured. It should address how the monitoring program will be designed to evaluate the effectiveness of non-structural treatment options.

As discussed in Section 14, the Town has developed a fertilizer education brochure and has prepared a PowerPoint to be used at community meetings and for outreach with residents, interested groups, and retailers. Stormwater management will be handled through the Town engineering department. At this time, the Town has elected to promote fertilizer education in lieu of enforcement. The Town is currently evaluating implementing stormwater best management practices and upgrades to existing infrastructure in those subwatersheds with higher nitrogen loading from stormwater. The Town will continue to address these areas as they lay out a master plan to address stormwater management throughout the town.

Comment 1-12:

The Single EIR should identify the process the Town will use to identify open space parcels for acquisition and its efforts to implement the necessary land use controls.

Successful implementation of non-structural solutions (e.g., fertilizer management, stormwater BMPs, open space acquisition, etc.) can provide a future component of the required nitrogen reduction, to ultimately reduce sewering needs. The Town of Dennis supports these non-structural solutions in all town watersheds. The Town will look at potential parcels for land acquisition in sensitive watersheds, particularly undeveloped or rehabilitated parcels. The Town recently purchased a 13-acre parcel in the Bass River Watershed and will continue to evaluate other potential parcels in the sensitive watersheds as phases of the recommended plan are implemented. The Town's approach to land use and open space is summarized in Section 14.7.11. The Town intends to minimize the extent of sewering to the maximum degree possible except in areas where sewering is needed for purposes other than to meet MEP goals. The Town is evaluating the data produced by the CCC's watershed tools and guidelines to explore if other means of source control can be added into the recommended program through adaptive management moving forward.

The recommended program presented herein shows the outer limits of sewering estimated to be required to meet the TMDLs for nitrogen at buildout. The adaptive management approach presented in Section 14 allows for adjustments to be made to the sewer service areas should non-structural nitrogen reduction methods prove more effective than estimated or should new, more cost-efficient technologies or means of nitrogen reduction be identified over time. With sewers proposed to be installed over a number of phases, there is ample opportunity for adjustments based on ongoing water quality monitoring.

Secondary growth impacts from sewering are a concern and will be a focus of the Dennis Planning Department as each phase of sewering is implemented. The town is presently working on identifying the best strategies for growth control. As each sewer implementation phase is brought to vote for construction funding, the community will have the opportunity to assess whether they feel growth controls are adequate or require revisions in the proposed sewered areas. The Town is in the process of developing Land Use Controls (required for State Revolving Fund [SRF]) to manage wastewater flows estimates put forth in the Final CWMP.

Comment 1-13:

The Single EIR should develop a contingency alternative to achieve required nitrogen levels without relying on non-traditional methods. It should be based on sewering and treatment only with effluent recharge areas outside of nitrogen-sensitive areas such as Swan Pond River watershed. As noted by the CCC, a third effluent recharge area identified in the CWMP has limited capacity; the Single EIR should identify other potential recharge sites.

An aquaculture pilot program was performed in Swan Pond in 2018 and 2019. While the scale of the project was not sufficient to demonstrate that it could make a significant difference in the water quality of the pond, it did demonstrate the nitrogen removal potential of a given area of oyster culture in the pond, and a measurable way of removing nitrogen to partially meet watershed TMDL limits. The project scale showed the feasibility of culturing up to 1 million oysters per acre and removing about 150 kg of N per acre at costs less than or equivalent to conventional means of treatment. Given the data collected in the pilot study, aquaculture may be a viable technology for additional nitrogen reduction in the Swan pond watershed or other impacted waterbodies in Town. where both Sites 1 and 2 are located. Additional desktop effluent recharge investigations have been performed in the past to preliminarily identify potential additional effluent recharge sites within Town. The Highlands Golf Course will be reevaluated for effluent recharge capacity during additional investigations in the coming year. The focus of additional effluent recharge investigations will be to target those areas where groundwater discharges to water bodies that are able to accept excess nitrogen without compromising the health of the waterbody. Comment 1-9 above provides additional details on this scenario.

Comment 1-14:

A regional wastewater facility should also be reviewed in detail in the Single EIR. The regional scenarios studies in the CWMP were the most cost-effective and efficient nitrogen-removal solutions and are encouraged by MasDEP and CCC. A regional solution would also expand the number of potential recharge areas outside of nitrogen sensitive areas.

The Towns of Dennis, Harwich and Yarmouth have been in active communication with one another in regard to a community approach to their wastewater management. Regional options may be part of future plans, as Dennis is open and willing to discuss regional options throughout the implementation process. A discussion of the proposed DHY Clean Waters Community Partnership plan is detailed in Section 14, where the adaptive management plan is outlined. At this time, the three communities are implementing separate plans but may revisit partnerships in the future.

Comment 1-15:

The Single EIR should identify areas of impacts to wetland resource areas and describe mitigation measures. It should address the project's compliance with appropriate standards of the Wetlands Regulations (310 CMR 10.00).

Figure 7-5 identifies these sensitive environmental areas. Mitigation impacts will be addressed during design on a parcel by parcel basis. As noted above, Section 16 provides a comprehensive environmental review of the recommended program, including details pertaining to the treatment and recharge sites, as well as the locations proposed for installation of sewer pipelines and pumping stations. This section includes subsections describing impacts and mitigation related to hydrology, water resources, wetlands, and wildlife habitat, as well as other sensitive resources identified in the MEPA regulations.

Comment 1-16:

The Single EIR should report on its consultation with NHESP, identify any impacts to rare specifies habitat and propose mitigation measures. The Town should continue to consult with NHESP as the design of the Preferred Alternative is finalized.

Rare species descriptions and potential impacts are discussed in Section 16. In its comments on the EENF, NHESP noted that additional guidance regarding rare species would be provided upon submission of more detailed site plans. As each component of the CWMP moves forward, NHESP consultation will be required during permitting. For each phase that requires a Notice of Intent (NOI) from the Dennis Conservation Commission and is within Priority Habitat and Estimated Habitat, the NOI will be sent to NHESP for review. Furthermore, during the design of each phase of the project, detailed construction plans will be provided to NHESP to confirm the exemption status or determine the need for further information.

Comment 1-17:

The Single EIR should include a chapter that addresses the capacity of the wastewater collection and treatment systems under projected levels of precipitation and sea level conditions and the resiliency of the system to the effects of climate change.

The recommended plan includes the construction of pressure and vacuum sewers along coastal areas which are generally more resilient to flooding conditions when compared to gravity sewers. Additionally, during final design of all pumping stations, per 750 CMR State Board of Building Regulations and Standards, new structures erected within coastal high hazard areas shall be elevated so that the lowest portion of all structural members supporting the lowest floor, with the exception of mat or raft foundations, piling, pile caps, grade beams and bracing, is to be located at or above design flood elevation plus three feet. This design requirement shall be followed for all new pumping stations constructed as part of the recommended plan. A more detailed discussion of resiliency planning is included in Section 14.

Comment 1-18:

The Single EIR should review alternative locations for system components, such as pump stations, including locations outside of the floodplain. It should identify design features that could increase the resiliency of the proposed infrastructure under future sea level conditions. Prior to preparing

this analysis, the Town should consult with the MEPA office regarding precipitation data that will be used.

The Recommended Program sites potential locations of pumping stations primarily based on the land availability, as shown in the GIS database. Final siting of all pumping stations will not occur until design of the recommended plan. At that time, the Town will consult with MEPA regarding this analysis and what precipitation data should be used. All efforts will be made to keep pumping stations out of flood zones. A more detailed discussion of resiliency planning is included in Section 14.

Comment 1-19:

This project is subject to review under the May 5, 2010 MEPA GHG Policy. The Policy requires Proponents to quantify carbon dioxide (CO2) emissions and identify measures to avoid, minimize or mitigate such emissions. The analysis should quantify the direct and indirect CO2 emissions of the projects energy use. Direct emissions include on-site stationary sources, which typically emit GHGs by burning fossil fuel for heat, hot water, steam and other processes. Indirect emissions result from the consumption of energy, such as electricity, that is generated off-site by burning of offal fuels, and from emissions from vehicles used by employees, vendors, customers and others. The Policy directs proponents to use applicable building codes to established emissions baseline that is "code-compliant". However, there is no building energy code equivalent that applies specifically to WWTFs or energy use models (such as eQuest) designed to estimate the projected energy use of the WWTF processing energy loads.

The EENF included a commitment to design the WWTF to use high-efficiency motors that are optimized for the expected wastewater flows as an energy conservation measure. It did not include a GHG analysis because the design of the WWTF is in a preliminary stage and has not been finalized. During the review period, the Town submitted a proposed method for evaluating energy-efficiency alternatives for the WWTF. The proposed method would use the EPA's Energy Star Portfolio Manager (ESPM) computer modeling program to compare the energy use of the planned wastewater treatment technologies to the energy use of the baseline treatment facility achieving ESPM Energy Performance Rank of 50, which reflects the average energy use of a comparable wastewater facility. This method has previously been used in MEPA filings (e.g. Harwich CWMP, EEA# 15022).

In place of the ESPM, the Single EIR should include a more project-specific GHG evaluation of emissions from the WWTF and pump stations. It should establish a Base Case and an as-proposed Preferred Alternative Case along with providing the other information required by the Policy. Both the projected energy consumption and related GHG emission should be quantified for both cases. Design assumptions for the base case should be based on a typical WWTF and pump station design that meets the requirements of TR-16, Guides for the Design of Wastewater Treatment Works, 2016 Edition, which is commonly used as a guide for wastewater facility design in Massachusetts. The as-proposed Preferred Alternative design should include features and measures that would result in a significant reduction from the Base Case in both the consumption of grid electricity and the related GHG emissions. Measures that should be evaluated include; increasing piping sizes to reduce friction loss, use of premium efficiency pumps and motors; and use of variable frequency pump drives (VFD).

….For key components and systems of the WWTF, the Single EIR should review energy-efficient alternatives identified in the reports cited above and indicate whether the Town will adopt the measure or not, and provide a rationale for the decision.

The Single EIR should review opportunities for on-site energy generation, including biogas and solar photovoltaic (PV) systems. The Greater Lawrence Sanitary District has set a net zero goal that includes the use of biogas produced at the facility as fuel for a combined heat and power (CHP) plant. The Single EIR should review the feasibility of using similar technology to generate energy. The Site of the proposed WWTF is not likely to be powered by the PV facility but may be funded in part by proceeds from the sale of solar power. The Single EIR should include an evaluation of adding capacity to the existing PV facility and/or adding rooftop or ground-mounted solar PV to provide power for the WWTF.

Section 16 of this CWMP/SEIR presents information to demonstrate compliance with the GHG Policy as requested by MEPA. The Town is committed to designing a facility that minimizes energy usage where feasible and exploring renewable energy options to offset additional usage, as described further in Section 16. The Town has made provisions for partial funding of the implementation of the CWMP from solar funds generated by the Town, discussed in Section 15.3.4. During final design, considerations will be made for installation of PV on the site of the WWTF, potentially over the infiltrations basins. Since there is no design at this time for a treatment facility in Dennis, the as-proposed case cannot be provided and will be evaluated during preliminary design of the facility and shared with MEPA. The draft Section 61 Findings presented in Section 18 also addresses energy efficiency measures being considered.

Comment 1-20:

The Single EIR should identify areas subject to MassDOT and/or DCR review, describe potential project impacts in those areas, and identify mitigation measures.

As stated above, Section 16 identifies permits that will be needed by MassDOT. The Town will work with MassDOT during design to develop traffic mitigation measures that will need to be addressed during construction. It is understood at this time that work cannot occur from Memorial Day through Labor Day and that major roadways must remain open to traffic. The Town is working closely with MassDOT on those projects which are currently under design and in construction so that provisions for the recommended plan are taken into account to minimize impacts to newly constructed roadways. Please reference Section 16 of the CWMP/SEIR.

The Town would also like to work with MassDOT on expanding the openings of the two Route 6 bridges at some point in the future. This would greatly improve water quality in the Bass River as a result of increased flushing north of Route 6.

Comment 1-21:

Construction period impacts and mitigation measures should be described in the Single EIR, including impacts from noise and dust, impacts on trees and other vegetation, and traffic impacts.

Construction impacts and various mitigation measures, including impacts from noise and dust are addressed in Section 17 which outlines the Construction Management Plan.

Comment 1-22:

The Single EIR should describe impervious areas to be created by the project and review alternatives for minimizing new impervious surfaces. The Single EIR should identify sedimentation and erosion control measures to be used during construction. A Stormwater Pollution Prevention Plan will be developed for the project in accordance with MassDEP's Stormwater Management Standards. The Single EIR should describe any stormwater BMPs to be constructed to offset new impervious area.

Section 18 identifies means of minimizing impervious surfaces and proposes potential alternatives for mitigation impacts from new impervious surfaces, such as green infrastructure on pumping station and wastewater treatment plant roofs and porous pavement in parking lots. Erosion and sedimentation control measures that will be in place during construction are outlined in Section 17, the Construction Management Plan. Stormwater BMPs are outlined in Section 14 as part of the Town's Stormwater Management Plan and a full Stormwater Pollution Prevention Plan (SWPPP) will be developed during final design.

Comment 1-23:

The Single EIR should include a summary of all mitigation measures to which the Town has committed that includes a schedule, estimated costs, and persons/agencies responsible for implementation the mitigation.

Section 16 includes a detailed discussion of environmental impacts and mitigation measures and Section 18 presents the project schedule. In Section 16, responsible agencies are identified for implementation of the different components of the recommended plan.

Comment 1-24:

The Single EIR should be circulated in compliance with Section 11.16 of the MEPA regulations and copies should also be sent to the list of "comments received" below and to Dennis. A copy of the Single EIR should be made available for public review at the Dennis Public Library.

The Single EIR shall be distributed to MassDOT, CZM, MHC, DMF, NHESP, MassDEP-SERO, CCC and DCR. A hard copy will also be kept at the Dennis public library.

19.2 Massachusetts Department of Transportation (MassDOT Letter) 6/30/2017

Comment 2-1:

The collection system (sewer main) will include Route 28, a state-owned highway, and therefore will require an Access Permit from MassDOT. Appendix C of the draft plan contains a letter to MassDOT requesting the widening of the Route 6 eastbound and westbound bridges, and the rail trail bridge over the Bass River, in order to removal flow restrictions and restore the water quality of the river. This effort will also require a MassDOT Access Permit. The widening of the rail bridge is currently incorporated in the Dennis-Yarmouth Cape Cod Rail Trail extension project advertised in 2014.

The Town will apply for the access permits during final design of the recommended plan for applicable phases. The widening of the former railroad bridge has been implemented as part of the MassDOT funded Dennis-Yarmouth Multi-use Path Bridge over the Bass River. Construction of

Phase 1 began in October of 2015 and was completed in 2017. Phase 2, began in 2017, which included the widening of the Bass River Bridge from 60 feet to 160 feet, improving the ecosystem of the upper Bass River was completed in the Summer of 2018. The Town encourages MassDOT to reevaluate the widening of both eastbound and westbound sides of Route 6 in future capital improvements projects as this adjustment to the roadway infrastructure has shown to increase tidal flushing which will improve impacted water quality. The restriction of the Route 6 bridges has a larger impact on water quality than the smaller rail trail bridge. There are currently no plans in place to widen the Route 6 bridges; however, the Town's of Dennis and Yarmouth have sent requests in 2016 and 2018 to MassDOT to consider widening when the bridge is eventually repaired or replaced. Assessments of this scenario have been performed by Applied Coastal Research Engineering, Inc. in 2013 and by VHB in 2015.

19.3 Massachusetts Office of Coastal Zone Management (CZM) Memorandum 7/6/2017

Comment 3-1:

Studies and Plans to reduce flow restrictions along the Bass River at the old railroad bridge and at Route 6 should include the investigation of both the local near field effects of improved flushing, as well as potential far field effects, looking at the fate of the nitrogen that would move downstream into the Bass River Estuary and Nantucket Sound.

Applied Coastal Research Engineering prepared a hydrodynamic tidal study of the Bass River in 2013. The analysis concluded that the impact from the widening of the railroad bridge and Route 6 bridge back to historic shoreline conditions would positively impact the entire system with regard to water quality. Historic conditions, where the original shoreline was not impacted by construction of the Route 6 bridge or the railroad bridge were compared to current day conditions as well as a scenario where just the railroad bridge is widened. The first scenario (historic) shows the greatest potential for water quality improvement, while the second also indicates that water quality will be slightly improved. In both scenarios, the downstream impacts to the Bass River estuary and Nantucket sound were both positive with regard to nitrogen impacts to water quality, with the impact at the shoreline of Nantucket sound being negligible at a zero percent change in concentration in both scenarios. See response to Comment 2-1 above on work that's been done to date.

Comment 3-2:

CZM suggests that the Town work closely with the Division of Marine Fisheries on how best to evaluate the feasibility of oyster-based nitrogen remediation, assess public health concerns and examine long-term costs and benefits. For all of these alternatives, CZM recommends that baseline monitoring for evaluating the efficacy of alternatives should be targeted for at least three years, and across several seasons and depths, in order to account for temporal and special variability.

Findings from the 2018-2019 aquaculture pilot project are summarized in Section 14.7.14 of the CWMP and in response to question 1-13 above. The final report can also be found in Appendix H.

Comment 3-3:

The draft CWMP references a 1 mg/L assumed nitrogen concentration, which is well below the current level of technology. We request that in the EIR, the Town clarify its near term and long term goals for nitrogen remediation and loading. We also note that the mathematical calculations on pg. 14-7 that describe the future nitrogen load to Swan Pond watershed are incorrect: (1.045 mgd x 1 mg/l x 8.34 lbs/day=8.72 lbs/day, not 26.11 lbs/day). Likewise, the calculations on p. 14-8 that describes future nitrogen load to the Bass River watershed are incorrect: (0.54 mgd x 1 mg/L x 8.34 = 4.30 lbs/day, not 13.5 lbs/day).

As stated above in response to comment 1-20, Section 9.6.1 includes an expanded discussion of achievable treatment levels with an application of a PRB. As stated in the CCC 208 plan, treatment of wastewater through a PRB can result in a 75% to 95% reduction in the concentration of nitrogen in the effluent. The treatment technologies chosen for application at the WWTP are capable of achieving an effluent nitrogen concentration of 3 mg/L, which is required by the TMDL set in the MEP reports for the Bass River and Swan pond watersheds. Assuming that the application of a PRB around effluent recharge ponds will result in an effluent nitrogen concentration of 1 mg/L is a conservative approach, as this would indicate that the PRB was capable of reducing nitrogen by 67%. Additional locations, such as downgradient of town owned landfills, which are suspected to contribute higher concentrations of nitrogen to the groundwater may also be further assessed in the final design stage as another means of achieving the TMDL is watersheds where effluent recharge is applied.

Mathematical errors have been corrected on Pg. 14-7.

Comment 3-4:

CZM suggest that the Town evaluate alternative locations for the proposed sewer collection system components outside of the flood plain, especially outside of Coastal A Zones and Velocity Zones. The EIR should document that the proposed sewer system is designed to be protected from inundation by significant storm events and that utility connections will be capable of withstanding storm forces without damage or contamination of nearby resources. The current Federal Emergency Management Agency (FEMA) flood zone maps only show the 1% annual chance event, not the less frequent, but more severe hurricanes that have the most effect on the south shore of Dennis. In addition to the FEMA flood zones identified in the initial analysis presented in the EENF, CZM recommends that the analysis of potential inundation include effects of sea level rise and hurricanes.

See response to Comment 1-17 and Section 14.9.

Comment 3-5:

The proposed lifespan of the infrastructure should be taken into account as part of the analysis, and the EIR should include a plan for re-evaluation of the proposed plans as new information becomes available, particularly regarding new projection for flood and erosion hazards.

The lifespan of sewer system components as well as the WWTP are included in the adaptive management plan, discussed in Section 14.8.

Comment 3-6:

The proposed project may be subject to CZM federal consistency review. For further information on this process, please contact, Robert Boeri, project Review Coordinator at 617-626-1050.

The Town will contact CZM at the start of design of the recommended plan.

19.4 Massachusetts Historical Commission (MHC) Letter 7/6/2017

Comment 4-1:

Project planners should submit scaled existing and proposed conditions project plans for the preferred project alternative to the MHC and other consulting parties, when they become available.

The Town will submit preliminary design drawings to MHC for review once completed.

Comment 4-2:

The MHC looks forward to reviewing the State Archaeologists permit application (950 CMR 70) from a qualified archaeological consultant with previous experience in this region of Massachusetts to conduct the archaeological reconnaissance survey (950 CMR 70) for the project. The goal of the investigation is to provide a detailed archeological sensitivity assessment for the project, and to provide recommendations for further archeological testing, if any, that may be required to locate and identify any significant archeological resources that could be affected by the project, in advance of project construction for each phase. The scope should include limited subsurface testing to assist in the sensitivity assessment and implementation of a contingency for archeological monitoring during construction as necessary. The results of survey(s) will be used in consultation in order to avoid, minimize or mitigate adverse effects to identified significant archaeological resources.

A Phase 1A Archaeological Survey was performed in April of 2017 by The Public Archaeology Laboratory, Inc. (PAL) at Site 1, the proposed location of the WWTP. Results from their analysis identified areas of low to moderate/high historical sensitivity. It is suspected that siting of the WWTP can occur outside of the moderate to highly sensitive areas. Effluent recharge will need to occur in areas deemed to be moderate/highly sensitive. As such, it is recommended that only areas where effluent recharge may occur be included in the scope of the intensive survey. A Phase 1A Survey was also conducted in 2019 of seven of the potential pumping station sites included in Phase 1 of the recommended plan. In two of the locations, an alternative site was identified as a potential pumping station site. In each of those instances, it was recommended that one of the sites be evaluated in an intensive survey. The results of the study indicated a recommendation to perform an intensive survey at pumping station No. 7, should that location be selected in final design of the pumping stations in Phase 1. Additional information on the surveys can be found in Section 16.12 and the reports themselves can be found in Appendix J.

Comment 4-3:

The MHC recommends that project planners provide project information to the Dennis Historical Commission and/or Dennis Historic District Commission as appropriate for any above-ground project elements in historic districts for concurrent review and comment. Copies of any written comments should be provided to the MHC.

The Town provided a link to the Draft CWMP/EENF on 10/20/2017 to the Dennis Historical Commission for their review and comment. To date, no comments have been received. Should the Town receive comments in the future, they will be addressed and a response to comments will be submitted accordingly.

19.5 The Division of Marine Fisheries (MarineFisheries) e-Mail 7/6/2017

Comment 5-1:

The proposed oyster aquaculture component of the preferred alternative should follow the Marine Fisheries Shellfish Planting Guidelines (Hickey et al. 2015).

The plan was designed to follow the guidelines. The Town subcontracted with Scott Lindell, Principal Investigator at Woods Hole Oceanographic Institution, who provided expert opinion on the implementation of the aquaculture pilot project. Also refer to response 3-2.

19.6 The Natural Heritage & Endangered Species Program of the Massachusetts Division of Fisheries & Wildlife (the Division) Letter 7/5/2017

Comment 6-1:

Those projects that will occur within Priority and Estimate Habitat for state-listed species, which are not otherwise exempt from MESA review pursuant to 321 CMR 10.4, require a direct filing with the Division for compliance with the Massachusetts Endangered Species Act. According to the Section 12 of the EENF, many of the scenarios recommended for further study may require review with the Division pursuant to the MESA and therefore the Proponent should consult with the Division as plans are developed. The Division notes that sewer systems within ten (10) feet of the edge of existing paved roads may be exempt from MESA review, please see 321 CMR 10.14(10).

Filing with the Division, if needed, will occur during the design phase of the recommended plan. Please see response to MEPA question No. 1-6.

19.7 The Southeast Regional Office of the Department of Environmental Protection (MassDEP) Letter 7/7/2017

Comment 7-1:

A local Order of Conditions is required from the Dennis Conservation Commission for each construction phase that proposes work within Areas Subject to Protection under M.G.L. c. 131 § 40 and buffer zones. The project is being proposed as a limited Project under 310 CMR 10.24(7) and 310 10.53(3)(d). The EENF indicated that there are proposed alternations to Land Subject to Coastal Storm Flowage, Boding Land Subject to Flooding and Riverfront Area. Pursuant to 310 CMR 10.58(6)(h) this project is exempted from requirements for the Riverfront area. Per 310 CMR 10.24(7) and 310 CMR 10.53(3)(d) in determining whether to exercise discretion to approve the limited project, the following factors should be considered: the magnitude of the alteration and the significance of the Project site to the interests identified in M.G.L. c. 131 § 40, the availability of

reasonable alternatives of the proposed activity, the extent to which adverse impact are minimized, and the extent to which mitigation measures, including replication or restoration, are provided to contribute to the protection of the interests identified in M.G.L. c. 131 § 40.

Please see response to MEPA comments No. 1-1 and 1-2.

Comment 7-2:

MassDEP is encouraged by the source controls proposed in the CWMP, and recommends that Dennis continue to evaluate and adopt additional source controls in the future to the maximum extent possible to reduce the need for alternative nutrient control strategies.

Through the Town's adaptive management plan, source controls will continue to be evaluated and implemented as results implementation deem them to be successful.

Comment 7-3:

MassDEP encourages this community partnership among the three towns and finds it preferable to individual arrangements between Dennis and Harwich or Dennis and Yarmouth.

Please see the response to MEPA comment No. 1-14.

Comment 7-4:

The CWMP should explicitly identify a contingency alternative to address the additional removal requirements should the performance of the non-traditional approaches fall short of expectations. This most likely would require identifying an infiltration site outside the Swan Pond River watershed.

Please see the response to MEPA comment No. 1-10 and 1-13.

Comment 7-5:

While transient models were used in the initial evaluations, MassDEP will want to confirm that the flows used adequately reflect the maximum and minimum conditions likely arise from operation of the treatment facility. If higher loading rates are considered for design, then additional field loading tests will be required at the permitting stage to determine if the increased loading rates are supportable if they are desired to be part of the design.

All wastewater flows will be confirmed during design phase and shared with MassDEP. Field tests to confirm flows will be conducted if necessary.

Comment 7-6:

The particle tracking for Site 2 in the Bass River watershed shows an encroachment in the Zone II. During the permitting process MassDEP will determine whether this may trigger water reclamation requirements for indirect recharge to the public water supply; however, given that the particle do not appear to encroach in a Zone of Contribution, MassDEP has the option to exercise discretion in requirement additional treatment.

The Town recently decided to use grant funding to perform additional effluent recharge investigations. The assessment will include evaluating potential sites outside of the Bass River

Watershed, with a specific focus on trying to find sites located outside of a Zone II's. Results of this characterization will be shared with MassDEP for review and comment.

Comment 7-7:

Drip irrigation is an option for flows exceeding 10,000 gpd. Given that the proposed treatment works will produce high quality effluent, this option may warrant additional consideration. It has the potential to provide some additional flexibility especially if alternate sites outside of the Swan Pond River watershed need to be considered. Further discussion with MassDEP regarding this alternative is encouraged.

The technology may be considered in the future, should the site location allow for its use. MassDEP will be included in future discussions as effluent recharge siting is further refined.

Comment 7-8:

The CWMP should acknowledge that additional evaluation may be needed for buildout assumptions depending upon how proposed zoning changes are enacted.

Please see response to MEPA comment No. 1-7.

Comment 7-9:

There should be further discussion of a monitoring program to evaluate the effectiveness of these strategies in meeting Project projected loading reductions for stormwater, aquaculture and PRBs. Additionally, the CWMP should develop a compliance and enforcement strategy to insure that fertilizer reduction targets are met. Finally, as mentioned previously, a contingency plan utilizing traditional approaches should be developed in the event that the non-traditional approaches not meet Projected reductions.

Please see response to MEPA comments, No. 1-11 regarding fertilizer strategy and No. 1-12 regarding long term monitoring once the recommended plan has been constructed to determine effectiveness in nitrogen removal through both traditional and non-traditional technologies. . The Town currently pays for the annual monitoring of sensitive waterbodies and will continue to do so following implementation of the recommended plan. This is summarized in Sections 14.7.5 and 14.8.1 of the CWMP.

Comment 7-10:

The CWMP is based on a 40 year design horizon in 8 phases. Traditionally, the CWMPs have been based on 20 years horizons; however, the scope and cost of the recommended alternative requires an extended timeframe for affordability and capital planning. MassDEP believes that further discussion on the timetable is required to arrive at a mutually acceptable schedule for completion.

The current phasing plan is longer than the 20 year time frame due to financial impacts on the Town. The cost recovery plan is presented in Section 15 of the Final CWMP/SEIR. Should MassDEP consider the 40 year design horizon to be insufficient to meet the TMDLs set for the watersheds within the Town, further discussion will be needed.

Comment 7-11:

As Projects approach the funding stage, the Town will need to show the percentage of each Project intended primarily to manage nutrients with reference to the final CWMP. Sewer regulations to be developed may need to comply with certain MassDEP and Department of Housing and Community Development requirements, depending on the funding program utilized. In particular, there is little discussion of growth neutrality in the CWMP. This item needs to be addressed if the town wishes to pursue 0% financing from the SRF.

The Town has outlined potential land use controls in Section 14.7.11. Town intends to meet all requirements to preserve SRF funding.

Comment 7-12:

The Massachusetts Natural Heritage and Endangered Species Program (NHESP) identified state-listed rare species in the vicinity of several Project components. During implementation of the CWMP, the Project Proponent must comply with 310 CMR 10.59, 310 CMR 10.32(6) and related performance standards for other resource areas, and 310 CMR 10.37 to ensure that there is no short or long term adverse effect on estimated habitats or rare wildlife.

Rare species descriptions and potential impacts are discussed in Section 16. In its comments on the EENF, NHESP noted that additional guidance regarding rare species would be provided upon submission of more detailed site plans. As each component of the CWMP moves forward, NHESP consultation will be required during permitting. For each phase that requires a Notice of Intent (NOI) from the Dennis Conservation Commission and is within Priority Habitat and Estimated Habitat, the NOI will be sent to NHESP for review. Furthermore, during the design of each phase of the project, detailed construction plans will be provided to NHESP to confirm the exemption status or determine the need for further information.

Comment 7-13:

On pages 14-7 and 14-8 there are some apparent miscalculations of nitrogen load. These should be reviewed and, if in error, checked to see if they have been carried through to other calculations in the
report.

The mathematical errors have been corrected on both pages.

Comment 7-14:

The Project activities are scheduled to disturb 8.06 acres of land and therefore, may require a NPDES Stormwater Permit for Construction Activities. The Proponent can access information regarding the NPDES Stormwater requirements and an application for the Construction general Permit at EPA website.

See Section 16.14 for a discussion of regulatory standards and permit requirements, including stormwater permits.

Comment 7-15:

The proposed project involved a town-wide initiative to address wastewater management needs, protect drinking water supplied, protect ponds, and restore estuaries. Please be advised that there are many listed BWSC disposal sites located in the vicinity of the proposed Project areas. Many of the sites have closed under the MCP, but many other disposal sites are open and require continued response actions under the MCP. A listing and discussion of each MCP site will not be presented here.

The Project Proponent is advised that is oil and/or hazardous materials are identified during the implementation of the Project, notification pursuant to the Massachusetts Contingency Plan (310 CMR 40,0000) may be necessary. A Licensed Site Professional (LSP) should be retained to determine if notification is required, and render appropriate options as necessary. The LSP may evaluate whether risk reduction measures are necessary if contamination is present. Please contact BWSC for guidance if questions arise regarding assessment and cleanup under the MCP.

A map of reported hazardous waste sites within the project area was developed and is provided as Figure 16-5. Included are the location of the hazardous waste sites by number and a listing of each site's regulatory compliance status and Remedial Action Outcome (RAO) status, including Chapter 21E sites as well as reported locations of spills or other contamination. Associated text is provided in Section 16.4.1. Should contaminated soils be encountered during construction, appropriate measures will be taken to handle the materials and report conditions to the regulatory agencies. Associated construction mitigation measures are included in the draft Construction Management Plan included in Section 17 of this CWMP/SEIR. The construction procedures and protocols are also listed in Section 17 and incorporated in the Section 61 Findings, provided in Section 18 of this report.

Comment 7-16:

MassDEP requests that the Proponent state specifically in the subsequent environmental filing how it plans to prohibit the excessive idling during the construction period. Typical methods of reducing idling include driver training, periodic inspections by site supervisors, and posting signage. In addition, to ensure compliance with this regulation once the Project is occupied, MassDEP requests that the Proponent establish permanent signage limiting idling to five minutes or less at the completed Project.

A draft Construction Management Plan (CMP) was developed and is presented in Section 17. The provisions listed in this draft CMP are also incorporated into the draft Section 61 Findings in Section 18. The draft CMP provided in Section 17 also includes provisions to comply with MassDEP's Clean Air Construction Initiative and Diesel Retrofit Program.

Comment 7-17:

Pursuant to MEPA Regulations 301 4 CMR 11.12(5)(d), the Proponent will prepare Proposed Section 61 Findings to be included in the EIR in a separate chapter updating and summarizing proposed mitigation measures. In accordance with 301 CMR 11.07(6)(k), this chapter should also include separate updated draft Section 61 Findings for each State agency that will issue permits for the Project.

Section 18 of this CWMP/SEIR summarizes mitigation measures associated with both the construction and final implementation of the recommended program and includes draft Section 61 Findings for state permits. Note that construction mitigation is also described in the draft CMP in Section 17. Specific costs for mitigation measures are not able to be estimated at this planning-level phase of the project.

19.8 The Department of Conservation and Recreation (DCR) Letter 7/7/2017

Comment 8-1:

On maps included in the EENF, the Proponent shows the Cape Cod Rail Trail as being town-owned, including a section of the rail trail west of Route 134 recently reopened. DCR notes that the CCRT is owned by the Commonwealth and managed by the Department, and requests that a correction is made to the EIR. Additionally, DCR notes that the CCRT is protected by Article 97 of the Amendments to the Mass Constitution and any disposition of a land interest, whether the conveyance of a fee interest or the granting of an easement would require legislative approval by 2/3 roll call vote. DCR notes that Figure 14-2 ("Recommended Phasing Plan") appears to include a pump station and gravity force mains near the Cape Cod Rail Trail, adjacent to Great Western Road. In the EIR DCR requests that the Proponents provide additional information of the location of this infrastructure in relation to the Cape Cod Rail Trail, and clarify whether a permanent disposition of land or an interest in land would be required from DCR. DCR also requests that the Proponent definitively identify whether a DCR Construction and Access Permit would be required for the Project, and, if so, clarify the proposed activity on DCR land which would trigger the need for such a permit.

Town ownership of the CCRT shown on Figure 9-11 has been modified as requested. The sewer layouts and siting of the sewer pumping stations will not be confirmed until final design of the applicable phases of work. Since work near the CCRT is proposed to occur within Phases 1 and 2, a request for either permanent disposition or interest will be discussed with DCR in a timely manner, following final approval and Town agreement of the Final CWMP/SEIR.

19.9 Mashpee Wampanoag Tribe Letter 7/25/2017

Comment 9-1:

The Mashpee Wampanoag Tribe requests that Dennis contract a reputable Archaeological firm for phase 1A of the proposed areas of potential effect (APE). Our office will need digital copies of preliminary design plans being considered, archaeological assessment information and geotechnical information as it develops. We will require a Tribal CRM to access/monitor ground disturbing activities involved with Archaeology and or preliminary field testing. We request contact information for the general contractor/project manager in charge of scheduling. The proponent will be responsible for cost associated with our monitoring at a rate of $75.00/hr. which is expected to be paid within 30 days of invoicing.

Please refer to response to MHC comment No 4-2.

19.10 Cape Cod Commission Letter 7/7/2017

Comment 10-1:

The Town proposed to incorporate fertilizer management into its plan through outreach and education. Commission staff recommends that the Town have an especially robust education and outreach plan, given that the town is now preempted by state law from adopting fertilizer management regulations, and didn't adopt regulations through the Cape-wide Fertilizer Management District of Critical Planning Concern. The EENF also mentions encouraging low impact landscaping, which is implemented widely, may help with reducing impacts from fertilizer. The Town may want to consider incorporating requirements for low impact design into town bylaws. Stormwater management will include BMPs at specified sites (e.g. potentially the Scargo Lake boat ramp), redirection of stormwater to avoid direct discharges, public education, and consideration of new funding options for stormwater management.

A more detailed discussion of the formal fertilizer education management plan is presented in Section 14.7.3 with a table of past, current and future stormwater management projects provided in Table 14-15. The Town continues to target the area around Scargo Lake as a priority for stormwater management.

Comment 10-2:

Commission staff supports the Town's efforts to conduct an aquaculture program in Swan Pond. The Town could consider identifying additional opportunities for deploying shellfish in Town waterbodies in the CWMP to ensure that the program is not limited to the small (half acre) pilot proposed. The EIR should also address how success of the pilot may support expansion of the aquaculture program in the future.

The aquaculture pilot project began in 2018 and completed in 2019. See response to Comment 1-13 for more information. Use of aquaculture in other locations around Town is discussed in the adaptive management plan, included in Section 14.

Comment 10-3:

In it's EIR, Commission staff recommends that: Dennis present a sewer-only scenario, with its associated costs, that doesn't use ocean outfall and which discharges treated effluent outside of nitrogen-sensitive watersheds.

See response to Comment 1-13. The Town is currently planning to conduct additional effluent recharge investigations in non-nitrogen sensitive watersheds. .

Comment 10-4:

In it's EIR, Commission staff recommends that: Identify potential suitable discharge sites outside of nitrogen sensitive watersheds other than Site 3, which has limited capacity.

In 2016, the Town received a grant from the CCC to further investigate additional effluent recharge sites within the Town. Results from the effort were included in a letter report, shown in Appendix F. Two additional sites were identified, aside from Site 3, the Highlands Golf Course (Site 5) as well as Site 4 N/S located North and South of Hokum Rock Road. Groundwater

discharge from both of these locations occurs within the Chase Garden Creek Watershed, which is capable or receiving excess nitrogen, based on the recently finalized MEP report.

Comment 10-5:

In it's EIR, Commission staff recommends that: More specifically document the phased loading reductions, discharge increases and mitigation in the Swan Pond watershed.

A Swan Pond watershed focused summary has been added to Section 14 of the Final CWMP/SEIR.

Comment 10-6:

If the town intends to proceed in reliance on MEP target numbers instead of the numbers presented in Appendix 8C of the 208 Plan Update (as those numbers may be updated in the 208 database), then the EIR should provide a roadmap for intermunicipal agreement for the allocation of nitrogen responsibility, and the town should pursue an IMA in each of its shared watersheds.

Dennis and neighboring towns Yarmouth and Harwich all based their recommended programs on the TMDLs presented in the MEP reports. Should an IMA be developed in the future between all three or two of the Towns, a roadmap for intermunicipal agreement for the allocation of nitrogen responsibility will be included therein and shared with the CCC.

Comment 10-7:

The EIR should detail how thresholds will be met at the sub-embayment level. The town should append to the EIR the calculations used to estimate nitrogen removal rates at the subwatershed level.

The nitrogen balance MEP data disk spreadsheets have been included as a CD in Appendix I.

Comment 10-8:

Include in the EIR a list of public meetings and other opportunities for public engagement on the Plan it has undertaken

Minutes and presentations from public meetings are included in Appendix G of the Final CWMP/SEIR.

Comment 10-9:

The EIR should evaluate how development in these areas will affect water quality and future infrastructure needs and costs.

In 2018, at the direction of the WIC, CDM Smith subcontracted the UMass Donohue Institute to conduct a study on wastewater development within the Town, discussed in Section 7.6.6. The study can also be found in Appendix K of the Final CWMP.. In each of the wastewater management scenarios, adequate nitrogen removal from future developments was accounted for in order to protect water quality.

Comment 10-10:

The EIR should detail and expand the Town's AMP to include performance monitoring of proposed non-traditional strategies such as PRBs and aquaculture.

Monitoring plans will be developed for each technology as they are implemented, in conjunction with MassDEP and 208 Plan Guidelines.

Appendix A

208 Technology Matrix with Recommended Technologies

Site Scale
Neighborhood
Watershed
Cape-Wide
Reduction
Treatment before disposal to ground
Remediation
Treatment in groundwater
Restoration
Treatment in water body
Title 5
Standard Title 5 Systems
IA
I/A Title 5 Systems
Enhanced IA
I/A Enhanced Systems
Toilets: Composting, Incinerating, Packaging, Urine Diverting
Hydroponic Treatment
Cluster Treatment System: Single- or Two-stage
Satellite Treatment
Nutrient Reducing Development
TDR
Transfer of Development Rights
Constructed Wetlands
Phytoirrigation
PRB
Permeable Reactive Barrier (PRB)
Phytoremediation
Stormwater: Bioretention / Soil Media Filters
N+P
Fertigation Wells: Turf, Cranberry Bogs
Stormwater: Constructed Wetlands
Aquaculture/Shellfish Farming
Coastal Habitat Restoration
Inlet / Culvert Widening
Constructed Wetlands: Floating
Pond and Estuary Circulators
SWR
Surface Water Remediation Wetlands
Pond and Estuary Dredging
Conventional Treatment
Advanced Treatment
Advanced
N+P+K MGMT
Fertilizer Management
Compact and Open Space Development
BMPs
Stormwater Best Managment Practices (BMPs)
Policy

FIGURE A-1

Fertilizer Management

N+P+K MGMT

SCALE: CAPE WIDE
APPROACH: REDUCTION

SCENARIO PLANNING: SELECTED FOR USE

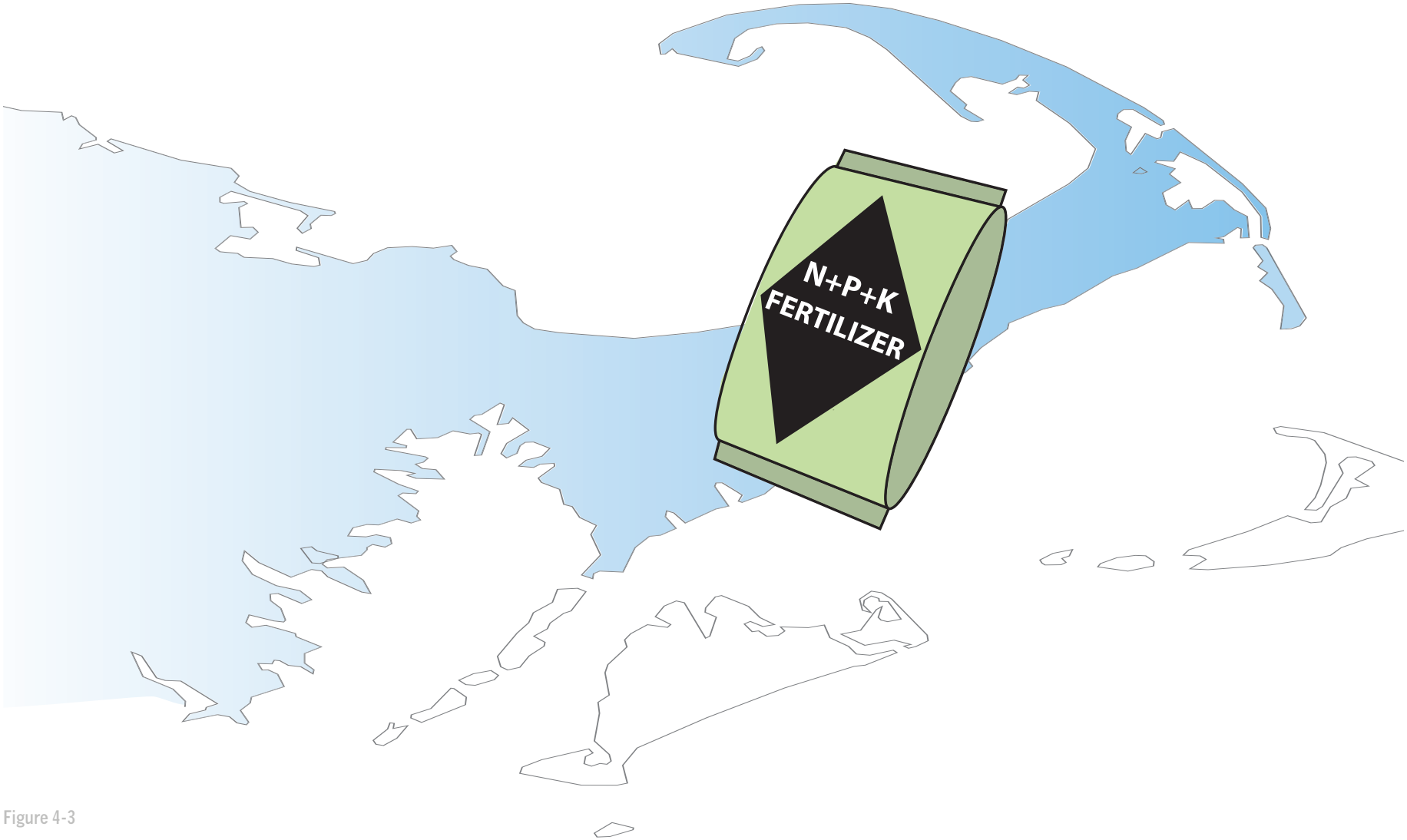


Figure 4-3

Fertilizer Management

SCALE: CAPE WIDE
APPROACH: REDUCTION

SCENARIO PLANNING: SELECTED FOR USE N+P+K MGMT

DESCRIPTION

This approach relies on managing fertilizer application rates to lawns, golf courses, athletic facilities and cranberry bogs. Residential lawn loading rates could be reduced on existing developed parcels through an intensive public education/ outreach program. This could include a "Cape Cod Lawn" branding program, replacing some turf areas with native vegetation, establishing naturally-vegetated buffer strips on waterfront lots, and reducing application rates. Fertilizer loading rates for new development could be accomplished by reducing lot sizes (cluster development), by restricting lawn sizes and/or by incorporating more naturally-vegetated open space areas. Municipalities could directly reduce fertilizer applications on athletic fields and other properties. Golf courses can significantly reduce nitrogen loading rates by using slow-release fertilizers and reducing application rates in rough areas.Cranberry bog fertilizer exports from the bogs can be reduced using tail water recovery systems. Site-specific assessments are needed to estimate load reductions.

SITING NEEDS

- Fertilizer management does not have specific site requirements.

ECO-BENEFITS

- Enhances Habitat / Wildlife / Biodiversity

PERFORMANCE CHALLENGES

- Resulting nutrient removal rates are highly dependent on homeowner / landowner behavior and participation in the program
- Site-specific assessments are needed to estimate load reductions

CLIMATE RESILIENCE: RISKS

- Fertilizer management does not result in significant climate resiliency risks.

CLIMATE RESILIENCE: SOLUTIONS

- Climate resiliency solutions are not needed for Fertilizer Management.

Permitting

POTENTIAL PERMITTING AUTHORITIES

- Municipal Board of Health
- Massachusetts Department of Agricultural Resources

Technology Performance

Nitrogen Removal 25% to 75%

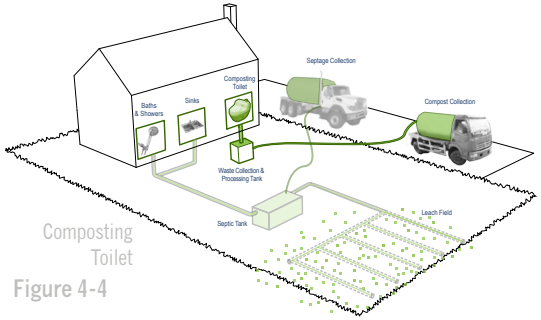
Phosphorus Removal 3% to 10%

$24	$141
Removal Cost per kg N (avg life cycle)	Removal Cost per kg P (avg life cycle)
20 years	1 to 10 years
Useful Life	Time to See Results

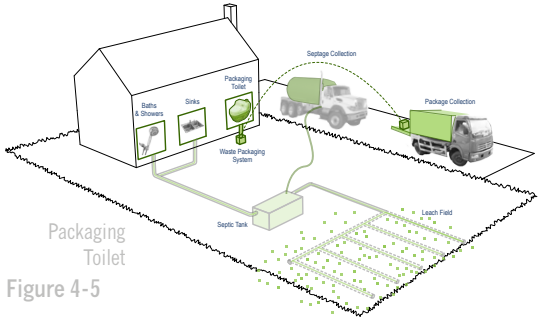
Waste Reduction Toilets

SCALE: SITE
APPROACH: REDUCTION

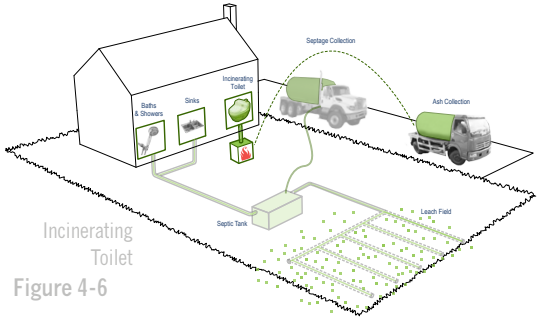
SCENARIO PLANNING: SELECTED FOR USE
IDENTIFIED FOR PILOTING



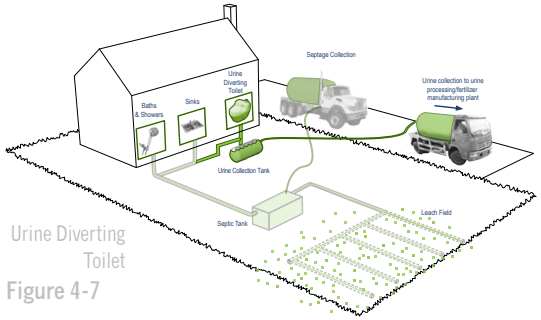
Composting Toilet
Figure 4-4



Packaging Toilet
Figure 4-5



Incinerating Toilet
Figure 4-6



Urine Diverting Toilet
Figure 4-7

DESCRIPTION

A waste reduction toilet is a system which separates human waste from shower, sink and other household water uses. These systems use no or minimal amounts of water. Waste reduction toilets require the installation of a separate toilet(s). Household water uses (i.e. sink and shower uses) continue to flow to the septic system.The four main categories of waste reducing toilets include: composting, incinerating, packaging and urine diverting. Composting toilets capture human waste in a container in the basement where it is decomposed and turned into compost. Incinerating toilets rely on electric power or natural or propane gas to incinerate human waste to sterile, clean ash. Packaging toilets encapsulate human waste in a durable material, stored beneath the toilet, for removal from the site when full. Urine diverting toilets divert urine to a holding tank where it is periodically collected by a servicing company; remaining human waste continues on to the septic system.

SITING NEEDS

- Requires a Title 5 System for ther gray water sources

ECO-BENEFITS

- Improves Energy Savings, Nutrient Recovery, Recycling

PERFORMANCE CHALLENGES

- Resulting nutrient removal rates are highly dependent on homeowner/landowner behavior and participation in the program
- Requires a significant number of citizens to participate to be effective

CLIMATE RESILIENCE: RISKS

- Degradation of materials and reduced asset lifespan due to increased exposure to saline water
- Mobilization of contamination as a result of failure of storage system
- Backflow of saline water into system causing overflows, increased degradation of materials and change in biological processes
- Reduced effectiveness of biological processes as a result of more frequent inundation or exposure to saline water (surface or ground water)
- Temporary restricted access to infrastructure to remove waste materials and undertake maintenance. Longer term access restriction may lead to reduced performance or overflow

Waste Reduction Toilets

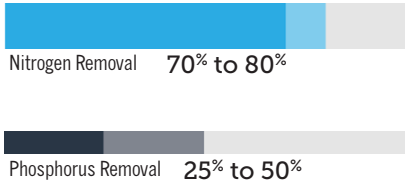
SCALE: SITE
APPROACH: REDUCTION

SCENARIO PLANNING: SELECTED FOR USE
IDENTIFIED FOR PILOTING

CLIMATE RESILIENCE: SOLUTIONS

- Select materials and coatings that are able to cope with an increasingly saline environment
- Ensure frequent maintenance inspections to monitor asset condition (e.g. rate of corrosion) and performance of technology (i.e. achieving nutrient removal targets)
- Backflow valves on system
- Anchoring of buried assets

Composting Toilet

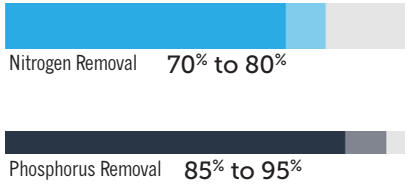


$266	$2,323
Removal Cost per kg N (avg life cycle)	Removal Cost per kg P (avg life cycle)
20 years	1 to 10 years
Useful Life	Time to See Results

SPECIFIC PERFORMANCE CHALLENGES

- Requires ongoing maintenance to function correctly
- Requires independent citizens to change systems to be cost effective

Incinerating Toilet

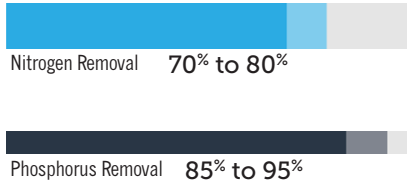


$328	$1,195
Removal Cost per kg N (avg life cycle)	Removal Cost per kg P (avg life cycle)
20 years	1 to 10 years
Useful Life	Time to See Results

SPECIFIC PERFORMANCE CHALLENGES

- Incineration process demolishes any nutrients found in human waste - meaning it cannot be used for nourishing soil
- Saves water, but uses more energy
- Still requires septic tank and leaching field for grey water
- The proprietary nature of this technology will impose high fees for waste removal and maintenance

Packaging Toilet

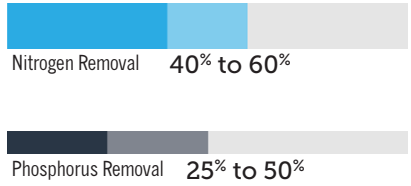


$198	$720
Removal Cost per kg N (avg life cycle)	Removal Cost per kg P (avg life cycle)
20 years	1 to 10 years
Useful Life	Time to See Results

SPECIFIC PERFORMANCE CHALLENGES

- Still requires septic tank and leaching field for grey water
- The proprietary nature of this technology will impose high fees for waste removal and maintenance

Urine Diverting Toilet



$333	$2,912
Removal Cost per kg N (avg life cycle)	Removal Cost per kg P (avg life cycle)
20 years	1 to 10 years
Useful Life	Time to See Results

SPECIFIC PERFORMANCE CHALLENGES

- Requires company infrastructure to pick up package
- Tight tank for urine storage required.

SPECIFIC POTENTIAL PERMITTING AUTHORITIES

- Municipality (Local plumbing inspector)
- Municipal Board of Health

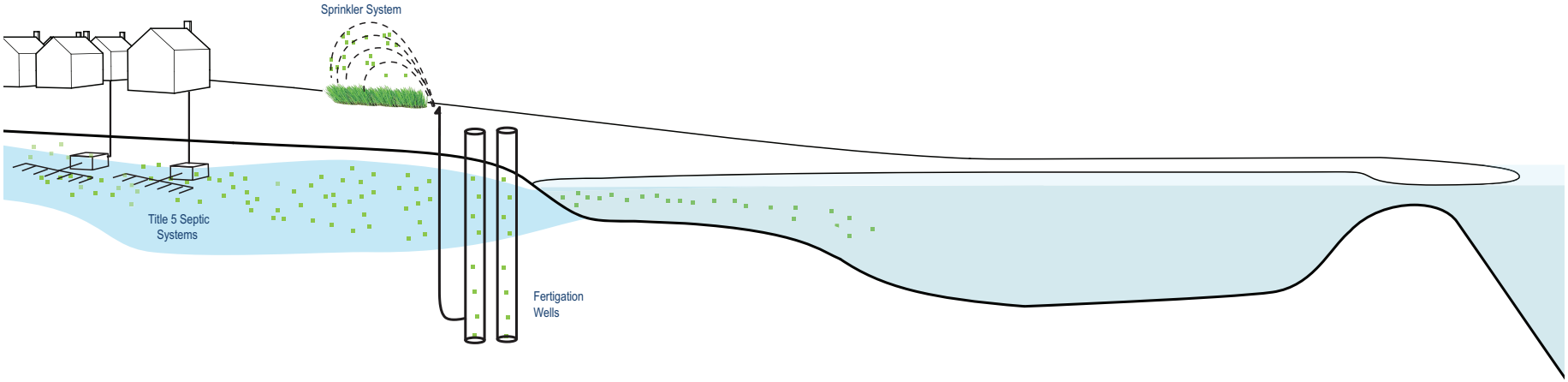


Figure 4-11

Fertigation Wells

SCALE: NEIGHBORHOOD/WATERSHED
APPROACH: REMEDIATION

SCENARIO PLANNING: SELECTED FOR USE
IDENTIFIED FOR PILOTING

DESCRIPTION

Fertigation consists of capturing nitrogen enriched groundwater via wells and using it to irrigate plants that use the nutrients. Fertigation wells can capture nutrient enriched groundwater and recycle it back to irrigate and fertilize turf grass areas, and to irrigate crops. Irrigated turf grass areas include golf courses, athletic fields and lawns, while irrigated crops typically include cranberry bogs. Fertigation can reduce nutrient loads to down gradient surface waters while reducing fertilizer costs to the irrigated areas.

Technology Performance

Nitrogen Removal 60% to 80%

Phosphorus Removal 60% to 80%

Turf:	Turf:
$151	$907
Cranberry Bogs:	Cranberry Bogs:
$132	$795
Removal Cost per kg N (avg life cycle)	Removal Cost per kg P (avg life cycle)
20 years	1 to 10 years
Useful Life	Time to See Results

Fertigation Wells

SCALE: NEIGHBORHOOD/WATERSHED
APPROACH: REMEDIATION

SCENARIO PLANNING: SELECTED FOR USE
IDENTIFIED FOR PILOTING

SITING NEEDS

- Fertigation wells should be located down gradient of nutrient source areas such as wastewater treatment plant disposal fields and compact development
- They can also be positioned down gradient of high-density subdivisions where they might capture nutrients derived from both septic systems and residential lawns
- The specific locations, depths and diameters can be optimized using standard hydrogeologic principles

ECO-BENEFITS

- Promotes Green Space / Conservation / Recreation
- Improves Energy Savings / Nutrient Recovery / Recycling

Permitting

POTENTIAL PERMITTING AUTHORITIES

- Turf: Massachusetts Department of Environmental Protection
- Cranberry Bogs: Massachusetts Department of Environmental Protection and Municipal Conservation Commission

PERFORMANCE CHALLENGES

- Seasonal technology potentially requiring several capture wells to capture entire nutrient plume
- Most effective in areas where groundwater contains a "plume" of high concentration of nutrients (i.e. down gradient of a WWTF discharge, etc.)
- Need an area to irrigate for nutrient uptake
- May require monitoring

CLIMATE RESILIENCE: RISKS

- Degradation of materials and reduced asset lifespan due to more frequent inundation and increased exposure to saline water
- Inundation leading to saltwater intrusion into groundwater potentially affecting reuse of water (e.g. irrigation)
- Destabilization of assets as a result of changes in groundwater levels or erosion

CLIMATE RESILIENCE: SOLUTIONS

- Ensure frequent maintenance inspections to monitor asset condition (e.g. rate of corrosion) and performance of technology (i.e. achieving nutrient removal targets)
- Select materials and coatings that are able to cope with an increasingly saline environment
- Backflow valves on outlets
- Anchoring of buried assets
- Locate technology outside flood hazard area anticipated for the life of the installation

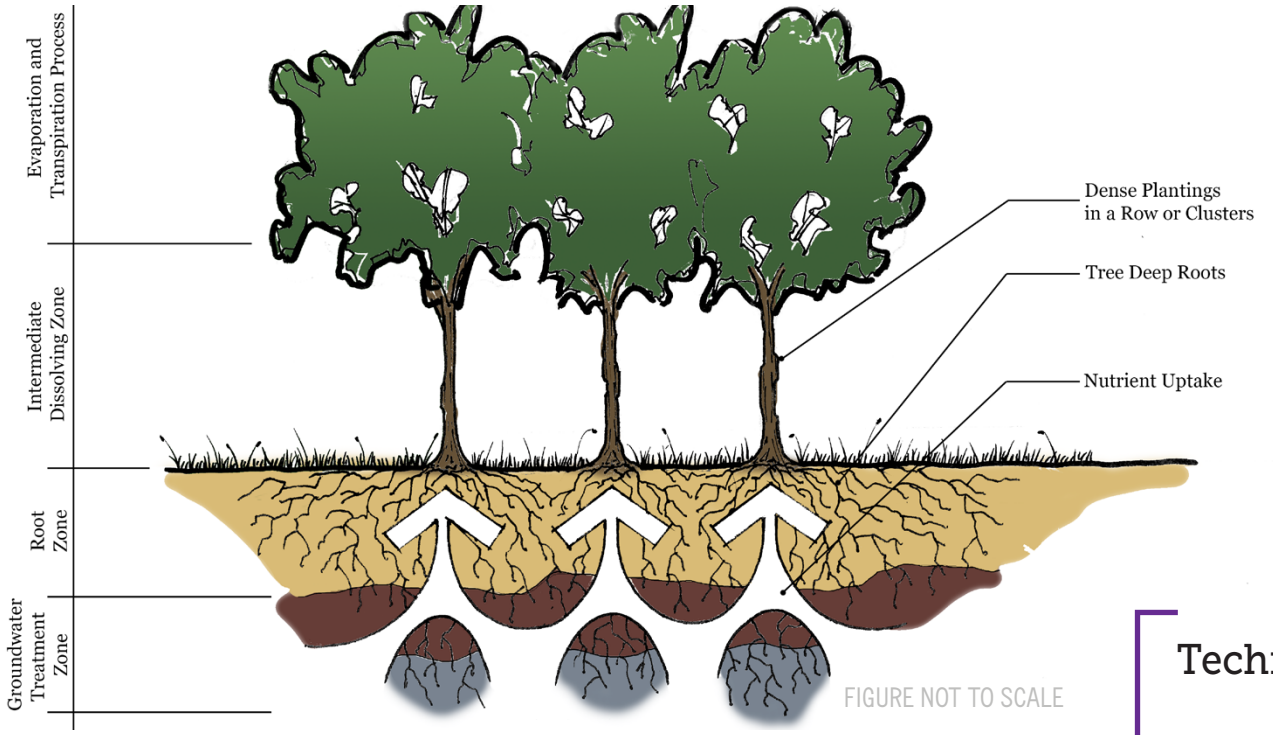


Figure 4-13

Phytoremediation

SCALE: SITE/NEIGHBORHOOD
APPROACH: REMEDIATION

SCENARIO PLANNING: SELECTED FOR USE IDENTIFIED FOR PILOTING

DESCRIPTION

Green plants with deep tap roots are planted as a buffer to intercept high nitrogen (nitrogen enriched) groundwater. The plants and microorganisms in their root zone reduce/use the nitrogen, removing it from the groundwater and watershed. Phytoremediation can be used to redirect a plume of nitrogen enriched groundwater or pull it up from deeper in the aquifer, allowing the plants to treat the plume.

Technology Performance

Nitrogen Removal 50% to 90%

Phosphorus Removal 20% to 60%

$228	$1,999
Removal Cost per kg N (avg life cycle)	Removal Cost per kg P (avg life cycle)
20 years	1 to 10 years
Useful Life	Time to See Results

Phytoremediation

SCALE: SITE/NEIGHBORHOOD
APPROACH: REMEDIATION

SCENARIO PLANNING: SELECTED FOR USE
IDENTIFIED FOR PILOTING

SITING NEEDS

- Permeable soils
- Depth to groundwater <10 feet
- Not within priority habitat areas
- Not within protected open space
- Benefit if site is located within a Zone II, has disturbed soils, parcel intersects with 50 to 100 foot wetland buffers, has municipal ownership, necessary nitrogen removal in groundwater filtering through parcel is high

ECO-BENEFITS

- Enhances Habitat / Wildlife / Biodiversity
- Promotes Green Space / Conservation / Recreation
- Improves Energy Savings / Nutrient Recovery / Recycling
- Improves Management of Flooding / Extreme Events

Permitting

POTENTIAL PERMITTING AUTHORITIES

- Licensed Site Professional/Massachusetts Department of Environmental Protection
- U.S. Environmental Protection Agency

PERFORMANCE CHALLENGES

- In year one after planting, no remediation occurs because trees have not reached the groundwater. As the trees get larger and pump more water, nitrogen removal rates increase and plateau
- Plants can only be irrigated during the growing season, requiring use of holding ponds in non-growing season.

CLIMATE RESILIENCE: RISKS

- Reduced effectiveness of biological processes as a result of more frequent inundation or exposure to saline water (surface or ground water)

CLIMATE RESILIENCE: SOLUTIONS

- Ensure frequent maintenance inspections to monitor condition and performance of technology (i.e. achieving nutrient removal targets and health of vegetation)
- Species selection to ensure adequate performance in increasingly saline environments
- Preserve areas / buffers to allow migration of salt marsh to higher elevations as MHW rises

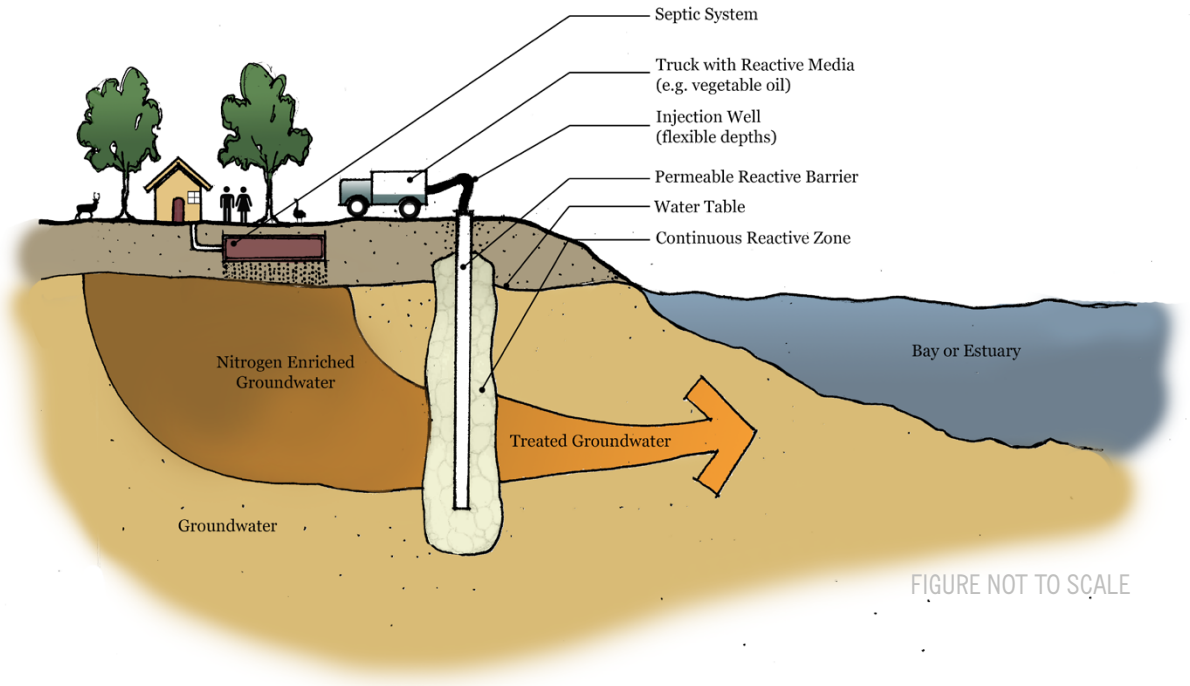


Figure 4-14

Permeable Reactive Barriers (PRBs) Injection Well Method

PRB

SCALE: SITE/NEIGHBORHOOD
APPROACH: REMEDIATION

SCENARIO PLANNING: SELECTED FOR USE
IDENTIFIED FOR PILOTING

DESCRIPTION

A permeable reactive barrier (PRB) is an in-situ (installed within the aquifer) treatment zone designed to intercept nitrogen enriched groundwater. Through use of a carbon source, microbes in the groundwater uptake the nitrogen, denitrifying the groundwater. An injection Well PRB system typically uses a series of injection wells to introduce the carbon source (medium) into the groundwater.The injection wells can be installed to depth greater than the PRB trench method. The injection well PRB method can be used in combination with the PRB trenching method described previously. As groundwater flows through the medium, microbes naturally occurring in the groundwater consume the carbon source, as well as oxygen, developing an anaerobic environment. This process releases nitrogen gas to the atmosphere, reducing the groundwater nitrogen load before reaching the estuary.

Technology Performance

Nitrogen Removal 75% to 95%

Phosphorus Removal 50% to 95%

$279	$1,310
Removal Cost per kg N (avg life cycle)	Removal Cost per kg P (avg life cycle)
20 years	1 to 10 years
Useful Life	Time to See Results

Permeable Reactive Barriers (PRBs) Injection Well Method

SCALE: SITE/NEIGHBORHOOD
APPROACH: REMEDIATION

SCENARIO PLANNING: SELECTED FOR USE IDENTIFIED FOR PILOTING

PRB

SITING NEEDS

- Suitable groundwater flow path (depth to intercept groundwater)
- Generally at least 20 feet of saturated aquifer thickness is desired
- In general, the injection well PRB can be installing areas with steeper topography than a trench PRB
- In general, the injection well PRB can be installing areas where utilities limit the installation of trench PRBs
- Ready access for construction
- Access to sites up gradient or down gradient to allow groundwater monitoring
- Permitting requirements if used in or near wetlands
- Construction cost based on 20-foot spacing between injection wells installed to an overall depth of 40 feet. Deeper installations are possible

Permitting

POTENTIAL PERMITTING AUTHORITIES

- Massachusetts Department of Environmental Protection

ECO-BENEFITS

- Improves Energy Savings / Nutrient Recovery / Recycling
- Improves Management of Flooding / Extreme Events

PERFORMANCE CHALLENGES

- Siting can be limited by wetlands, public utilities and abutter concerns
- Detailed knowledge of local groundwater hydrology needed
- Large projects may require a hydrogeologic investigation and groundwater modeling to estimate effectiveness of PRB
- Permitting requirements may be extensive and time consuming
- Projects may require extensive groundwater monitoring early in the project to quantify nitrogen load reduction
- Projects may require groundwater monitoring near or in embayments as well as monitoring of vegetation and benthic monitoring where groundwater surfaces in the receiving estuary

CLIMATE RESILIENCE: RISKS

- Degradation of materials and reduced asset lifespan due to more frequent inundation and increased exposure to saline water
- Inundation leading to saltwater intrusion into groundwater potentially affecting reuse of water (e.g. irrigation)
- Destabilization of assets as a result of changes in groundwater levels or erosion

CLIMATE RESILIENCE: SOLUTIONS

- Ensure frequent maintenance inspections to monitor asset condition (e.g. rate of corrosion) and performance of technology (i.e. achieving nutrient removal targets)
- Select materials and coatings that are able to cope with an increasingly saline environment
- Backflow valves on outlets
- Anchoring of buried assets
- Locate technology outside flood hazard area anticipated for the life of the installation

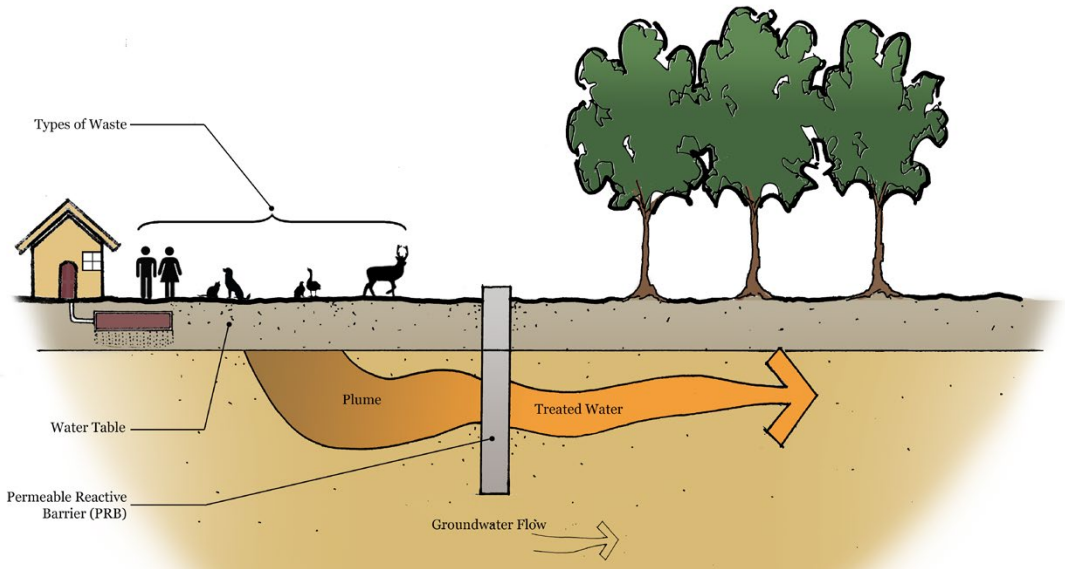


FIGURE NOT TO SCALE

Figure 4-15

Permeable Reactive Barriers (PRBs) Trench Method

PRB

SCALE: SITE/NEIGHBORHOOD
APPROACH: REMEDIATION

SCENARIO PLANNING: SELECTED FOR USE
IDENTIFIED FOR PILOTING

DESCRIPTION

A permeable reactive barrier (PRB) is an in-situ (installed within the aquifer) treatment zone designed to intercept nitrogen enriched groundwater. Through use of a carbon source (the PRB medium), microbes in the groundwater uptake the nitrogen, denitrifying the groundwater. The trench method PRB uses large trenching equipment to install a mixture of coarse sand, wood chips, compost and/or other materials (medium) in the trench created by the trencher. The vertical wall can be installed to a depth of 40 feet with a width of 1.5 to 3 feet; PRBs can also be installed in large diameter columns. As groundwater flows through the wall, the medium provides a carbon source for microbes living in the groundwater. The microbes consume the carbon source as well as oxygen, developing an anaerobic environment which releases nitrogen gas to the atmosphere, reducing the groundwater nitrogen load before reaching the estuary.

Technology Performance

Nitrogen Removal 75% to 95%

Phosphorus Removal 50% to 95%

$158	$743
Removal Cost per kg N (avg life cycle)	Removal Cost per kg P (avg life cycle)
20 years	1 to 10 years
Useful Life	Time to See Results

Permeable Reactive Barriers (PRBs) Trench Method

SCALE: SITE/NEIGHBORHOOD
APPROACH: REMEDIATION

SCENARIO PLANNING: SELECTED FOR USE IDENTIFIED FOR PILOTING

PRB

SITING NEEDS

- Suitable groundwater flow path (depth to intercept groundwater)
- Generally at least 20 feet of saturated aquifer thickness is desired
- Relatively level site
- Ready access for construction
- Access to sites up gradient or down gradient to allow groundwater monitoring
- Limited vegetation, Limited public utilities
- Permitting requirements if used in or near wetlands
- Construction cost based on width of 3 feet width, and an overall depth of 40 feet (using existing trenching equipment - deeper in installations are possible using injection well PRBs described below)

ECO-BENEFITS

- Improves Energy Savings / Nutrient Recovery / Recycling
- Improves Management of Flooding / Extreme Events

Permitting

POTENTIAL PERMITTING AUTHORITIES

- Massachusetts Department of Environmental Protection

PERFORMANCE CHALLENGES

- Siting can be limited by wetlands, public utilities and abutter concerns
- Detailed knowledge of local groundwater hydrology needed
- Projects may require a hydrogeologic investigation and groundwater modeling to estimate effectiveness of PRB
- Permitting requirements may be extensive and time consuming
- Projects may require extensive groundwater monitoring early in the project to quantify nitrogen load reduction
- Projects may require groundwater monitoring near or in embayments as well as monitoring of vegetation and benthic monitoring where groundwater surfaces in the receiving estuary

CLIMATE RESILIENCE: RISKS

- Degradation of materials and reduced asset lifespan due to more frequent inundation and increased exposure to saline water
- Inundation leading to saltwater intrusion into groundwater potentially affecting reuse of water (e.g. irrigation)
- Destabilization of assets as a result of changes in groundwater levels or erosion

CLIMATE RESILIENCE: SOLUTIONS

- Ensure frequent maintenance inspections to monitor asset condition (e.g. rate of corrosion) and performance of technology (i.e. achieving nutrient removal targets)
- Select materials and coatings that are able to cope with an increasingly saline environment
- Backflow valves on outlets
- Anchoring of buried assets
- Locate technology outside flood hazard area anticipated for the life of the installation

Stormwater BMPs

SCALE: CAPE WIDE
APPROACH: REMEDIATION

SCENARIO PLANNING: SELECTED FOR USE

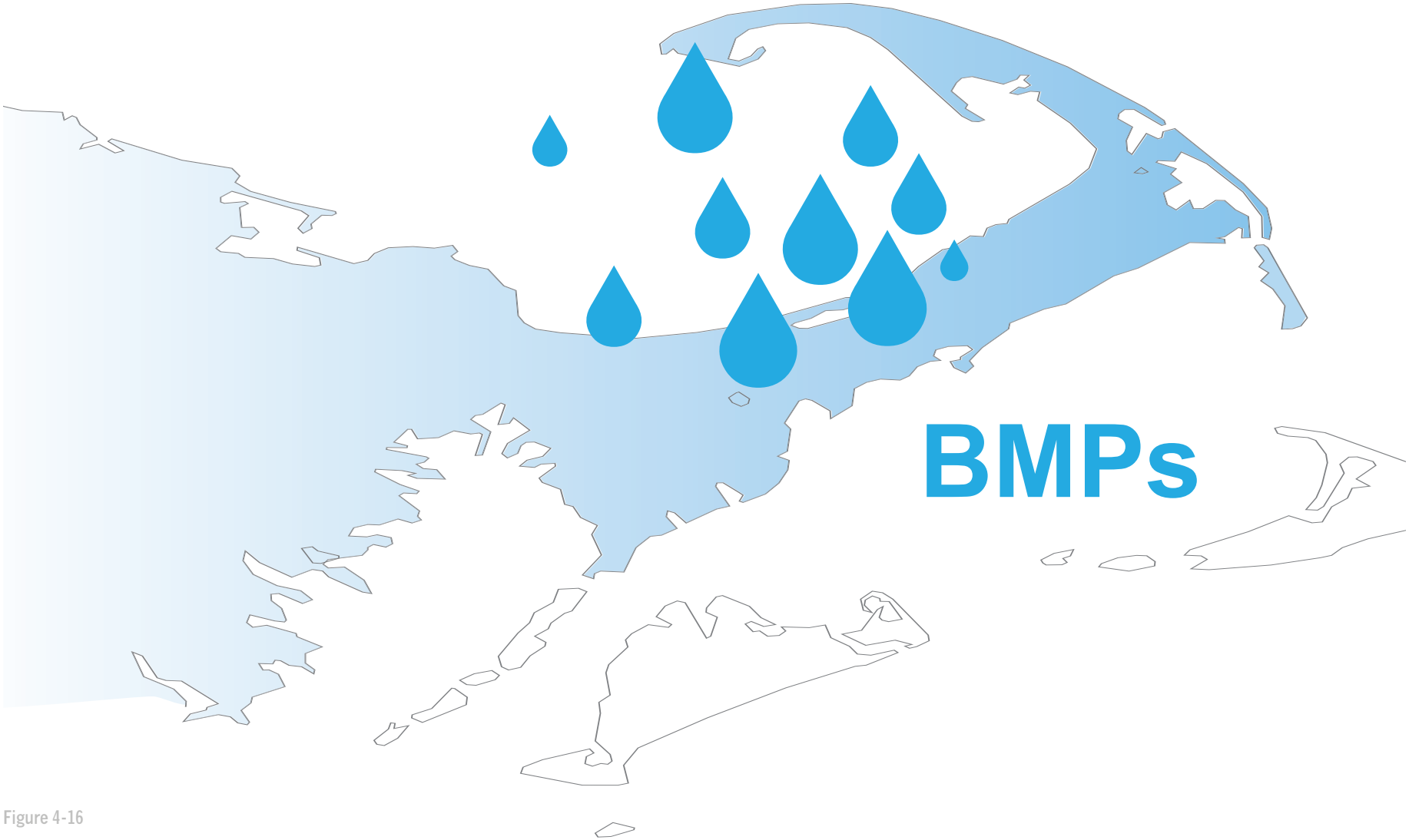


Figure 4-16

Stormwater BMPs

SCALE: CAPE WIDE
APPROACH: REMEDIATION

SCENARIO PLANNING: SELECTED FOR USE

DESCRIPTION

Non-Structural Stormwater strategies. These strategies include street sweeping, maintenance of stormwater utilities, education and public outreach programs, land use planning, and IC reduction and control.

SITING NEEDS

- Varies

ECO-BENEFITS

- Enhances Habitat / Wildlife / Biodiversity
- Promotes Green Space / Conservation / Recreation
- Improves Management of Flooding / Extreme Events

PERFORMANCE CHALLENGES

- Requires the creation and enforce of stormwater regulations and policies

CLIMATE RESILIENCE: RISKS

- Reduced effectiveness of biological processes as a result of more frequent inundation or exposure to saline water (surface or ground water

CLIMATE RESILIENCE: SOLUTIONS

- Ensure frequent maintenance inspections to monitor condition and performance of technology (e.g. achieving nutrient removal targets, health of vegetation)
- Project design and species selection to ensure adequate performance in increasingly saline environments

Permitting

POTENTIAL PERMITTING AUTHORITIES

- Municipal Conservation Commission
- Massachusetts Department of Environmental Protection

Technology Performance

Nitrogen Removal 25% to 75%

Phosphorus Removal 1% to 8%

$695	$51,470
Removal Cost per kg N (avg life cycle)	Removal Cost per kg P (avg life cycle)
20 years	1 to 10 years
Useful Life	Time to See Results

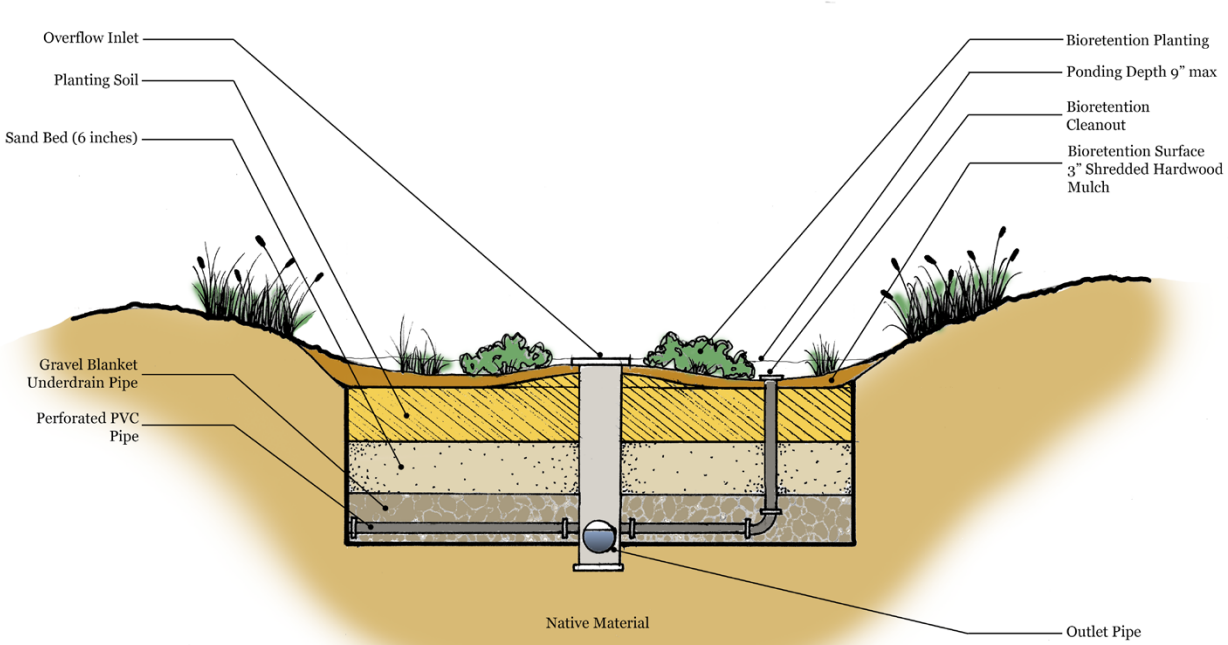


FIGURE NOT TO SCALE

Figure 4-17

Stormwater Bioretention Soil Media Filters

SCALE: SITE
APPROACH: REMEDIATION

SCENARIO PLANNING: NOT SELECTED FOR USE
IDENTIFIED FOR PILOTING

DESCRIPTION

Bioretention is the process in which contaminants and sedimentation are removed from stormwater runoff through physical, biological and chemical treatment processes. Stormwater is collected into the treatment area which consists of a grass buffer strip, sand bed, ponding area, organic layer or mulch layer, planting soil, and plants. Runoff passes first over or through a sand bed, which slows the runoff's velocity, distributes it evenly along the length of the ponding area, which consists of a surface organic layer and/or groundcover and the underlying planting soil. The ponding area is graded, its center depressed. Water is ponded and gradually infiltrates the bioretention area or is evapotranspired. The bioretention area is graded to divert excess runoff away from itself. Stored water in the bioretention area planting soil exfiltrates over a period of days into the underlying soils.

Technology Performance

Nitrogen Removal 25% to 45%

Phosphorus Removal 20% to 30%

$2,241	$20,912
Removal Cost per kg N (avg life cycle)	Removal Cost per kg P (avg life cycle)
20 years	1 to 10 years
Useful Life	Time to See Results

Stormwater Bioretention Soil Media Filters

SCALE: SITE
APPROACH: REMEDIATION
SCENARIO PLANNING: NOT SELECTED FOR USE
IDENTIFIED FOR PILOTING

SITING NEEDS

- GW depth > 4 feet
- Footprint is greatly scalable

ECO-BENEFITS

- Enhances Habitat / Wildlife / Biodiversity
- Promotes Green Space / Conservation / Recreation
- Improves Management of Flooding / Extreme Events

PERFORMANCE CHALLENGES

- Open space required for construction

CLIMATE RESILIENCE: RISKS

- Reduced effectiveness of biological processes as a result of more frequent inundation or exposure to saline water (surface or ground water)

CLIMATE RESILIENCE: SOLUTIONS

- Ensure frequent maintenance inspections to monitor condition and performance of technology (i.e. achieving nutrient removal targets, health of vegetation)
- Species selection to ensure adequate performance in increasingly saline environments

Stormwater Constructed Wetlands, BMPs

SCALE: CAPE WIDE
APPROACH: REMEDIATION

SCENARIO PLANNING: SELECTED FOR USE
PHYTOBUFFERS IDENTIFIED FOR PILOTING

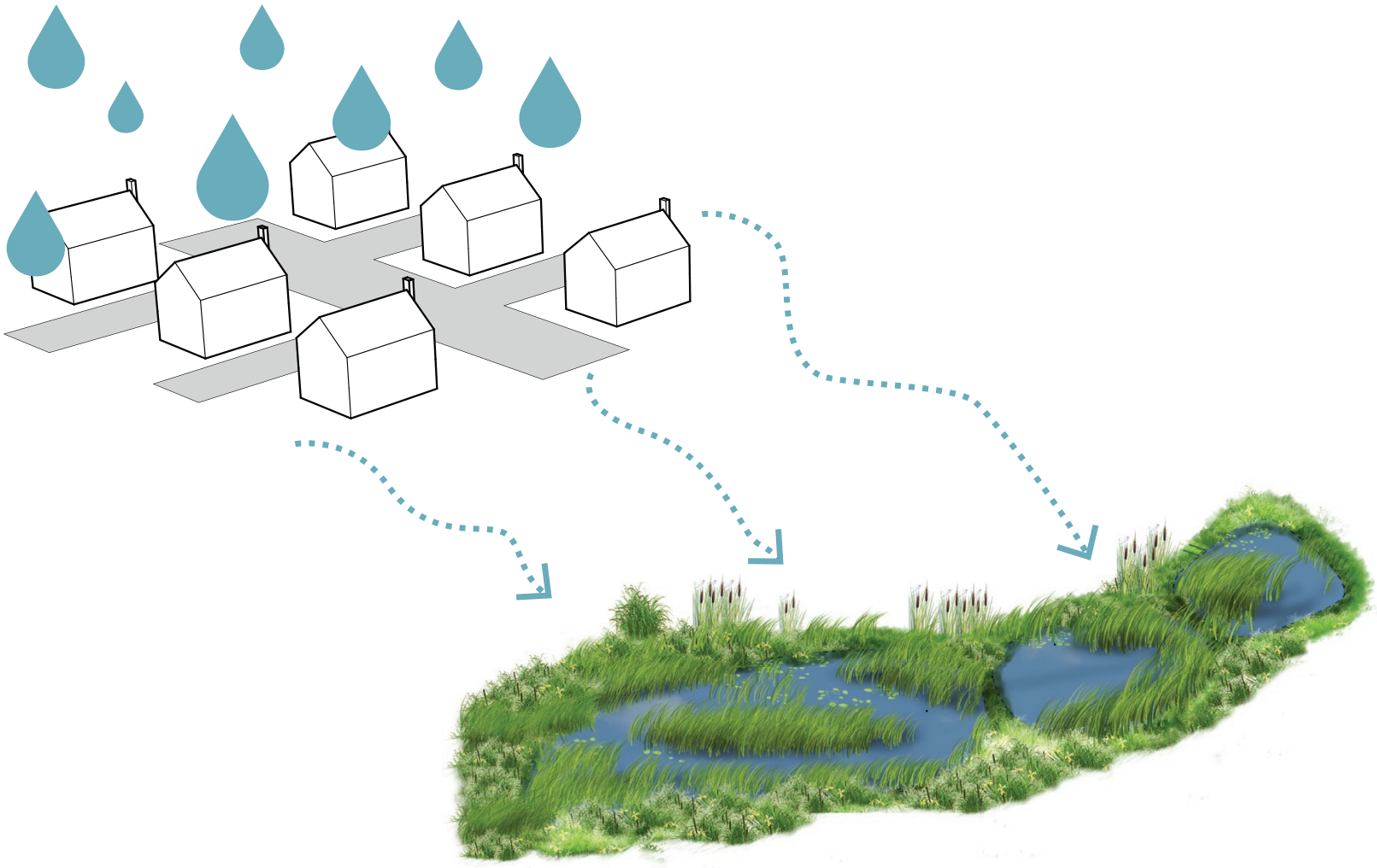


Figure 4-18

Stormwater Constructed Wetlands, BMPs

SCALE: CAPE WIDE
APPROACH: REMEDIATION

SCENARIO PLANNING: SELECTED FOR USE
PHYTOBUFFERS IDENTIFIED FOR PILOTING

DESCRIPTION

There are several types of structural stormwater BMPs, such as phytobuffers, vegetated swales, and constructed wetlands, which can contribute to nutrient removal. These approaches typically employ an excavated elongated basin engineered to accommodate the requirements of the site, together with components designed to enhance nutrient attenuation. These components may include: a swale to convey runoff; a system of chambers that allow for filtration, sediment settling, aerobic and anaerobic activity; and vegetation for nutrient uptake. Vegetated swales are typically grassed parabolic basins with relatively flat side slopes. Phytobuffers employ fast growing poplars and willow trees to remove nutrients and other contaminants. Constructed wetlands filter stormwater as it flows horizontally through a sediment forebay and a series of gravel-bottomed wetland cells, where algae and microbes grow in abundance. Constructed wetlands can be engineered to mimic natural systems, but designed to improve residence time within anaerobic chambers, allowing for year round nitrogen removal.

SITING NEEDS

- Varies

ECO-BENEFITS

- Enhances Habitat / Wildlife / Biodiversity
- Promotes Green Space / Conservation / Recreation
- Improves Management of Flooding / Extreme Events

PERFORMANCE CHALLENGES

- Requires the creation and enforcement of stormwater regulations and policies

CLIMATE RESILIENCE: RISKS

- Reduced effectiveness of biological processes as a result of more frequent inundation or exposure to saline water (surface or ground water)

CLIMATE RESILIENCE: SOLUTIONS

- Ensure frequent maintenance inspections to monitor condition and performance of technology (e.g. achieving nutrient removal targets, health of vegetation)
- Project design and species selection to ensure adequate performance in increasingly saline environments

Permitting

POTENTIAL PERMITTING AUTHORITIES

- Municipal Conservation Commission
- Massachusetts Department of Environmental Protection

Technology Performance

Nitrogen Removal % 25 to 90

Phosporous Removal %1 to 80

$156 to $1,900	$6,483 to $74,143
Removal Cost per kg N (avg life cycle)	Removal Cost per kg P (avg life cycle)
20 years	1 to 10 years
Useful Life	Time to See Results

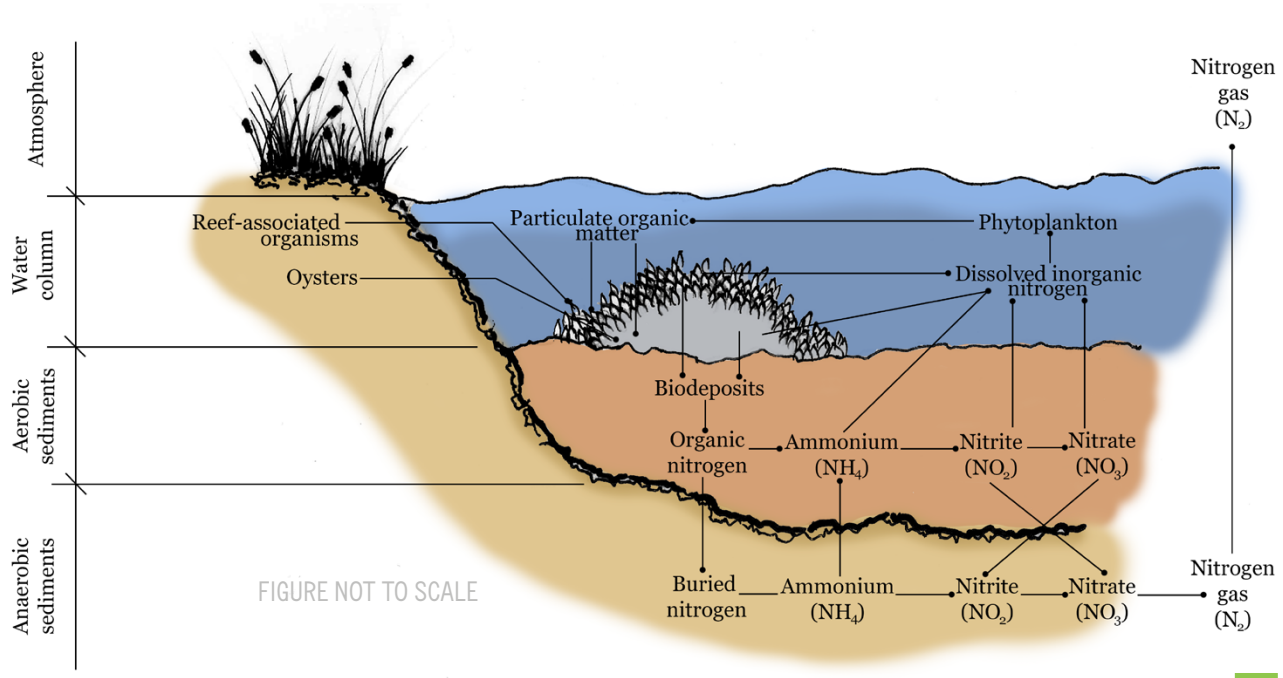


Figure 4-20

Aquaculture Shellfish

SCALE: NEIGHBORHOOD/WATERSHED
APPROACH: RESTORATION

SCENARIO PLANNING: SELECTED FOR USE
IDENTIFIED FOR PILOTING

DESCRIPTION

Shellfish, specifically oysters, remove nitrogen from their environment. The growing and removal of the mature oysters can remove nitrogen from an estuary, reducing the estuary's nitrogen load. Aquaculture can become a dual purpose project where shellfish are harvested for market while there will be a local reduction in nitrogen in the overlying water column during the growth and maturation of the oysters.

Shellfish may be cultivated above or within the estuary bed. The "in-estuary bed" method cultivates the shellfish in the benthic soils of the estuary. Shellfish may also be cultivated above the estuary bed in containters. With either approach, harvesting a portion of the oysters is required to remove nitrogen. Shellfish cultivation may be used in combination with other types of aquaculture (e.g mariculture), as well as floating constructed wetlands designed for brackish water.

Technology Performance

Nitrogen Removal 8% to 15%

Phosphorus Removal n/a

$61
Removal Cost per kg N
(avg life cycle)

20 years
Useful Life

1 to 3 years
Time to See Results

Aquaculture Shellfish

SCALE: NEIGHBORHOOD/WATERSHED
APPROACH: RESTORATION

SCENARIO PLANNING: SELECTED FOR USE
IDENTIFIED FOR PILOTING

SITING NEEDS

- Suitable area within estuary to seed and cultivate shellfish

ECO-BENEFITS

- Enhances Habitat / Wildlife / Biodiversity
- Promotes Green Space / Conservation / Recreation
- Improves Energy Savings / Nutrient Recovery / Recycling
- Improves Management of Flooding / Extreme Events

PERFORMANCE CHALLENGES

- growing conditions, aesthetics or navigation may limit applicability

Permitting

POTENTIAL PERMITTING AUTHORITIES

- Municipal Conservation Commission
- Massachusetts Department of Environmental Protection
- Army Corps of Engineers
- Office of Coastal Zone Management
- Board of Selectmen or Aldermen or designee
- Massachusetss Division of Marine Fisheries

- Seasonal nitrogen uptake coincident with natural cycle and algal blooms
- Requires removal of shellfish in order to take credit for nitrogen removal
- Nitrogen uptake subject to possible disruption due to disease or population crash
- Population monitoring is important to maintain persistence of the benefit
- Large concentrations of shellfish can generate waste products, reduce dissolved oxygen levels, and possibly generate ammonia
- Shellfish will undergo rapid growth to a marketable size after which they must be harvested.
- Can require large areas to gain significant nitrogen removal
- If the waterbody is closed for shell fishing, management will be required to prevent the shellfish from getting into the food supply

CLIMATE RESILIENCE: RISKS

- Damage to shorelines or subsurface structures from storm events (e.g. wave action)

CLIMATE RESILIENCE: SOLUTIONS

- Ensure frequent maintenance inspections to monitor asset condition and performance of technology (i.e. achieving nutrient removal targets)
- Potential anchoring of structures
- Protective structures to reduce impacts to reefs (e.g. wind walls)

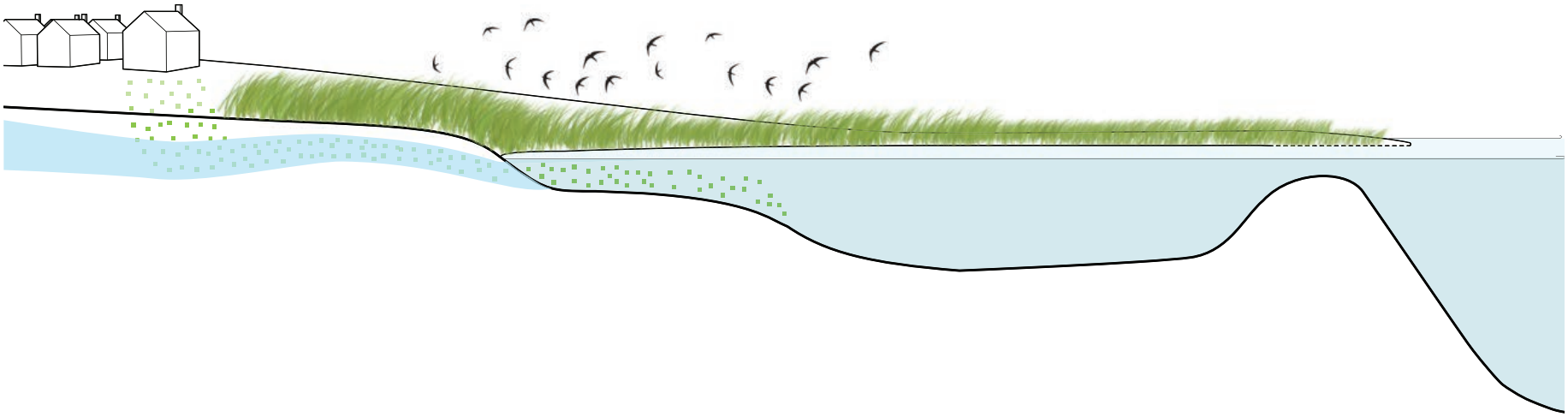


Figure 4-21

Coastal Habitat Restoration

SCALE: NEIGHBORHOOD/WATERSHED
APPROACH: RESTORATION

SCENARIO PLANNING: SELECTED FOR USE
IDENTIFIED FOR PILOTING

DESCRIPTION

Restoration of coastal habitats includes establishing and/or enhancing estuary salt marshes, eel grass beds, as well as shellfish and oyster beds together as an ecosystem.When considering restoration of coastal habitats, implementing these ecosystems jointly should be considered. The installation of riparian buffer zones and Floating Constructed Wetlands should be considered when restoring coastal habitats. Habitat restoration should focus on creating or rehabilitating habitats, including creating communities that are natural to the area.

Technology Performance

Nitrogen Removal 5% to 12%

Phosphorus Removal n/a

$163
Removal Cost per kg N
(avg life cycle)

20 years
Useful Life

0.5 to 3 years
Time to See Results

Coastal Habitat Restoration

SCALE: NEIGHBORHOOD/WATERSHED
APPROACH: RESTORATION

SCENARIO PLANNING: SELECTED FOR USE
IDENTIFIED FOR PILOTING

SITING NEEDS

- Site specific requirements based on the characteristics of the estuary
- Suitable substrate in saltwater/ estuarine environments
- Suitable area within estuary to seed and grow shellfish

ECO-BENEFITS

- Enhances Habitat / Wildlife / Biodiversity
- Promotes Green Space / Conservation / Recreation
- Improves Energy Savings / Nutrient Recovery / Recycling
- Improves Management of Flooding / Extreme Events

CLIMATE RESILIENCE: RISKS

- Reduced effectiveness of biological processes as a result of more frequent inundation or exposure to saline water (surface or ground water)

CLIMATE RESILIENCE: SOLUTIONS

- Ensure frequent maintenance inspections to monitor condition and performance of technology (i.e. achieving nutrient removal targets and health of vegetation)
- Species selection to ensure adequate performance in increasingly saline environments
- Preserve areas / buffers to allow migration of salt marsh to higher elevations as MHW rises

Permitting

POTENTIAL PERMITTING AUTHORITIES

- Municipal Conservation Commission
- Massachusetts Department of Environmental Protection
- U.S. Army Corps of Engineers
- Office of Coastal Zone Management

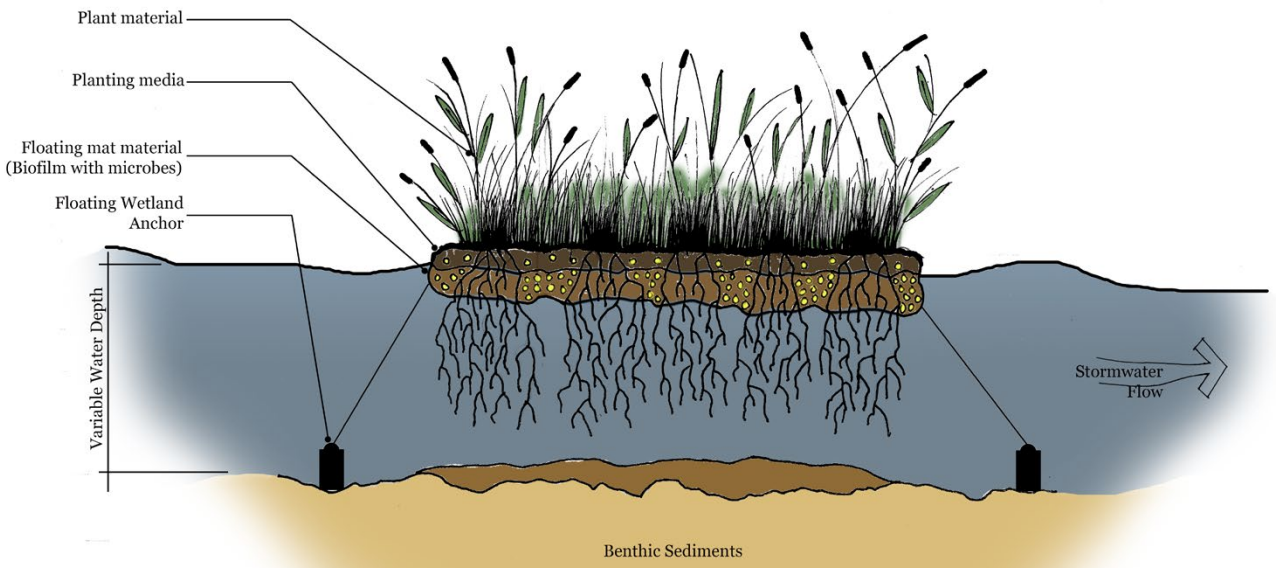


Figure 4-22

FIGURE NOT TO SCALE

Floating Constructed Wetlands

SCALE: NEIGHBORHOOD/WATERSHED
APPROACH: RESTORATION

SCENARIO PLANNING: SELECTED FOR USE
IDENTIFIED FOR PILOTING

DESCRIPTION

FCWs are manmade floating "islands" that act as floating wetlands that treat waters within ponds and estuaries. The islands are made of recycled materials that float on ponds or estuaries, exposing the plant's roots to the pond and estuarine waters. The root zones provide habitat for fish and microorganisms while reducing nitrogen and phosphorus levels. The floating islands can also be designed to allow shellfish and seaweed to grow which can be harvested, offsetting some of the systems costs. Some systems circulate surface water through the island, exposing the water to the root zones of the plants. The islands can be installed with shellfish beds and/or salt marsh grasses potentially assisting with their establishment. The islands are generally stationary and can be installed with walkways to access and maintain the plants growing on the islands. The islands require little O&M and do not need to be removed during the winter months, even if freezing water is a concern.

Technology Performance

Nitrogen Removal 8 to 15

Phosphorus Removal 0.5 to 1

$20	$454
Removal Cost per kg N (avg life cycle)	Removal Cost per kg P (avg life cycle)
20 years	0.5 to 3 years
Useful Life	Time to See Results

Floating Constructed Wetlands

SCALE: NEIGHBORHOOD/WATERSHED
APPROACH: RESTORATION

SCENARIO PLANNING: SELECTED FOR USE
IDENTIFIED FOR PILOTING

SITING NEEDS

- Site specific requirements based on the characteristics of the estuary or pond
- A location(s) within the estuary or pond to locate a floating island year around

ECO-BENEFITS

- Enhances Habitat / Wildlife / Biodiversity
- Promotes Green Space / Conservation / Recreation
- Improves Energy Savings / Nutrient Recovery / Recycling
- Improves Management of Flooding / Extreme Events

PERFORMANCE CHALLENGES

- Not listed

Permitting

POTENTIAL PERMITTING AUTHORITIES

- Municipal Conservation Commission
- Massachusetts Department of Environmental Protection
- U.S. Army Corps of Engineers

CLIMATE RESILIENCE: RISKS

- Damage to structures from storm events (e.g. wind and wave action)

CLIMATE RESILIENCE: SOLUTIONS

- Ensure frequent maintenance inspections to monitor asset condition and performance of technology (i.e. achieving nutrient removal targets)
- Potential anchoring of structures
- Protective structures to reduce impacts to wetlands (e.g. wind walls)

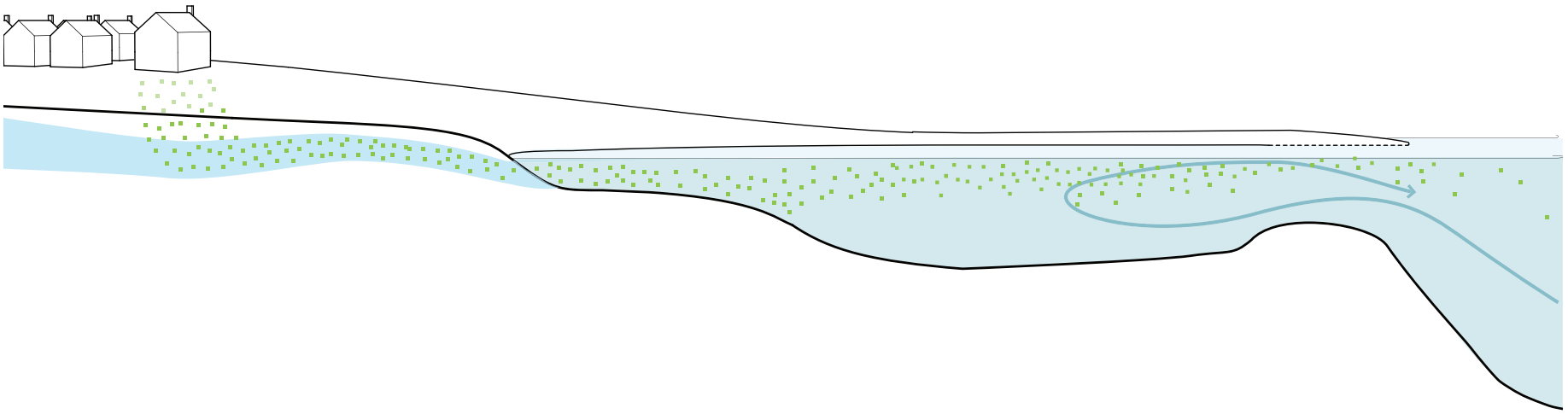


Figure 4-23

Inlet/Culvert Widening

SCALE: NEIGHBORHOOD/WATERSHED
APPROACH: RESTORATION

SCENARIO PLANNING: SELECTED FOR USE

DESCRIPTION

This approach considers re-engineering and reconstruction of bridge or culvert openings to increase the tidal flux through the culvert or inlet. In the right settings, increasing the tidal flux can decrease the nitrogen residence time, lowering the nutrient concentration in the estuary and/or tidal marsh upstream of the widened inlet or culvert.

Technology Performance

Nitrogen Removal 8% to 15%

Phosphorus Removal 0.5% to 1%

$20	$464
Removal Cost per kg N (avg life cycle)	Removal Cost per kg P (avg life cycle)
10 years	0.5 to 3 years
Useful Life	Time to See Results

Inlet/Culvert Widening

SCALE: NEIGHBORHOOD/WATERSHED
APPROACH: RESTORATION

SCENARIO PLANNING: SELECTED FOR USE

SITING NEEDS

- Site specific requirements, based on existing culvert bridge dimensions, hydraulics and other characteristics

ECO-BENEFITS

- Enhances Habitat / Wildlife / Biodiversity
- Promotes Green Space / Conservation / Recreation
- Improves Energy Savings / Nutrient Recovery / Recycling
- Improves Management of Flooding / Extreme Events

Permitting

POTENTIAL PERMITTING AUTHORITIES

- Municipal Conservation Commission
- Massachusetts Department of Environmental Protection
- U.S. Army Corps of Engineers
- Office of Coastal Zone Management

PERFORMANCE CHALLENGES

- Widening a tidal culvert or bridge could increase the depth of flooding during high tides and storm surges in flood prone area and upstream of the structure.
- Disruption of coastal processes must be considered
- Can have significant construction impacts
- Permitting requirements may be extensive and time consuming
- Modeling is required to accurately predict the upstream tidal and coastal process impacts of the culvert/bridge modifications
- Will only return an estuary to a more natural hydrologic regime if the original opening has been restricted

CLIMATE RESILIENCE: RISKS

- Damage to shorelines or subsurface structures from storm events (e.g. wave action)

CLIMATE RESILIENCE: SOLUTIONS

- Ensure frequent maintenance inspections to monitor asset condition and performance of technology (i.e. achieving nutrient removal targets)
- Potential anchoring of structures
- Protective structures to reduce impacts to reefs (e.g. wind walls)

Pond and Estuary Circulators

SCALE: NEIGHBORHOOD/WATERSHED
APPROACH: RESTORATION

SCENARIO PLANNING: NOT SELECTED FOR USE

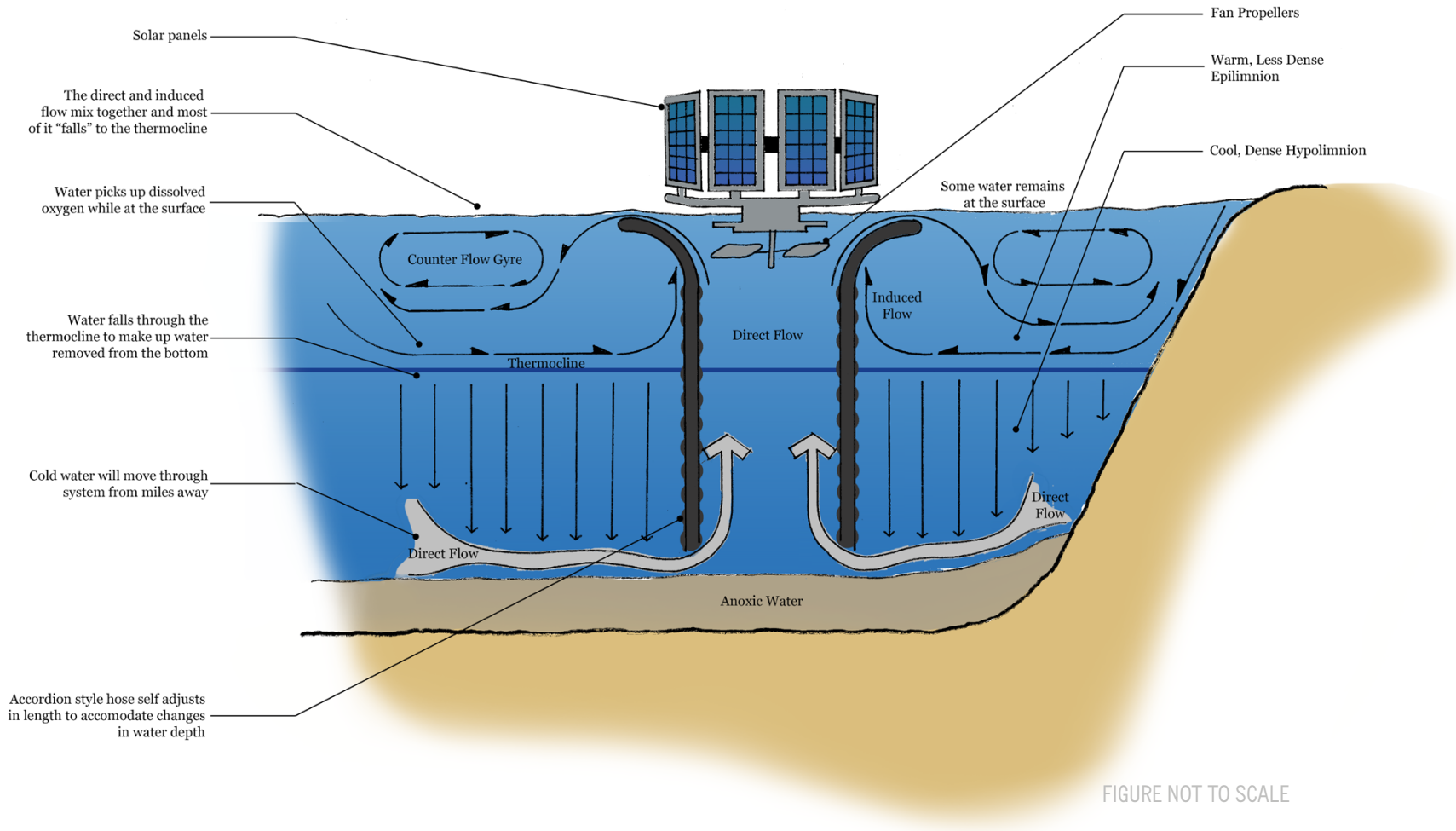


FIGURE NOT TO SCALE

Figure 4-24

Pond and Estuary Circulators

SCALE: NEIGHBORHOOD/WATERSHED
APPROACH: RESTORATION

SCENARIO PLANNING: NOT SELECTED FOR USE

DESCRIPTION

The circulation of pond and estuary water increases the oxygen concentration while reducing nutrients (nitrogen and/or phosphorus) concentrations, reducing odors, and enhancing fish habitat. The circulation is generally performed mechanically by installing solar or electric powered circulators.

Pond and estuary circulators work by reducing stratification in ponds and estuaries. Anoxic conditions can occur within the lower stratified layers leading to harmful algae blooms, fish kills and odors. Circulators mix these stratified layers, thereby increasing dissolved oxygen concentrations throughout the pond depths.

Technology Performance

10	0.5 to 3 years
Useful Life	Time to See Results

Permitting

POTENTIAL PERMITTING AUTHORITIES

- Municipal Conservation Commission
- Massachusetts Department of Environmental Protection
- U.S. Army Corps of Engineers
- U.S. EPA

SITING NEEDS

- Site specific requirements based on the characteristics of the estuary or pond
- A location(s) within the estuary or pond to permanently locate floating island

ECO-BENEFITS

- Enhances Habitat / Wildlife / Biodiversity
- Promotes Green Space / Conservation / Recreation
- Improves Energy Savings / Nutrient Recovery / Recycling
- Improves Management of Flooding / Extreme Events

Traditional Approaches for Nutrient Management

There are four categories of traditional infrastructure wastewater systems. These include:

- Individual on-site systems with and without enhanced nitrogen removal
- Cluster systems serving up to approximately 30 homes with aggregate wastewater flows less than 10,000 gallons per day (gpd)
- Satellite systems serving from 30 to 1,000 homes (wastewater flows between 10,000 and 300,000 gpd), intended to treat and dispose of wastewater from one area of a community
- Centralized systems that can provide for most or all of a community's wastewater management needs

These traditional approaches are summarized below; more complete discussions of individual treatment techniques can be found in Appendix 4A; the most detailed and extensive information can be found in the Technologies Matrix, available in Appendix 4B and on the web at: http://capecodcommission.org/matrix.

INDIVIDUAL ON-SITE SYSTEMS

The most common infrastructure on Cape Cod is individual on-site systems. These systems include cesspools, non-Title 5 compliant septic systems, Title 5 compliant septic systems, innovative/alternative (I/A) septic systems and enhanced I/A systems. All of these systems work similarly (**Figure 4-27**). Title 5 systems include a septic tank into which wastewater from households and businesses is discharged, and a distribution box from which effluent from the septic tank flows and is distributed to the soil absorption system (SAS), which releases the effluent to the ground. Cesspools do not include a distribution box, leach field, or SAS. The amount of nitrogen removed through denitrifying septic systems is about 40% and can be somewhat enhanced dependent on the soil type and the distance between the discharge and groundwater. Very sandy soils with little organic material, soils common on the Cape, provide less treatment than other soil types.

When estimating nitrogen concentrations being discharged to groundwater, Title 5 compliant systems have a discharge concentration of 26.25 milligrams per liter (mg/L). This concentration includes all denitrification that occurs in the wastewater within the septic system and in the unsaturated soils as it reaches the water table. The Massachusetts Department of Environmental Protection (MassDEP) approves I/A septic systems for 19 mg/L. This value is typically used when estimating nitrogen reduction for nutrient management plans. Enhanced I/A systems may achieve a greater reduction. I/A septic systems may play a significant role in helping to manage nutrients entering the groundwater.

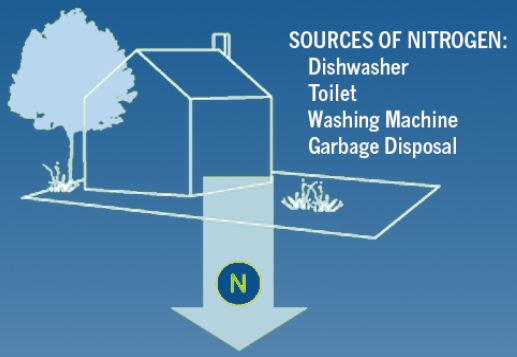
One of the limiting factors in optimizing the performance of I/A systems is variability and inconsistency in maintenance. Outside oversight of I/A systems, potentially at the municipal or county level, could improve performance. Management entities with oversight of private I/A systems can ensure high quality system installation and inspection, maintenance and operation, service provider training and certification, qualified installers and construction inspectors and performance tracking. There are many forms of so-called "Responsible Management Entities" (RME), including public utilities, regional service authorities and county entities, among others. Two US EPA documents – "Voluntary National Guidelines for Management of Onsite and Clustered (Decentralized) Wastewater Treatment Systems" dated March 2003, and "Handbook for Management of Onsite and Clustered (Decentralized) Wastewater Treatment Systems" dated December 2005 – provide useful references for considering management oversight of on-site systems. The establishment of I/A management entities, and the definition of their essential roles and functions, is an area that merits further consideration. Currently, the Barnstable County Department of Health and the Environment (BCDHE) provides a maintenance and monitoring database to assist towns in meeting compliance requirements and the potential to expand this program could be considered.

On-Site Treatment systems

individual on-site systems

Individual on-site systems represent the most common traditional infrastructure on Cape Cod. These systems include cesspools, Title 5 compliant and non-Title 5 septic systems, and innovative/alternative (I/A) and enhanced I/A septic systems and any remaining cesspools.

Wastewater from households and businesses are collected and treated to varying degrees by microbes in these systems. Once treated, the liquid wastewater is discharged, leaving behind small amounts of solid waste.



The soil absorption system (SAS) from a Title 5 system is located at least four feet above the high water table under the discharge area. A Title 5 system has the same general design as a non-Title 5 septic system, but meets MassDEP standards outlined in Title 5 regulations.

of the development on Cape Cod uses septic systems designed for wastewater treatment.

The amount of nitrogen reduction depends on soil type and distance to groundwater. Very sandy soils with little organic material, where are common on the Cape, allow septic system discharges to drain to the water table with less treatment than other soil types.

has standards for maintenance, operation and approval of I/A and enhanced I/A septic systems that nitrogen to 19 and 13 mg/L of discharge.

On-Site Treatment Systems

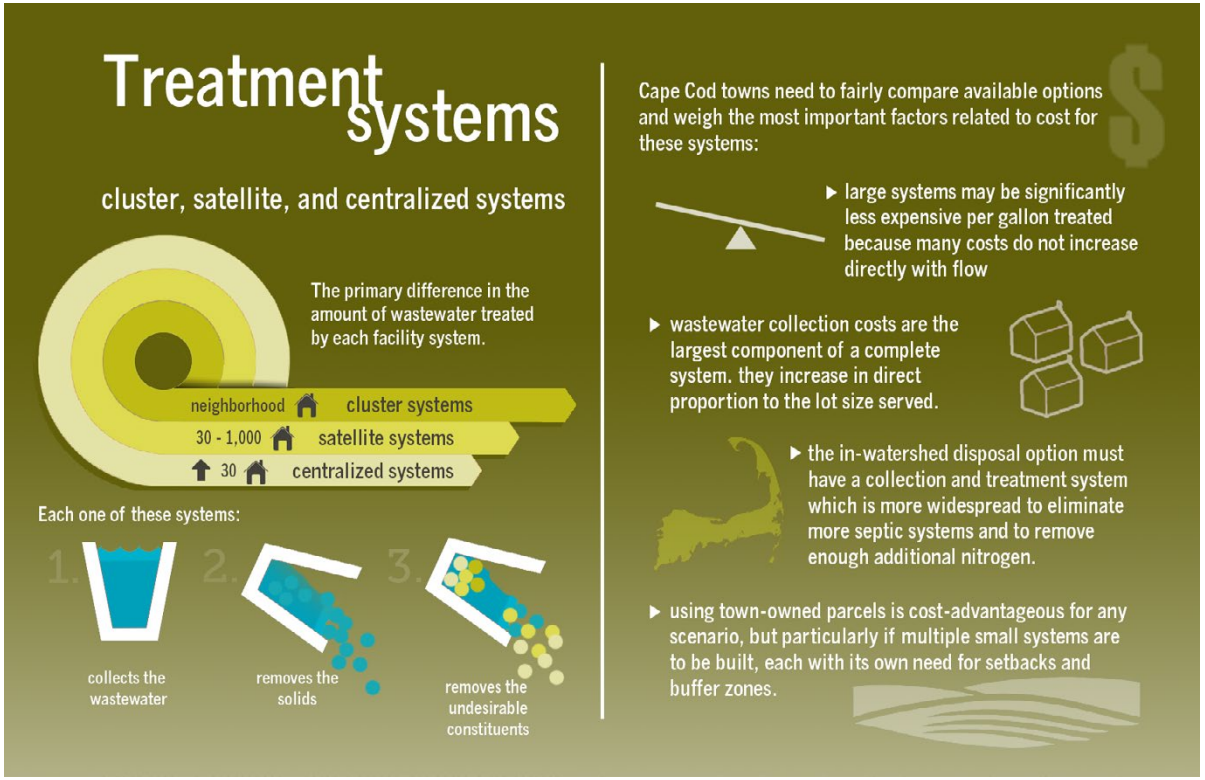
Figure 4-27

CLUSTER, SATELLITE AND CENTRALIZED SYSTEMS

Cluster, satellite and centralized systems all have a series of pipes and sometimes pumps that collect wastewater from multiple households and convey it to a centralized facility for the treatment and disposal of wastewater (effluent) and solids. The primary difference in the facilities is the amount of wastewater each treats. In general, cluster systems treat less than 10,000 gpd, satellite systems treat up to 300,000 gpd and centralized systems treat flows over 100,000 gpd (**Figure 4-28**).

Each of these systems collects wastewater, removes the solids, and through a series of treatment technologies treats the wastewater by partially reducing the undesirable constituents, including nitrogen and phosphorus, prior to discharge to the groundwater, surface water or an ocean outfall. The degree of removal is dependent on the treatment type and degree of treatment designed into the facility. In general, the greater the treatment, the greater the costs to design and build the facility and collection system, operate and maintain the facility, and treat and discharge the wastewater.

The effectiveness of traditional infrastructure can vary and is site-specific. Many wastewater pollutants can be managed with traditional systems, including nitrogen, phosphorus, total suspended solids, biological oxygen demand, pH, suspended metals, total petroleum



Treatment Systems

Figure 4-28

hydrocarbon and pathogens. Traditional systems may be able to remove or manage some contaminants of emerging concern, though which CECs and how well they may be managed is still largely unknown. CECs are addressed in more detail later in this chapter.

Traditional infrastructure generally performs well when operated properly. However, it is possible for these systems to operate below their nutrient reduction potential if not operated properly. Decreases in performance can occur if the design flow is exceeded, the influent contains too much fats, oils or grease, or if the influent contains a compound that compromises the health of the microbes in the system.

Appendix B

Introduction to Shellfish Bioremediation Case Studies of Relevance to Town of Dennis by Scott Lindell

Swan Pond Oyster Demonstration project Final Report (8.29.20): Oyster Growth, Nitrogen Removal and Associated Water Quality Monitoring by Scott Lindell

Swan Pond Oyster Demonstration Project Final Report (8.29.20)

Oyster Growth, Nitrogen Removal and associated Water Quality Monitoring

Introduction

In July of 2018, the Town of Dennis established a pilot scale oyster aquaculture demonstration project in Swan Pond with the goal of documenting possible water quality improvements and nitrogen removal via bioremediation. The pilot project was established and maintained by the Shellfish Constable, Chris Southwood, and a contractor, Steve Tag. Before the 2018 growing season ended, Mr. Southwood had taken another job. A new Shellfish Constable, Amber Salvage, was hired in 2018, and the Town hired a shellfish farming consultant, Ward Aquafarms, to manage the demonstration site. The monitoring program for oyster growth, survival, and water quality at the project site and at a control site in Swan Pond was established by a consultant, Scott Lindell, who composed this report.

Pilot Project Summary Description

In 2018 and 2019, a site for mooring a floating oyster bag array was chosen in a northwest section of Swan Pond abutting conservation land. Initially the 2018 array started with 150 floating oyster bags, each targeted to be stocked with approximately 950 oysters for a total of approximately 143,000 oysters. The contents of most oyster bags were divided into two oyster bags to continue growing optimally, thus forming an array of 270 floating bags. Mr. Tag moved the oyster bags and sunk them to the bottom in overwintering spots on firm pond bottom to avoid ice damage. In the spring of 2019 Ward Aquafarms retrieved the previous season's bagged oysters, and restored them to the floating array. In July 2019, the Town purchased an additional 140,000 seed which were stocked at 1000 per bag. This enlarged the floating culture bag array to 640 bags. Over both growing seasons, oyster bags were frequently tumbled and flipped (at least weekly) to prevent fouling which might impede water flow and impact oyster growth and survival. Oyster measures and sample counts to assess growth and survival were first conducted within a week of stocking new seed in July 2018 and 2019. Subsequent oyster growth and survival sampling was conducted in late August, and October of both years. Water quality sampling and assessment was conducted per the pilot project plan to estimate nitrogen removal by oysters and other possible associated water quality improvements.

Oyster Growth and Survival

Based on estimated cumulative mortality of 11% in the 2018 growing season, the population of oysters at the end of October 2018 was approximately 127,500. Ward Aquafarm recovered the over wintered oyster bags, and overwintering survival was good (91 to 93%) as measured on May 25, 2019. Thus an estimated 117,000 oysters in 250 culture bags, or 82% from the 2018 stocking, survived to enter a second growing season. To better optimize and manage oyster growth, Ward Aquafarms graded the oysters into large and medium sizes (approximately 200 and 300 oysters to a bag, respectively, - 500 bags total) in early June. Two bags, one of large grade and one of medium grade representing the 2018 yearclass were sampled during the 2019 growing season.

In tracking the 2018 yearclass to the conclusion of the 2019 growing season, these took a mortality hit between the May and July sampling (the size grading was in-between) of 19% and 22% respectively. Cumulative mortality for the remaining growing season was 12%. The medium grade oysters averaged nearly 40 grams, and the large oysters averaged 65 grams. A "bomb cyclone" type storm hit Dennis on October 17th and some portions of the floating array were stripped from their mooring and scattered around the pond. The "large" bag was not found so another "large" bag was measured to estimate average weight at the end of October

Three of the newly seeded 2019 oyster bags were stocked with a hand-count of 1000 oysters each. These bags were specially marked and monitored throughout the growing season. Individual oyster weights were about 0.2 grams at the start, and grew to 7 grams and average length of 1.7 inches by the end of October 2019. For comparison, seed planted in 2018 grew to an average of 14.5 grams and nearly 2.5 inches. In contrast to 2018, the 2019 bags' contents were not divided and consequently more crowded conditions may be responsible for slower individual oyster growth compared to 2018. However, mortality remained similarly low. Tables 1 and 2 summarize 2019 oyster seed growth and survival.

Table 1. Swan Pond oyster bag weights (grams)

Date	Bag 1	Bag 2	Bag 3	Medium '18	Large '18
7/12/19	249	202	179	6530	7380
8/20/19	2470	2330	2070	8120	8780
10/29/19	6800	5550	4560	8910	lost*

*another bag

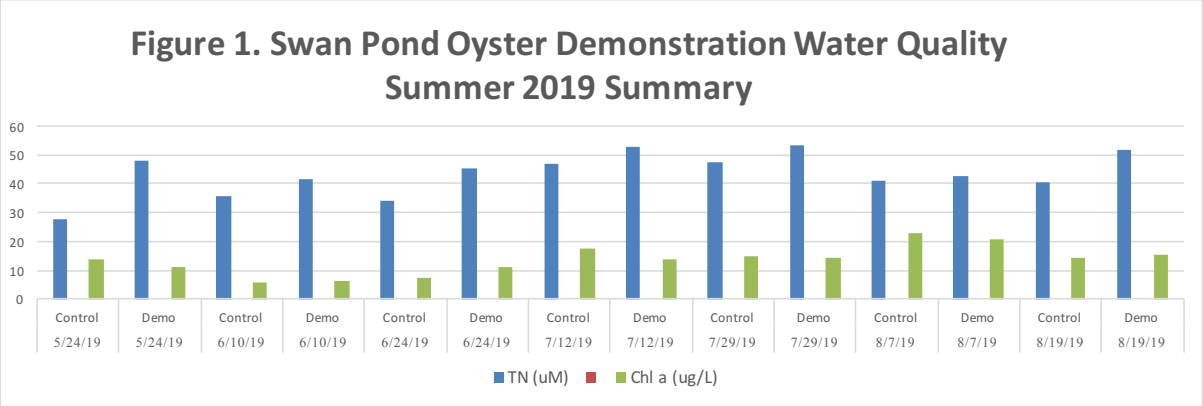
Table 2. Swan Pond oyster bag percent mortality

Date	Bag 1	Bag 2	Bag 3	Medium '18	Large '18
7/12/19	0	0	0	22%	19%
8/20/19	2%	7%	6%	9%	6%
10/29/19	5%	5%	4%	3%	n/a

Water Quality Sampling and Analyses

An environmental sampling plan to quantify potential nitrogen removal and water quality improvements by the proposed project in Swan Pond was prepared. The sampling and chemical analyses followed the same procedures and methodologies as employed for the Massachusetts Estuaries Project baseline analysis; bi-weekly water sampling was conducted (June – October 2018, May to September 2019) and analysis for the following parameters: temperature, total nitrogen (nitrate + nitrite, ammonia, dissolved organic nitrogen, particulate organic nitrogen, dissolved organic nitrogen), chlorophyll-a, pheophytin-a, orthophosphate, temperature, dissolved oxygen. Sampling was completed synoptically during a narrow (~2 hr.) window to minimize the effects of a changing tide (ebb tide sampling) as well as weather-related effects on samples (e.g. significant precipitation events). Water samples were analyzed by the Center for Coastal Studies

(CCS). A demonstration project of this modest scale is not expected to impact the water quality of Swan Pond measurably except for possible near- field affects, so sampling was immediately inside the oyster-farming array and outside of the array (a "control" site). CCS also loaned the project two sondes for frequent recording (every 15 minutes) of dissolved oxygen and temperature measurements at the oyster and control sites. Figure 1 below summarizes the measurements of two key parameters, Total Nitrogen and Chlorophyll-a measured within the oyster growing area and at the control site.



No meaningful trend or differences can be detected between the water quality within or outside of the floating bag array. Measures of Turbidity (NTU) did not show any trend in differences between the two sites. See Appendix A which tabulates all the laboratory analyses conducted on the bi-weekly water samples. Also included are plots of dissolved oxygen and temperature at the oyster and control sites collected at high frequency (every 15 minutes) via sondes. Sondes were removed for mid-season servicing and re-calibration between August 7th and 20th.

Estimates of Nitrogen Removal in Oyster Meats and Shell

In addition to water quality assessments, sample measurements of the percent nitrogen in oyster shell and tissues were conducted to directly quantify N removal. Samples of 24 oysters representing twelve 2-year old (> 3 inch) and twelve sub-year old (< 2 inch) oysters were collected in October 2019 and delivered to Boston University's Stable Isotope Laboratory for nitrogen and carbon analysis in the oyster meats and shells. The results are integrated with the estimated wet weight at the project conclusion, and the dry tissue and shell weights calculated in the lab.

Our results show that we had an estimated biomass of 5,102 kg of 2-year old oysters (n= 103,000), and 789 kg of sub-year-old oysters (n= 126,000). That totals to 5,892 kg of oysters measured in late October 2019 at the project's conclusion. Using the N analyses conducted by Boston University on these two size-classes of oysters, this total contained approximately 5.1 kg N in shells, and 10.8 kg N in tissue, for a total sequestered N of 15.9 kg. This amounts to about 0.15g of N removed per oysters as opposed to 0.32g used in previous projections.

It is important to compare these to 2018 which was miscalculated in last year's report and is corrected here:

2018 results showed that an estimated biomass of 3,384 kg of oysters measured in late October contained approximately 3.39 kg N in shells, and 7.51 kg N in tissue, for a total sequestered N of 10.9 kg.

Cost-Benefit of Oyster Farming

This two year project cost about $108,491 including contracts and consultants for demonstration farm management, growth rate and survival measures, water quality monitoring and nitrogen tissue sampling. The first year the Town spent approximately $34,240. This includes seed purchase, gear and equipment, as well as payroll for one seasonal employee. Oysters were overwintered in the pond (there is no Town owned property available for storage). Year 2 the Town contracted out all the work. The bid estimate was $46,000. This did not include seed purchase which was another $7,000. The total Town monies spent for Year 2 was $52,250. Any increase in the amount of shellfish would require additional manpower as well as some type of building for overwintering.

The project sequestered an estimated 15.9 kg of N into 1-year and 2-year old oyster tissues and shells at a cost of $6,821 per kg or $3,100 per pound. For comparison, Rose et al. (2015) reported costs for a variety of methods to reduce net nitrogen loading to the coastal environment. These solutions were grouped into six categories and summarized as a minimum-maximum range. Categories of solutions included shellfish aquaculture, agricultural, urban stormwater, wastewater treatment upgrades, wetland, and others. The range of reported costs for each of these categories was quite large (3–4 orders of magnitude). The range reported for shellfish aquaculture was $6 to $150 USD lb. of N and compared favorably to the other categories, all of which had higher maximum estimates ($214–7,610 USD lb. of N). Given the small scale of the pilot demonstration project in Swan Pond, it isn't surprising that its costs were many times higher than typical commercial shellfish aquaculture reported above. Still, this is on par with or less than other more conventional methods.

All oysters were relayed to the bottom sediments at the southern end of Swan Pond (west of Indian Trail) before October 31st. According to the Town, recreational or commercial shellfish permit holders will be allowed to harvest the oysters during the normal open seasons so that the nitrogen sequestered in the tissues can be removed. Otherwise, the oysters will die and their nitrogen will slowly leach back into the aquatic environment.

Conclusions

Oyster growth and survival in Swan Pond is similar to that seen in commercial settings

elsewhere on Cape Cod. While the scale of the project was not sufficient to demonstrate that it could make a difference in the water quality of the pond, it did demonstrate the nitrogen removal potential of a given area of oyster culture in the pond, and a measurable way of removing nitrogen to partially meet watershed TMDL limits. The demonstration project followed the plans but fell short of the N removal predictions made in a 2016 report prepared for the Town (See Appendix B). Now, given the management costs, the Town can evaluate its economic viability. Briefly, the project scale showed the feasibility of culturing up to 1 million oysters per acre and removing about 150 kg of N per acre at costs less than or equivalent to conventional means of treatment.

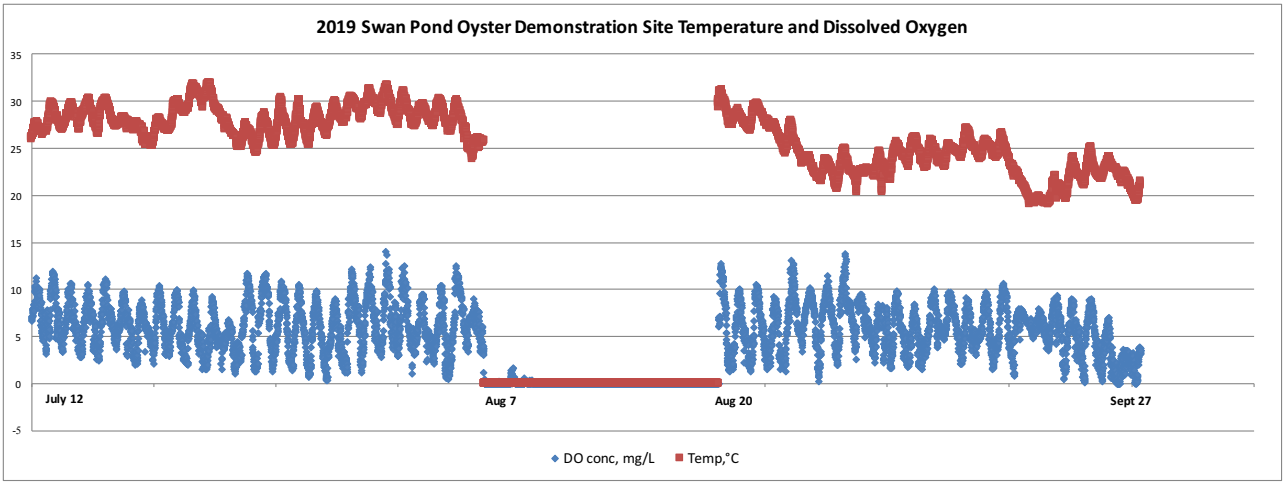
However, during the autumn of 2019, the Massachusetts Division of Marine Fisheries reclassified the waters of Swan Pond from "Conditionally Open" (meaning seasonally open to shellfishing in the winter) to "Closed" year round. This means the end of the oyster farming in Swan Pond until water quality improves and re-testing demonstrates it is safe again. It's possible that after another year or two that the waters will improve and be open again, especially if the Town could seek a solution to the reducing the source of contamination.

Reference cited

Rose JM, Bricker SB, Ferreira JG (2015) Comparative analysis of modeled nitrogen removal by shellfish farms. Marine Pollution Bulletin 91:185–190. doi:10.1016/j.marpolbul.2014.12.006

Appendix A. Swan Pond Water Quality Data - Summer 2019 mg/l except TN & Turb

Date	Station	Nitrate	Ortho.Ph	NH3	SiO2	TN	TP	TDN	TDP	PON	Chl a	Pheo a	Turb
5/24/19	Control	BDL	0.07	0.12	18.43	27.91	1.15	23.52	0.60	4.39	13.98	5.22	3.97
5/24/19	Demo	1.24	0.07	1.11	20.07	48.05	1.58	33.32	0.64	14.73	10.94	3.45	3.54
6/10/19	Control	0.07	BDL	0.40	18.80	35.74	1.67	21.85	0.50	13.89	5.55	3.18	2.11
6/10/19	Demo	0.12	BDL	0.38	41.23	41.38	1.79	22.71	0.60	18.67	6.02	2.72	2.55
6/24/19	Control	0.27	BDL	0.84	21.16	34.27	1.61	19.63	0.85	14.65	7.38	3.43	2.61
6/24/19	Demo	BDL	BDL	0.41	36.20	45.28	2.20	25.65	1.28	19.63	11.23	4.82	2.96
7/12/19	Control	0.16	1.33	0.30	43.28	46.94	4.51	22.29	2.50	24.64	17.31	9.09	4.53
7/12/19	Demo	0.20	1.44	0.41	52.52	52.80	4.69	23.33	2.41	29.47	14.01	9.14	6.04
7/29/19	Control	0.19	1.61	0.93	72.41	47.30	4.05	28.47	2.92	18.83	14.61	3.45	3.57
7/29/19	Demo	1.09	1.27	6.45	78.65	53.22	5.98	29.47	2.15	23.74	14.55	14.29	13.30
8/7/19	Control	BDL	2.07	0.14	53.43	41.07	4.37	23.39	3.13	17.68	23.04	5.57	2.57
8/7/19	Demo	0.14	1.41	0.32	45.85	42.43	5.07	21.14	2.84	21.29	20.57	8.30	5.34
8/19/19	Control	0.25	1.84	2.07	65.84	40.57	3.80	24.86	2.61	15.71	14.53	5.16	3.82
8/19/19	Demo	0.39	2.22	5.72	62.61	51.59	5.59	24.74	2.68	26.85	15.18	13.61	7.46
9/4/19	Control	0.06	1.14	0.20	40.03	46.53	3.62	27.75	2.31	18.78	22.50	3.72	2.86
9/4/19	Demo	0.07	1.14	1.08	43.59	35.08	2.83	22.56	1.75	12.52	16.96	2.84	1.97
9/16/19	Control	1.22	0.44	2.36	36.17	41.54	2.52	27.75	1.63	13.79	15.49	2.69	2.66
9/16/19	Demo	0.39	0.70	3.17	37.17	39.05	2.52	26.84	1.63	12.21	12.62	2.49	2.57



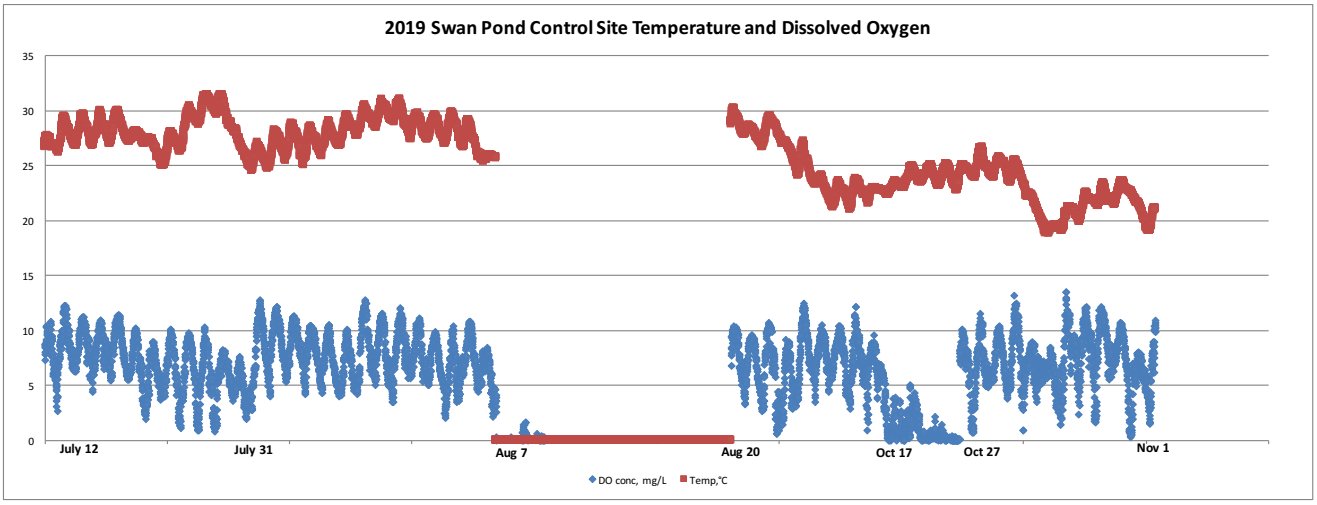


Photo Gallery

The configuration of floating oyster bags in Swan Pond in May 2019

Floating oyster bags in July 2019 including new seed and as well as 2018 oysters (640 bags total)

Appendix B. Plans for pilot shellfish culture projects to aid water quality improvements

TO: Dennis Comprehensive Wastewater Management Task Force and Shellfish Advisory Committee
FROM: Scott Lindell, Technical Consultant
DATE: 2/1/2016
RE: Plans for pilot shellfish culture projects to aid water quality improvements

1. Background

Shellfish culture and harvest is an attractive "alternative" lower cost water quality management tool that can supplement more costly sewering solutions that have been traditionally employed. Several Cape Cod towns are examining shellfish culture projects. The nitrogen (N) removal strategies and water quality improvement scenarios that the Dennis Comprehensive Wastewater Management Task Force (CWMTF) is considering each contain shellfish culture as part of the solution, and are detailed in an August 2015 report that is published on the Town's website: **http://www.town.dennis.ma.us/Pages/DennisMA_BComm/wastewater/1.pdf**

The CWMTF is currently evaluating 4 scenarios. Each scenario assumes that each acre will support 1 million oysters to a 3" size and that each oyster will be harvested from the watershed to remove 0.32 g of nitrogen.
Scenario 3B - I/A systems, Sewering and Aquaculture in 3.5 acres of Bass River (Bass River Middle and Mill Pond/Stream and Follins Pond subwatersheds) and 7.31 acres in Swan Pond (Swan Pond River and Swan Pond River North subwatersheds).
Scenario 5A and B - Sewering and Aquaculture in 9.67 acres in Swan Pond (Swan Pond River and Swan Pond River North subwatersheds)
Scenario 6B - Sewering and Aquaculture in 5.97 acres in Swan Pond (Swan Pond River and Swan Pond River North subwatersheds)
The Wastewater Management Task Force will be selecting their final scenario late spring 2016, which will be carried forward in more detail in the Town's final comprehensive wastewater management plan.

2. Conceptual Pilot Project Description

In December 2015, Scott Lindell met with the Dennis Shellfish Advisory Committee to discuss previous recommendations for oyster grow-out pilot projects. Based on those discussions, the following issues were identified as critical to the successful implementation and evaluation of an aquaculture pilot project:

- Growing methods
- General costs and benefits
- Potential locations and sizes
- Potential CWMTF scenario costs

Growing Methods - The committee recommended examining the use of floating "Oyster Gro" cages because they can be sited over a non-productive bottom, and recommended these instead of floating bags due to the ease of sinking them below the ice in the winter time. Based on guidance from other municipal propagation programs, the most cost-effective approach may be

to bottom plant oysters at approximately 1.5 inches after the first growing season. Some Shellfish Advisory Committee members suggested that there may not be enough appropriately firm sediment (in Swan Pond, for instance) for bottom planting or that bottom-planting may conflict with other wild shellfishing. This needs closer assessment. In contrast to bottom planting, oysters can also be reared in floating cages for a second and final growing season, but this approach requires additional labor and capital costs. Better survival may offset some of those costs.

General Costs and Benefits - Tables 1 and 2 shown below outline the general costs and benefits of two methods for oyster culture pilot projects (with and without bottom planting after Year 1) and at two different scales (100K seed vs 500K seed) that the Town may choose to conduct. Each method could be subdivided between different parts of watersheds to test different environments for the best oyster growth and survival, and to match them with the needs for N removal. The more locally concentrated the culture operations are, the more economical they will be to manage. Swan Pond appears to be the most impaired water body that could be significantly improved and successfully host floating cage cultures, and is used as a graphic example in Figure 1. Follins Pond and Kelly's Bay may also be good candidate water bodies. In December 2015, Scott Lindell and the Shellfish Advisory Committee discussed how to make a pilot project most feasible and cost-effective to the Town, specifically how to cost-effectively manage the oysters for best survival, growth and maximum N removal, and then make them available for harvest. A current project in Falmouth was discussed as an example. Falmouth relays their 6-month old oysters from prohibited waters to hard bottom in approved waters of other estuaries where a closure is managed for 12 months before opened to recreational and commercial harvesters. Dennis may elect to grow oysters in seasonally closed waters until harvest for maximum N removal, or plant them in another watershed and then open those waters for harvest in the fall/winter.

Potential Locations and Sizes - Where are the best places for a pilot project in Dennis? We use Swan Pond as an example. The area demarcated by the blue rectangle in Figure 1 shows the approximate scale of a pilot project that could hold 60 floating "Oyster Gro" cages in a 6,000 square-foot area with good tidal flushing, which is preferred. Also shown in Figure 1 and demarcated by the white polygons are areas that Scott Lindell walked along the shoreline east and west from the Indian Trail Landing. There he found a 20 to 30 foot margin of firm sediment for bottom planting in about 2 to 3 feet of water. Conceivably half a million oysters could be planted after the first growing season to the west of the landing one year and another half a million planted east of the landing the next year. Consideration need to be given to the availability and access to firm bottom and enforcement of shellfish closures in these conditionally approved waters.

Potential CWMTF Scenario Costs - Table 3 shows the acreage needs of the various CWMTF scenarios that include oyster bio-remediation projects at proposed scales from 1 million to 9

million oysters per year. This assumes that oysters are only grown in cages the first year and then are bottom planted with 60 % survival from seed to 3 inch harvestable size. It further assumes these oysters are harvested by recreational and commercial shellfishermen. The projected cost per kilogram of nitrogen removed is $375. No economy of scale is presumed.

Table 4 below shows the acreage needs of the various Wastewater Management Task Force scenarios (1 million to 9 million oysters per year) assuming that more "Oyster Gro" cages are bought and oysters are only grown in cages for 2 growing season with 80 % survival from seed to 3 inch harvestable size. Minimal or no firm bottom is assumed for this scenario. Its assumed oysters are made available at various Town Landings for recreational or commercial harvest. The projected cost per kilogram of nitrogen removed is $720. No economy of scale is presumed.

Table 1: General costs for conducting pilot projects at a size to demonstrate feasibility, and to ground-truth methods and labor needs

Table 1. Projected costs for small scale 2-year oyster culture demonstation project for Town of Dennis, and kilograms of N harvested

Method	# of seed oysters	cost of seed per K[a]	total seed cost	# OG cages and rigging	unit cost	capital cost*	labor**	# market oysters	Kg of N removed ***	total cost	$/kg of N removed
A. Floating cage + bottom relay 1st season	100,000	$25	$2,500	20	$200	$4,000	$4,000	60000 60% survival	19.2	$10,500	$547
B. Floating cage to 3" before relay and harvest	100,000	$25	$2,500	70	$200	$14,000	$20,000	80000 80% survival	25.6	$36,500	$1,426

*Not including cost of small boat necessary for managing Oyster Grow cages. Cages and rigging (lines and anchors) should last 10 years.
**Assumes two seasonal workers for 20 weeks (June - October) at $20/hr for 20 hrs/wk (w/ 100 floating cages, split proportionally), with a second season of expanded labor required for Method B but not A. Additional labor costs of up to $5K may be required for assembly and installation.
***Assumes 0.32 grams of nitrogen per oyster harvested after second summer
[a] Prices for seed suitable for 4 mm mesh bags. Alternatively cheaper seed of 1.5mm size may be tested inside spat bags at 1K to 4K per ADPI bag

Table 2: Pilot project of a size suitable for showing local water quality improvement such as water clarity

Table 2. Projected costs for larger scale 2-year oyster culture demonstation projects for Town of Dennis, and kilograms of N harvested

Method	# of seed oysters	cost of seed per K[a]	total seed cost	# OG cages and rigging	unit cost	capital cost*	labor**	# market oysters	Kg of N removed ***	total cost	$/kg of N removed
C. Floating cage + bottom relay 1st season	500,000	$25	$12,500	100	$200	$20,000	$16,000	300000 60% survival	96	$48,500	$505
D. Floating cage to 3" before relay and harvest	500,000	$25	$12,500	350	$200	$70,000	$100,000	400000 80% survival	128	$182,500	$1,426

*Not including cost of small boat necessary for managing Oyster Grow cages. Cages and rigging (lines and anchors) should last 10 years.
**Assumes two seasonal workers for 20 weeks (June - October) at $20/hr for 20 hrs/wk (w/ 100 floating cages, split proportionally), with a second season of expanded labor required for Plan B but not A. Additional labor costs of $15K to $20K may be required for assembly and installation.
***Assumes 0.32 grams of nitrogen per oyster harvested after second summer
[a] Prices for seed suitable for 4 mm mesh bags. Alternatively cheaper seed of 1.5mm size may be tested inside spat bags at 1K to 4K per ADPI bag

Figure 1: example of the scale at which pilot projects might be conducted.

Table 3: Potential costs related to CWMTF scenarios using bottom planting

Method	# of seed oysters	total seed cost	# OG cages and rigging	capital cost*	labor**	total cost	# market oysters	floating acreage for 2-year cycle	hard bottom acreage required
	1.6 million	$ 40,000	200	$ 40,000	$ 40,000	$ 120,000	1 million	0.5	1
Floating cage + bottom relay 1st season	4.8 million	$ 120,000	600	$ 120,000	$ 120,000	$ 360,000	3 million	1.5	3
	9.6 million	$ 240,000	1200	$ 240,000	$ 240,000	$ 720,000	6 million	3	6
	14.4 million	$ 360,000	1800	$ 360,000	$ 360,000	$ 1,080,000	9 million	14	9

Table 4: Potential costs related to CWMTF scenarios using floating cages

Method	# of seed oysters	total seed cost	# OG cages and rigging	capital cost*	labor**	total cost	# market oysters	floating acreage for 2-year cycle	hard bottom acreage required
	1.2 million	$ 30,000	800	$ 160,000	$ 40,000	$ 230,000	1 million	2	0
Floating cage to 3" before relay and harvest	3.6 million	$ 90,000	2400	$ 480,000	$ 120,000	$ 690,000	3 million	6	0
	7.2 million	$ 180,000	4800	$ 960,000	$ 240,000	$ 1,380,000	6 million	12	0
	10.8 million	$ 270,000	7200	$ 1,440,000	$ 360,000	$ 2,070,000	9 million	18	0

Appendix C

Letter to MassDOT regarding Inlet Widening

Town of Dennis
P.O. Box 2060, South Dennis, MA 02660 / Telephone: 508-394-8300 Fax: 508-394-8309

Tuesday, January 13, 2015

Mr. Frank DePaola
Acting Secretary
Massachusetts Department of Transportation
Highway Division
10 Park Plaza, Suite 4160
Boston, MA 02116

And

Ms. Mary-Joe Perry
District 5 Highway Director
1000 County Street
Taunton, MA 02780

Subject: Request to Have MassDOT Widen Bass River Bridge Opening on Route 6 in Dennis

Dear Mr. DePaola and Ms. Perry:

The Town of Dennis is in the process of developing a plan to protect and restore its valuable water resources. This effort is being overseen by our Comprehensive Wastewater Management Task Force with support from several town staff, the Board of Selectmen and our consultant, CDM Smith. It is also being coordinated with the Draft 208 Water Quality Plan for Barnstable County recently prepared by the Cape Cod Commission and with the Massachusetts Estuaries Project (MEP) reports for Dennis watersheds. The goal of our water resources plan is to develop affordable solutions that will protect and restore the water quality in our estuaries, freshwater ponds and drinking water supplies.

The Massachusetts Estuaries Project report issued for the Bass River Watershed in April 2011 identified a significant amount of nitrogen that needs to be removed in the watershed, mainly coming from septic systems leaching nitrogen into the groundwater, in

Town of Dennis
P.O. Box 2060, South Dennis, MA 02660 / Telephone: 508-394-8300 Fax: 508-394-8309

order to restore the water quality to a healthy environment. One solution evaluated to help improved the Bass River water quality conditions included removal of the flow restrictions resulting from the former railroad bridge south of Route 6 and from the Route 6 east and west bound bridges. The Bass River Watershed MEP and the Hydrodynamic Tidal Study of Bass River, Dennis and Yarmouth, Massachusetts, Final Report, August 2013, evaluated options for widening those two restrictions. The studies concluded that widening each restriction to pre-bridge conditions would have a positive impact on this tidally influenced portion of the river. The average tidal prism upstream of Route 6 would increase by 35 percent resulting in a 25 percent reduction in total time required to exchange water in that area. That results in a significant reduction in the amount of nitrogen needing to be removed since the residence time is reduced. This solution offers the best potential for long-term restoration of salt marsh and benthic habitat in the upper reaches of the Bass River system. Both are indicators of a healthy water quality ecosystem.

The widening of the former railroad bridge is being implemented as part of the MassDOT funded Dennis-Yarmouth Multi-use Path Bridge over the Bass River with construction expected to start in 2015. That project is being coordinated with the MassDOT Environmental Section and is being designed to match the current opening of the Route 6 bridge with provisions to potentially increase the width further in the future. However, the larger restriction being the two Route 6 bridges is not currently in any plan that we are aware of at this time. Those bridges are over 50 years old now and likely in need of significant repair in the next few years. Thus the Town of Dennis would like to formally request that MassDOT include widening of the Route 6 bridge openings to pre-bridge conditions (about double existing width) when doing any improvements which we would expect to occur in the next few years. The documented water quality improvements resulting from this opening will greatly enhance the valuable water resources of Dennis and Yarmouth and result in significant cost saving to the water resources management plans in each community.

Town of Dennis
P.O. Box 2060, South Dennis, MA 02660 / Telephone: 508-394-8300 Fax: 508-394-8309

We would be pleased to meet with you and your staff to discuss this project request and to address questions you may have regarding this project. Please contact us at 508-760-6148 to set up a time to meet to further discuss the project.
Very truly yours,

Diane Chamberlain
Chair, Task Force
Dennis Town Hall
485 Main Street
Dennis, MA 02660

Richard White
Town Administrator
Dennis Town Hall
485 Main Street
Dennis, MA 02660

CC: Dennis Board of Selectmen
Local State Reps and Senators
Cape Cod Commission
David Young, CDM Smith
Yarmouth Board of Selectmen
Brian Dudley, MassDEP

Appendix D

Planning-Level Cost Analysis Backup Information

Appendix D

Planning-Level Cost Analysis Backup Information

D.1 Introduction

Planning-level costs were developed for each of the fourteen water quality management scenarios described in Section 10. This section provides back-up information and assumptions used in that analysis.

D.2 Planning-level Cost Estimates for Section 10 Scenarios

As noted in Section 10, the cost estimates are based on the values and methodology provided in the Barnstable County Wastewater Cost Task Force's document entitled, "*Comparison of Costs for Wastewater Management Systems Applicable to Cape Cod, Guidance to Cape Cod Towns Undertaking Comprehensive Wastewater Management Planning*," dated April 2014 (version 2). This document is available as Appendix 4C to the Cape Cod Commission's 208 Plan at: cape2o.org, and is referred to herein as the "208 Plan cost document." This document provides capital and operations and maintenance (O&M) cost estimates for both traditional and non-traditional wastewater and water remediation technologies. For most technologies, costs are presented in a table showing low, high, and average costs, for both capital and annual O&M expenditures. In all cases unless otherwise noted herein, the average costs were selected for each technology. For conventional wastewater treatment, cost curves are provided, one for capital and one for O&M costs, from which a treatment facility flow capacity (listed as average daily flow) is selected, and the corresponding cost can then be determined based on the curves provided. For the analysis herein, average daily summertime flows have been used, estimated to be 2.2 times the annual average daily flow based on 90 percent of actual water usage in the areas identified for sewering.

D.2.1 Cost Estimating Spreadsheet and Assumptions

The spreadsheet showing all cost inputs for the planning-level cost estimates is attached as Table D-1. Costs were examined for a period of 20-years to allow comparison of capital, O&M, and equivalent annual costs. Equivalent annual costs were determined by assuming that the entire capital cost was borrowed in Year 1, and the loan is repaid over a 20-year period at an interest rate of 2 percent (equivalent to the typical Clean Water State Revolving Fund interest rate). The annual loan repayment cost is then added to the annual O&M cost for an equivalent annualized cost. While this approach would not actually be taken, in that the entire capital cost would not be borrowed in Year 1, but rather a phased implementation program will ultimately be proposed, this method allows for a fair comparison of technologies that factors in both up-front and long-term costs.

The following assumptions were made in the development of the planning-level estimates:

1. The cost of achieving the 25 percent stormwater nitrogen credit was assumed to be equal across all scenarios at $110,000/curb mile. This value comes from the 208 Plan cost document. To achieve the 25 percent nitrogen reduction, 50 percent of the total roads in the Bass River and Swan Pond River watersheds were assumed to require stormwater Best Management Practices

(BMPs). Stormwater O&M is assumed to be $6,400/curb mile, with curb miles calculated in the same manner.

2. Fertilizer education was assumed to have minimal capital costs and to have an annual O&M cost of $5,000 throughout the 20-year cost evaluation duration.

3. Aquaculture was assumed to cost $63,000/acre, which originates from the 208 Plan cost document; a lower value was estimated based on past similar work in New England, however the 208 Plan cost document value was used to be more conservative. Aquaculture O&M is assumed to be $5,500/acre, originating from the 208 Plan cost document.

4. Advanced innovative/alternative (I/A) onsite systems were assumed to have a capital cost of $28,000/parcel, which originates from the 208 Plan cost document. Advanced I/A system O&M is assumed to be $3,850/system, based on the 208 Plan cost document.

5. Sewer collection system length was assumed to be 90% of the total road length within the sewered areas.

6. The collection system cost was assumed to be $228/lf, from the 208 Plan cost document average cost for gravity sewers.

7. House connections to the sewer system (from the home to the street) were assumed to cost $3,000 per parcel.

8. One sewer pumping station was assumed to be necessary for every 200 parcels sewered. The 208 Plan cost document uses one pumping station per 100 parcels, but this resulted in what was deemed to be an unrealistic total number of stations. Each pumping station is assumed to require one half mile of force main, at a cost of $245/ft from the 208 Plan cost document.

9. Each pumping station capital cost is assumed to be $750,000, slightly above the average value per station listed in the 208 Plan cost document, based on past CDM Smith experience. Pumping station O&M is assumed to be $62,500/station, based on the 208 Plan cost document.

10. Effluent recharge is assumed to require 1 acre per 120,000 gpd, using 2.2 times the annual average daily flow to the basins, and the cost of effluent recharge is assumed to be $250,000 per acre, from the 208 Plan cost document. Effluent recharge O&M cost is assumed to be $0.17 per square foot.

11. Wastewater generation is assumed to be 90 percent of actual water usage on a parcel-by-parcel basis. Water usage used for the analysis originates from the MEP datadisk for areas within the Bass River and Swan Pond River watersheds and from the CCC for all other areas of town.

12. Unit construction costs for the wastewater treatment facilities (WWTFs) are from the 208 Plan cost curves. WWTF capital costs are based on the summertime flows, estimated to be 2.2 times

annual average daily flow. WWTF O&M assumes costs per the 208 Plan cost document using the same peaking factor of 2.2.

13. The length of force main between the WWTF and the effluent recharge site is assumed to be 100 feet for onsite recharge locations and actual measured distances along roads for offsite locations.

14. The length of force main for Scenario 7D from Site #1 to the location of the potential ocean outfall is 4 miles, or 21,120 linear feet. The force main to the ocean outfall assumes a distance of 6 miles from the shore to discharge outside of Nantucket Sound. A cost of $2,730/lf of outfall is assumed per the 208 Plan cost document.

15. A cost has been assumed of $50,000 for a 12” force main to cross a 200’ stretch across Route 6 using directional drilling. This estimate was provided by CDM Smith’s cost estimators. All “A” scenarios will have to cross Route 6 twice.

16. Permeable reactive barriers (PRBs) are assumed to be $3,010/lf, which is the average of shallow and deep trench PRBs per CDM Smith’s PRB study in Falmouth, MA. The length of PRBs is calculated as the perimeter of the total acreage of the effluent recharge area(s). PRB O&M costs are assumed to be $55,000/year per site per CDM Smith’s Falmouth study.

Table D-1

	Capital Costs													
Scenario	**1**	**2A**	**3A**	**3B**	**4A**	**4B**	**5A**	**5B**	**6A**	**6B**	**7A**	**7B**	**7C**	**7D**
Reference Figure	Figure 10-4	Figure 10-5	Figure 10-6	Figure 10-6	Figure 10-7	Figure 10-7	Figure 10-8	Figure 10-8	Figure 10-9	Figure 10-9	Figure 10-10	Figure 10-10	Figure 10-11	Figure 10-12
25% Stormwater Credit Cost ($110,000/curb mile)	$ 8,252,053	$ 8,252,053	$ 8,252,053	$ 8,252,053	$ 8,252,053	$ 8,252,053	$ 8,252,053	$ 8,252,053	$ 8,252,053	$ 8,252,053	$ 8,252,053	$ 8,252,053	$ 8,252,053	$ 8,252,053
25% Fertilizer Credit Cost	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Number of Acres of Aquaculture		28	6.25	6.25			9.5	9.5	3.25	3.25	5	5	3.75	
Cost of Aquaculture ($63,000/acre)		$ 1,764,000	$ 393,750	$ 393,750			$ 598,500	$ 598,500	$ 204,750	$ 204,750	$ 315,000	$ 315,000	$ 236,250	$ -
Number of Parcels with I/A Systems	6905	6472	395	395										
I/A Cost ($28,000/parcel)	$ 193,340,000	$ 181,216,000	$ 11,060,000	$ 11,060,000										
Number of Parcels Sewered			4,826	4,826	5,092	5,092	5,234	5,234	5,471	5,471	8,297	8,297	8,297	8,297
Total LF of Roads in Sewered Area			392,338	392,338	444,772	444,772	466,177	466,177	484,278	484,278	707,124	707,124	707,124	707,124
LF of Roads (90%)/parcel in Sewered Area			73	73	79	79	80	80	80	80	77	77	77	77
# of Pump Stations (1 PS/200 parcels)			24	24	25	25	26	26	27	27	41	41	41	41
Construction Cost per Property ($228/lf +$3,000)			$ 19,682	$ 19,682	$ 20,924	$ 20,924	$ 21,277	$ 21,277	$ 21,164	$ 21,164	$ 20,488	$ 20,488	$ 20,488	$ 20,488.47
Collection Cost			$ 94,985,758	$ 94,985,758	$ 106,543,214	$ 106,543,214	$ 111,361,520	$ 111,361,520	$ 115,786,846	$ 115,786,846	$ 169,992,845	$ 169,992,845	$ 169,992,845	$ 169,992,845
Length of Force Mains in LF (assume 1/2 mile per PS)			63,360	63,360	66,000	66,000	68,640	68,640	71,280	71,280	108,240	108,240	108,240	108,240
Pump Station Cost ($750,000/PS)			$ 18,000,000	$ 18,000,000	$ 18,750,000	$ 18,750,000	$ 19,500,000	$ 19,500,000	$ 20,250,000	$ 20,250,000	$ 30,750,000	$ 30,750,000	$ 30,750,000	$ 30,750,000
FM Cost ($193/ft)			$ 12,228,480	$ 12,228,480	$ 12,738,000	$ 12,738,000	$ 13,247,520	$ 13,247,520	$ 13,757,040	$ 13,757,040	$ 20,890,320	$ 20,890,320	$ 20,890,320	$ 20,890,320
Cost for Force Main Crossing Route 6 ($/lf)			$ 50,000		$ 50,000		$ 50,000		$ 50,000		$ 50,000			
Collection + Conveyance Cost			$ 125,264,238	$ 125,214,238	$ 138,081,214	$ 138,031,214	$ 144,159,040	$ 144,109,040	$ 149,843,886	$ 149,793,886	$ 221,633,165	$ 221,633,165	$ 221,633,165	$ 221,633,165
Total Water Use in Bass River (gpd)			839,945	839,945	839,945	839,945	839,945	839,945	839,945	839,945	839,945	839,945	839,945	839,945
Total Water Use in Swan Pond River			320,008	320,008	320,008	320,008	320,008	320,008	320,008	320,008	320,008	320,008	320,008	320,008
Total Water Use in Herring River- assume avg for developed parcels			29,553	29,553	29,553	29,553	29,553	29,553	29,553	29,553	29,553	29,553	29,553	29,553
Total Water Use			1,189,507	1,189,507	1,189,507	1,189,507	1,189,507	1,189,507	1,189,507	1,189,507	1,189,507	1,189,507	1,189,507	1,189,507
Water Use in Bass River for Sewered Parcels			415,641	415,641	471,230	471,230	495,477	495,477	487,918	487,918	665,926	665,926	665,926	665,926
Water Use in Swan Pond River for Sewered Parcels			261,948	261,948	314,340	314,340	316,088	316,088	316,088	316,088	316,088	316,088	316,088	316,088
Water Use in Herring River for Sewered Parcels			27,553	27,553	27,858	27,858	27,858	27,858	28,123	28,123	28,123	28,123	28,123	28,123
Water Use in Sesuit Harbor/Chase Garden Creek for Sewered Parcels					310	310	310	310	310	310	7,756	7,756	7,756	7,756
Water Use in Direct Discharge Area for Sewered Parcels									137,422	137,422	353,567	353,567	353,567	353,567
Total Water Use for Sewered Parcels			705,142	705,142	813,737	813,737	839,732	839,732	969,860	969,860	1,371,460	1,371,460	1,371,460	1,371,460
Sewer Use in Bass River			374,077	374,077	424,107	424,107	445,929	445,929	439,126	439,126	599,333	599,333	599,333	599,333
Sewer Use in Swan Pond River			235,753	235,753	282,906	282,906	284,479	284,479	284,479	284,479	284,479	284,479	284,479	284,479
Sewer Use in Herring River			24,798	24,798	25,072	25,072	25,072	25,072	25,311	25,311	25,311	25,311	25,311	25,311
Sewer Use in Sesuit Harbor/Chase Garden Creek			-	-	279	279	279	279	279	279	6,981	6,981	6,981	6,981
Sewer Use in Direct Discharge Areas			-	-	-	-	-	-	123,680	123,680	318,210	318,210	318,210	318,210
Total Sewer Use			634,628	634,628	732,363	732,363	755,758	755,758	872,874	872,874	1,234,314	1,234,314	1,234,314	1,234,314
WWTP 1- DPW Site														
Total ADF to WWTP #1 (gpd)			634,628	366,904	732,366	443,323	755,758	462,780	872,874	583,676	1,234,312	926,534	586,346	1,234,312
Short Term Peak Flow to WWTP #1 (2.2 x ADF) (gpd)			1,396,182	807,189	1,611,205	975,310	1,662,668	1,018,116	1,920,323	1,284,087	2,715,486	2,038,375	1,289,962	2,715,486
Unit Construction Cost #1			17	20	16	19	16	17	16	19	15	16	19	15
Treatment Goal #1 (ppm)			3	3	3	3	3	3	3	3	3	3	3	3
Capital Cost WWTP #1			$ 23,735,095	$ 16,143,781	$ 25,779,275	$ 18,530,891	$ 26,602,694	$ 17,307,972	$ 30,725,173	$ 24,397,652	$ 40,732,289	$ 32,613,996	$ 24,509,275	$ 40,732,289
Effluent Disposal Cost ($250,000/acre at 120,000 gpd/acre)			$ 2,908,713	$ 1,681,644	$ 3,356,676	$ 2,031,896	$ 3,463,892	$ 2,121,075	$ 4,000,674	$ 2,675,181	$ 5,657,262	$ 4,246,614	$ 2,687,421	
Pump Station Cost to Recharge ($700,000 per PS or $3M for ocean outfall PS)			$ 700,000		$ 700,000		$ 700,000		$ 700,000		$ 700,000			$ 3,000,000
Length of Force Main to Recharge Site #1 (or Ocean Outfall for 7D) (lf)			8,917	100	8,917	100	8,917	100	8,917	100	8,917	100	100	18,480
Cost for Force Main for WWTP #1 ($245/ft)			$ 2,184,665	$ 24,500	$ 2,184,665	$ 24,500	$ 2,184,665	$ 24,500	$ 2,184,665	$ 24,500	$ 2,184,665	$ 24,500	$ 24,500	$ 4,527,600
Cost for Force Main Crossing Route 6 ($/lf)			$ 50,000		$ 50,000		$ 50,000		$ 50,000		$ 50,000			
Cost for Ocean Outfall (assumes 6 miles at $2,730/lf + $1 Mil for permitting)														$ 87,486,400
WWTP 2- North of Route 6														
Total ADF to WWTP #2 (gpd)				267,724		289,043		292,978		289,196		307,778	307,778	
Short Term Peak Flow to WWTP #2 (2.2 x ADF) (gpd)				588,993		635,895		644,552		636,231		677,111	677,111.2	
Unit Construction Cost #2				23		23		23		23		23	23	
Treatment Goal #2 (ppm)				3		3		3		3		3	3	
Capital Cost WWTP #2				$ 13,546,840		$ 14,625,576		$ 14,824,705		$ 14,633,312		$ 15,573,557	$ 15,573,557	
Effluent Disposal Cost ($250,000/acre at 120,000 gpd/acre)				$ 1,227,068.84		$ 1,324,780		$ 1,342,817		$ 1,325,481		$ 1,410,648	$ 1,410,648	
Length of Force Main to Recharge Site #2 (lf)				100		100		100		100		100	100	
Cost for Force Main for WWTP #2 ($245/ft)				$ 24,500		$ 24,500		$ 24,500		$ 24,500		$ 24,500	$ 24,500	
WWTP 3- Dennisport														
Total ADF to WWTP #3 (gpd)													340,188	
Short Term Peak Flow to WWTP #3 (2.2 x ADF) (gpd)													748,413	
Unit Construction Cost #3													21	
Treatment Goal #3 (ppm)													3	
Capital Cost WWTP #3													$ 15,716,670	
Effluent Disposal Cost ($250,000/acre at 120,000 gpd/acre)													$ 1,559,193	
Length of Force Main to Recharge Site #3 (lf)													100	
Cost for Force Main for WWTP #3 ($245/ft)													$ 24,500	
Total ADF all three WWTPs (check)			634,628	634,628	732,366	732,366	755,758	755,758	872,874	872,872	1,234,312	1,234,312	1,234,312	1,234,312
PRB #1 Cost ($3,010/lf)			$ 9,389,478	$ 7,139,340	$ 10,086,623	$ 7,847,689			$ 11,011,782	$ 9,004,667	$ 13,094,659	$ 11,345,207	$ 9,025,242	
PRB #2 Cost ($3,010/lf)				$ 6,098,535		$ 6,336,698				$ 6,338,373		$ 6,538,836	$ 6,538,836	
Total Capital Cost: Stormwater, Fertilizer, Aquaculture, I/A, Collection, Conveyance, Treatment	$ 201,592,053	$ 191,232,053	$ 183,937,992	$ 190,806,248	$ 188,490,506	$ 197,029,797	$ 186,010,845	$ 188,605,163	$ 206,972,983	$ 216,674,355	$ 292,669,093	$ 301,978,076	$ 307,215,811	$ 365,631,506
Annual Loan Payment	$ 12,329,000	$ 11,695,000	$ 11,249,000	$ 11,669,000	$ 11,527,000	$ 12,050,000	$ 11,376,000	$ 11,534,000	$ 12,658,000	$ 13,251,000	$ 17,899,000	$ 18,468,000	$ 18,788,000	$ 22,361,000

Table D-1 Continued

	O&M Costs													
Scenario	**1**	**2A**	**3A**	**3B**	**4A**	**4B**	**5A**	**5B**	**6A**	**6B**	**7A**	**7B**	**7C**	**7D**
Reference Figure	Figure 10-4	Figure 10-5	Figure 10-6	Figure 10-6	Figure 10-7	Figure 10-7	Figure 10-8	Figure 10-8	Figure 10-9	Figure 10-9	Figure 10-10	Figure 10-10	Figure 10-11	Figure 10-12
Pump Station O&M ($62,500)			$ 1,500,000	$ 1,500,000	$ 1,562,500	$ 1,562,500	$ 1,625,000	$ 1,625,000	$ 1,687,500	$ 1,687,500	$ 2,562,500	$ 2,562,500	$ 2,562,500	$ 2,562,500
O&M Dollars Per gpd of Flow at WWTP #1			$ 2,094,273	$ 1,614,378	$ 2,416,807	$ 1,853,089	$ 2,494,003	$ 1,934,420	$ 2,880,485	$ 2,439,765	$ 4,073,229	$ 3,057,562	$ 1,934,943	$ 4,073,229
O&M Dollars Per gpd of Flow at WWTP #2				$ 1,472,483		$ 1,589,737		$ 1,611,381		$ 1,590,577		$ 1,421,933	$ 1,421,933	
O&M Dollars Per gpd of Flow at WWTP #3													$ 1,496,826	
I/A O&M ($3,850/system)	$ 26,584,250	$ 24,917,200	$ 1,520,750	$ 1,520,750										
Stormwater BMPs O&M	$ 6,400	$ 6,400	$ 6,400	$ 6,400	$ 6,400	$ 6,400	$ 6,400	$ 6,400	$ 6,400	$ 6,400	$ 6,400	$ 6,400	$ 6,400	$ 6,400
Fertilizer O&M	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000
Collection System O&M	$ -	$ -	$ 706,208	$ 706,208	$ 800,590	$ 800,590	$ 839,119	$ 839,119	$ 871,700	$ 871,700	$ 1,272,823	$ 1,272,823	$ 1,272,823	$ 1,272,823
Effluent Recharge O&M			$ 86,158	$ 86,158	$ 99,427	$ 99,427	$ 102,603	$ 102,603	$ 118,503	$ 118,503	$ 167,573	$ 167,573	$ 167,573	
PRB O&M ($55,000 per year per site)			$ 55,000	$ 110,000	$ 55,000	$ 110,000			$ 55,000	$ 110,000	$ 55,000	$ 110,000	$ 110,000	
Ocean Outfall O&M														$ 10,560
Force Main O&M ($1/LF)			$ 72,277	$ 63,560	$ 74,917	$ 66,200	$ 77,557	$ 68,840	$ 80,197	$ 71,480	$ 117,157	$ 108,440	$ 108,540	$ 126,720
Aquaculture ($5,500/acre or $75,000 Minimum)		$ 154,000	$ 75,000	$ 75,000			$ 75,000	$ 75,000	$ 75,000	$ 75,000	$ 75,000	$ 75,000	$ 75,000	
Total Annual O&M	$ 26,595,650	$ 25,082,600	$ 6,121,067	$ 7,159,937	$ 5,020,641	$ 6,092,943	$ 5,224,681	$ 6,267,763	$ 5,779,786	$ 6,975,926	$ 8,334,682	$ 8,787,231	$ 9,161,538	$ 8,057,232

Aggregated Costs														
Equivalent Annual Cost (EAC)	$ 38,924,650	$ 36,777,600	$ 17,370,067	$ 18,828,937	$ 16,547,641	$ 18,142,943	$ 16,600,681	$ 17,801,763	$ 18,437,786	$ 20,226,926	$ 26,233,682	$ 27,255,231	$ 27,949,538	$ 30,418,232
Nitrogen Removed (lbs/yr)	$ 48,644	$ 64,297	$ 67,179	$ 67,179	$ 64,684	$ 64,684	$ 66,422	$ 66,422	$ 71,184	$ 71,184	$ 89,125	$ 89,125	$ 88,307	$ 88,396
Annual cost per Pound Removed	$ 800	$ 570	$ 260	$ 280	$ 260	$ 280	$ 250	$ 270	$ 260	$ 280	$ 290	$ 310	$ 320	$ 340

Legend
Stormwater
Fertilizer
Aquaculture
I/A
Collection and Conveyance (sewers, force mains, pump stations)
Wastewater Treatment
PRB

Appendix E

Site Visit memorandum, Site Screening memorandum, Soil Boring Data and Steady-State and Transient Model Development and Calibration

Memorandum

To: *Dave Young, Kara Johnston*

From: *Karilyn Heisen*

Date: *December 3, 2015*

Subject: *Site Visit to Potential Effluent Recharge Sites – Dennis, MA*

Summary

On November 24, 2015, Bob Schreiber and I visited three sites which have been identified for potential wastewater effluent recharge as part of the Water Quality Evaluation Study/ Comprehensive Wastewater Management Plan (CWMP) for the Town of Dennis. As part of the site visits, we walked through areas which had previously been identified as likely recharge areas based on Zone II areas. General site conditions including topography and indications of potential vernal pools such as variations in topography, flora, and standing water or damp locations were observed. Coordinates and photographs of key features and locations were taken. Following the site visit, potential areas for recharge basins were estimated using GIS. Based on the site visits, recharge basin area estimates, and currently known groundwater conditions, Sites 1 and 2 likely have sufficient area for effluent recharge assuming an average recharge rate of 3 gpd/ft^2. Site 3 will not be considered further at this time.

Site 1 – Department of Public Works Adjacent to Former Landfill

Site 1 is a 91 acre, town-owned parcel near the current DPW office and garage. It is located east of the former landfill. Figure 1 shows points recorded in the site walk, locations of photographs and locations of wells found during the site walk. Points are labeled with numbers which correspond to the accompanying data table.

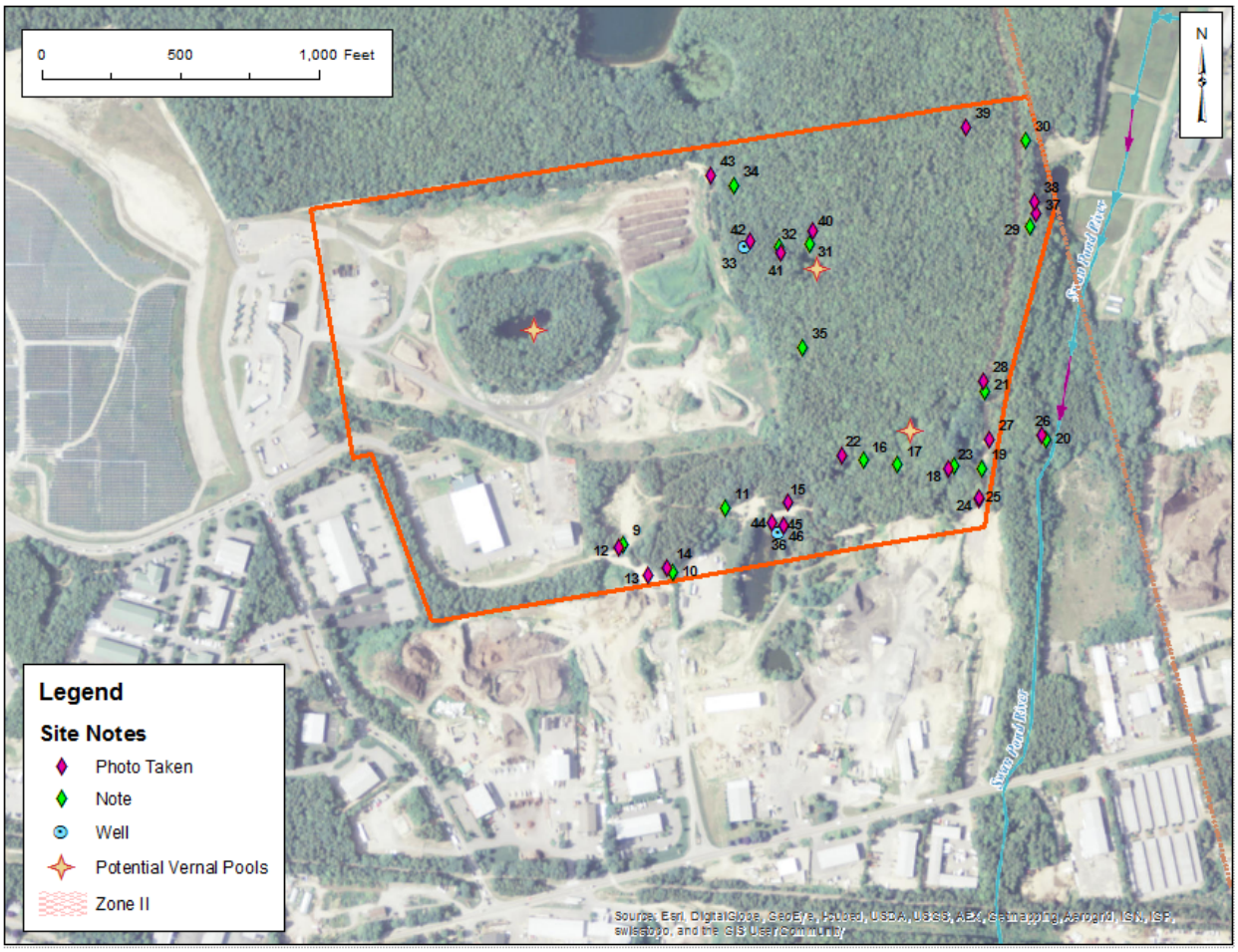


Figure 1 – Site 1 – Note, Well and Photo Locations

As part of the site walk we located 3 wells. One pair of wells is located in the woods east of the compost area (picture IMG_1432) and one well is at the southern boundary of the site (pictures IMG_1435 and IMG_1436). The metal stick-ups were rusted, not locked or secured and the PVC casings were not capped or plugged. The well stick-up near the pond on the southern property boundary was broken and the sample tubing removed. Estimated length of the tubing was 40 feet.

Potential vernal pools were identified on the site based on review of aerial photography by DEP. We were able to locate kettle holes in the locations of the potential vernal pools. The vegetation in these pools was denser with more shrubs than the surrounding uplands, however no standing water was observed. This supports the findings of potential vernal pools. Verification of the vernal pool status would need to be done in the spring.

In addition to the site walk we reviewed some existing well data. Drawing SP-1 from the Hydrogeologic Evaluation Dennis Landfill, Dennis MA by GHR Engineering, dated March 28, 1985

prepared for the Dennis Health Department has locations of several monitoring wells and pumping wells. The preparation of pump wells and a hydrogeologic evaluation suggests that there is additional data that was collected in the area including boring logs, pump tests and possibly geophysical analysis.

The site was listed as Town of Dennis Disposal Area Extension on a figure titled Well Locations in South Dennis, MA dated May 22, 1987 from the Town Engineering Department. The area is currently used for sand and gravel storage for the Dennis DPW and for composting operations. The portions of the site used for these activities appear to have been excavated to a depth of several tens of feet below surrounding grade.

We did note many of the wells shown on the data sources listed above during the drive to and from the site. However, the 3 wells we found during the site walk were not shown on either of the two data sources listed above.

Additional data sources which would assist modeling efforts for this site include

- The Hydrogeologic Evaluation Dennis Landfill, Dennis MA prepared by GHR Engineering, March 1985
- boring logs for the known landfill well locations,
- information on wells identified during site walk including boring logs, water levels, water quality and any additional wells installed in the area
- landfill and site history including reasons for discontinuing landfilling operations
- plans or proposed plans which resulted in the excavation and site grading of the area currently used for DPW storage and composting, particularly as pertains to the well installation and buffer zone around the pond in the center of that portion of the site
- test wells, boring logs and pump tests for supply wells GPW-8 through GPW-13 near Centre St, north of Swan pond

Site 2 – Former Department of Public Works site

Site 2 is located north and south of Bob Crowell Road. The 71.5 acre site includes areas within the Zone II well protection areas. The site walk focused on the area of the site outside the Zone II, north of the former DPW area. Figure 2 shows points recorded in the site walk and locations of photographs. Points are labeled with numbers which correspond to the accompanying data table.

Figure 2 – Site 2 - Note and Photo Locations

The site walk for this area was focused on the wooded area north of the former DPW site and outside of the Zone II. This area is wooded with no deep kettle holes or depressions observed. An old road or path leads from behind an apartment complex into the area, which would facility subsurface site investigations. No wells were identified.

Boring log data for public supply wells, test wells and USGS wells near the site have not been obtained and reviewed.

Site 3 – Park and area adjacent to Sea View

Site 3 is located in Dennis Port off Lower County Road. Figure 3 shows points recorded in the site walk and locations of photographs. Points are labeled with numbers which correspond to the accompanying data table. Initial assessment of the site suggests that the depth to groundwater in the portion of the site which is currently undeveloped would not be sufficient for effluent recharge.

A sign and sandy area indicates possible turtle nesting on the site. One possible location would be the empty portion of the site adjacent to the community garden and parking lot.

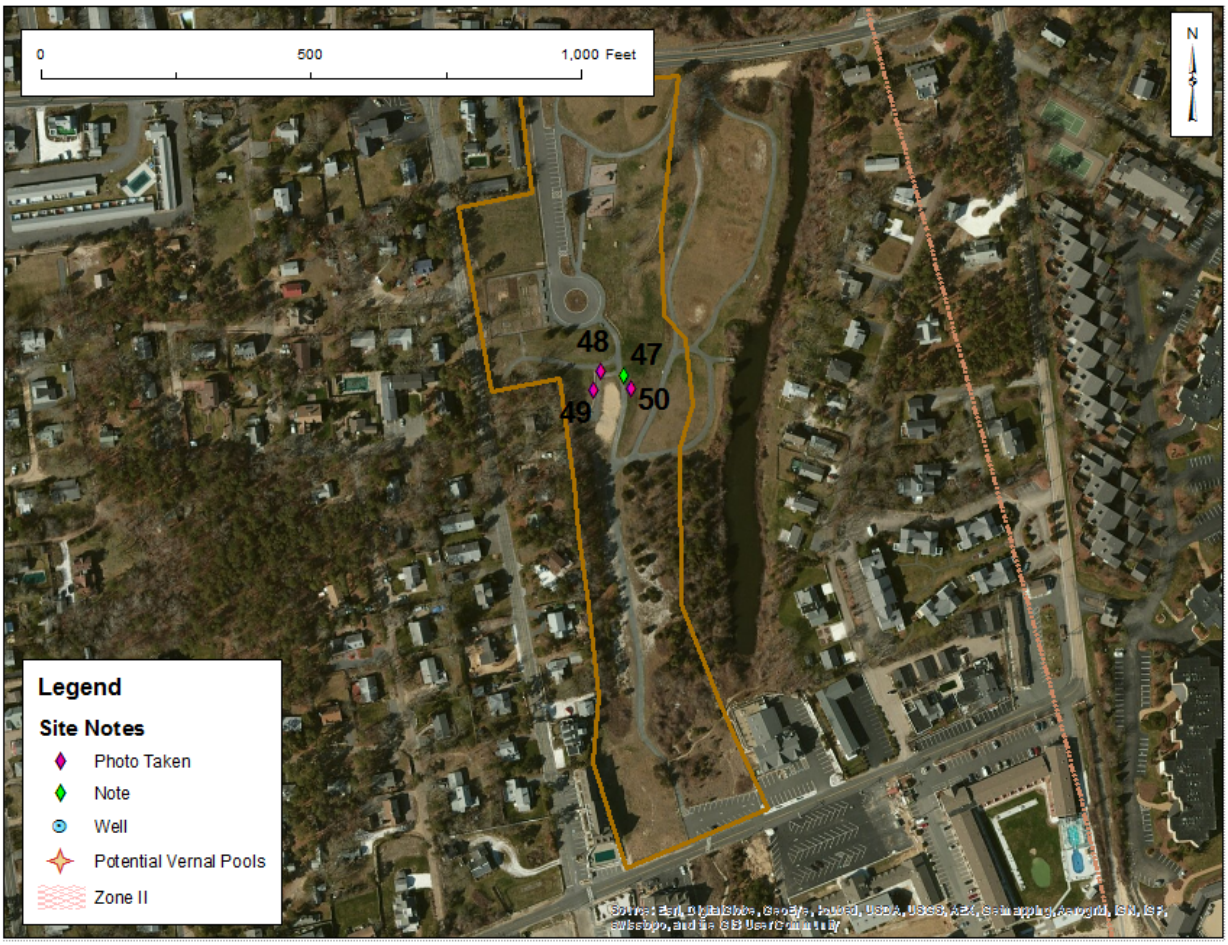


Figure 3 – Site 3 - Note and Photo Locations

Memorandum

To: *Comprehensive Wastewater Management Task Force*

From: *Karilyn Heisen*

Date: *January 7, 2016*

Subject: *Site Screening for Effluent Recharge, Dennis, MA*

In support of the Dennis Comprehensive Wastewater Management Plan (CWMP), effluent recharge at two potential sites was modeled using the USGS Monomoy Flow Lens groundwater model, which includes the towns of Dennis, Harwich, Chatham, Brewster and parts of Orleans. This groundwater model was developed in the 1990s and early 2000s and was used to delineate groundwater contribution areas to embayments as part of the Massachusetts Estuaries Project (MEP). The model was created in MODFLOW, a finite-difference groundwater model code developed by the USGS and widely used for groundwater modeling applications. The simulated groundwater elevations generated by the model represent steady-state 2003 pumping and recharge conditions. Model documentation is provided in the USGS report *Simulated Water Sources and Effects of Pumping on Surface and Ground Water, Sagamore and Monomoy Flow Lenses, Cape Cod, Massachusetts* (SIR 2004-5181).

Model Updates

For this site-specific application, the model grid discretization was increased at the potential sites. Grid spacing was changed from 400 ft by 400 ft cells to 100 ft by 100 ft cells at the recharge sites to represent the recharge areas in greater detail.

No changes were made to stream stage or streamflow, hydrogeologic properties, applied rainfall recharge or pumping withdrawals as information was not readily available. While long-term average precipitation has not likely changed since 2003, pumping values may have increased, decreased or been shifted within the vicinity of the water withdrawal locations. Therefore, CDM Smith verified the model calibration using average regional water level data from 2000 to 2015 available from the USGS NWIS database.

Site Descriptions

Site walks were conducted at three locations on November 24, 2015 and information collected was used to identify potential issues and identify the most likely locations for effluent recharge basins. Based on the site walk and CWMP analysis two sites were selected for simulation of effluent recharge.

The Bass River site is located north of Route 6 near the former DPW site on Bob Crowell Road. Based on the site walk, Zone II extent, and use limitations on other portions of the property, the area west of the former DPW site was selected for effluent recharge. This area has ground

surface elevations of around 50 feet (MSL) with an estimated depth to groundwater of around 20 to 30 feet below ground surface.

The Swan Pond River site is located south of Route 6 near the current DPW office and garage and east of the former landfill. The site walk identified multiple potential vernal pools, an active cranberry bog east of the site and industrial activities located in excavated areas south of the site which may be impacted by increases in groundwater levels. An area in the northeast portion of the site was selected as the location for potential recharge. This area has ground surface elevations of between 40 and 50 feet and estimated depth to groundwater of around 20 feet below ground surface.

Recharge Simulations

Recharge simulations were conducted to simulate the highest flow rates developed as part of the CWMP based on current wastewater flow estimates and build-out wastewater flow estimates. These values are shown in the Table 1.

	Swan Pond River	**Bass River**
Modeled Basins Area	8.72 acres	3.21 acres
Current WW Flows		
Effluent Recharge	575,000 gpd	410,000 gpd
Loading Rate	1.51 gpd/ft^2	2.93 gpd/ft^2
Build-out WW Flows		
Effluent Recharge	1,045,151 gpd	540,000 gpd
Loading Rate	2.75 gpd/ft^2	3.86 gpd/ft^2

Table 1 – Effluent Recharge Simulated Flows

The simulated increase in groundwater table elevation, or mounding, due to effluent recharge scenarios listed in Table 1 is shown in Figures 1 through 4 as blue contours along with simulated paths for particles released at the effluent recharge site. Particle tracks or paths were created using MODPATH and represent the path a particle would follow based on the simulated flow field. For this simulation, particles were released at the water table at the boundary of the recharge area. The path lines from these particles indicate where effluent recharged at the site will flow and identify the final discharge location of the recharged water.

As shown on Figure 1, the maximum mounding due to recharge of current estimated wastewater flows at the Bass River site is around 4.5 feet, situated beneath the site. Particle tracks indicate the recharged effluent discharges to the Bass River and is not captured by the public water supply wellfield 4075000-01G, which is located south of the site. It should be noted that this wellfield is pumping at a rate of 0.19 mgd in this simulation. Model simulations should be conducted to test for potential impacts to this well under various recharge and pumping scenarios. Maximum mounding due to build-out wastewater flows is around 5.5 feet at the site as shown in Figure 2.

Maximum mounding at the Swan Pond River site is around 3 feet for current estimated wastewater flows as shown in Figure 3 and 6 feet for build-out wastewater flows as shown on Figure 4. Particle tracks indicate that effluent from this site will discharge to the Swan Pond

River, Herring River and Swan Pond. Based on the model results, mounding impacts for the following should be considered in future designs.

- Average (annual) groundwater levels beneath the cranberry bog east of the site may increase between 1.5 and 2 feet. This impact may be mitigated by control structures in the bogs which allow for drainage to the Swan Pond River.
- Average (annual) groundwater levels at vernal pools may increase between 1.5 and 2.5 feet. Vernal pools fed by groundwater require water tables to drop annually for the pool to dry out. Seasonal fluctuations should be measured and modeled to assess if the seasonality of the pools is impacted.
- Average (annual) groundwater levels at the gravel pit south of the site may increase by 1.5 feet. This area is sensitive because the excavation of the gravel has lowered the ground surface close to the existing water table. Additional information on current depth to groundwater should be obtained.

Recommendations

Multiple wells were identified at the Swan Pond River site during the site walk in November 2015. The limited data identified on water levels in the area indicate a hydrogeologic study was conducted in the 1980s to support landfill operations and/or expansion. However, to date, stratigraphic data or boring logs for installed wells near the landfill and located during the site walk have not been obtained. Obtaining this information would reduce the scope of future fieldwork at this site.

Additional data on seasonal water levels in ponds, streams and wells should be obtained, particularly at the Swan Pond River site in order to understand seasonal fluctuations and assess impacts on vernal pools and water table rise south of the site.

The USGS model was calibrated to regional steady-state conditions for use in regional groundwater flow assessment. Additional calibration needs to be conducted, particularly at the Swan Pond River site in order to adequately assess flow directions and mounding for this site specific application. In particular, based on the elevations of the base of the vernal pools and the Swan Pond River, it is suspected that the model simulated water levels are low in the Swan Pond Area.

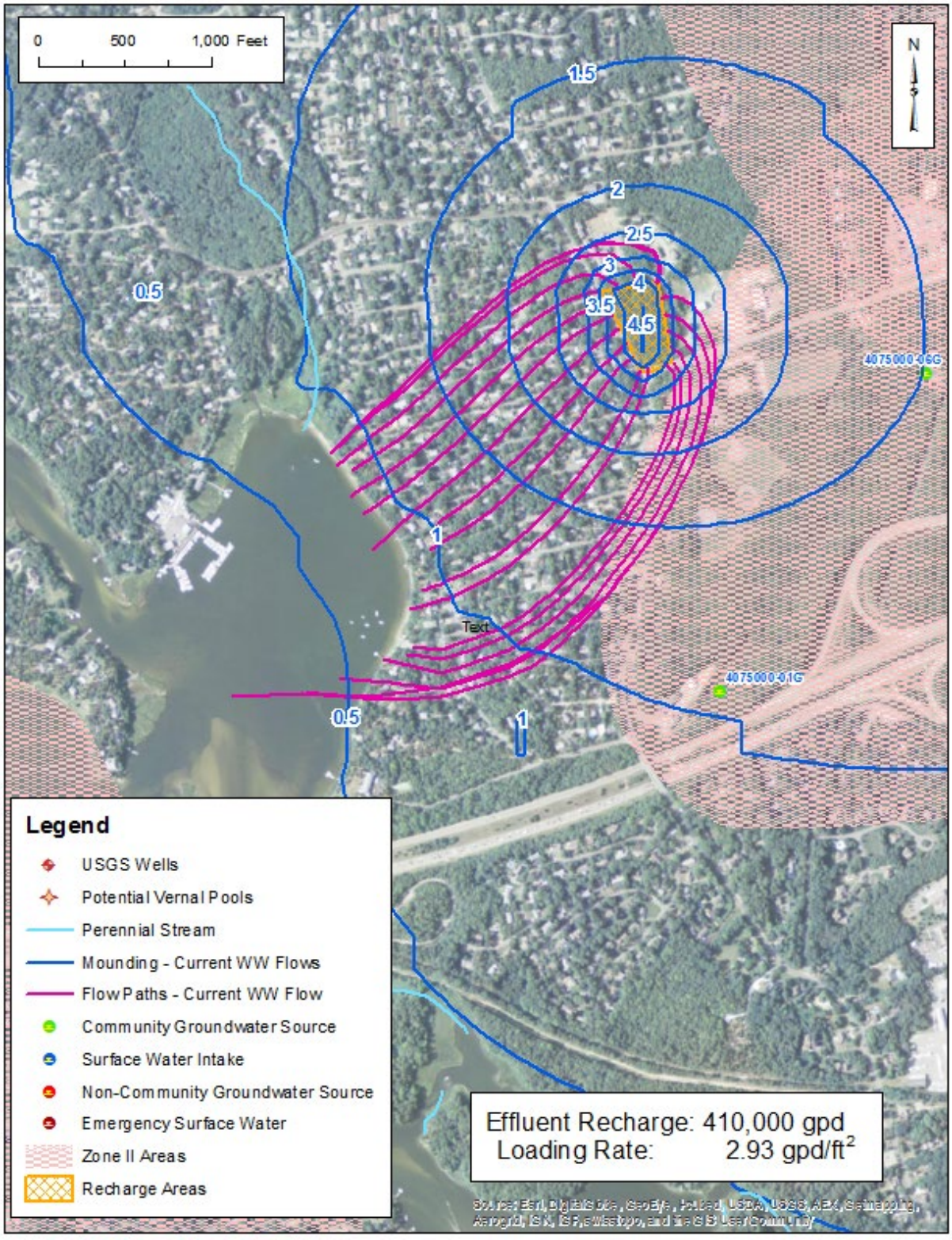


Figure 1– Bass River Effluent Recharge, Current Flows – Mounding and Particle Flow Direction

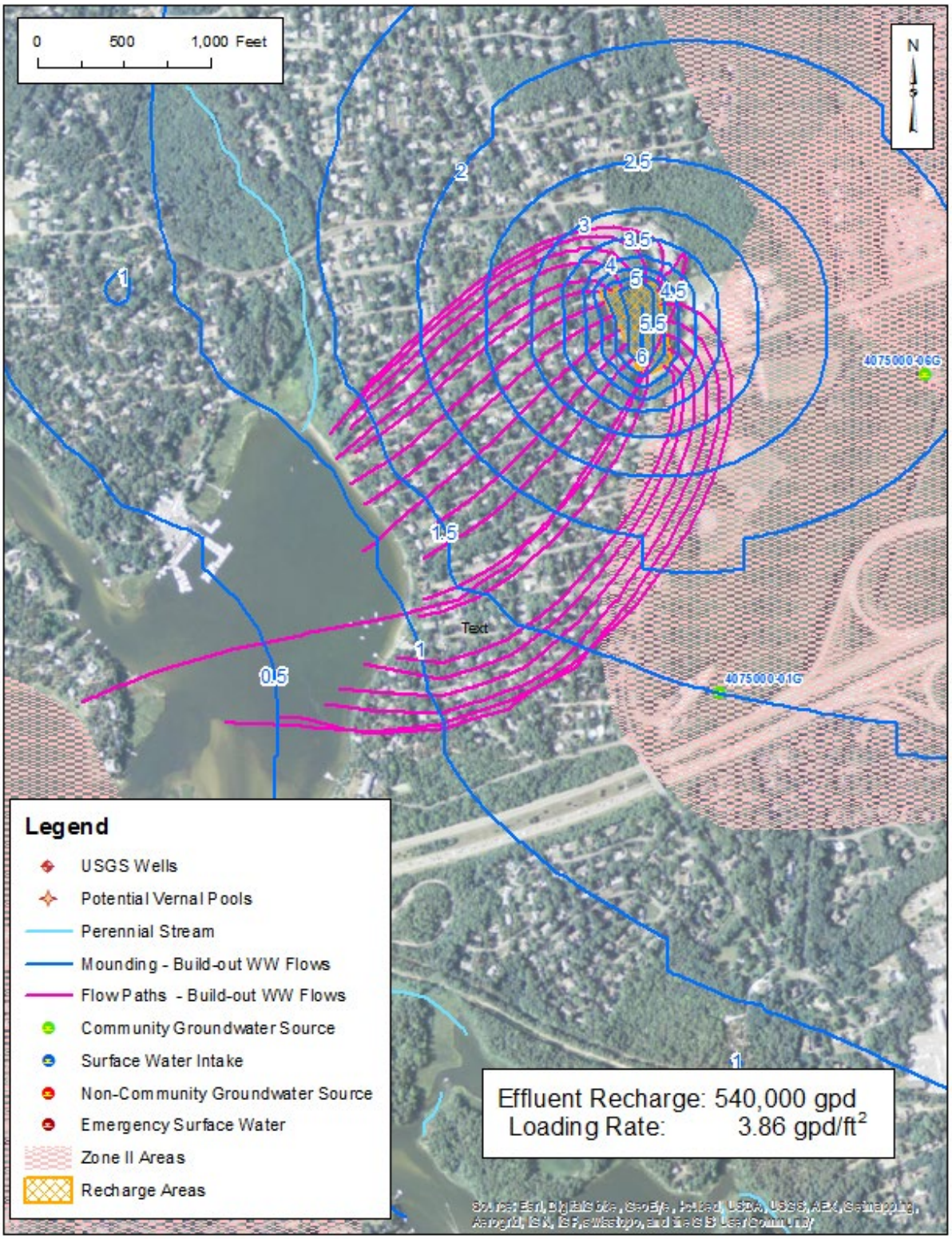


Figure 2- Bass River Effluent Recharge, Build-out Flows – Mounding and Particle Flow Directions

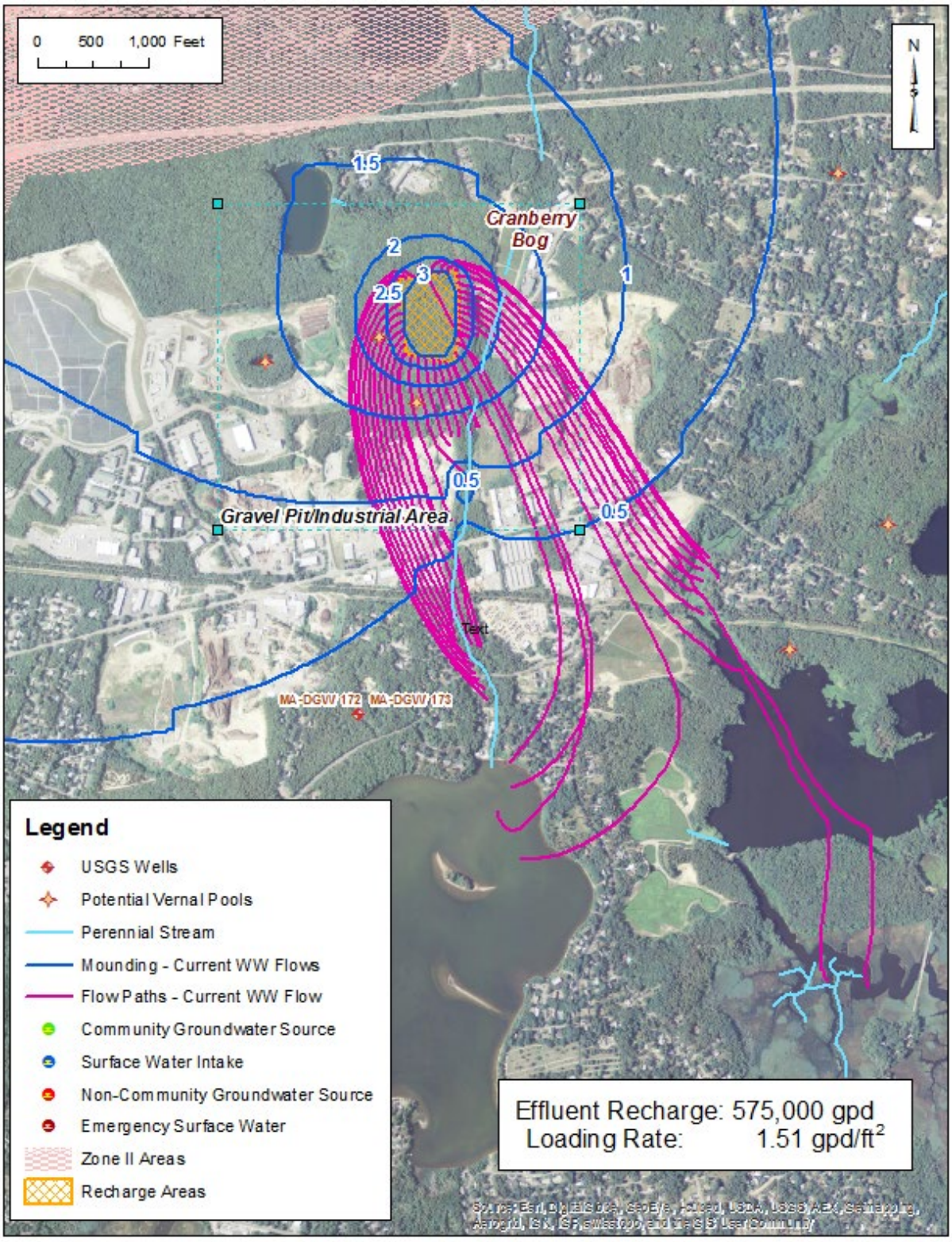


Figure 3 – Swan Pond River Effluent Recharge, Current Flows – Mounding and Particle Flow Direction

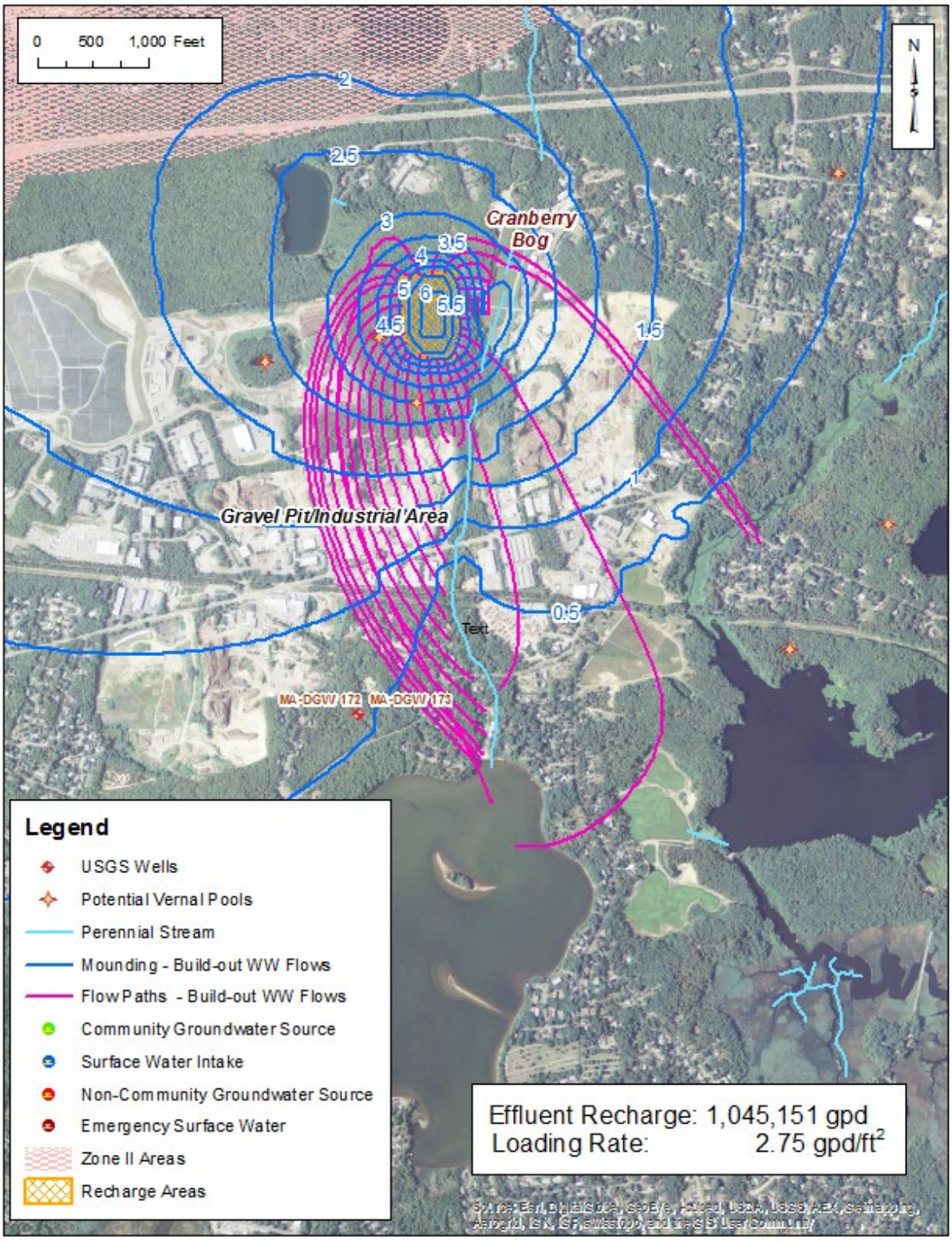


Figure 4 – Swan Pond River Effluent Recharge, Build-out Flows – Mounding and Particle Flow Direction

Memorandum

To: *Dave Young and Ed Sanderson*

From: *Karilyn Heisen*

Date: *February 22, 2016*

Subject: *Review of Boring Data, DPW/Landfill Site, Dennis, MA*

In support of the Dennis Comprehensive Wastewater Management Plan (CWMP), I conducted a file review of available reports and data at the Mass DEP Lakeville office on February 3, 2016. Boring log data obtained as part of the file review was input into Leapfrog Hydro to provide a three-dimensional view of the stratigraphy and compared to model properties and water table from the USGS Monomoy Lense MODFLOW model.

File Review

The following files were reviewed at the Mass DEP office and copies made:

- Comprehensive Site Assessment for the Landfill date February 1996 prepared by SEA Consultants
    - Chapter 2 contains a hydrogeologic evaluation which focuses on the landfill site but does include information on wells to the east in the area proposed for effluent recharge
    - Figure 2-3B is geologic cross-sections under the site. Unfortunately it was missing from the map pocket. One of the DEP staff double checked the files but couldn't find the figure.
    - Appendix D contains monitoring well boring and construction logs (70 pages) including logs from as far back as 1976 and the 1985 GHR data
    - Appendix E contains hydraulic conductivity calculations (18 pages) for tests conducted in 1995 and 3 field permeability test reports from the GHR Phase II Hydrogeologic Study
- Comprehensive Site Assessment Addendum Report for the Landfill dated March 2002 prepared by SEA Consultants.
    - This report contains additional groundwater information but is more narrowly focused on the area immediate beneath the landfill.
- Copies of 2 larger figures showing the well locations and hydraulic gradients from the late 1980s were requested.

Based on the information obtained, the wells located during the site walk were installed in 1990 to support a Whitman & Howard hydrogeologic investigation for a proposed disposal site. That report was not in the Mass DEP files.

Site Stratigraphy

Estimated locations of the wells with boring data logs in Appendix D of the 1996 CSA report are shown in Figure 1. Boring log data indicate sand and sand/clay layers at 30 to 50 feet below ground surface beneath the uplands site and the current DPW compost and storage area as shown in Figure 2 (West-East Cross-section A-A'). Clay and silt occur at similar elevations in many of the boring logs from the site wells. Layers of clay were recorded in borings south of the site beneath the excavation of the former gravel pit as shown in Figure 3 (North-South Cross-section B-B'). Interval data taken from the boring logs is attached in Table 1.

The existing Monomoy MODFLOW Model does not include these local clay lenses. Modeled horizontal hydraulic conductivities are around 120 feet per day at the depth of the clay encountered beneath MW-27. The model hydraulic conductivity beneath the site is representative of expected values for fine to medium sand. Values for clay would be less than 1 foot per day.

Very little information is available on stream flows. It is unclear if the stream is fed primarily by groundwater or through releases from upstream cranberry bog operations. Figures from the CSA report suggest wells may exist near the stream to the east of the site (PW-A, PW-B, PW-C). Surveyed data of water levels, stream bed elevations and observed water levels in wells or vernal pools near the stream would be needed to assess the interaction of the stream and groundwater.

Recommendations

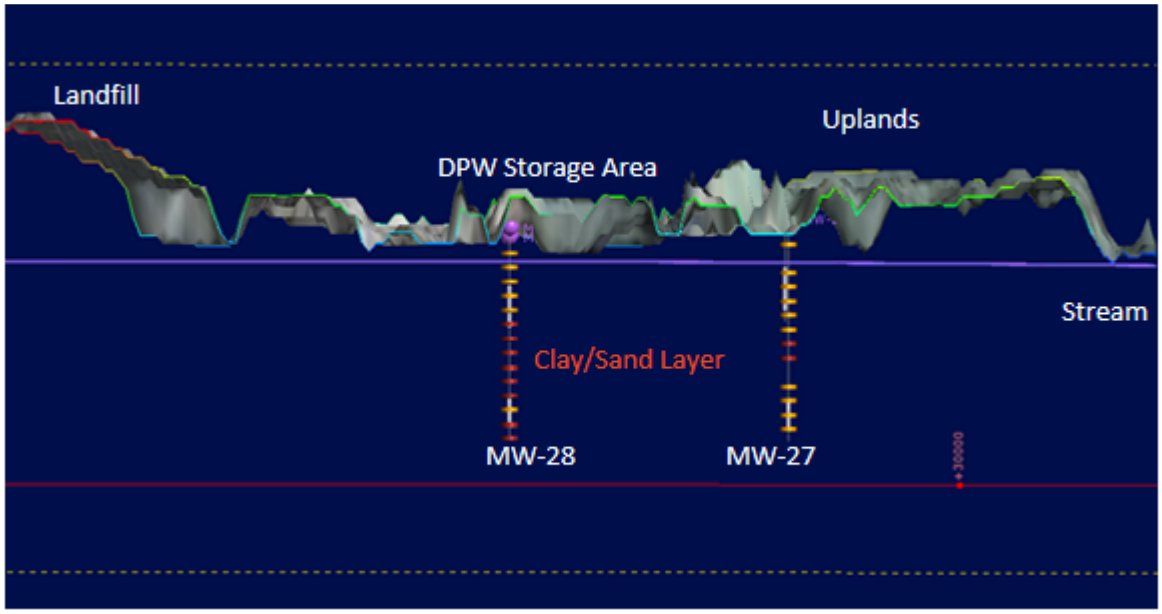
The boring information obtained provided a better understanding of subsurface conditions. Based on the logs, several of these locations are screened at levels that will be useful for future permitting and design. The information obtained does not significantly alter the previous assessment of the site. The impacts to the vernal pools and the former gravel pit south of the site could limit the recharge capacity of the site.

Based on the site visit in November 2015, the file review and review of boring logs, the following steps are recommended:

- Conduct detailed survey of wells, vernal pool elevations, excavation elevations, stream elevations and stream water levels. This is needed to better understand the interaction between surface and groundwater and to document the seasonal water table in order to understand impacts to vernal pools and whether pools are fed by groundwater or exist due to perched water on clay lenses.
- Repair and secure well casings. All three wells identified during the site walk were not properly secured.
- Conduct synoptic water level rounds, preferably during multiple seasons.
- Review depositional history and revise conceptual site model
- Update and calibrate model to include local clay lenses and revise stream elevations

- Install additional wells on-site. These could be placed on or near the existing road which runs parallel to stream to provide better information on subsurface conditions beneath the proposed recharge area and interactions with the stream.

M-10
M-9
MW-12
MW-10B
MW-10
MW-7
MW-6
MW-9
MW-27D
MW-27S
A
A'
B
MW-28S
MW-28D
MW-8
MW-3
MW-1
MW-11
MW-4
MW-5
M-1
M-3
MW-11A
MW-102
MW-13
MW-14
MW-2
MW-14A
PW-A
MW-25
PW-C
PW-B
MW-20D
MW-20S
M-4
M-5
MW-16
MW-16A
MW-17
MW-101S
MW-101D
MW-29
MW-15
M-6
MW-24S
MW-24D
MW-26
MW-21D
MW-21S
M-7
OBS-10
52D
MW-19
MW-22D
MW-22S
MW-23
B'


Landfill
DPW Storage Area
Uplands
Stream
Clay/Sand Layer
MW-28
MW-27

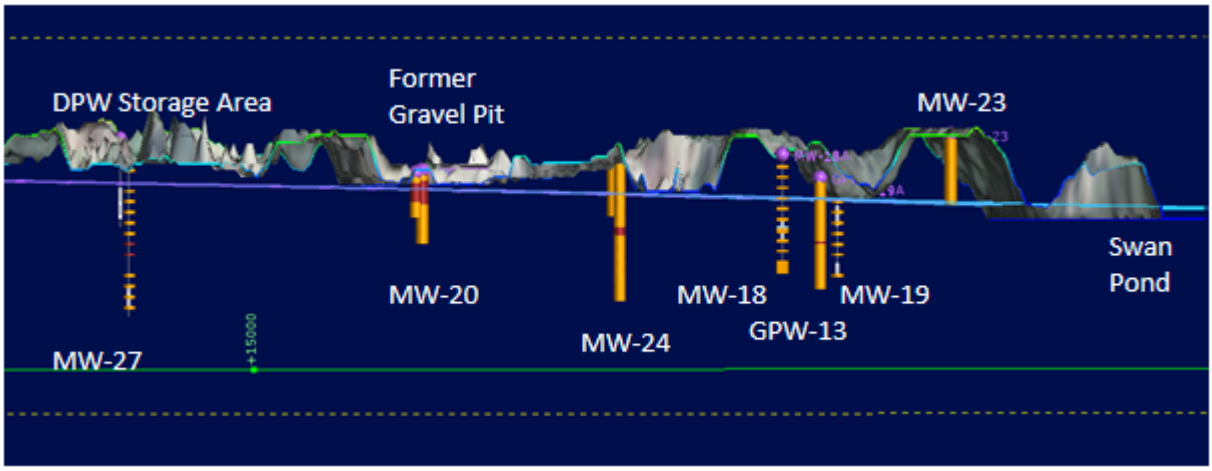

DPW Storage Area
Former
Gravel Pit
MW-23
Swan
Pond
MW-20
MW-18
MW-19
MW-24
GPW-13
MW-27

Table 1 – Boring/Interval Data

Hole ID	Start Depth (ft)	End Depth (ft)	Category 1	Category 2	Lithology
GPW-13	0	2	TOP SOIL	TOP SOIL	Top Soil
GPW-13	2	8	SAND	SAND	Fine medium brown sand
GPW-13	8	16	SAND	SAND	Fine medium brown sand
GPW-13	16	25	SAND	SAND	Fine medium brown sand
GPW-13	25	30	SAND	SAND	Fine medium brown sand
GPW-13	30	31.5	SAND/CLAY	SAND/CLAY	Brown sand with streak gray clay
GPW-13	31.5	40	SAND	SAND	Fine medium brown sand
GPW-13	40	45	SAND/GRAVEL	SAND tr. GRAVEL	Fine medium brown sand, trace of gravel
GPW-13	45	50	SAND	SAND	Fine medium brown sand
GPW-13	50	53	SAND	SAND	Fine medium brown sand
MW-102	2	4	SAND	SAND	Yellow/brown fine to medium SAND, light brown very fine SAND
MW-102	7	9	SAND	SAND	light brown fine to medium SAND
MW-102	12	14	SAND	SAND	fine to medium light brown SAND, medium to coarse orange SAND, light tan medium SAND
MW-102	17	19	SAND	SAND	light tan fine to medium SAND
MW-102	22	24	SAND	SAND	coarse to fine SAND, light tan with orange tinge, light tan, fine SAND
MW-102	27	29	SAND/GRAVEL	SAND/GRAVEL	light tan fine to medium SAND, light tan fine to medium SAND with some fine GRAVEL
MW-102	32	34	SAND/GRAVEL	SAND tr. GRAVEL	orange brown coarse to medium SAND, trace fine GRAVEL
MW-102	37	39	SAND	SAND	wet, light brown, coarse to medium SAND
MW-102	42	44	SAND	SAND	wet, light tan, medium to coarse Sand, trace fine sand
MW-102	47	49	SAND	SAND	gray coarse to medium quartzite SAND
MW-101D	2	4	SAND/GRAVEL	SAND tr. GRAVEL	light brown medium SAND, trace fine sand, trace fine GRAVEL
MW-101D	7	9	SAND/GRAVEL	SAND tr. GRAVEL	light brown medium SAND, trace fine sand, trace fine GRAVEL, light tan fine SAND
MW-101D	12	14	SAND	SAND	light brown coarse to medium SAND, light tan, fine to medium SAND
MW-101D	17	19	SAND/GRAVEL	SAND tr. GRAVEL	light brown, fine SAND, trace pea GRAVEL
MW-101D	22	24	SAND/GRAVEL	SAND tr. GRAVEL	light orange-brown, fine to medium SAND, trace GRAVEL
MW-101D	27	29	SAND	SAND	gray-brown fine to medium SAND
MW-101D	32	34	SAND	SAND	gray-brown fine to medium SAND
MW-101D	37	39	SAND	SAND	gray-brown fine to medium SAND
MW-101D	42	44	SAND/SILT	SAND/SILT	brown-gray coarse to fine SAND, gray fine SAND and SILT
MW-101D	45	47	SAND	SAND	gray-brown to medium SAND, trace coarse sand
MW-101D	47	49	SAND	SAND	gray-brown to medium SAND, trace coarse sand

Hole ID	Start Depth (ft)	End Depth (ft)	Category 1	Category 2	Lithology
MW-101D	49	51	SAND	SAND	gray-brown to medium SAND, trace coarse sand
MW-101D	51	53	SAND	SAND	brown (slight orange tint) coarse to medium SAND, trace fine sand
MW-101D	53	55	SAND	SAND	light brown fine to medium SAND
MW-101D	55	57	SAND	SAND	light grayish brown fine to coarse SAND
MW-101D	57	59	SAND	SAND	light grayish brown fine to coarse SAND
MW-101D	59	61	SAND	SAND	light brown coarse to fine SAND
MW-101D	65	66	SAND	SAND	light brown medium to fine SAND
MW-101D	69	71	SAND	SAND	light brown medium to fine SAND
MW-101D	79	81	SAND/SILT	SAND tr. SILT	gray, medium to fine SAND, gray very fine sand, trace SILT
MW-29	30	31.5	SAND	SAND	clean medium/coarse sand
MW-29	35	36.5	SAND	SAND	clean medium/coarse tan sand
MW-29	40	41.5	SAND	SAND	clean medium/coarse tan sand
MW-29	50	51.5	SAND	SAND	clean medium sand
MW-29	55	56.5	SAND	SAND	clean medium sand
MW-29	60	61.5	SAND	SAND	clean medium sand
MW-29	65	66.5	SAND	SAND	medium tan sand, some fines
MW-29	70	71.5	SAND	SAND	fine/medium tan sand
MW-29	75	76.5	SAND	SAND	fine/medium tan sand
MW-29	80	81.5	SAND	SAND	fine/medium tan sand
MW-29	85	86.5	SAND	SAND	fine/medium tan sand
MW-29	90	91.5	SAND/SILT	SAND/SILT	fine/medium sand with SILT
MW-29	95	96.5	SAND/SILT	SAND/SILT	fine/medium sand with SILT
MW-29	100	101.5	SAND/SILT	SAND/SILT	fine gray sand and SILT
MW-28D	0	1.5	SAND/SILT	SAND tr. SILT	light yellow-brown fine sand, trace SILT, fill and topsoil, dry
MW-28D	9	10.5	SAND	SAND	rust-yellow-brown fine/coarse sand, some very rusty lenses, last 2" grey fine/medium sand. Wet
MW-28D	14	15.5	SAND/GRAVEL	SAND tr. GRAVEL	yellow-grey fine/medium sand, trace coarse sand and fine gravel. Wet
MW-28D	19	20.5	SAND/GRAVEL	SAND tr. GRAVEL	grey fine/coarse sand, trace fine gravel, one 1" rusty coarse sand lense
MW-28D	24	25.5	SAND/GRAVEL	SAND tr. GRAVEL	grey-rust fine/coarse sand, trace fine gravel, some rusty lenses
MW-28D	29	30.5	SAND/GRAVEL	SAND tr. GRAVEL	grey-rust fine coarse sand, trace fine/medium gravel. Alternating lenses of fine to coarse sand
MW-28D	34	35.5	GRAVEL/SAND/CLAY	SAND/CLAY tr. GRAVEL	grey fine/coarse sand, trace gravel, grey-green-brown CLAY
MW-28D	39	40.5	CLAY	CLAY	brown clay, some gravel, blue-grey clay

Hole ID	Start Depth (ft)	End Depth (ft)	Category 1	Category 2	Lithology
MW-28D	44	45.5	GRAVEL/SAND/CLAY	SAND/CLAY tr. GRAVEL	brown clay, some coarse sand, blue-grey clay, some coarse sand lenses, rust brown coarse sand, trace gravel
MW-28D	59	51	SAND/CLAY	SAND/CLAY	medium coarse grey sand, grey-blue clay, some sand lenses, trace brown clay, yellow-brown fine/medium sand
MW-28D	54	55.5	GRAVEL/SAND/CLAY	SAND/CLAY tr. GRAVEL	grey clay, some fine/coarse sand, grey-yellow-rust fine/coarse sand, trace gravel
MW-28D	59	60.5	GRAVEL/SAND/CLAY	SAND/CLAY tr. GRAVEL	blue-grey clay, some sand, grey-white brown medium to very coarse sand, little fine sand, trace gravel
MW-28D	64	65.5	SAND/GRAVEL	SAND tr. GRAVEL	light yellow-brown fine to coarse sand, trace gravel
MW-28D	69	71	SAND/CLAY	SAND/CLAY	blue-grey clay yellow-white fine to coarse sand, some clay lenses
MW-28D	74	75.5	SAND/CLAY	SAND/CLAY	light yellow-brown fine to coarse sand, some 1" clay lenses
MW-27D	0	1.5	SAND/GRAVEL	SAND tr. GRAVEL	dark-light red-brown fine to coarse sand, trace gravel topsoil
MW-27D	9	10.5	SAND/SILT	SAND tr. SILT	light yellow-rusty-brown medium to coarse sand, little fine sand, trace silt
MW-27D	19	20.5	SAND/GRAVEL	SAND/GRAVEL	light brown-yellow fine to coarse sand, little fine gravel
MW-27D	24	25.5	SAND/GRAVEL	SAND tr. GRAVEL	light rusty-brown fine to medium sand, little coarse sand, trace gravel
MW-27D	29	30.5	SAND	SAND	light brown fine to medium sand, some coarse sand
MW-27D	34	35.5	SAND	SAND	light brown fine to medium sand, light coarse sand, grey-white medium coarse sand, little fine sand
MW-27D	39	40.5	GRAVEL/SAND/SILT/CLAY	SAND tr. GRAVEL/SILT/CLAY	light brown fine sand, little medium to coarse sand, trace gravel, very fine sand and silt, trace clay
MW-27D	44	45.5	GRAVEL/SAND/CLAY	SAND/CLAY tr. GRAVEL	grey clay, trace gravel and sand, grey fine to coarse sand
MW-27D	49	50.5	GRAVEL/SAND/CLAY	SAND/CLAY tr. GRAVEL	grey clay, trace sand and gravel, grey fine to coarse sand
MW-27D	59	60.5	GRAVEL/SAND/SILT/CLAY	SAND/GRAVEL tr. SILT/CLAY	grey fine to medium sand, little silt, trace clay (1" clay lense with gravel)
MW-27D	64	65.5	SAND/SILT	SAND tr. SILT	grey fine sand, trace silt and medium to coarse sand
MW-27D	69	70.5	SAND/GRAVEL	SAND tr. GRAVEL	grey fine sand, little medium to coarse sand, trace gravel
MW-27D	74	75.5	SAND/GRAVEL	SAND tr. GRAVEL	grey fine to coarse sand, trace gravel
MW-26	0	1.5	SAND/SILT	SAND/SILT	fill, grey-brown fine to medium sand and silt with grass, yellow-brown-rust medium to coarse sand, trace silt
MW-26	4	5.5	CLAY	CLAY	brown clay, blue-grey clay
MW-26	9	10.5	CLAY	CLAY	blue-grey clay
MW-26	14	15.5	GRAVEL/SAND/CLAY	SAND/CLAY tr. GRAVEL	brown fine to medium sand, little coarse sand, grey clay, white fine to coarse sand, some rusty-yellow-brown lenses, trace gravel

Hole ID	Start Depth (ft)	End Depth (ft)	Category 1	Category 2	Lithology
MW-26	19	20.5	SAND/GRAVEL	SAND tr. GRAVEL	grey-white fine to very coarse sand, trace gravel
MW-26	24	25.5	SAND/GRAVEL	SAND tr. GRAVEL	grey-white fine to medium sand, little coarse sand, trace gravel
MW-26	29	30.5	SAND/GRAVEL	SAND tr. GRAVEL	light yellow-white fine to coarse sand, trace gravel
MW-26	34	35.5	SAND/GRAVEL	SAND tr. GRAVEL	grey-white fine to medium sand, little coarse sand, trace gravel
MW-26	39	40.5	SAND	SAND	yellow-grey-white medium to coarse sand, little fine sand, grey fine sand
MW-26	44	45.5	SAND	SAND	grey-white fine to medium sand, some coarse sand
MW-26	49	50.5	SAND	SAND	grey-white fine to medium sand, little coarse sand
MW-26	54	55.5	SAND	SAND	grey-white fine to medium sand, some coarse sand
MW-26	60	61.5	SAND	SAND	grey-white fine to medium sand, little coarse sand
MW-26	64	65.5	SAND	SAND	grey-white fine to coarse sand, one 2" very coarse sand lense
MW-26	69.5	71	SAND	SAND	grey-white fine to coarse sand
MW-26	73.5	75	SAND	SAND	grey-white fine to medium sand, some coarse sand
MW-25	0	1.5	SAND	SAND	black, yellow-brown fine to coarse sand
MW-25	10	11.5	SAND/GRAVEL	SAND tr. GRAVEL	yellow-brown fine to coarse sand, trace gravel
MW-25	18.5	20	SAND	SAND	dark brown fine to coarse sand
MW-25	24	25.5	GRAVEL/SAND/SILT	SAND tr. SILT and GRAVEL	dark to light brown fine to medium sand, little coarse sand, trace silt and gravel
MW-25	28.5	30	SAND/CLAY	SAND/CLAY	fine to medium brown sand, medium to coarse brown sand, grey clay
MW-25	34	35.5	SAND/SILT	SAND/SILT	light gray-white fine sand, little medium to coarse sand, yellow fine sand and silt (silt lenses)
MW-25	39	40	SAND/SILT	SAND tr. SILT	light grey-white fine sand, little medium coarse sand, trace silt
MW-25	43.5	45	SAND	SAND	light grey-white fine sand, little medium to coarse sand
MW-25	48.5	50	SAND	SAND	light grey-white fine sand, little medium to coarse sand
MW-25	53.5	55	SAND	SAND	light grey-white fine to medium sand, little coarse sand
MW-25	58.5	60	SAND	SAND	light grey-white medium to coarse sand little fine sand, few rusty lenses about 1/8" thick
MW-25	63.5	65	SAND	SAND	light grey-white fine to coarse sand
MW-25	68.5	70	SAND	SAND	light grey-white fine to coarse sand, some iron staining
MW-25	73.5	75	SAND	SAND	light grey-white fine to medium sand, little coarse sand
MW-24D	0	9	SAND	SAND	dark brown fine and medium sand
MW-24D	9	18	SAND	SAND	light brown medium and coarse sand

Hole ID	Start Depth (ft)	End Depth (ft)	Category 1	Category 2	Lithology
MW-24D	18	25	SAND	SAND	light brown medium sand
MW-24D	25	33	SAND/GRAVEL	SAND/GRAVEL	light brown medium sand and fine gravel
MW-24D	33	36	CLAY	CLAY	brown clay
MW-24D	36	41	SAND	SAND	brown medium and coarse sand
MW-24D	41	47	SAND	SAND	light brown fine sand
MW-24D	47	60	SAND	SAND	light brown medium and fine sand
MW-24	7	9	SAND	SAND	dark brown fine and medium sand
MW-24	14	16	SAND	SAND	light brown medium and coarse sand
MW-24	21	23	SAND	SAND	light brown medium sand
MW-24	28	30	SAND/GRAVEL	SAND/GRAVEL	light brown medium sand and fine gravel
MW-24	35	37	SAND/CLAY	SAND/CLAY	brown clay and medium and coarse sand
MW-24	42	44	SAND	SAND	light brown fine sand
MW-24	49	51	SAND	SAND	brown medium and fine sand
MW-24	56	68	SAND	SAND	light brown fine sand
MW-24S	0	9	SAND	SAND	dark brown fine and medium sand
MW-24S	9	18	SAND	SAND	light brown medium and coarse sand
MW-24S	18	28	SAND	SAND	light brown medium sand
MW-23	0	12	SAND	SAND	dark brown medium sand
MW-23	12	20	SAND	SAND	brown medium and fine sand
MW-23	20	29	SAND	SAND	brown medium and fine sand
MW-23	29	33	SAND	SAND	brown medium and fine sand
MW-22D	0	15	SAND	SAND	brown fine sand
MW-22D	15	21	SAND	SAND	brown fine and medium sand
MW-22D	21	27	SAND	SAND	light brown medium and coarse sand
MW-22D	27	31	CLAY	CLAY	brown clay and silt
MW-22D	31	40	CLAY	CLAY	gray clay
MW-22D	40	55	SAND	SAND	light brown medium sand
MW-22D	55	60	SAND/SILT/CLAY	SAND/SILT/CLAY	gray silty fine sand and clay
MW-22	7	9	SAND	SAND	brown fine sand
MW-22	14	16	SAND	SAND	light brown fine and medium sand
MW-22	21	23	SAND	SAND	light brown medium and coarse sand
MW-22	28	30	CLAY	CLAY	brown silt and clay
MW-22	35	37	CLAY	CLAY	gray clay
MW-22	42	44	SAND	SAND	light brown medium sand
MW-22	49	51	SAND	SAND	light brown medium and coarse sand
MW-22	56	58	CLAY	CLAY	gray silt and clay
MW-22	60	62	CLAY	CLAY	gray silt and clay
MW-22S	0	15	SAND	SAND	brown fine sand
MW-22S	15	21	SAND	SAND	brown fine and medium sand

Hole ID	Start Depth (ft)	End Depth (ft)	Category 1	Category 2	Lithology
MW-22S	21	27	SAND	SAND	light brown medium and coarse sand
MW-21D	0	19	SAND	SAND	brown medium and coarse sand
MW-21D	19	24	SAND	SAND	brown medium and some fine sand
MW-21D	24	26	SAND/GRAVEL	SAND/GRAVEL	brown coarse sand and gravel
MW-21D	26	28	CLAY	CLAY	brown clay
MW-21D	29	36	CLAY	CLAY	gray clay
MW-21D	36	42	SAND/CLAY	SAND/CLAY	brown coarse sand and some clay
MW-21D	42	57	SAND	SAND	brown medium sand
MW-21D	57	60	SAND	SAND	brown fine sand
MW-21	7	9	SAND	SAND	brown coarse sand
MW-21	14	16	SAND	SAND	brown medium and coarse sand
MW-21	21	23	SAND	SAND	brown medium sand and some stones
MW-21	28	30	CLAY	CLAY	gray and brown clay
MW-21	35	37	SAND/CLAY	SAND/CLAY	gray clay and brown medium sand
MW-21	42	44	CLAY	CLAY	brown silt and clay
MW-21	49	51	SAND	SAND	light brown medium and fine sand
MW-21	56	68	SAND	SAND	light brown medium and fine sand
MW-21S	0	19	SAND	SAND	brown medium and coarse sand
MW-21S	19	22	SAND	SAND	brown medium and some fine sand
MW-20D	0	5	SAND	SAND	brown medium and fine sand
MW-20D	5	8	CLAY	CLAY	brown silty clay and broken gravel
MW-20D	8	14	CLAY	CLAY	gray clay
MW-20D	14	20	SAND	SAND	dark brown medium sand
MW-20D	20	35	SAND	SAND	light brown medium and coarse sand
MW-20	7	9	SAND/CLAY	SAND/CLAY	brown fine sand and clay, gray clay
MW-20	14	16	SAND/CLAY	SAND/CLAY	gray clay and brown fine sand
MW-20	21	23	SAND	SAND	light brown medium and coarse sand
MW-20	28	30	SAND	SAND	light brown medium and coarse sand
MW-20S	0	5	SAND	SAND	brown medium and fine sand
MW-20S	5	8	CLAY	CLAY	brown silty clay and broken gravel
MW-20S	8	14	CLAY	CLAY	gray clay
MW-20S	14	21	SAND	SAND	dark brown medium sand
MW-19	0	1.5	SAND/SILT	SAND/SILT	forest duff grading to light brown medium fine sand, little silt, trace coarse sand
MW-19	5	6.5	GRAVEL/SAND/SILT	SAND/GRAVEL tr. SILT	light brown fine to medium sand trace silt, trace medium gravel, trace coarse sand
MW-19	10	11.5	GRAVEL/SAND/SILT	SAND tr. SILT and GRAVEL	rust brown fine medium sand, trace silt, trace medium gravel, trace coarse sand
MW-19	15	16.5	GRAVEL/SAND/SILT	SAND tr. SILT and GRAVEL	light brown fine to medium sand, trace coarse sand, trace silt, trace fine to medium gravel
MW-19	20	21.5	GRAVEL/SAND/SILT	SAND tr. SILT and GRAVEL	light tan fine to medium sand, trace coarse sand, trace fine gravel, trace silt

Hole ID	Start Depth (ft)	End Depth (ft)	Category 1	Category 2	Lithology
MW-19	25	26.5	GRAVEL/SAND/SILT	SAND tr. SILT and GRAVEL	tan fine to medium sand, little coarse sand, trace fine gravel, trace silt
MW-19	30	31.5	GRAVEL/SAND/SILT	SAND tr. SILT and GRAVEL	yellow brown fine to coarse sand, trace fine gravel, trace silt
MW-19	35	35.3	SAND/GRAVEL	SAND tr. GRAVEL	yellow brown medium coarse sand, some fine sand, trace fine gravel
MW-19	40	41.5	SAND/SILT	SAND tr. SILT	light brown fine to medium sand, little coarse sand, trace silt
MW-18	0	1.5	SAND/SILT	SAND/SILT	forest duff, grading to rust brown medium fine sand, little silt, trace coarse sand
MW-18	5	6.5	SAND/GRAVEL	SAND tr. GRAVEL	tan coarse to medium sand, trace fine gravel
MW-18	10	11.5	GRAVEL/SAND/SILT	SAND tr. SILT and GRAVEL	tan coarse to medium sand, trace fine gravel, grading abruptly to tan fine to medium sand, trace silt
MW-18	15	16.5	GRAVEL/SAND/SILT	SAND tr. SILT and GRAVEL	tan medium to fine sand, little fine gravel, trace silt
MW-18	20	21.5	SAND/SILT	SAND tr. SILT	rust-brown fine to very fine sand, trace silt
MW-18	25	26.5	SAND/SILT	SAND tr. SILT	grey fine to very fine sand, trace coarse sand, trace silt
MW-18	30	31.5	SAND/SILT	SAND tr. SILT	grey to rust-brown fine to very fine sand, trace coarse sand, trace silt
MW-18	34	35	GRAVEL	GRAVEL	gravel
MW-18	35	37.5	SAND/GRAVEL	SAND/GRAVEL	grey coarse sand and fine to medium gravel
MW-18	40	41.5	SAND/SILT	SAND tr. SILT	tan fine to very fine sand, trace silt
MW-18	45	46.5	SAND/SILT	SAND tr. SILT	tan fine to very fine sand, trace silt
MW-18	50	55.5	SAND/SILT	SAND tr. SILT	tan fine to very fine sand, trace silt
MW-18	55	56.5	SAND	SAND	light tan medium to fine sand
MW-17	0	1.5	SAND/SILT	SAND tr. SILT	forest duff, grading to rust brown fine to very fine sand, little silt, trace coarse sand
MW-17	5	6.5	SAND/SILT	SAND tr. SILT	light brown fine to very fine sand, trace medium to coarse sand, trace silt
MW-17	10	11.5	GRAVEL/SAND/SILT	SAND/SILT tr. GRAVEL	tan very fine sand, little silt, trace medium gravel, many iron stains
MW-17	15	16.5	SAND/SILT	SAND tr. SILT	light brown fine to very fine sand, trace medium sand, trace silt
MW-17	20	21.5	SAND/SILT	SAND tr. SILT	tan very fine sand, little silt, trace fine to medium sand
MW-17	25	26.5	SAND/GRAVEL	SAND tr. GRAVEL	tan fine to medium sand, trace coarse sand, trace fine gravel
MW-17	29	30	CLAY	CLAY	clay and silt lenses
MW-17	30	31.5	SAND/SILT/CLAY	SAND/SILT/CLAY	light brown silt and clay grading abruptly to light brown fine to medium sand, trace clay, trace silt, little very fine sand
MW-17	31.5	35	CLAY	CLAY	clay and silt lenses
MW-17	35	36.5	SAND/GRAVEL	SAND tr. GRAVEL	tan fine to medium sand, little very fine sand trace coarse sand, trace fine gravel
MW-17	39	40	SAND/GRAVEL	SAND tr. GRAVEL	tan medium to coarse sand, little fine to very fine sand, trace fine gravel
MW-17	45	46.5	SAND	SAND	tan fine to medium sand, trace coarse sand

Hole ID	Start Depth (ft)	End Depth (ft)	Category 1	Category 2	Lithology
MW-16A	35	36.5	SAND/SILT/CLAY	SAND/SILT/CLAY	tight silty and some clay, clean tan medium to coarse sand
MW-16A	40	41.5	SAND	SAND	medium to coarse brown sand
MW-16A	45	46.5	SAND	SAND	medium to coarse brown sand
MW-16A	50	51.5	SAND	SAND	medium to coarse tan sand
MW-16A	55	56.5	SAND	SAND	medium to coarse tan sand
MW-16A	60	61.5	SAND	SAND	medium to coarse tan sand
MW-16A	65	66.5	SAND	SAND	medium to coarse tan sand
MW-16A	70	71.5	SAND	SAND	medium to coarse tan sand
MW-16A	75	76.5	SAND	SAND	medium to coarse tan sand
MW-16A	81	81.5	SAND/SILT	SAND/SILT	fine to medium tan sand, some silt
MW-16A	85	86.5	SAND/SILT	SAND/SILT	fine to medium tan sand, slightly silt
MW-16	0	5	SAND/SILT	SAND tr. SILT	light brown fine to very fine sand, trace silt
MW-16	5	10	SAND	SAND	tan fine to medium sand, little coarse sand
MW-16	10	11.5	SAND	SAND	buff medium to coarse sand, trace iron staining
MW-16	11.5	20	SAND	SAND	tan fine to coarse sand
MW-16	20	21.5	SAND/SILT	SAND tr. SILT	ten fine to medium sand, trace silt, trace iron staining, trace coarse sand
MW-16	21.5	30	CLAY	CLAY	light brown clay grading to bluish gray clay
MW-16	30	31.5	SAND	SAND	tan fine to medium sand, trace coarse sand
MW-16	35	36.5	SAND	SAND	tan fine to medium sand
MW-15	5	6.5	SAND	SAND	light brown fine to medium sand
MW-15	10	11.5	SAND	SAND	light brown fine to medium sand, little coarse sand
MW-15	15	16.5	GRAVEL/SAND/SILT	SAND tr. SILT and GRAVEL	light brown fine to medium sand, trace fine gravel, trace silt
MW-15	20	21.5	SAND/GRAVEL	SAND tr. GRAVEL	tan fine to medium sand, trace coarse sand, trace fine gravel
MW-15	25	26.5	SAND	SAND	tan fine to very fine sand
MW-15	30	31.5	SAND	SAND	tan very fine sand
MW-15	35	36.5	GRAVEL/SAND/SILT/CLAY	GRAVEL/SAND/SILT/CLAY	light brown very fine to coarse sand, little fine gravel, grading to brown silt and clay grading to bluish clay
MW-14C	30	31.5	SAND/SILT	SAND/SILT	medium to coarse tan sand, fine to medium brown sand, some silt
MW-14C	35	36.5	SAND/CLAY	SAND/CLAY	medium to coarse tan sand, gray clay, gray sand
MW-14C	40	41.5	SAND/CLAY	SAND/CLAY	medium to coarse gray sand with some clay
MW-14C	45	46.5	SAND/CLAY	SAND/CLAY	medium to coarse gray sand with some clay
MW-14C	50	51.5	SAND	SAND	fine gray sand, fine to medium gray sand
MW-14C	55	56.5	SAND	SAND	medium to coarse gray sand
MW-14C	60	60.5	SAND	SAND	medium to coarse gray sand
MW-14C	65	66.5	SAND	SAND	medium to coarse sand, some fines, medium to coarse light gray sand

Hole ID	Start Depth (ft)	End Depth (ft)	Category 1	Category 2	Lithology
MW-14C	70	71.5	SAND	SAND	fine to medium gray sand, medium to coarse brown sand
MW-14C	75	76.5	SAND	SAND	fine to medium brown sand
MW-14C	80	80.5	SAND	SAND	fine to medium brown sand
MW-14	40	45	SAND	SAND	light gray very fine sand
MW-14	45	50	SAND	SAND	light gray very fine sand
MW-14	50	55	SAND	SAND	light gray very fine sand
MW-14	55	60	SAND	SAND	light gray very fine sand
MW-14	5	6.5	SAND/GRAVEL	SAND tr. GRAVEL	tan fine to coarse sand, trace fine gravel, cobbles
MW-14	10	11.5	GRAVEL/SAND/SILT	GRAVEL/SAND/SILT	fan fine to coarse sand, little fine gravel, little silt
MW-14	15	16.5	SAND	SAND	tan fine to coarse sand, cobbles
MW-14	20	21.5	SAND	SAND	tan fine to medium sand
MW-14	25	26.5	SAND	SAND	tan coarse sand, trace medium sand
MW-14	30	31.5	SAND	SAND	tan medium to coarse sand
MW-14	35	36.5	SAND/SILT/CLAY	SAND/SILT/CLAY	tan medium to coarse sand, grading to light brown clay, grading to light brown fine to medium sand, some silt
MW-13	5	6.5	SAND	SAND	light brown fine to medium sand
MW-13	10	15	SAND	SAND	tan fine sand
MW-13	15	16.5	SAND/GRAVEL	SAND tr. GRAVEL	tan fine sand, trace fine gravel
MW-13	20	25	SAND	SAND	tan fine sand
MW-13	25	26.5	SAND	SAND	light brown fine to coarse sand
MW-13	30	35	SAND	SAND	tan fine to coarse sand
MW-13	35	36.5	SAND	SAND	tan fine to coarse sand
MW-11A	10	11.5	SAND	SAND	coarse sand with iron stains
MW-11A	20	21.5	SAND	SAND	medium rust colored sand
MW-11A	30	31.5	SAND/CLAY	SAND/CLAY	coarse rust colored sand, brown clay, gray clay, brown clay
MW-11A	40	41.5	SAND	SAND	clean fine light brown sand
MW-11A	50	51.5	SAND	SAND	clean fine tan sand
MW-11A	55	56.5	SAND	SAND	clean fine tan sand
MW-11A	60	61.5	SAND	SAND	clean fine tan sand
MW-11A	65	66.5	SAND	SAND	clean fine tan sand
MW-11A	70	71.5	SAND	SAND	clean fine tan sand
MW-11A	75	76.5	SAND	SAND	clean fine tan sand with tight plug
MW-11A	80	81.5	SAND	SAND	clean fine tan sand
MW-100	2	4	SAND	SAND	light brown medium sand, little fine sand, some iron staining
MW-100	7	9	SAND	SAND	light brown medium to fine sand, some iron staining
MW-100	12	14	SAND	SAND	light brown fine sand, tannish gray fine sand

Hole ID	Start Depth (ft)	End Depth (ft)	Category 1	Category 2	Lithology
MW-100	17	19	SAND	SAND	light grayish brown, fine sand, some iron staining, light brown, coarse to fine sand, some iron staining
MW-100	22	24	SAND	SAND	orangish brown coarse to medium sand, light brown medium to fine sand
MW-100	27	29	SAND/SILT	SAND/SILT	orange/brown coarse to medium sand, gray medium to fine sand, stiff, olive silt
MW-100	32	34	SAND/SILT/CLAY	SAND/SILT tr. CLAY	light brown coarse to medium sand, stiff, gray silt with trace to little clay
MW-100	37	39	SAND/SILT/CLAY	SAND/SILT/CLAY	light brown fine to medium sand, stiff, gray silt with some clay
MW-100	42	44	SAND/SILT/CLAY	SAND/SILT/CLAY	brown medium sand, gray silt and clay, grayish tan, fine sand
MW-100	47	49	SAND/SILT/CLAY	SAND/SILT/CLAY	interbedded layers of medium sand and clayey silt, light grayish brown, fine to medium sand
MW-100	52	54	SAND	SAND	brown, medium to fine sand
MW-100	57	59	SAND/SILT/CLAY	SAND/SILT/CLAY	orangey brown medium to fine sand, light brown, medium to fine sand with lenses of clayey silt, reddish-brown coarse to medium sand
MW-100	62	64	SAND	SAND	light brown fine to medium sand
MW-100	67	69	SAND/SILT/CLAY	SAND/SILT/CLAY	brown fine to medium sand, lenses of gray clayey silt, brown clayey silt, brown fine to medium sand
M-7	0	26	SAND/GRAVEL	SAND/GRAVEL	fine to medium brown sand and gravel
M-7	26	63	SAND/SILT	SAND/SILT	fine silty sand
M-7	63	74	CLAY	CLAY tr. SILT	clay with trace of silt
M-6	0	21	SAND/GRAVEL	SAND/GRAVEL	fine to medium sand and gravel
M-6	21	58	SAND/GRAVEL	SAND/GRAVEL	fine to medium sand, fine gravel
M-6	58	73	SAND/SILT	SAND/SILT	very fine silty sand
M-5	0	21	SAND/GRAVEL	SAND/GRAVEL	fine to medium brown sand and gravel
M-5	21	37	SAND	SAND	fine to medium brown sand
M-5	37	49	CLAY	SAND tr. CLAY	silty brown sand with traces of blue clay
M-5	49	63	SAND/SILT	SAND/SILT	fine to medium sand with silt
M-5	63	68	SILT	SILT	silt
M-4	0	21	SAND/GRAVEL	SAND/GRAVEL	fine to medium brown sand and gravel
M-4	21	36.1	SAND	SAND	fine to medium brown sand
M-3	0	20	SAND/GRAVEL	SAND/GRAVEL	fine to medium brown sand and gravel
M-3	20	34	SAND/GRAVEL	SAND/GRAVEL	fine to medium brown sand, fine gravel
M-3	34	39	SAND/CLAY	SAND tr. CLAY	fine to medium sand, trace of clay
M-3	39	67	GRAVEL/SAND/SILT	GRAVEL/SAND/SILT	fine to medium sand, fine gravel, silty
M-3	67	75	GRAVEL/SAND/SILT	GRAVEL/SAND/SILT	silty sand, broken and some gravel, tight
M-2	0	20	SAND/GRAVEL	SAND/GRAVEL	fine to medium brown sand and gravel
M-2	20	34	SAND/GRAVEL	SAND/GRAVEL	fine to medium sand, fine gravel
M-2	34	39	SAND/CLAY	SAND tr. CLAY	fine to medium sand, trace blue clay

Hole ID	Start Depth (ft)	End Depth (ft)	Category 1	Category 2	Lithology
M-2	39	53.05	GRAVEL/SAND/SILT	GRAVEL/SAND/SILT	fine to medium sand, fine gravel, silt
M-1	0	20	SAND/GRAVEL	SAND/GRAVEL	fine to medium brown sand and gravel
M-1	20	37.335	SAND/GRAVEL	SAND/GRAVEL	fine to medium sand, fine gravel

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1 Introduction

In support of the Dennis Comprehensive Wastewater Management Plan (CWMP), effluent recharge at two potential sites was simulated using a groundwater flow model. The model was based on the United States Geological Survey (USGS) Monomoy Flow Lens groundwater model (Walter and Whealan 2005, Walter and Masterson 2011, Carlson et al 2015) and updated to include additional grid refinements, local surface features and local subsurface data. The local model was calibrated to selected regional water levels and local data collected on-site.

The Monomoy Freshwater Groundwater Flow Lens underlies the towns of Dennis, Harwich, Chatham, Brewster, and parts of Orleans. The USGS Monomoy Flow Lens groundwater flow simulation model was developed in the 1990s and early 2000s and was used to delineate groundwater contribution areas to embayments as part of the Massachusetts Estuaries Project (MEP). The model was developed using MODFLOW (Harbaugh et al 2000), a finite-difference groundwater flow simulation modeling code developed by the USGS and widely used for groundwater flow modeling applications. The simulated groundwater elevations generated by the model represent steady-state 2003 pumping and recharge conditions. In addition, a transient model representing variations during a typical year was used to assess the seasonal impacts of recharge and pumping at the proposed sites. The transient model was based on a transient model of the Monomoy Flow Lens developed by the USGS (Carlson et al 2015). The typical year represents average pumping and long-term recharge conditions and does not simulate extremely wet or dry years. Assignment of pumping at public supply wells was based on 2003 pumping rates. USGS Monomoy Flow Lens Model documentation is provided in the USGS report *Simulated Water Sources and Effects of Pumping on Surface and Ground Water, Sagamore and Monomoy Flow Lenses, Cape Cod, Massachusetts*, SIR 2004-5181, (Walter and Whealan 2005) with model updates and transient

simulations described in *Simulated Responses of Streams and Ponds to Groundwater and Wastewater Return Flows in Southeastern Massachusetts, SIR 2015-5168* (Carlson et al 2015).

This memorandum provides additional details of the groundwater flow modeling and field data collection that were conducted to support the Hydrogeologic Assessment of the Effluent Recharge Sites summarized in Section 11 of the CWMP. The two candidate effluent recharge sites, shown on **Figure 1**, are

- **Swan Pond River Site, (Site 1 or DPW site)** - south of Route 6 near the current DPW office and garage, east of the former landfill (shown on **Figure 2**) off Theophilis Smith Road in the Swan Pond River watershed

- **Bass River Site, (Site 2 or Bob Crowell Rd site)** – north of Route 6 near the former DPW site on Bob Crowell Road in the Bass River watershed

Groundwater generally flows south or southwest beneath both sites and discharges to the nearest water bodies. Water elevations are heavily influenced by groundwater withdrawals and flow in and out of ponds, streams and discharge to coastal estuaries.

This memorandum presents the findings from a boring and well installed at the Bass River Site (Bob Crowell Road, Site 2) and incorporates boring data obtained from a file review at Mass DEP on February 3, 2016 discussed in a separate memo in this Appendix and data from the United States Environmental Protection Agency (USEPA) Permeable Reactive Barrier (PRB) study conducted at Vinland Road (WaterVision 2016) and incorporates the new data into groundwater flow model.

The Hydrogeologic Assessment summarized in this section is for use in planning and selecting potential recharge sites and developing preliminary designs. It is insufficient for submission to the Massachusetts Department of Environmental Protection (MassDEP) in support of the required groundwater discharge permit application. Per MassDEP regulations and guidance, site walks will need to be conducted with MassDEP and a Scope of Work will need to be submitted to and approved by MassDEP prior to conducting field work and developing a formal Hydrogeologic Evaluation to support the discharge permit application. The Scope of Work to support the Hydrogeologic Evaluation for a discharge permit may require additional subsurface borings, well installation, multiple groundwater measurement events, infiltration testing and additional transient groundwater flow modeling.

2 Data Collection

As part of the CWMP, a program for hydrogeologic data collection and groundwater flow modeling was conducted to evaluate the potential impacts of effluent recharge to groundwater at two potential sites in Dennis. The field program included installation of a boring and monitoring well, an elevation survey of existing wells, streams and potential vernal pools, and measurement of groundwater elevations at six wells in November 2016.

2.1 Subsurface Stratigraphy and Boring Data

The subsurface in Cape Cod consists of unconsolidated sediments deposited by the retreat of glaciers. Subsurface lithology is documented in several USGS reports including Groundwater Resources of Cape Cod HA-692 (LeBlanc et al 1986) and USGS model documentation (Walter and Whealan 2005 and Carlson et al 2015). North of Route 6 near the Swan Pond River Site, higher permeability sediments

overlay till which consists of poorly sorted sand gravel, silt, clay and boulders. South of Route 6 near the Bass River Site, high permeability sediments are underlain by layers with increasing clay and silt encountered with depth. Clay and silt appear as lenses of variable thickness and extent.

The Swan Pond River Site is located to the east of the Dennis sanitary landfill (**Figure 2**). Data for borings at the landfill and the DPW site were obtained from a file review conducted at the Massachusetts Department of Environmental Protection (MassDEP) Southeast Region Office in February 2016. The boring logs indicate mixtures of sand, silt and clay layers. Beneath the proposed recharge area, silt and clay are present at approximately -10 ft.

Site 2, the Bass River Site, is located north of Route 6 near the former Department of Public Works (DPW) site on Bob Crowell Road (see **Figure 1**). Based on the site walk which identified candidate sites based on topography and absence of wetlands, Zone II mapping for nearby water supply wells, and the conservation land-use limitation on the northern portion of the property, the area west of the former DPW site was selected as a candidate site for effluent recharge. Based on LiDAR, this area has ground surface elevations of approximately 50 feet above mean sea level (MSL). The USGS groundwater model estimated a depth to groundwater of approximately 20 to 30 feet below ground surface.

A boring was advanced in October 2016 to collect subsurface data at this location. The boring log indicates fine, medium and coarse sand with traces of silt from the ground surface until a clay layer at 45 ft bgs. A monitoring well was installed from 35 ft to 45 ft bgs at this location at the water table, located above the clay layer. Water levels collected in November 2016 showed a depth to water of 29 ft bgs.

2.2 Survey Data of wells and Stream-bed

A location and elevation survey was conducted on October 19, 2016 and including the locations of existing well casings at the Swan Pond River Site (Site 1) and the new well installed at the Bass River Site (Site 2). In addition to the location of wells, the survey included the top of the inner and outer casings, the ground surface and the groundwater elevation. Locations and elevations were surveyed for the edges of on-site ponds and potential vernal pools including ground surface and water elevation if present. These locations were surveyed to support model refinement and assessment of impacts to potential vernal pools. Points along the stream to the east of the site were measured at approximately 500 ft intervals and included water elevations. Spot elevations were taken at several locations including in the area of proposed effluent recharge. Locations are shown on **Figure 2** and elevations listed in **Table 1**.

Table 1: Survey Data, October 19, 2016

Location/Description	Point	Northing (ft NAD83)	Easting (ft NAD83)	Elevation (NAVD88 ft)
Bob Crowell Rd	GRND_MW	2719430.899	1021916.352	40.133
Bob Crowell Rd	TOPMW	2719430.486	1021916.128	42.498
DPW Well	GRND_MW 28S	2716653.764	1028053.339	24.546
DPW Well	TOPMW 28S	2716653.757	1028053.574	26.467
DPW Well	TOPMW 28D	2716651.158	1028054.04	26.679
DPW Well	GRND_MW 28D	2716651.419	1028054.146	24.778

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Location/Description	Point	Northing (ft NAD83)	Easting (ft NAD83)	Elevation (NAVD88 ft)
DPW Well	GRND_MW 27S	2716934.253	1029072.43	31.737
DPW Well	TOPMW 27S	2716934.17	1029072.371	33.349
DPW Well	TOPMW 27D	2716931.4	1029074.091	33.888
DPW Well	GRND_MW 27D	2716931.613	1029074.166	31.949
DPW Well	TOPMW 25	2715910.556	1029205.718	18.221
DPW Well	PVCTOP 25	2715910.515	1029205.627	18.355
DPW Well	GRND_MW25	2715910.584	1029205.705	16.508
On-site Pond	WTRSHOT P5	2716619.638	1028221.336	17.777
On-site Pond	BRUSHLINE	2716599.356	1028220.789	18.451
On-site Pond	BRUSHLINE	2716622.383	1028179.559	18.895
On-site Pond	BRUSHLINE	2716662.509	1028210.776	17.946
On-site Pond	SPOTEL P5	2716633.242	1028239.178	17.223
On-site Pond	BRUSHLINE	2716687.211	1028285.355	17.673
On-site Pond	BRUSHLINE	2716690.826	1028377.422	18.421
On-site Pond	BRUSHLINE	2716621.555	1028321.483	17.985
On-site Pond	SPOTEL P5	2716640.089	1028304.69	17.372
Potential Recharge Area	SPOTEL R3	2716833.083	1029740.877	37.576
Potential Recharge Area	SPOTEL R4	2717133.491	1029720.692	46.395
Potential Recharge Area	SPOTEL R2	2716848.904	1029943.84	41.485
Potential Recharge Area	SPOTEL R1	2717143.066	1029961.182	46.641
Potential Vernal Pool	BRUSHLINE	2716852.557	1029313.765	19.852
Potential Vernal Pool	BRUSHLINE	2716888.373	1029277.403	19.778
Potential Vernal Pool	SPOTEL P1	2716886.429	1029294.156	19.405
Potential Vernal Pool	BRUSHLINE	2716898.811	1029290.785	20.034
Potential Vernal Pool	BRUSHLINE	2716891.143	1029319.159	19.818
Potential Vernal Pool	BRUSHLINE	2716880.859	1029334.649	19.446
Potential Vernal Pool	BRUSHLINE	2716867.456	1029350.989	19.86
Potential Vernal Pool	BRUSHLINE	2716855.641	1029346.646	19.632
Potential Vernal Pool	BRUSHLINE	2716243.53	1029689.176	17.178
Potential Vernal Pool	BRUSHLINE	2716271.73	1029704.823	16.997
Potential Vernal Pool	BRUSHLINE	2716300.438	1029677.629	16.846
Potential Vernal Pool	BRUSHLINE	2716281.652	1029650.221	16.742
Potential Vernal Pool	BRUSHLINE	2716257.541	1029662.137	16.734
Potential Vernal Pool	SPOTEL P2	2716273.344	1029680.561	15.809
Potential Vernal Pool	BRUSHLINE	2716098.156	1029801.829	18.075
Potential Vernal Pool	BRUSHLINE	2716079.643	1029819.764	17.706
Potential Vernal Pool	BRUSHLINE	2716100.171	1029824.412	17.256

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Location/Description	Point	Northing (ft NAD83)	Easting (ft NAD83)	Elevation (NAVD88 ft)
Potential Vernal Pool	SPOTEL P4	2716094.77	1029813.16	17.092
Potential Vernal Pool	BRUSHLINE	2716128.542	1029458.313	18.344
Potential Vernal Pool	SPOTEL P3	2716137.821	1029436.705	16.661
Potential Vernal Pool	BRUSHLINE	2716155.604	1029460.549	17.726
Potential Vernal Pool	BRUSHLINE	2716133.597	1029405.973	18.705
Potential Vernal Pool	BRUSHLINE	2716112.301	1029419.089	16.943
Swan Pond River	BNKTOP	2716928.168	1030233.198	22.717
Swan Pond River	BNKBOT	2716927.251	1030235.164	20.107
Swan Pond River	BNKBOT	2716926.219	1030238.471	20.071
Swan Pond River	BNKTOP	2716924	1030240.651	20.662
Swan Pond River	EDIRTR	2716833.781	1030216.333	22.783
Swan Pond River	EDIRTR	2716827.744	1030214.207	23.579
Swan Pond River	EDIRTR	2716820.584	1030228.861	22.971
Swan Pond River	EDIRTR	2716831.637	1030236.336	22.508
Swan Pond River	CPPTOP 12	2716835.699	1030228.334	20.027
Swan Pond River	CPPTOP 12	2716819.108	1030219.728	19.848
Swan Pond River	BNKTOP	2716765.004	1030214.549	20.484
Swan Pond River	BNKBOT	2716763.156	1030216.484	19.147
Swan Pond River	BNKBOT	2716763.99	1030219.325	19.19
Swan Pond River	BNKTOP	2716764.122	1030220.709	20.052
Swan Pond River	BNKTOP	2716610.886	1030216.173	19.216
Swan Pond River	BNKBOT	2716612.605	1030218.671	18.782
Swan Pond River	BNKBOT	2716611.628	1030220.718	18.658
Swan Pond River	BNKTOP	2716611.687	1030221.307	18.974
Swan Pond River	BNKTOP	2716425.824	1030166.504	18.185
Swan Pond River	BNKBOT	2716423.898	1030169.347	16.917
Swan Pond River	BNKBOT	2716423.171	1030170.63	16.909
Swan Pond River	BNKTOP	2716423.55	1030173.144	18.022
Swan Pond River	BNKTOP	2716260	1030168.384	18.289
Swan Pond River	BNKBOT	2716258.533	1030169.71	17.273
Swan Pond River	BNKBOT	2716256.335	1030171.748	17.232
Swan Pond River	BNKTOP	2716254.853	1030173.099	18.225
Swan Pond River	BNKTOP	2716093.819	1030077.638	17.864
Swan Pond River	BNKBOT	2716092.647	1030079.572	16.195
Swan Pond River	BNKBOT	2716093.588	1030082.524	16.032
Swan Pond River	BNKTOP	2716093.243	1030085.421	17.458
Swan Pond River	RCPINV 15	2715026.651	1029997.203	13.607

Location/Description	Point	Northing (ft NAD83)	Easting (ft NAD83)	Elevation (NAVD88 ft)
Swan Pond River	HWALBOT	2715030.498	1030003.161	14.23
Swan Pond River	HWALBOT	2715025.685	1030000.711	14.06
Swan Pond River	HWALBOT	2715024.304	1029993.436	14.673
Swan Pond River	HWALBOT	2715028.206	1029990.168	17.064
Swan Pond River	BNKTOP	2715044.846	1030005.643	16.471
Swan Pond River	BNKBOT	2715043.8	1030006.473	14.12
Swan Pond River	BNKBOT	2715041.048	1030007.648	14.11
Swan Pond River	BNKTOP	2715038.771	1030008.334	16.414
Swan Pond River	EOP	2714992.872	1029980.348	24.882
Swan Pond River	EOP	2715006.962	1030037.804	23.324
Swan Pond River	EOP	2714979.992	1030043.698	23.522
Swan Pond River	EOP	2714968.014	1029994.872	24.688
Swan Pond River	RCPINV 15	2714936.807	1030018.488	13.247
Swan Pond River	HWALBOT	2714938.575	1030020.457	14.187
Swan Pond River	HWALBOT	2714938.073	1030014.68	14.413
Swan Pond River	BNKTOP	2715267.275	1030084.868	15.796
Swan Pond River	BNKBOT	2715269.074	1030087.909	14.346
Swan Pond River	BNKBOT	2715269.481	1030090.583	14.454
Swan Pond River	BNKTOP	2715269.817	1030092.866	16.174
Swan Pond River	BNKTOP	2715459.456	1030102.922	16.203
Swan Pond River	BNKBOT	2715459.367	1030104.911	14.974
Swan Pond River	BNKBOT	2715460.605	1030107.555	14.89
Swan Pond River	BNKTOP	2715461.177	1030109.603	16.535
Swan Pond River	BNKTOP	2715638.846	1030088.29	16.985
Swan Pond River	BNKBOT	2715639.637	1030089.569	15.216
Swan Pond River	BNKBOT	2715641.209	1030093.697	15.136
Swan Pond River	BNKTOP	2715642.254	1030095.319	16.425
Swan Pond River	BNKTOP	2715848.136	1030095.733	15.8
Swan Pond River	BNKBOT	2715847.5	1030101.114	15.681
Swan Pond River	BNKBOT	2715848.698	1030099.823	15.791
Swan Pond River	BNKTOP	2715851.051	1030093.833	17.369

2.3 Dennis Public Water Supply Pumping

Since groundwater withdrawal data in the model is based on 2003 values, the groundwater withdrawals were compared to more recent data from 2013 and 2014, which represent typical pumping prior to the recent drought years. Monthly groundwater withdrawal data for 2013 and 2014 and Dennis Water District public water supply wells were obtained for 2013 and 2014. Monthly variations in pumping and

assignments to wells were compared to monthly pumping and assignments to wells in the USGS transient model. **Figure 3** shows the total monthly pumping assigned to Dennis wells in the USGS transient model compared to the reported 2013 and 2014 values. Model simulated withdrawals are slightly higher in the winter months than reported in 2013/2014 data and slightly lower in the summer months. The model pumping represents an average value and therefore may differ when compared to a particular year of withdrawal data. The representation of monthly pumping in the model is generally consistent with reported data, except as noted above, and as such the model is considered representative of current local pumping conditions.

The Dennis Water District groups wells into Northside wells and Southside wells. In the model, 64% of the pumping is assigned to the Southside well and 36% to the Northside wells, shown on **Figure 4**. The 2013/2014 data suggest that the distribution of pumping among the Northside and Southside wells varies each month. The percent of total pumping from the Northside wells ranges from 35% to 44%, and for most months is greater than the 36% of total pumping assigned in the USGS model.

2.4 Observed Water Levels

A synoptic water level round was conducted at five wells at Swan Pond River Site and at the new well (CDM-1) at the Bass River site on November 14, 2016. Depth to water data, calculated from the measured depth from top of casing and surveyed casing elevation data are shown **in Table 2** below. Ground elevation and top of casing elevation data were obtained from the survey conducted in September 2016. Well locations are shown on **Figure 2** for Swan Pond River Site wells and on **Figure 5** for the Bass River Site. Depth to water data will be used to determine the maximum allowable increase in groundwater at each site.

Table 2: November 14, 2016 Synoptic Water Level Data

Well ID	Elevation Top of Casing (ft NAVD88)	Ground Elevation (ft NAVD88)	Depth to Water from Top of Casing (ft)	Water Elevation (ft NAVD88)	Depth to Water Below Ground Surface (ft bgs)
CDM-1	42.50	40.13	29.35	13.15	26.99
MW-25	18.22	16.51	7.65	10.57	5.94
MW-27D	33.89	31.95	22.37	11.52	20.43
MW-27S	33.35	31.74	15.2	18.15	13.59
MW-28D	26.68	24.78	14.78	11.90	12.88
MW-28S	26.47	24.55	9.77	16.70	7.85

2.4.1 Long-term Groundwater Levels

Water levels in Dennis vary seasonally and annually depending on monthly groundwater recharge and seasonal fluctuations in groundwater withdrawals. **Figure 5** shows the historical groundwater elevation data for well MA-DGW 158 which is located near the Bob Crowell Road site and near the Southside Dennis water supply wells particularly GW Well 5 (4075000-06G) and GW Well 21 (4075000-21G). Water levels at MA-DGW 158 vary seasonally and annually in response to changes in pumping and recharge. The average seasonal variation during a year is 2.8 ft, but extended wet or dry periods result in a

historical range of 7.52 ft. The lowest recorded elevation was 15.75 ft (NGVD29) in November 2002 and the highest recorded water level was 23.27 ft (NGVD29) in May 1983.

2.4.2 USEPA PRB Investigation – Vinland

The United States Environmental Protection Agency (USEPA), USGS and the Cape Cod Commission (CCC) have partnered to evaluate the potential for use of Permeable Reactive Barriers (PRB) to remove nitrogen from groundwater on Cape Cod. As part of this project they have funded initial characterization activities at multiple sites on Cape Cod including in Dennis along Vinland Drive. This site is downgradient of the proposed Bass River Site and groundwater discharge into the Bass River at Kelleys Bay shown on **Figure 5**.

Initial site characterization including 6 borings, well and piezometer installation, water level measurements and water quality sampling and analysis was completed in 2016 (Watervision 2016a and 2016b).

Borings indicate that subsurface units are composed of primarily medium to coarse sand, with a 1- to 4-foot thick layer of clay encountered at around 45 to 49 ft bgs (-3 to -7 ft mean sea level). A second layer of clay was encountered at 66 ft bgs. The shallow clay layer observed in the borings generally corresponds with elevation of the clay encountered at the boring installed at the Bass River Site (CDM-1). Five foot screens were installed at approximately 35 to 40 ft bgs in each well at the PRB sites. Additionally, in one location, six 1-foot screens were installed with two located above the first clay layer and the remaining three between the two clay layers.

Depth to groundwater was between 35 and 41 feet bgs. Vertical gradients suggest the shallow clay is a partially confining unit (Watervision 2016a and 2016b).

3 Potential Impacts

For the Swan Pond River Site the site walk and review of local data identified several areas where increased water table elevations or increased groundwater discharge could have a potential negative impact. These areas include low elevation areas downgradient (south) of the recharge location, potential vernal pools that could be negatively impacted by rise in water table and cranberry bogs that need to regulate water levels. The site walk and data review for the Bass River Site did not identify any potential negative impacts due to increased water levels.

3.1 Excavated areas

Areas of low elevations south of the Swan Pond River Site, potential vernal pools on-site, excavated areas on-site and low lying areas near the Swan Pond River are shaded on **Figure 6**. South of the site is a former gravel and sand mine. The former ground surface in this area has been excavated to elevations close to the water table. Because the water table is already near the ground surface, special attention was paid to these areas as part of model simulation and evaluation. Information on subsurface structures (i.e. basements) that may influence groundwater flow is unknown.

3.2 Vernal Pools

Mapping data from MassGIS was reviewed to identify Natural Heritage and Endangered Species Program (NHESP) Certified Vernal Pools and potential vernal pools. Potential vernal pools have been identified by NHESP staff from aerial photographs, but have not been investigated or certified. Aerial

photos and LiDAR data were also combined with site walk and survey data to identify additional potential vernal pool locations. Vernal pools are sensitive to changes in water table. Species such as salamanders and wood frogs that live or reproduce in vernal pools are sensitive to fish predation. The fluctuations in water table prevent fish species from living in these locations.

There are no NHESP Certified Vernal Pools at or near either of the proposed recharge sites. Five potential vernal pools were identified at the Swan Pond River site shown on **Figure 6**. Three were identified from MassGIS mapping and an additional two locations based on elevation data and site walks. Observations of water levels and if necessary indicator species should be conducted to determine if these locations are vernal pools.

3.3 Cranberry Bogs

An active cranberry bog is located on the Swan Pond River to the northeast of the proposed recharge area shown on **Figure 7**. The cranberry bog is approximately 5 acres in size. Information has not yet been obtained on operations or construction of this bog. The recharge and groundwater flow analysis described in this memorandum assumes that recharged groundwater will not discharge to the bogs or if water does enter the bogs it can be drained with minimal impact to the bog operation.

4 Baseline Numerical Flow Model

The effluent recharge sites analyzed herein are located in the Monomoy Lens, one of six groundwater flow lenses under Cape Cod. This lens can be thought of as a mound of fresh groundwater bordered by saline marine waters at the edges, and bedrock on the bottom. The entire layer of fresh groundwater beneath the Cape is known as the Cape Cod Sole Source Aquifer.

Precipitation infiltration is the primary source of water to the aquifer system. On the Cape, about 45 inches of precipitation falls during an average year (LeBlanc and others, 1986) with generally over half reaching the groundwater table. The rest is lost to evapotranspiration and some minor runoff (generally minimal on Cape Cod due to sandy soils) as well as consumptive use through irrigation, commercial, and residential activities. This results in about 27 inches per year of recharge to the aquifer or about 137 million gallons per day (MGD) in the Monomoy Lens (USGS, 2004). Some studies suggest that 5 to 10 percent of the water recharging the Cape Cod aquifer system is removed for water supply (Masterson and others, 1997); however, most of the water is recharged back in the form of disposed wastewater from septic systems or other point discharges.

Previous simulations of groundwater elevation and flow direction beneath the proposed recharge areas were conducted in steady-state mode and are documented in the memorandum dated January 7, 2016 included in this Appendix. Steady-state groundwater models use average recharge and pumping conditions to simulate the average groundwater elevations and flow directions.

The previous steady-state model developed for the Dennis evaluation was updated with monthly recharge from precipitation and septic system return flows and pumping withdrawals for the average year developed by the USGS (Walter and Masterson 2011). The model was then refined based on boring log data obtained from the landfill CSA documentation, the Vinland Road PRB study, the boring installed at the Bass River Site in 2016 and survey data and water level observations conducted in 2016. Model calibration was verified against the USGS steady-state model data set, local water level data, and

average monthly values at selected wells to verify the transient simulation. Updates made to the groundwater model are discussed below.

For the CWMP, transient groundwater flow simulations were conducted to evaluate potential changes in groundwater flow conditions that may result with the operation of the effluent recharge areas. The transient simulation represents monthly groundwater recharge and pumping for a typical (average) year, and . the recharge and pumping inputs were adjusted monthly.

4.1 Model Updates

Based on presence of clay observed in boring data for the Former Landfill near the Swan Pond River Site, the boring installed at the Bass River Site, and in borings at Vinland Road, areas of clay were simulated in model layer 9 (elevation of -10 to -20 ft) at Swan Pond River Site and at model layers 9 (elevation of -10 to -20 ft) and 11 (elevation of -30 to -40 ft) under the Bass River Site. The clay was simulated with a horizontal hydraulic conductivity of 1 ft/day and a vertical hydraulic conductivity of 0.001 ft/day. The extent of the clay was based on both the presence of clay indicated in the borings and the simulated water model properties. Regional geology indicates that there are fine-grained lenses of silt and clay of variable thickness present with increasing clay and silt at deeper depths (LeBlanc et al 1986). Hydraulic conductivity was increased in units below the clay layer at Swan Pond River Site and above and below the clay at the Bass River Site in order to achieve a match between simulated water levels and observed data. Localized changes to hydraulic conductivity for model layers 6 through 13 are shown for each site in **Table 3** below and shown on **Figure 8**.

Table 3: Model Properties

Layer	Top Elev. (ft)	Bottom Elev. (ft)	Layer Thickness (ft)	Swan Pond River Site			Bass River Site		
				K_h (ft/day)	K_v (ft/day)	Notes	K_h (ft/day)	K_v (ft/day)	Notes
6	20	10	10	130	8.5	↓ k_v	100	10	No change
7	10	-1	11	130	8.5	↓ k_v	150	15	↑ k_h, k_v x1.5
8	-1	-10	9	120	8.5	↓ k_v	150	15	↑ k_h, k_v x1.5
9	-10	-20	10	1	0.001	clay	1	0.001	clay
10	-20	-30	10	360	36	↑ k_h, k_v x3	300	30	↑ k_h, k_v x3
11	-30	-40	10	240	24	↑ k_h, k_v x3	1	0.001	clay
12	-40	-50	10	240	24	↑ k_h, k_v x3	90	9	↑ k_h, k_v x3
13	-50	-60	10	240	24	↑ k_h, k_v x3	90	9	↑ k_h, k_v x3

Notes indicate local changes in horizontal or vertical model conductivities as compared to USGS regional groundwater flow model.

In the northern portion of Dennis, horizontal conductivities were reduced by 1/10th for areas beneath the Sesuit Creek and Quivett Creek Marshes based on calibration and regional geological models (USGS

HA-692) which indicate very fine sand silts and clay from Scargo Lake extending north under Cape Cod Bay.

The regional USGS groundwater model does not simulate the Swan Pond River north of Swan Pond. For this application, this river was added as a stream boundary and bed and water surface elevations were set based on LiDAR and survey data.

The Bass River location was revised in Kelleys Bay and south of Route 6 to better reflect the actual shoreline. Drain elevations for the Herring River, Swan Pond and the Swan Pond River from Swan Pond to the coast were lowered to 0.85 ft.

For the calibration, the monthly pumping stresses, recharge and return flow values were taken from the transient USGS model. These values represent withdrawals from 2003 and average recharge and return flow values. Comparison of model simulated pumping withdrawals in Dennis to monthly values for 2013 to 2014 indicate that the model generally simulates the currently total pumping withdrawals (see **Figure 2**). However, since the transient model applies pumping to wells based on a percentage that does not vary monthly, there is some discrepancy in assignments from month to month (see **Figure 3**). Collection of monthly water levels on site and inclusion of recent pumping data is recommended in Section 6 in order to provide data for improved model calibration.

4.2 Model Calibration

The model was calibrated both in steady-state and transient modes. The initial calibration was based on steady-state of the average simulation and compared to the USGS regional model calibration and to local measured groundwater elevations. Transient calibration was conducted by comparing average changes in water levels at USGS wells with average annual observed monthly change in heads. This approach allows for a transient calibration for relative changes, but does not reflect absolute values. Further work is needed to incorporate long-term pumping and recharge and simulate long-term water level values.

Thirteen locations were selected from USGS calibration data points and observed local water levels for model verification. These locations included:

- four USGS wells to provide a regional check on calibration,
- five wells at the Swan Pond River site,
- one well at the Bass River Site,
- two wells at Vinland Road and
- one pond in Harwich to provide an additional calibration point to the east.

The well locations and the model residuals (difference between the observed and simulated head) at each location are shown on **Figure 9** along with the simulated July groundwater table. The groundwater contour lines are shown in 2-foot intervals. Groundwater generally flows south or southwest beneath both sites. **Figure 10** shows a 45-degree plot of the simulated and average observed water levels. Calibration statistics are shown in **Table 4** below.

The model is generally representative of groundwater conditions at the near the proposed Swan Pond River and Bass River Sites effluent recharge sites and is appropriate for screening level simulations. Calibration statistics indicate the model is within the calibration criteria used for the USGS regional model development (Walter and Whealan 2005).

Table 4: Steady-State Model Calibration Statistics

Calibration Statistics	Calibration Criteria	Calibration Statistics for Steady-State Model
No. Monitor Wells		13
Avg. of Residuals (ft)	< 5	0.44
Avg. of Abs Residuals (ft)		1.84
STDV of Residuals (ft)	< 5	2.18
RMS Error of Residuals (ft)	< 5	2.23
Obs Head Diff Across Layers at MWs (ft)	28.9	
Avg of Res/Head Diff at MW (%)	< 10%	2%
STDV of Res/Head Diff MW (%)	< 10%	8%

Simulated vertical head differences at 3 locations were compared with measured data, listed in **Table 5** below. Two locations at Swan Pond River Site, MW-27S/D and MW-28S/D, and one location at Vinland Road (VLZ-A/F) had well screens above and below the simulated clay in model layer 9 layer. The model was able to adequately simulate the direction of flow and magnitude head difference at MW-27 and MW-28, but not at the Vinland Road well. Modifications to layer thicknesses and elevations are needed to more adequately simulate the groundwater discharge in the Kelleys Bay vicinity.

Table 5: Vertical Head Difference Calibration

Vertical Head Difference	Observed (ft), + down, - up	Simulated (ft)
MW-28	4.80	3.16
MW-27	6.60	4.71
VLZ (Vinland)	-2.70	1.03

Transient model calibration was verified by comparison of the observed water level fluctuations at four USGS wells with model simulated water level fluctuations. The fluctuation in water level was used for comparison, rather than absolute values since the model represents a typical transient year and not a specific time-period. **Figure 11** shows the monthly simulated and observed changes in water elevations. The orange error bars show the range in observed historical data compared to the monthly average for each month. The figures show the model respond to monthly changes in pumping and recharge

Figure 12 shows the observed water levels at MA DGW-158 from 2000 to 2016 in orange and the simulated water levels for the average year in blue. While the average monthly change in water levels, shown in **Figure 11**, is adequately simulated by the model, the model does not simulate current groundwater conditions. This could be due to a shift in distribution of withdrawals from the Dennis Public Water Supply wells, the assignment of model properties, a change in recharge patterns or a combination of all three. The change in water levels in 2003 suggests a shift in withdrawal locations from the Southside to the Northside wells. The monthly pumping simulated in the model is similar to reported pumping from 2013-2014 shown previously in **Figure 3**. However, the distribution between the Northside and Southside wells, shown in **Figure 4**, supports the shift in a larger percentage of the wter being withdrawn from the Northside wells then is currently simulated.

4.3 Model Water Balance

To verify model set-up and calibration, the water balance was computed and compared to the reported water balance for the Monomoy Model (Table 2 in Walter and Masterson 2011), shown in **Table 6** below. This indicates that the model was not substantially modified in terms of overall inflows and outflows. The overall model water balance is similar. Higher recharge in the Dennis model is likely due to modifications in the boundaries of some recharge zones due to changes in discretization and modification of local water features. The differences in the stream and estuary water balance components may be associated with the inclusion of the Swan Pond River and modifications to the Swan Pond River and Herring River drains based on model calibration. Overall the net outflow to the streams, drains and estuaries increased, while the outflow to the coast decreased.

Table 6: USGS and Dennis Water Balance Comparison

Water Balance Component	USGS Monomoy (MGD)	Calibrated Dennis Steady-State Model (MGD)
Recharge + Septic Return Flows	109.7	117.5
Inflow from Streams	0.9	1.9
Outflow to Streams/Drains/Estuaries	-64	-79
Outflow to Coast	-39	-32.4
Withdrawals at Wells	-7.6	-8

5 Effluent Recharge Scenarios

For the Swan Pond River site (DPW site or Site 1), an area of 8.95 acres in the northeast portion of the site was selected as the location for potential recharge. This area was selected based on the relatively flat terrain, the ground surface elevations of between 40 and 50 feet above mean sea level (MSL) and estimated depth to groundwater of around 20 feet below ground surface (ft bgs).

For the Bass River site (Bob Crowell Road or Site 2), the area of 2.75 acres west of the former DPW site was selected for effluent recharge. This area was selected to be outside the public water supply Zone II extent and due to land use limitations on other portions of the property. This area has ground surface elevations of around 50 feet above MSL with an estimated depth to groundwater of around 20 to 30 ft bgs. There were no potential vernal pools or other concerns that were identified downgradient of the Bass River site.

Five transient simulations were conducted as part of this assessment, shown in **Table 7**. Model simulations 1 through 4 are steady-state simulations conducted previously and documented in the January 7, 2016 Technical Memo. These simulations included the initial base simulation and additional simulations to mitigate impacts to potential vernal pools and excavated areas south of the Swan Pond River site. The simulations are briefly described below. The recharge area and maximum loading rate are listed for each site and simulation in **Table 7**.

- Simulations 5 was the initial transient simulation with recharge spread over the entire potential recharge area.

- Simulation 6 increased the loading rate at the Swan Pond River site with all recharge being applied to a smaller area within the northeast corner of the proposed recharge site.
- Simulation 7 shifted the location of the recharge area for the Swan Pond River site farther north to a parcel of land north of the site boundary.
- Simulation 8 was used to determine the maximum potential discharge at the Bass River Site (Site 2).
- Simulation 9 contains the same annual discharge to the site as Simulation 8? but shifts discharge during the winter months (October through April) from the Swan Pond River (Site 1) to Bass River (Site 2) to determine if vernal pools near the Swan Pond River site would dry out during periods of no recharge in the winter.

Table 7: Transient Effluent Recharge Model Simulations with Update Model

Model Simulation No.	Swan Pond River – Site 1		Bass River – Site 2	
	Area (acres)	Maximum Loading Rate [3] (gpd/ft^2)	Area (acres)	Maximum Loading Rate [3] (gpd/ft^2)
5	8.95	3.45	2.75	7.99
6	2.75	11.21	2.75	7.99
7	2.75 [2]	11.21	2.75	7.99
8	2.75	11.21	2.75	8.40 [3]
9	2.75	11.21	2.75	7.99

Notes

1. Maximum Loading occurs in July except as noted
2. Recharge area located on parcel north of DPW site
3. Maximum potential load at Site 2 occurs in October

Impacts from the recharge scenarios were assessed by reviewing the extent of the maximum groundwater mound during periods of peak loading (July) and hydrographs showing changes in water levels at selected locations.

The impact of water table mounding is typically evaluated by plotting the “separation distance”, or “depth-to-water” between the simulated water level with effluent loading and the ground surface. MassDEP requires a minimum vertical separation distance of 4 feet between seasonal high groundwater, with effluent recharge, and the ground surface, a standard requirement of Title 5 systems that MassDEP typically applies to all wastewater discharges to groundwater, regardless of the quality of the treated wastewater effluent.

The groundwater mound was calculated by subtracting the simulated water table for the base simulation with no additional recharge from the simulated water table for the effluent recharge simulation. Since proposed recharge rates are highest in July, plan views of the simulated groundwater mound are highest in July. Base water table contours are shown in **Figure 13**. Groundwater generally flows south or southwest beneath both sites and discharges to the nearest water bodies. Water

elevations are heavily influenced by groundwater withdrawals and flow in and out of ponds, streams and discharge to coastal estuaries.

5.1 Site 1 in Swan Pond River Watershed

Transient simulations indicate the maximum groundwater mound will be over 10 feet during the highest recharge period in July, as shown in **Figure 14**. The colors on the figure show ranges of expected rise in the groundwater table, or mound, due to the proposed recharge. Based on estimated seasonal variation in flow, the July effluent recharge is estimated to be 1,340,000 gpd. The groundwater level at the former gravel pit south of the site may increase by almost two feet (blue/purple color on **Figure 14**), which would result in flooding and expansion of the existing groundwater pond in this area. Groundwater levels at the nearest vernal pool would potentially increase by several feet (orange color).

Since the seasonal fluctuations in water levels may be important at vernal pools, groundwater hydrographs were created at three locations, shown as green symbols on **Figure 14**. These locations include a location near the recharge area, the location of a potential vernal pool, and a location at the southern boundary of the site. Hydrographs of monthly groundwater levels are shown in **Figure 15** for the base water table and Simulations 5, 6, and 7. Each hydrograph shows the simulated water elevation at the location under baseline conditions (yellow) line for each month simulation and the approximate elevation of the lowest ground elevation near the point (brown line). The base water table hydrograph shows that the simulated water table is highest in the spring during April and May and lowest in the late fall. The scenarios are shown with colored lines as indicated on the figures. The hydrographs for the vernal pool and southern boundary show that the simulated water table rises to the ground surface in May under average year conditions. The addition of recharge raises the water table five feet above the ground surface at the potential vernal pool and over a foot at the southern boundary. Moving the recharge area to a smaller area and farther north (Simulations 6 and 7) does little to reduce the high water table.

Figure 16 shows the hydrographs for Simulation 9 which moves flows during the winter season to Site 2. The reduction in flows still results in a water table which is elevated above base conditions due to the slow response time of the aquifer south of the site. However, shifting the flows in the winter allows the water table at the vernal pool to drop below the ground surface and reduces the overall mound at the southern boundary. Additional mitigation measures at the southern boundary to allow for seasonal flooding will still be needed as part of this scenario. Possible mitigation approaches include enlarging the existing pond, construction of wetlands to reduce nitrogen and increase evapotranspiration or simply allowing the low-lying areas to flood. Since vernal pools are based on the existence of indicator species and the absence of predator species such as fish, they do not need to dry out for a specified time period, just long enough to prevent predator species from thriving. The scenario shown in **Figure 16** is one possible solution which would allow the pools to dry out during the winter months and would prevent the predator species from surviving. A biologist should inspect the suspected vernal pools to confirm their classification during future work.

5.2 Site 2 in Bass River Watershed

Transient simulations indicate the maximum groundwater mound could be over 10 feet during the highest recharge period in July as shown in **Figure 17**. Hydrographs were created at one location on-site, shown on **Figure 17**, to show simulated seasonal fluctuations in water levels. Hydrographs of simulated monthly groundwater levels are shown in **Figure 18** for the base water table and Simulations 5 and 9.

Simulation 9 moves flows during the winter season to Site 2. The figure shows that higher flows can be discharged during the winter months without raising the water table to within 5 feet of the ground surface, below the Title 5 requirement.

Simulation 8 was used to determine the maximum potential discharge at the Bass River Site. The maximum potential recharge rate was estimated by fixing heads beneath the site at an elevation 5 feet below the ground surface. The model computes a flux that would be needed to maintain the groundwater level at this elevation. This model application is one way to estimate the maximum recharge load that could potentially be applied at the site without violating the depth to water criteria. **Figure 19** shows the maximum simulated recharge load as a blue line compared to the proposed load for the Bass River Site (orange bars) and the proposed load for the sum of the Swan Pond River and Bass River Sites. The maximum simulated recharge load varies monthly with the lowest recharge potential in the spring when the existing water table is high and the highest recharge potential in the fall when the water table is low. The figure shows that there is plenty of capacity at the site in the winter months to recharge flow from both the Bass River and Swan Pond River sites, however in the summer, the capacity Is limited to the proposed Bass River Site loads.

6 Conclusions and Recommendations

This hydrogeologic assessment is appropriate for a screening level assessment and wastewater planning. Additional data collection and model refinement is needed to develop final design and estimates of potential impacts.

The model simulations suggest that effluent can be recharged for all months at the Swan Pond Road site (Site 1) and Bob Crowell Road site (Site 2) for the projected average annual wastewater flows (575,000 gpd and 410,000 gpd respectively) while maintaining the depth to water of 5 to 6 feet that likely will be required by MassDEP. Transient simulations suggest that the sites have sufficient capacity to recharge peak flows in July of a 1,340,000 gpd at Site 1 and 960,000 gpd at Site 2.

For projected build-out flows (average annual flows of 1,045,000 gpd and 540,000 gpd respectively), both sites operating together have sufficient capacity during winter months but lack sufficient capacity during summer months when effluent recharge flows for build-out are expected to be more than twice the average annual flows (July peak flows of 2,450,000 gpd at Site 1 and 1,260,000 gpd at Site 2).

In addition to the criteria for depth to water beneath the recharge area, impacts to downgradient areas were reviewed as part of the hydrogeologic assessment. Impacted resources include downgradient water users such as cranberry bogs, natural areas such as certified and potential vernal pools, Zone II areas, low elevation areas and building basements. At the Bob Crowell Road site (Site 2) modeling and site walks did not identify any resources described above that would limit the disposal of treated wastewater. However, at the Swan Pond Road site (Site 1), the modeling indicates concerns in regards to elevated water table at the cranberry bog east of the site, at potential vernal pools on-site and at an excavated area with ground surface elevation close to the existing water table south of the site. Mitigation options for these areas include recharge of all effluent at Site 2 during the winter months and negotiating to allow the low elevation area to flood during wet periods. The transient modeling indicates that water levels at the vernal pools can be adjusted if effluent is discharged only at Site 2 for a few months.

The simulations results presented herein represent screening level analyses that were conducted to perform preliminary assesment of the candidate recharge sites. Prior to final design, additional information needs to be collected and reviewed. Recommendations made below focus on additional data to be collected to support the implementation of these sites. Additional load-testing data are needed to confirm model projections. Simulations performed to date suggest that additional recharge capacity will likely be needed for the peak usage months in the summer under build-out conditions.

In addition to investigating the mitigation measures proposed, the following steps are necessary to collect information to support future analysis and design of the effluent discharge facilities at the Swan Pond River and Bass River Sites:

- Conduct monthly synoptic water level measurement rounds to support future evaluation efforts and the development of a hydrogeologic evaluation which will be needed to obtain a groundwater discharge permit. If possible, install continuous water level recorders at each site to provide more data on short-term water table fluctuations.
- Conduct visual inspections of the potential vernal pools at the Swan Pond River in March, April and May to identify the presence or absence of standing water. If water is noted, a wetland biologist should verify the existence of species which would indicate a vernal pool.
- Information should be obtained about the cranberry bog located to the East of the Swan Pond River. Information about water levels required for bog operations and bog construction would help assess potential impacts to these bogs.
- The transient and steady-state USGS models are based on 2003 pumping and recharge data. Current, historic and projected future public supply pumping data should be obtained in order to simulate potential pumping scenarios and assess how pumping may impact flow directions at the Bass River site (Site 2) and assist with model calibration at the Swan Pond River site (Site 1). Public water supply data from the last 5 years paired with proposed monthly site-specific water level readings and continuous water table data recommended above would provide valuable data to calibrate the model to existing conditions. If the flow model was calibrated to existing pumping and recharge stresses, it would provide a better tool for understanding of how the system responds to the proposed recharge loads.
- Repair outer casing for MW-25 and secure well casings for MW-27S and MW-27D.

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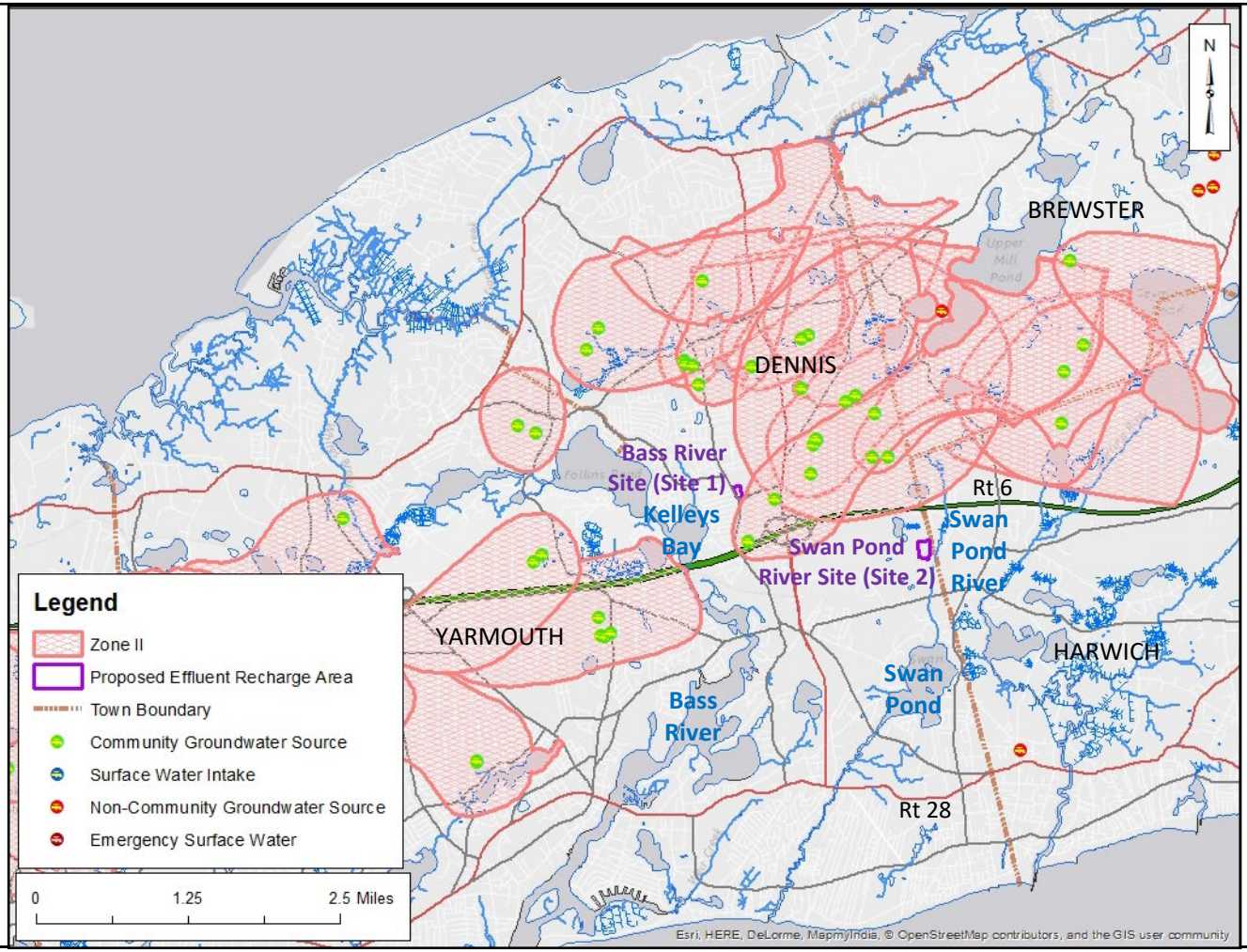
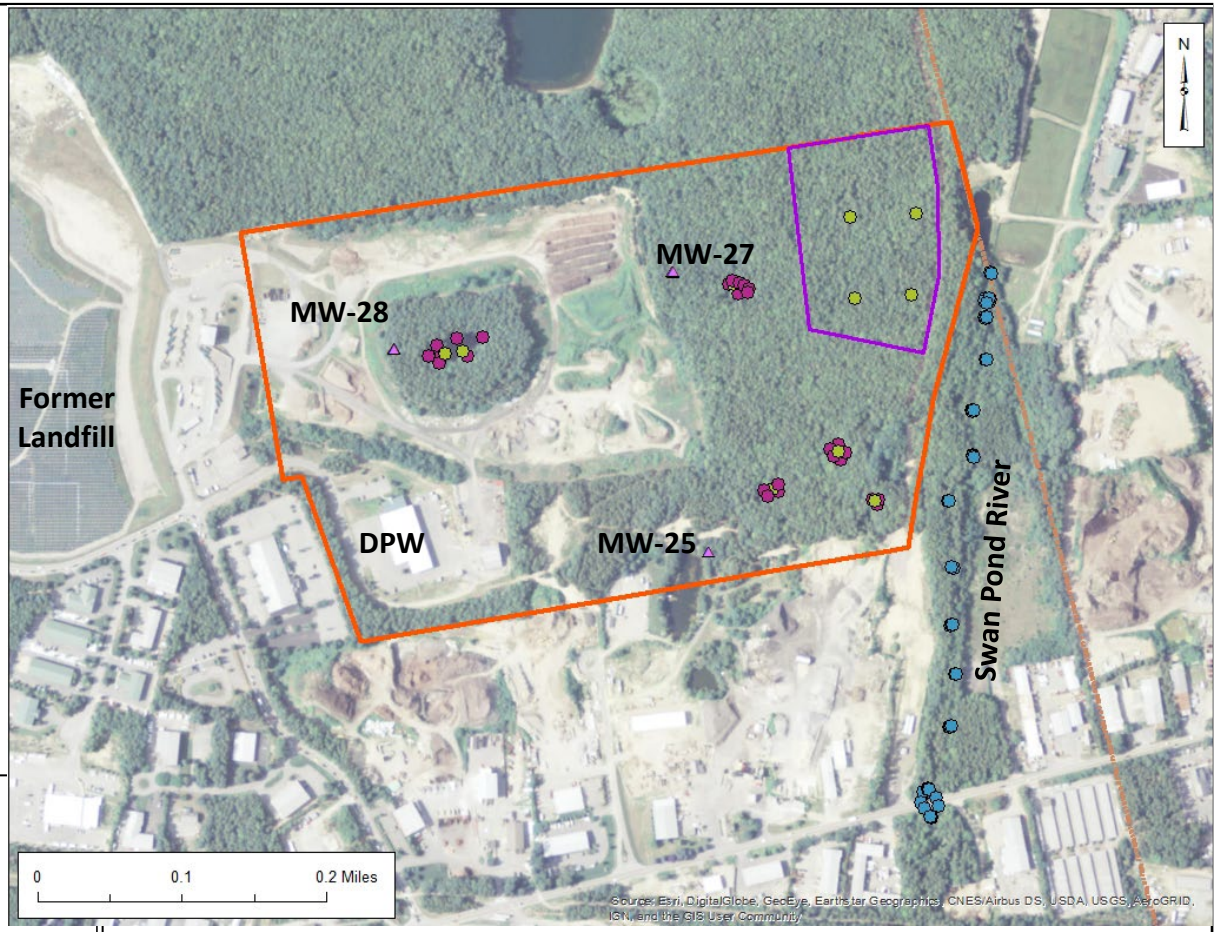


Site Locations

Figure 1

Town of Dennis, MA
Comprehensive Wastewater Management Plan

CDM Smith

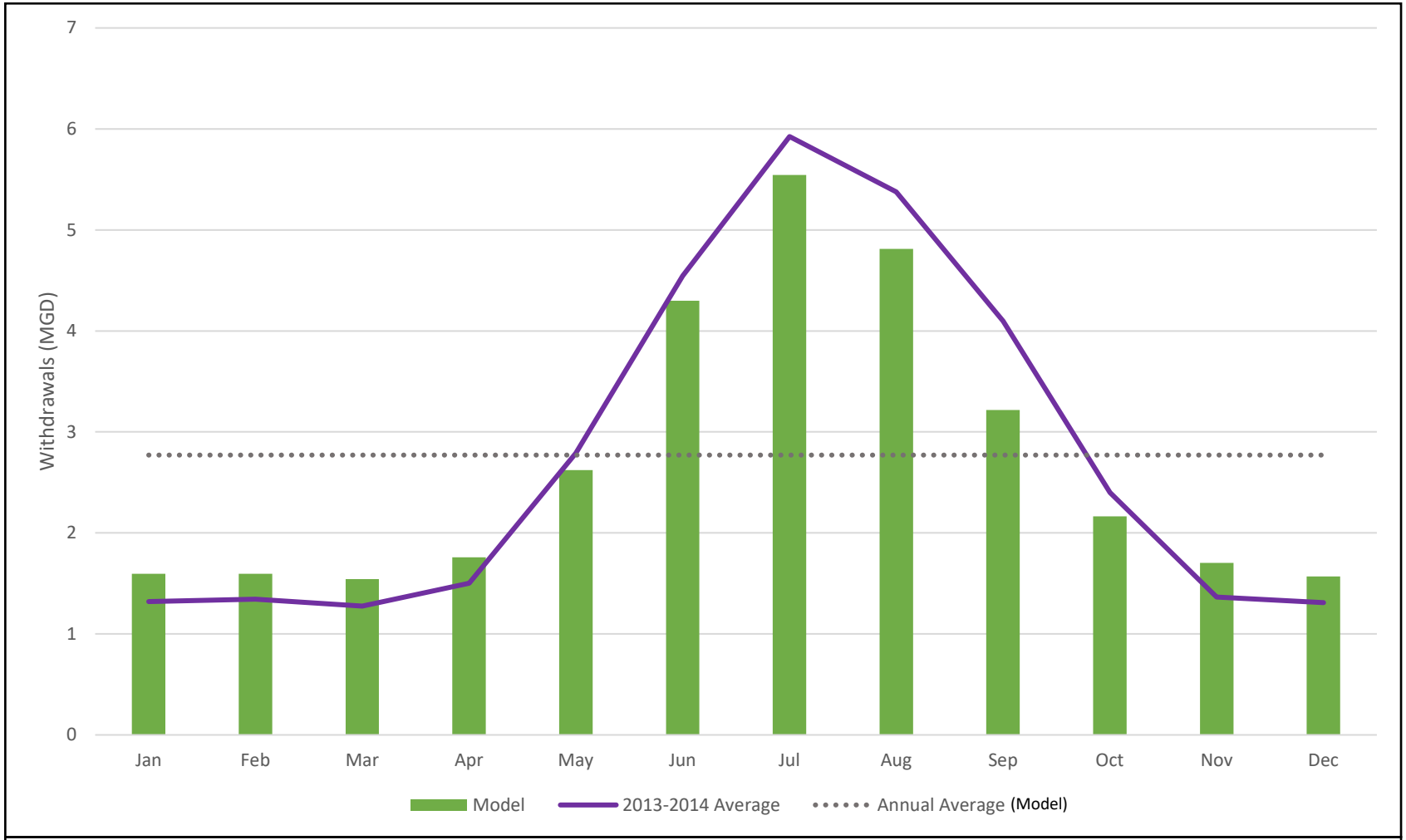


Survey Points - Swan Pond River Sites

Figure 2

Town of Dennis, MA
Comprehensive Wastewater Management Plan

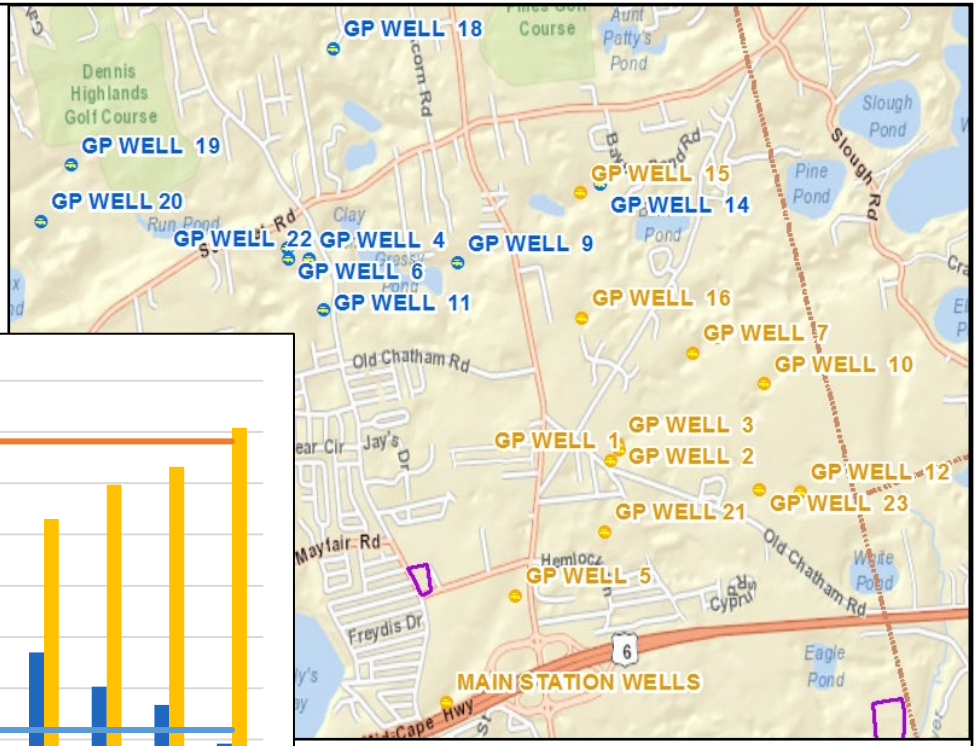
CDM Smith

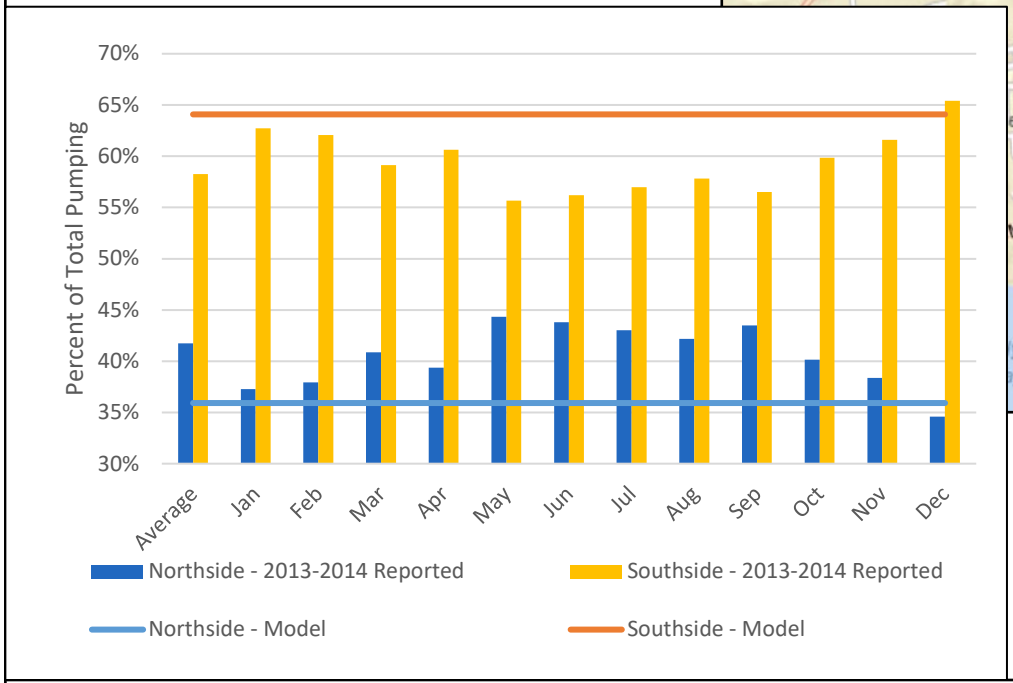


Model Simulated and Reported
2013-2014 Pumping - Dennis

Figure 3

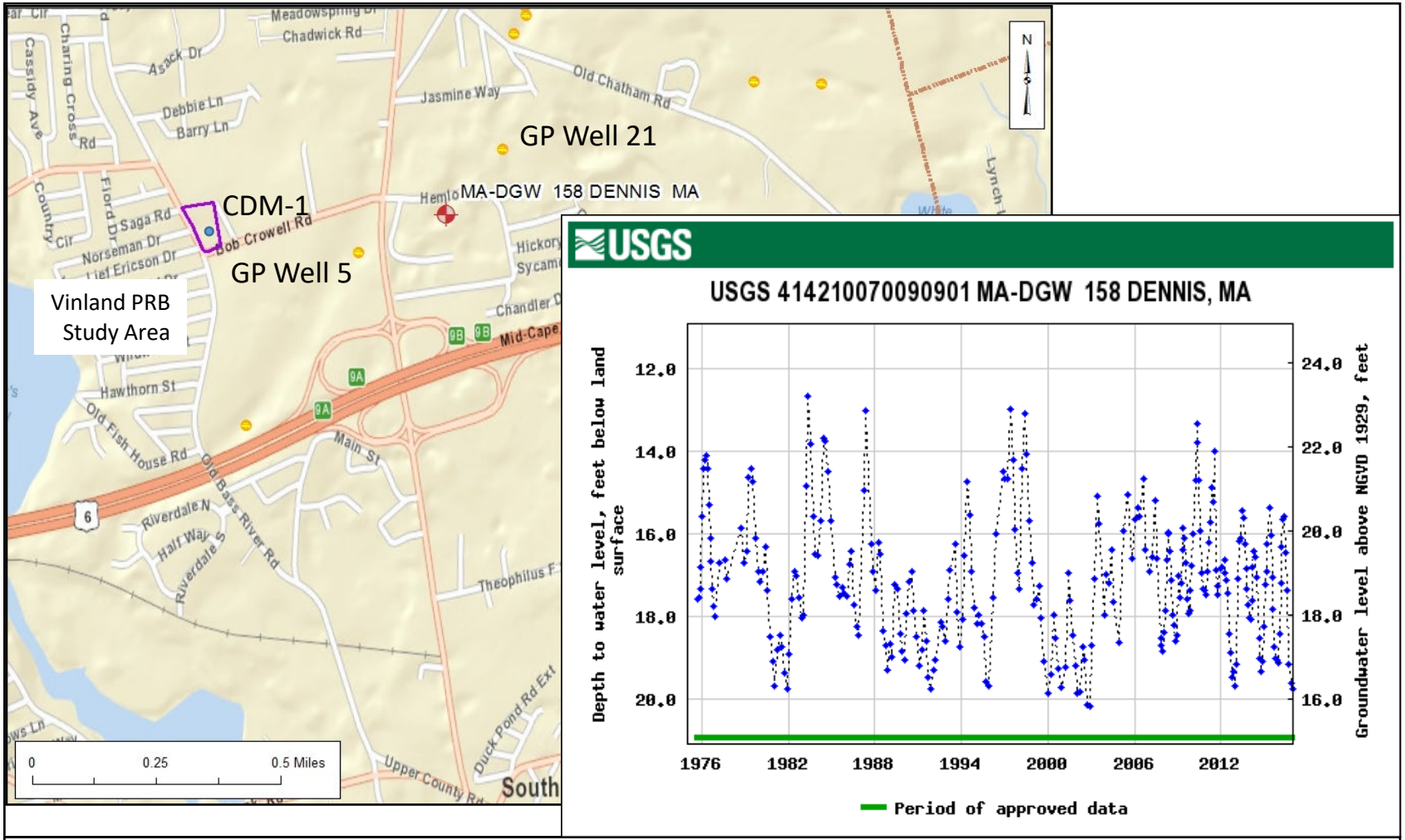
Town of Dennis, MA
Comprehensive Wastewater Management Plan





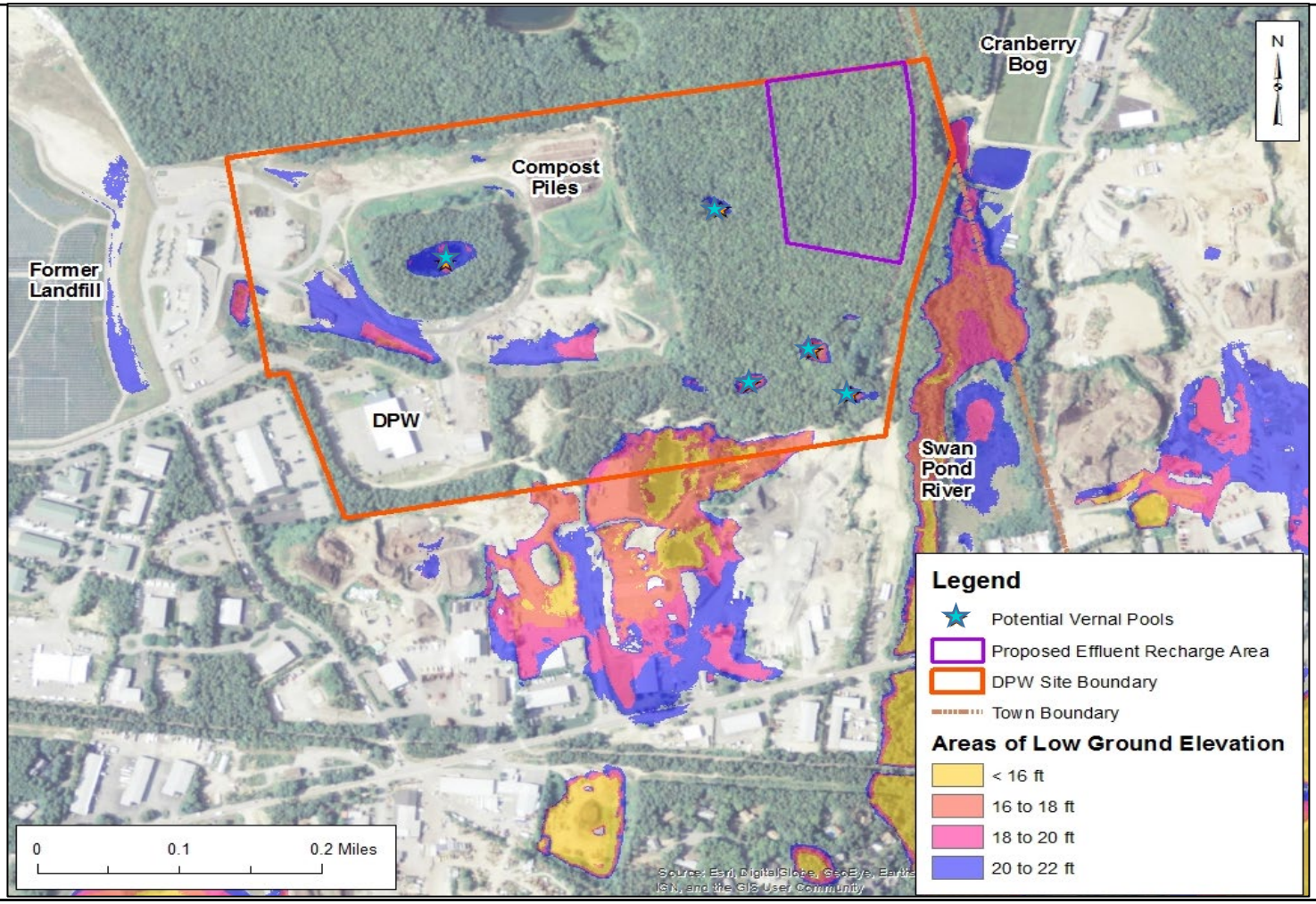
Dennis Water Supply Withdrawal Distribution for Northside and Southside Wells

Figure 4



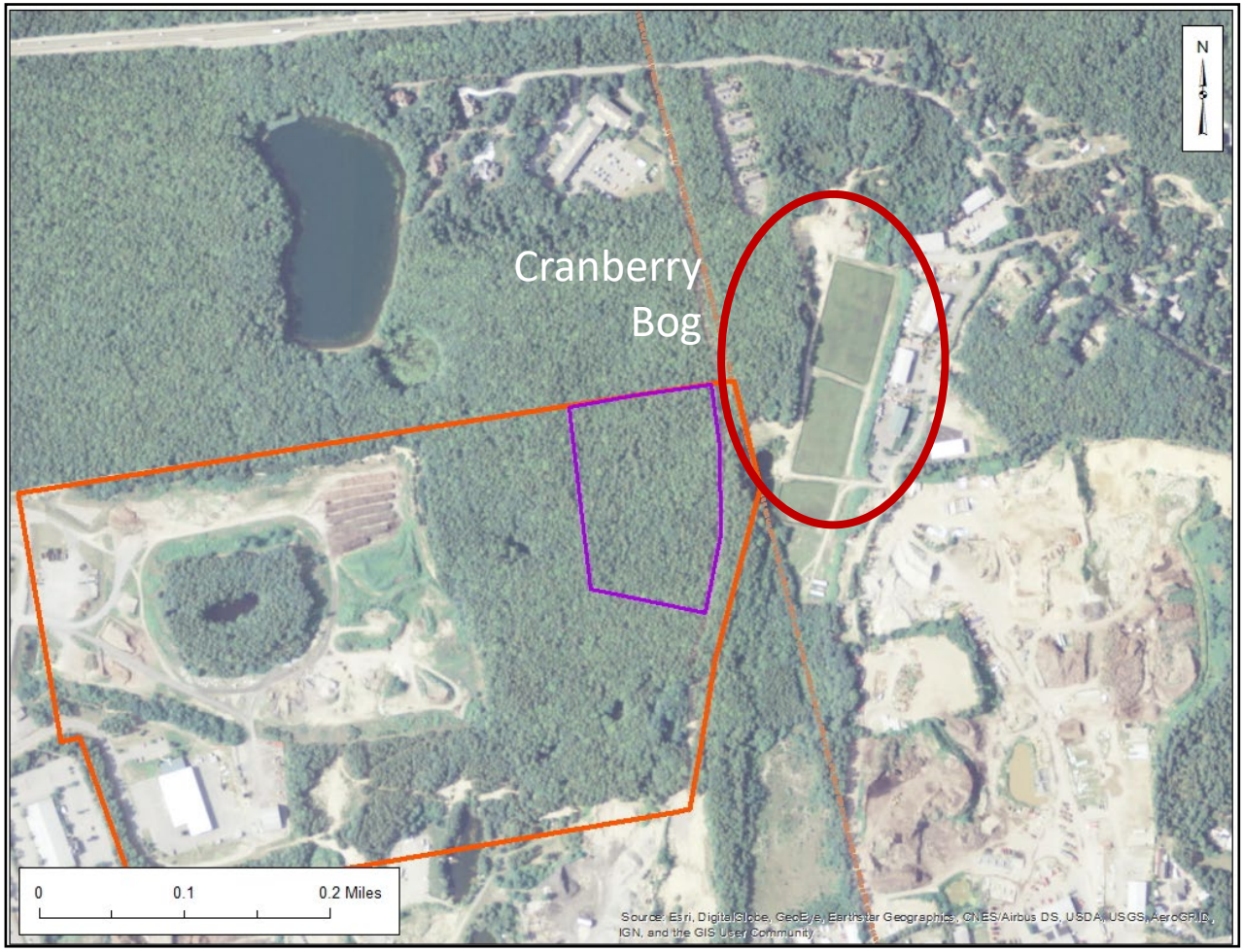
Long-term Water Levels
MA-DGW 158

Figure 5



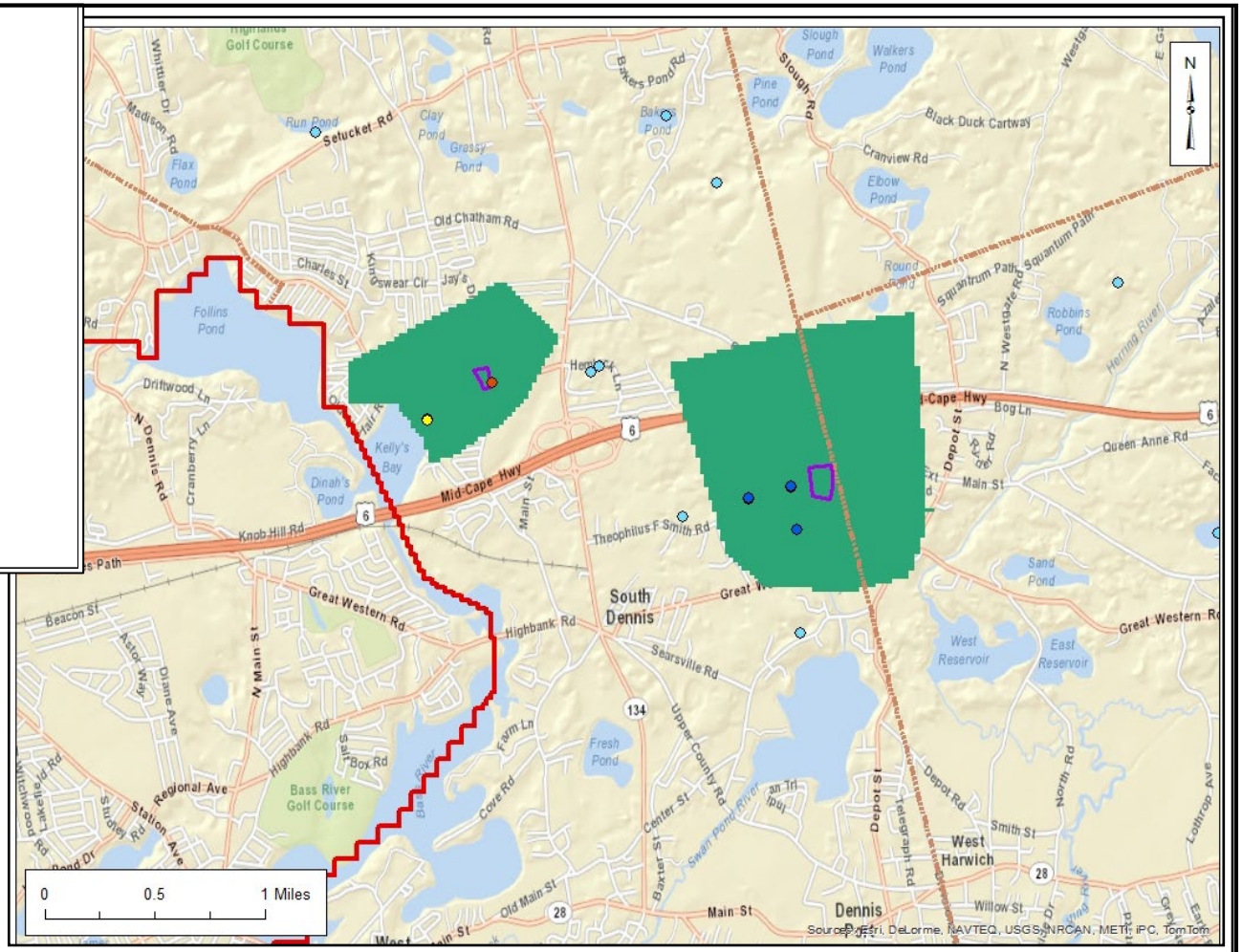
Low Ground Surface Elevations and Potential Vernal Pools – Swan Pond River Site

Figure 6



Location of Cranberry Bogs –
Swan Pond River Site

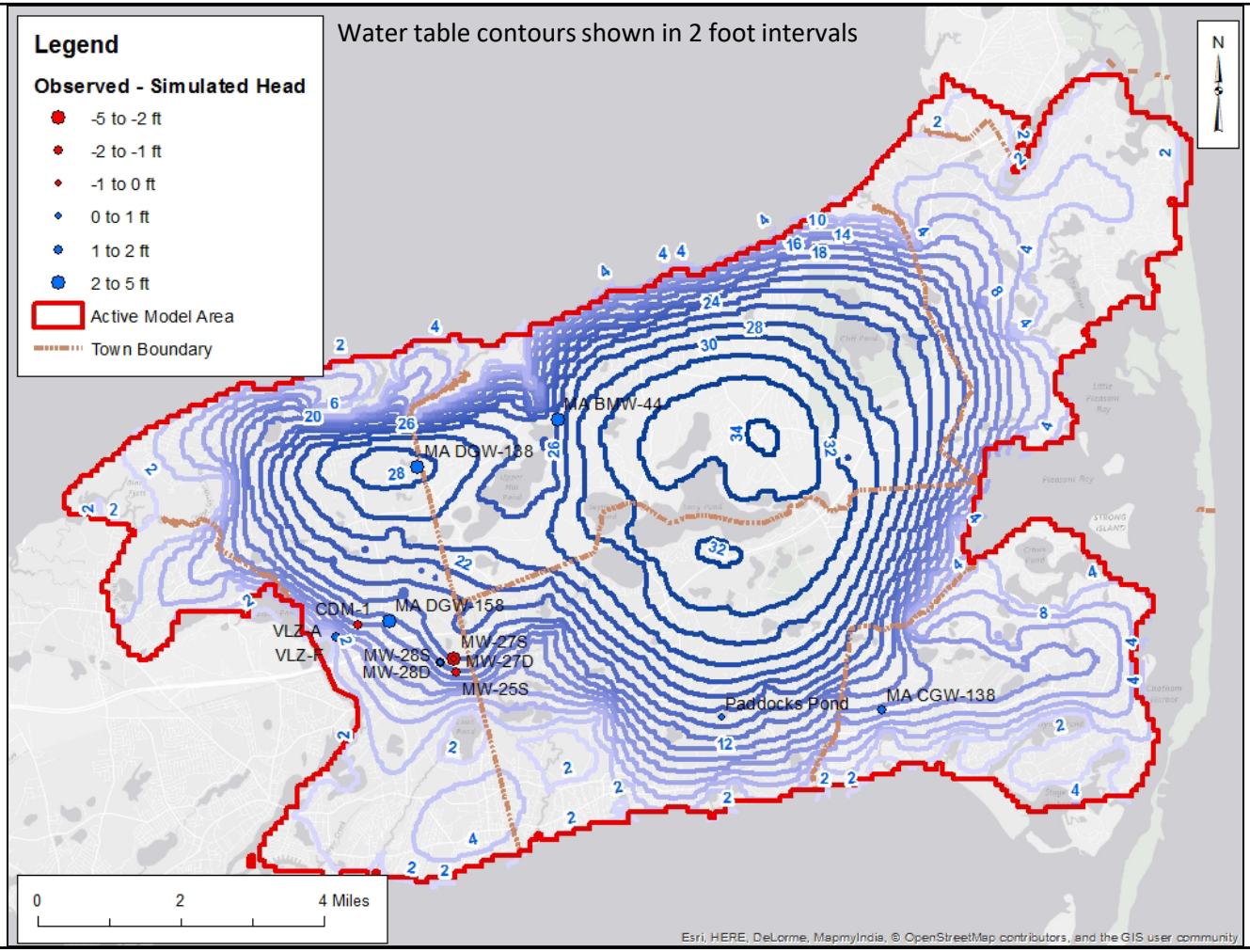
Figure 7



Areas of Simulated Clay

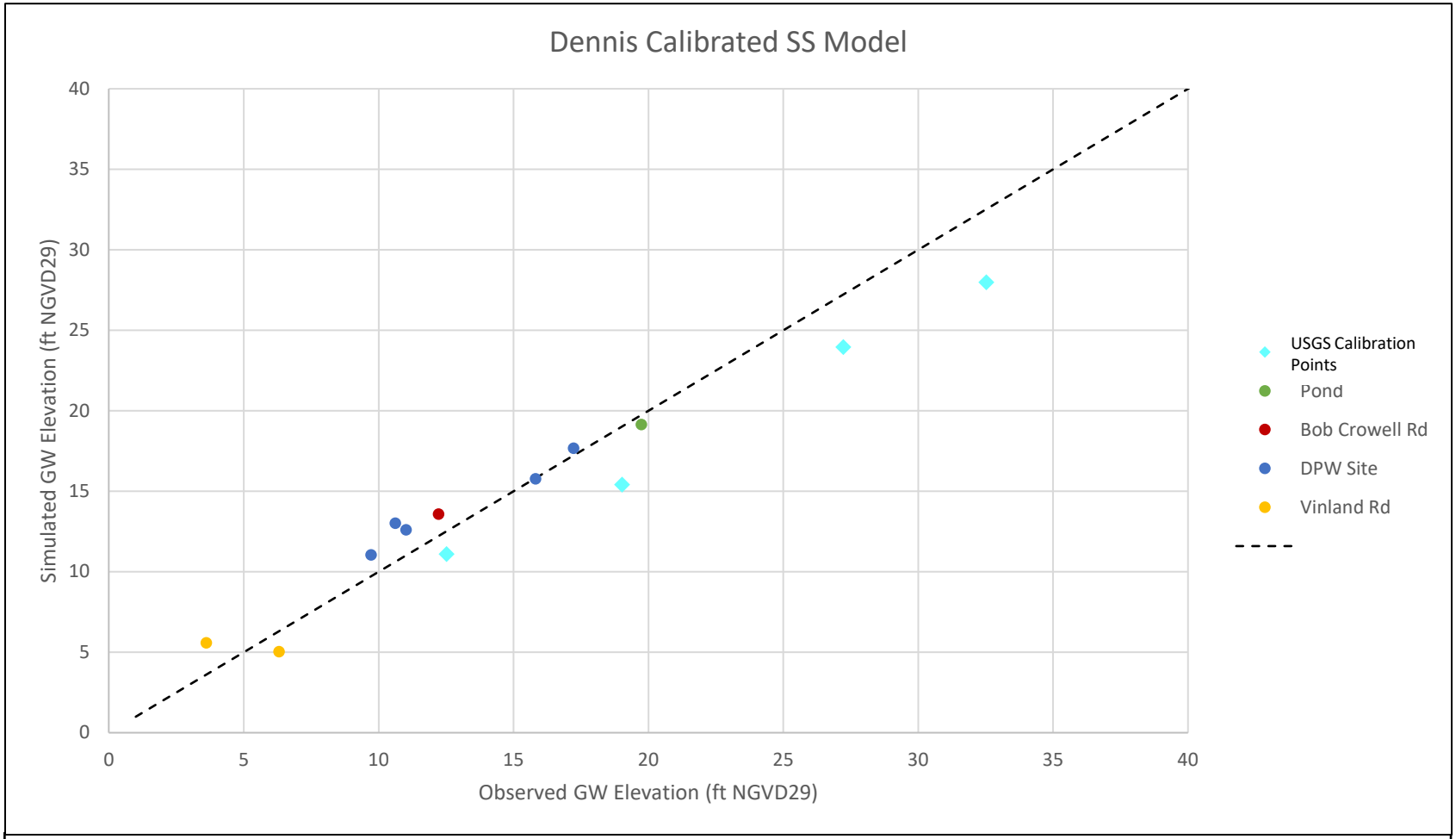
Figure 8

Town of Dennis, MA
Comprehensive Wastewater Management Plan



Model Calibration Residuals and Base Water Table (July)

Figure 9

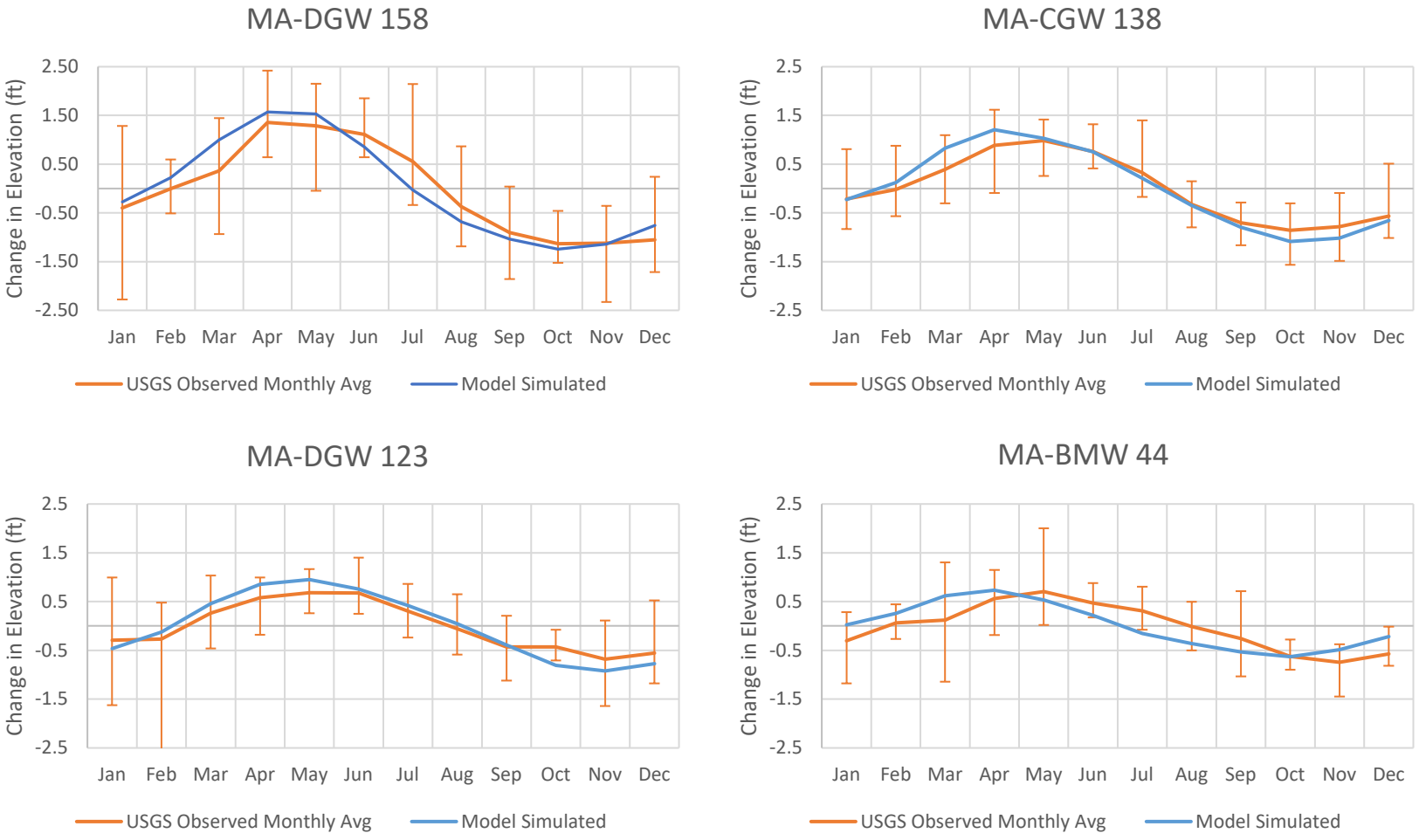


Steady-State Model
Calibration Scatter Plot

Figure 10

Town of Dennis, MA
Comprehensive Wastewater Management Plan

CDM Smith

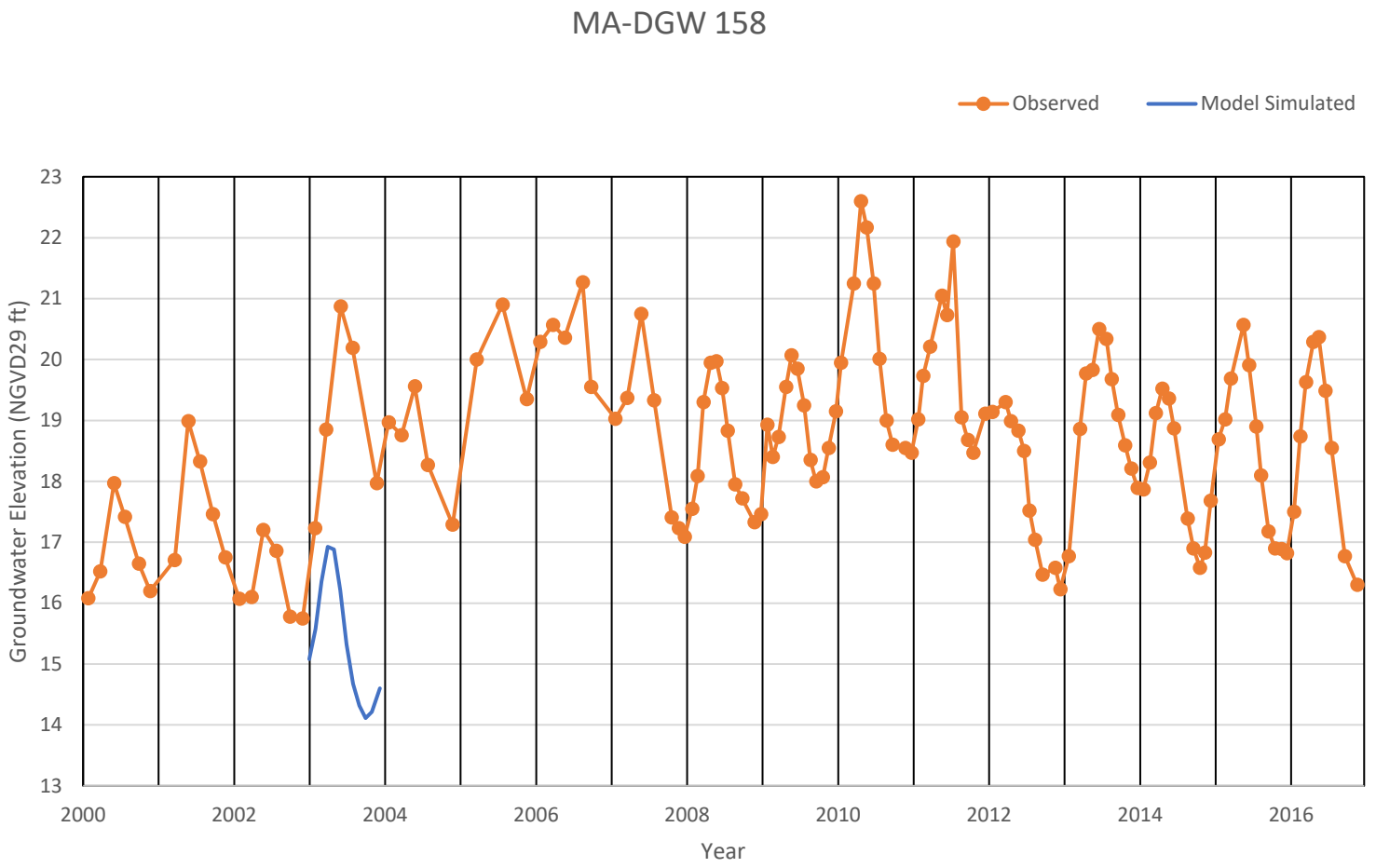


Transient Water Levels – Relative Change

Figure 11

Town of Dennis, MA
Comprehensive Wastewater Management Plan

CDM Smith

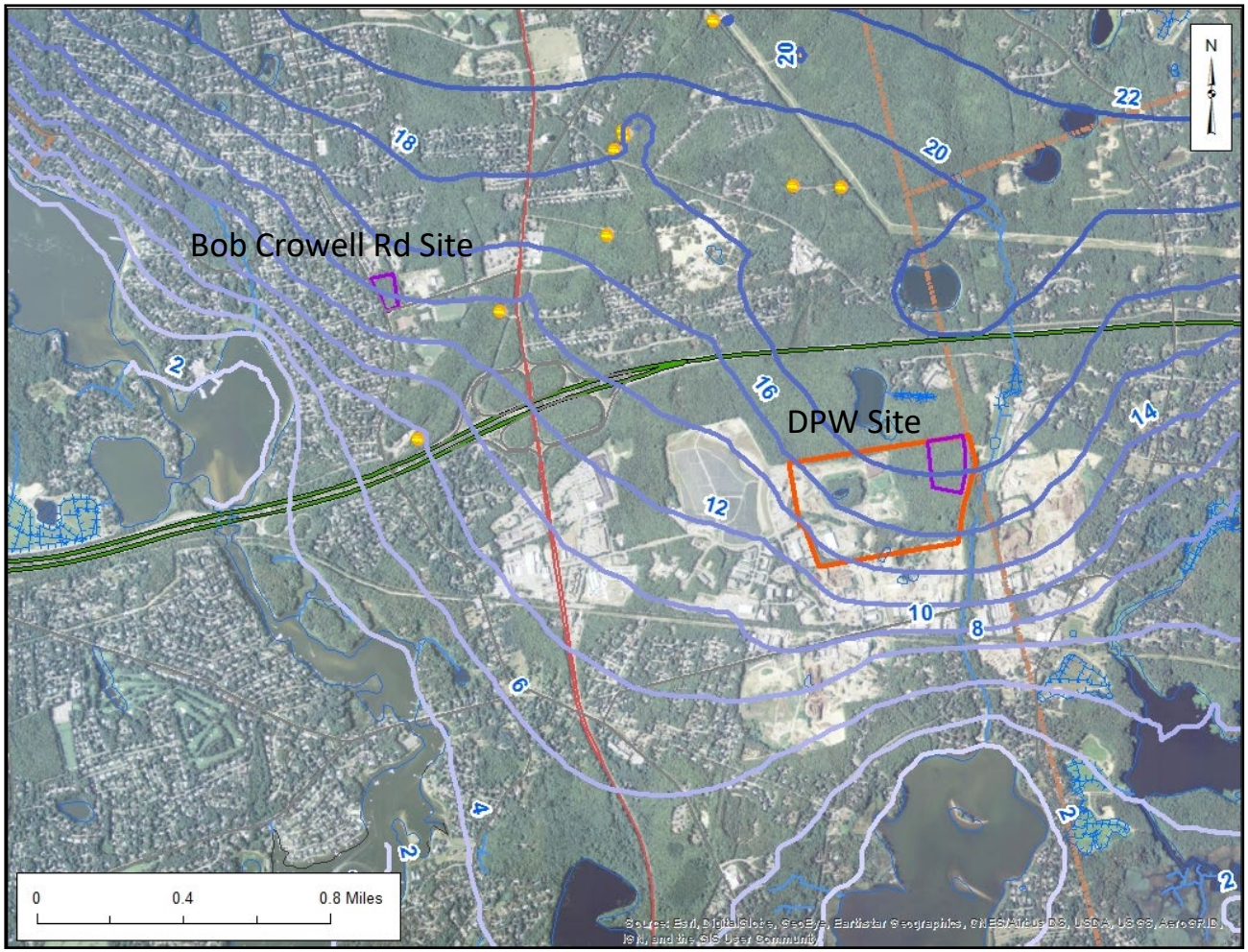


Transient Water Levels – Model "Average Year" and Observed Data

Figure 12

Town of Dennis, MA
Comprehensive Wastewater Management Plan

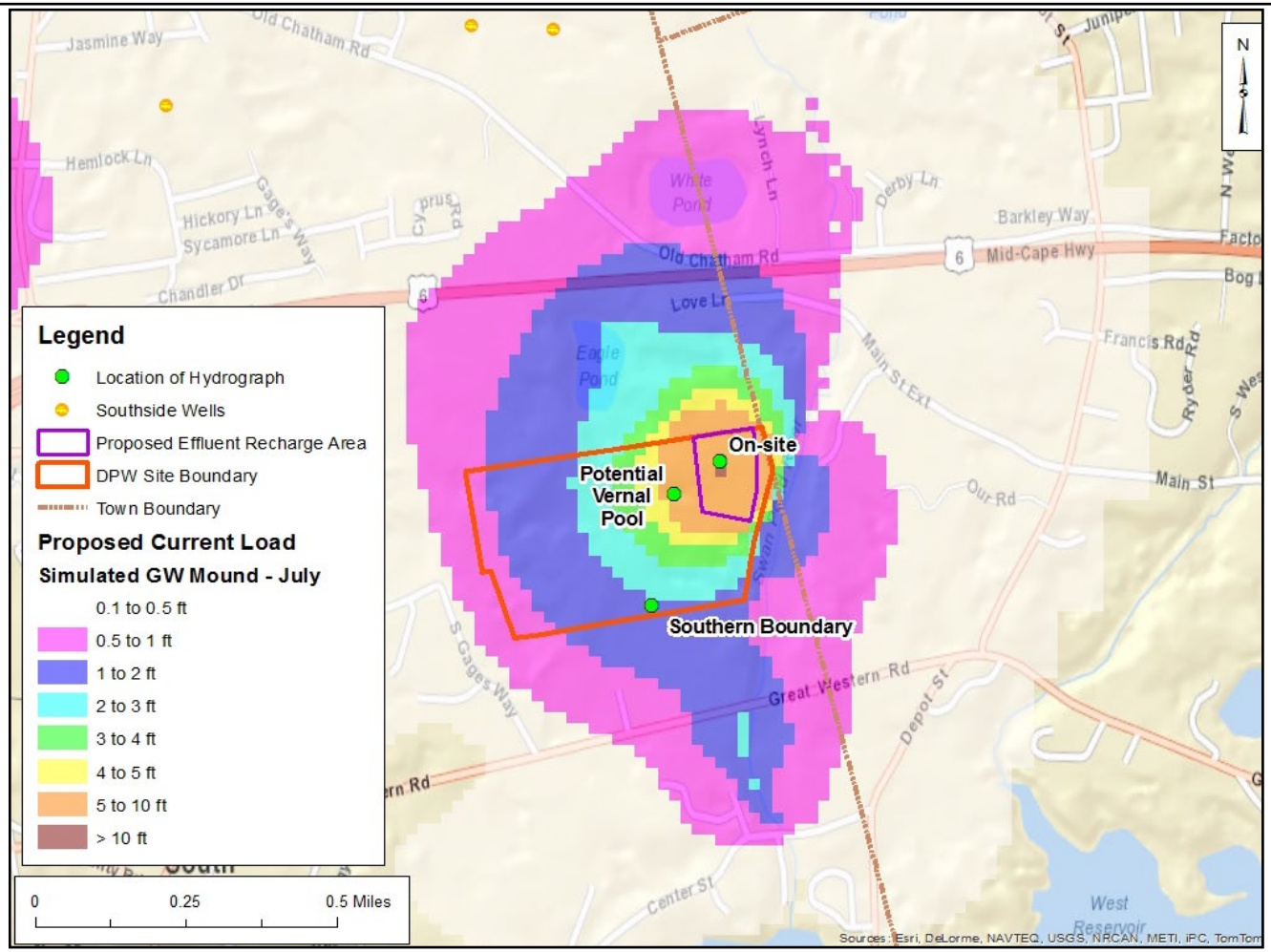
CDM Smith



Base Groundwater - July

Figure 13

Town of Dennis, MA
Comprehensive Wastewater Management Plan



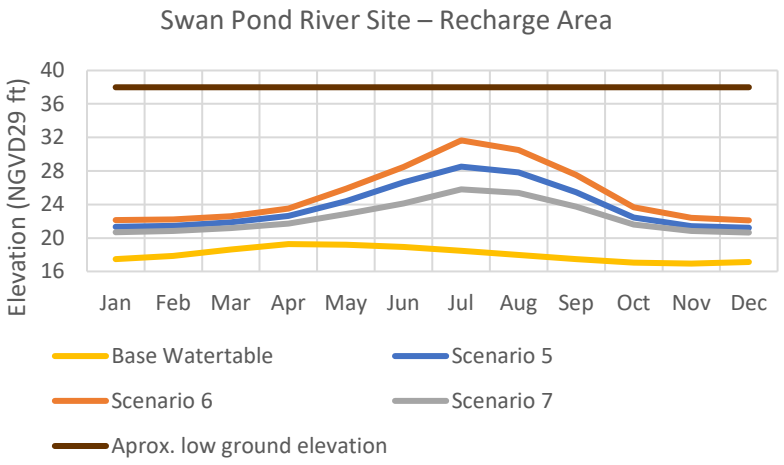
Simulated July Groundwater Mound with Hydrograph Locations – Swan Pond River Site

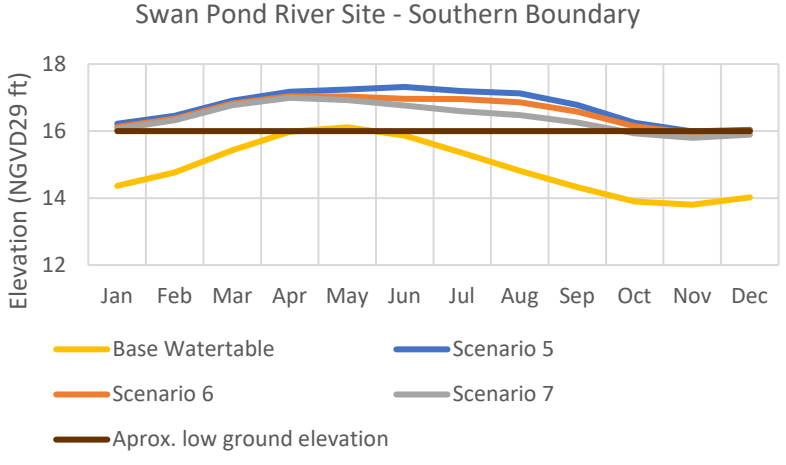
Figure 14

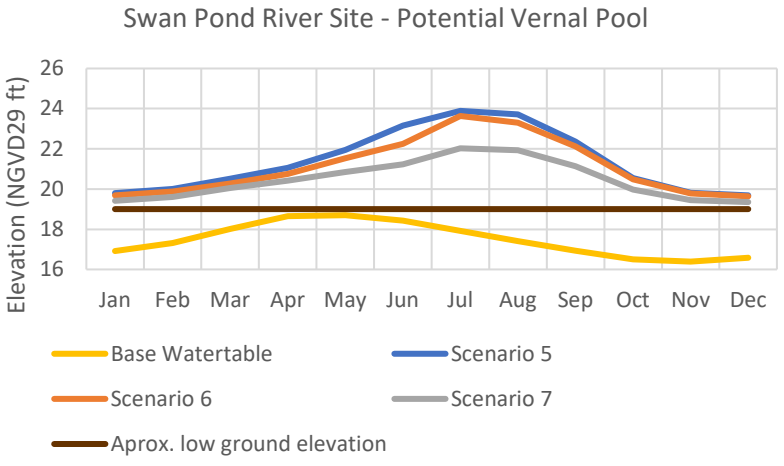
July Effluent Recharge of 1,340,000 gpd

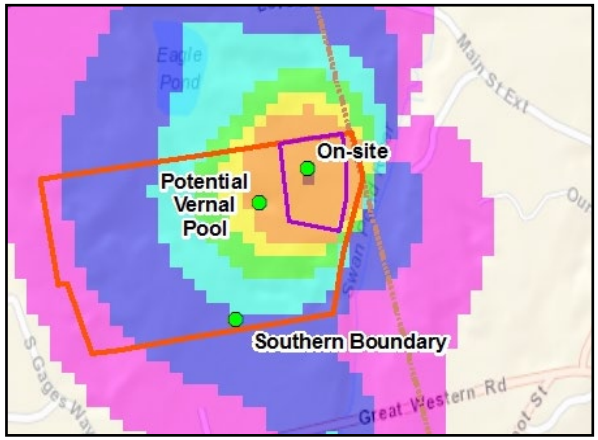
Town of Dennis, MA
Comprehensive Wastewater Management Plan

CDM Smith







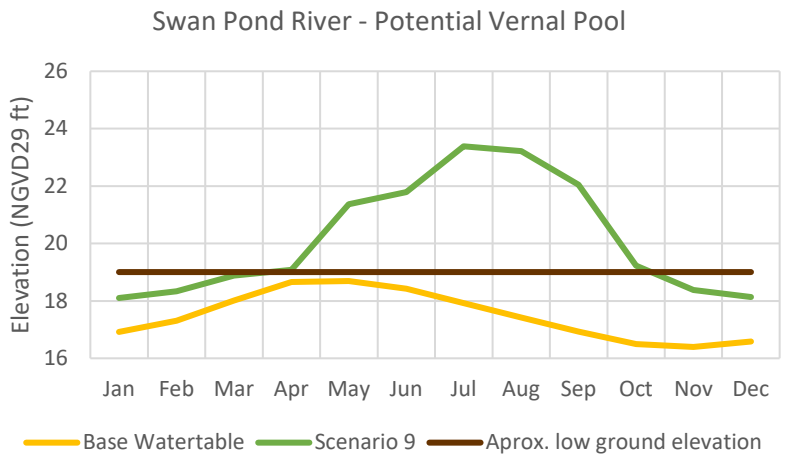


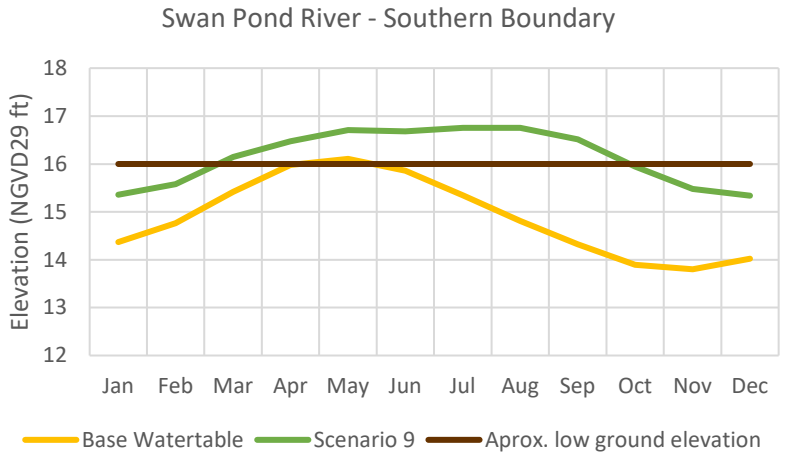
Hydrographs for Simulations 5, 6 and 7 – Swan Pond River Site

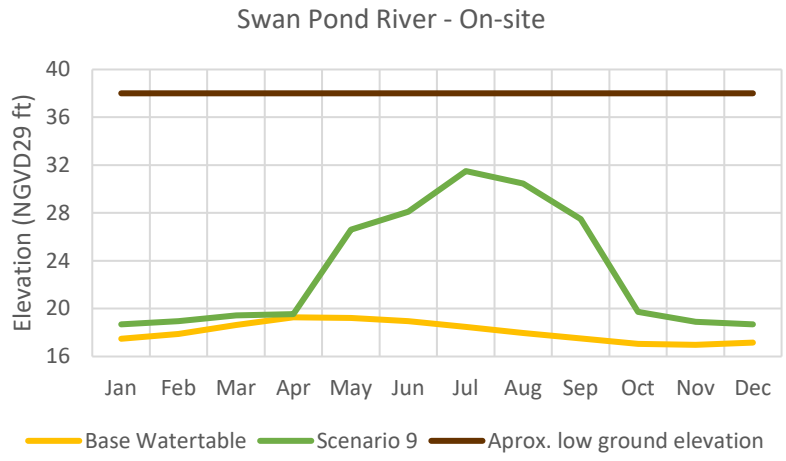
Figure 15

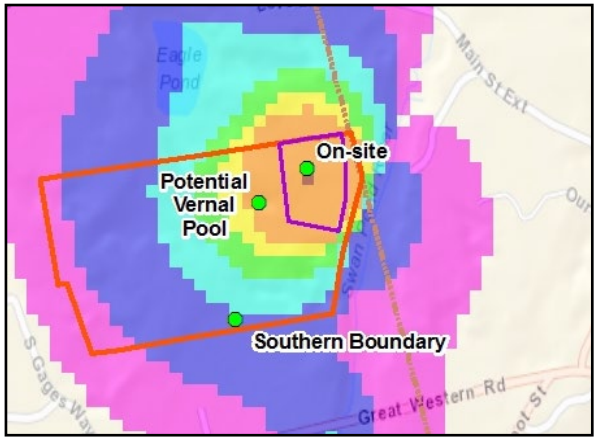
Average Effluent Recharge: 575,000 gpd
July Peak Effluent Recharge: 1,340,000 gpd

CDM Smith







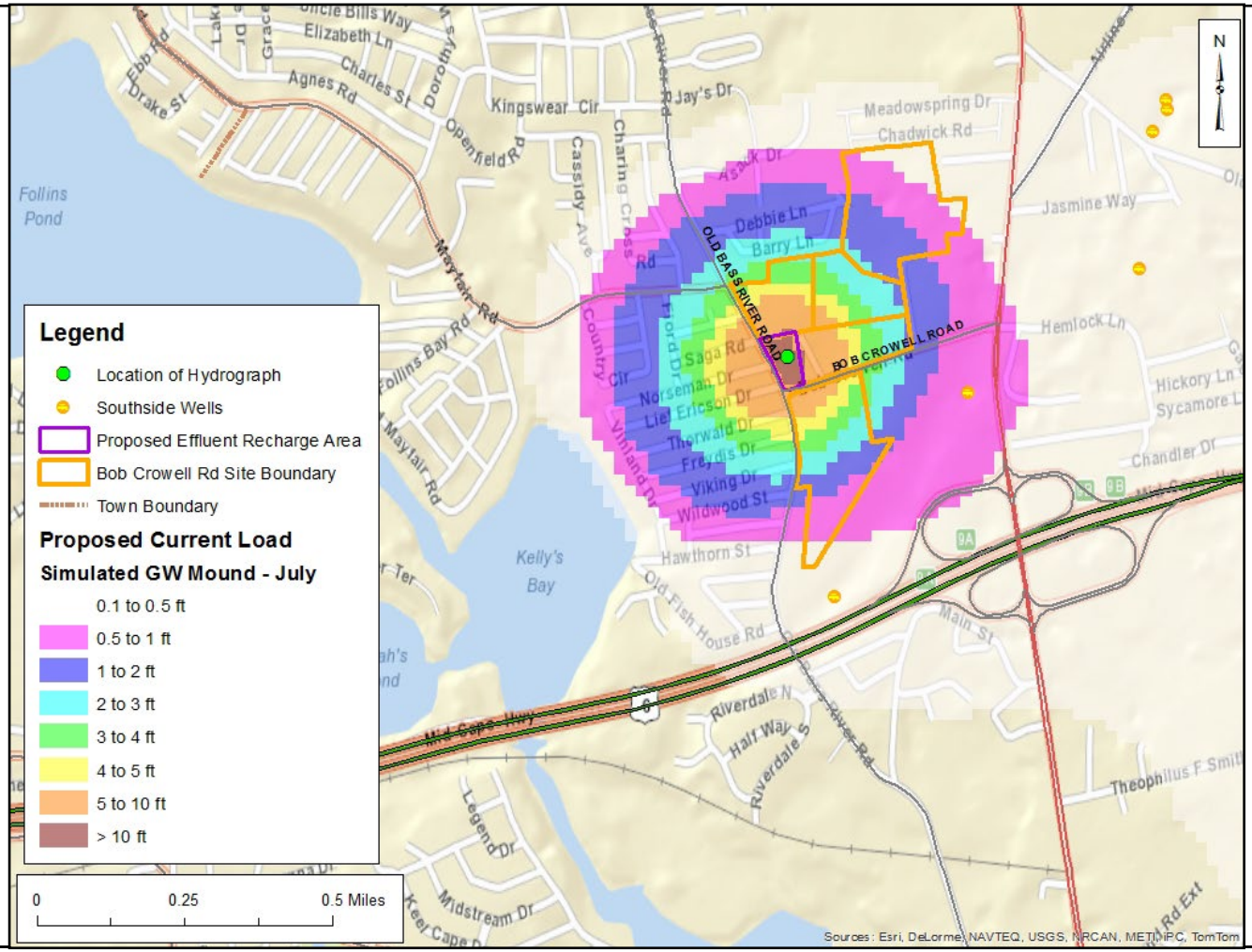


Hydrographs for Simulation 9 – Swan Pond River Site

Figure 16

Winter Effluent Recharge: 0 gpd
July Peak Effluent Recharge: 1,340,000 gpd

CDM Smith



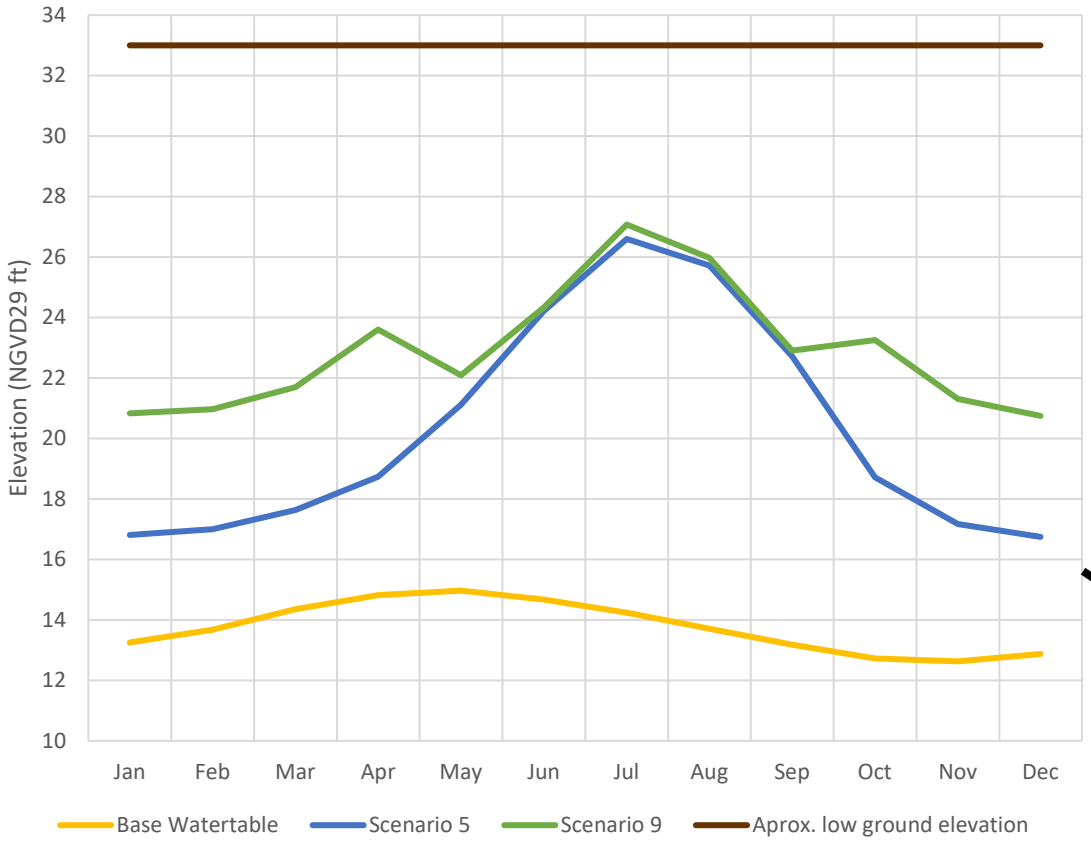
Simulated July Groundwater Mound with Hydrograph Location – Bass River Site

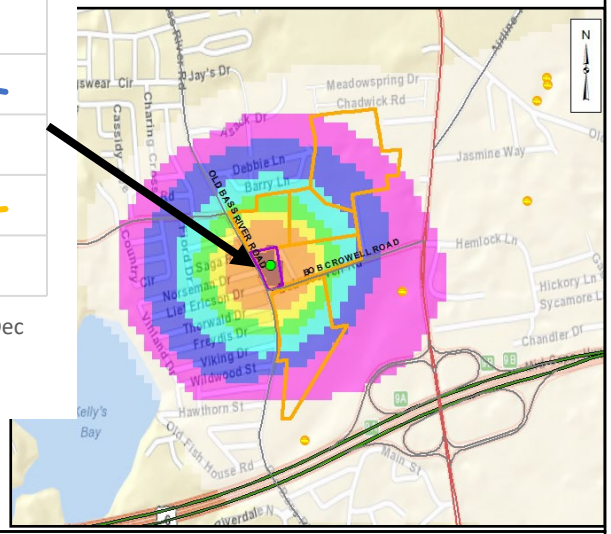
Figure 17

July Effluent Recharge of 960,000 gpd

Town of Dennis, MA
Comprehensive Wastewater Management Plan

CDM Smith



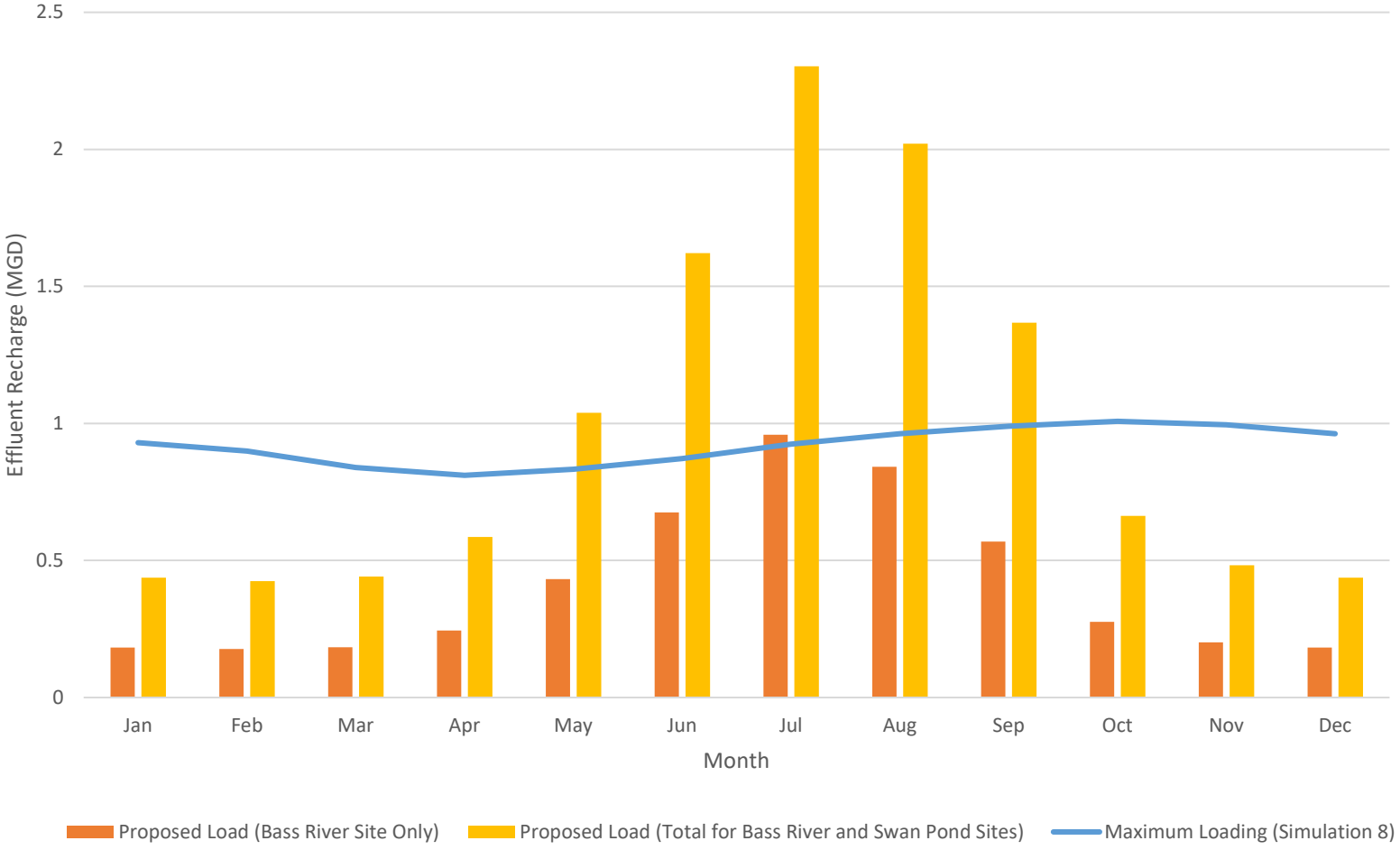


Scenario 5
Average Effluent Recharge: 410,000 gpd
July Peak Effluent Recharge: 960,000 gpd

Scenario 9
Average Effluent Recharge: 580,000 gpd
July Peak Effluent Recharge: 960,00 gpd

Hydrographs for Scenarios 5 and 9 – Bass River Site

Figure 18



Maximum Simulated Recharge Load (Bass River Site, Simulation 8) Compared to Proposed Monthly Loads

Figure 19

Appendix F

Evaluation of Additional Effluent Recharge Sites, CCC Grant Letter Report

75 State Street, Suite 701
Boston, Massachusetts 02109
tel: 617 452-6000

June 30, 2016

Ms. Diane Chamberlain, Chair
Dennis Comprehensive Wastewater Management Task Force
P.O. Box 2060 / 685 Route 134
South Dennis, MA 02660

Subject: Evaluation of Additional Effluent Recharge Sites
CCC Grant Letter Report

Dear Ms. Chamberlain:

In accordance with our Agreement dated June 3, 2016, CDM Smith has completed the Cape Cod Commission (CCC) grant-funded Evaluation of Additional Effluent Recharge Sites Project (The Project). In particular, the Project includes:

- Verifying, revising and/or expanding effluent site screening criteria used previously to identify potential sites as part of the Water Quality Evaluation and Mitigation Alternative Study Final Report completed in August 2015 (2015 Report);
- Developing a list of additional top rated sites with highest potential flow recharge capacity. The goal is to identify as a minimum, enough sites to recharge the estimated build-out flows from Scenario 7A as identified in the 2015 Report; and
- Completing an evaluation of additional top rated sites by visually reviewing each of the top sites to document surface conditions, surrounding area conditions and other unique site features; and using existing geological and soils information, develop a conceptual groundwater model for each site. The goal of the modeling is to determine order of magnitude flow potential for each site; potential groundwater mounding impacts, and to identify downgradient receptors.

This letter report includes the following sections:

- Section 1: Site Screening Criteria
- Section 2: Analysis and Results
- Section 3: Site Modeling and Recharge Potential
- Section 4: Conclusion and Next Steps
- Appendix A: Figures
- Appendix B: Tables

1.0 Site Screening Criteria

1.1 2015 Report Results

As part of the site screening evaluation completed in the 2015 Report, 10 criteria were identified to use in screening the total 15,114 parcels in Dennis. These criteria included:

1. Parcel sizes greater than three acres
2. Outside zone of contribution to a municipal well
3. Outside special flood hazard areas
4. Outside of wetlands
5. Favorable depth to groundwater
6. Permeable soils
7. Favorable development status
8. Outside priority habitat areas
9. Outside municipal wellhead protection Zone II areas
10. Town-owned property

From there, further analysis was completed, manually eliminating parcels located within cemeteries, parcels that had been very recently and substantially developed, and undeveloped parcels owned by the Dennis Water District. This process reduced the number of parcels to 166. These 166 parcels were narrowed down further through discussions with Town staff and consideration of the parcels with protected and recreational open space designation. This step in the process resulted in 10 preferred sites, three of which were carried forward to satisfy the recharge requirements for the Scenario 6A build-out flow of 1,554,000 gpd.

1.2 Additional Recharge Requirements

The Dennis Comprehensive Wastewater Management Task Force (CWMTF) selected Scenario 6A as its recommended scenario to be developed in detail in its Comprehensive Wastewater Management Plan (CWMP) because it provides for the greatest wastewater collection from all of the town's economic development planning districts, which is above and beyond the required nitrogen removal requirements. In addition, the potential community partnership scenarios with Harwich and/or Yarmouth are built around Scenario 6A.

More recently, the CWMTF was looking at opportunities to potentially expand on Scenario 6A to incorporate implementation of Scenario 7A in the long-term since additional Areas of Concern (AOCs) included in that scenario are characterized by high groundwater and very small lots even though groundwater flow from those areas discharges directly to Nantucket Sound. Scenario 7A build-out flows are estimated to be 2,146,000 gpd, requiring additional effluent recharge areas to accommodate the increased flows, approximately 592,000 gpd. In addition, a community partnership option currently being discussed with Harwich and Yarmouth is the construction of a regional wastewater treatment facility (WWTF) adjacent to Dennis' current Department of Public Works (DPW) Facilities at 120 Theophilis Smith Road. To make this option more economically viable, effluent recharge areas in close proximity to the WWTF make the most sense to reduce conveyance costs to recharge sites. Thus, additional sites to recharge flows from Yarmouth and/or Harwich in Dennis are also being identified as part of this exercise.

1.3 Revised Site Screening Criteria

The following site screening criteria were revised and/or added to the 2015 Report screening analysis to identify potential additional recharge sites:

- **Criterion No. 1 - Parcel Sizes:** In the 2015 Report, parcels less than three acres were excluded from further consideration. While it is difficult to site recharge basins on parcels smaller than three acres, aggregating adjacent smaller parcels to create larger sites could provide an opportunity to identify recharge sites in favorable locations. To evaluate this potential, parcel size was not used as an initial excluding criterion.

- **Criteria Nos. 2 and 9 - Zone of Contribution, Zone IIs, and Time of Travel:** A zone of contribution is the groundwater that regularly supplies water to a municipal drinking water supply well. Zone IIs are conservatively delineated to provide buffer space around a zone of contribution for a public drinking water well. A Zone II as defined by MassDEP is an area of an aquifer which contributes water to a well under the most severe pumping and recharge conditions that can be realistically anticipated, 180 days of pumping at safe yield with no recharge from precipitation (i.e. a drought). In the 2015 Report, parcels with any portion of their area within a zone of contribution were excluded from further consideration. This approach eliminated some large parcels, such as the Dennis Pines Golf Course and the Dennis Highland Golf Course, which have large swaths of land outside of zones of contribution, making them potentially viable sites. However, these sites are also located in Zone IIs, potentially increasing wastewater effluent treatment requirements. Based on a review of 314 CMR 5.00, the groundwater discharge permit regulations, and further discussions with MassDEP, treatment requirements become less stringent with increasing travel time to wells, and potential for no requirement for total organic carbon for travel times greater than five years. With this in mind, a travel time buffer of 10 years was estimated around each of

Dennis' drinking water wells (i.e. the time it would take for treated effluent to reach a well). Thus, in evaluating potential sites, sites were only chosen if they would not discharge to a zone of contribution and would maintain a 10-year time of travel to the nearest well, protecting the Town's drinking water supply while providing additional treated wastewater effluent recharge locations.

- **Criterion No. 4 - Outside of Wetlands:** In the 2015 Report, All parcels with wetlands were eliminated from further analysis. This criterion has been revised to only eliminate the portion of parcels in wetlands, not the entire parcel. This approach allows for identification of larger parcels that may have sizeable acreage not located within a wetland and potentially feasible for effluent recharge.

- **Criterion No. 5 - Depth to Groundwater:** Depth to groundwater is another measure of the capacity of soils to accept effluent recharge. In the 2015 Report, parcels with groundwater levels less than five feet below grade were eliminated from further analysis. This criterion has been revised to eliminate parcels with groundwater levels less than 10 feet below grade. This refined criterion, coupled with the other criteria mention above focuses the results to much more feasible sites for effluent recharge.

- **Criterion No. 7 - Favorable Development Status:** In the 2015 Report, development status was applied as a ranking criterion with undeveloped parcels given a more favorable ranking than developed parcels. This criterion has been revised in this current analysis. Rather than using development status to rank parcels in Dennis, the resulting sites were reviewed one by one through a manual elimination process, using local knowledge on individual sites. This approach allowed capture of developed parcels that still might be viable for effluent recharge.

- **Criterion No. 10 - Ownership:** In the 2015 Report, town-owned land was identified as favorable over private or other public land for effluent recharge sites. While this still remains the case, private, state, and Dennis Water District-owned parcels were also identified in this revised analysis. While these sites may prove more difficult to acquire, permit and develop for recharge, in some instances these parcels are larger in size and/or have other characteristics that make them more viable for effluent recharge. As an example, CDM Smith recently helped another client identify and purchase a privately-owned parcel to recharge up to 1,000,000 gpd. As a result, this criterion has been revised in this current analysis. Rather than using ownership to rank parcels in Dennis, the resulting sites were reviewed one by one through a manual elimination process, using local knowledge on individual sites. This approach allowed capture of non-Town-owned parcels that still might be viable for effluent recharge.

The revised criteria are shown in Figure 1 in Appendix A.

2.0 Analysis and Results

2.1 Criteria Application

The site screening analysis in Dennis was performed in ArcGIS using the overlay analysis tools "erase" and "identity" within ArcToolbox. These tools are used to remove or erase areas such as flood plains, and to identify parcel areas that intersect layers that do not require complete removal from the site screening analysis.

Wetlands, zones of contribution, groundwater depths, and 100-year FEMA flood zones were used as exclusion criteria. If one of these layers falls on a site, that portion of the site was erased from the parcel layer and excluded from consideration for effluent recharge. Portions of the sites that fall outside of the erased layer remain for consideration for effluent recharge. The following criterion were used as exclusion criteria:

- Zone of Contribution (Data Source: UMass Dartmouth School for Marine Science and Technology (SMAST))
- Wetlands (Data Source: MassDEP)
- Groundwater Depth <10 ft (Data Source: Cape Cod Commission groundwater elevation data combined with LiDAR ground surface elevation data)
- 100 year FEMA Flood Zone (Data Source: FEMA)

After applying the exclusion criteria listed above, the initial screening reduced the total 15,114 parcels in Dennis to 125 potential sites. These sites are shown on Figure 1 and are listed in Table 1.

Supplemental criteria were then applied to the 125 remaining sites in order to determine which sites should be further analyzed and modeled for effluent recharge capacity. The identity approach was used in GIS in order to categorize which of these layers below intersected the remaining 125 parcels.

- Permeable Soils (Data Source: Natural Resources Conservation Service (NRCS) Soil Survey Geographic Database (SSURGO))
- Natural Heritage & Endangered Species (NHESP) (Data Source: MassGIS)
- Zone II (Data Source: MassDEP)
- Open Space Conservation (Data Source: Massachusetts Executive Office of Energy and Environmental Affairs)

- Ten Year Time of Travel (Data Source: CDM Smith)
- Ownership (Data Source: Town of Dennis)
- Parcel Size (Data Source: Town of Dennis)

Following this initial screening step, more investigation was necessary to ensure all reasonable locations were considered for further assessment. Isolated parcels of limited size were looked at unfavorably. Sites that had been very recently and substantially developed were eliminated. Sites with permeable soils were looked at more favorable, while sites within priority habitat areas and/or protected and recreational open space were deemed unfavorable. Larger sites, or adjacent smaller sites taken together to form a large site were viewed favorably. Town-owned parcels were also viewed more favorably. Table 1 shows the criteria analysis for each of the sites as well as the estimated acreage available for effluent recharge for all listed parcels.

2.2 Recommended Sites

Based on the criteria met in Table 1, review of site aerial photography, and discussions with Town staff, the following sites were recommended for conceptual groundwater modeling to determine each site's potential effluent recharge capacity:

- **Site No. 1 – S59:** Dennis Effluent Recharge Site 1 recommended in the Dennis Water Quality Evaluation and Mitigation Alternative Study Final Report (August 2015). This is located on the same parcel as the proposed Dennis Wastewater Treatment Facility (WWTF).
- **Site No. 2 – S125:** Dennis Effluent Recharge Site 2 recommended in the Dennis Water Quality Evaluation and Mitigation Alternative Study Final Report (August 2015). This is located approximately 2 miles from the proposed location of the Dennis WWTF.
- **Site No. 3 - S92:** Located north of Setucket Road, west of Greenland Circle and east of Route 134 (East-West Dennis Road), the northern section of the Dennis Pines Golf Course consists of 117.6 acres. It is located approximately 3 miles from the proposed location of the Dennis WWTF. While the town is proposing development of some of these parcels, subsurface leaching may be viable on portions of the site.
- **Site No. 4N/S - S39, S43, S6, S95, and S98:** Located north and south of Hokum Rock Road between Paddocks Path and Fox Run Circle, these four town-owned parcels and one privately-owned parcel are adjacent to one another and together total 45.5 acres. It is located approximately 3.5 miles from the proposed location of the Dennis WWTF.

- **Site No. 5 - S97:** Located south of Old Bass River Road and west of Ronda Lane, the northern section of the Dennis Highland Golf Course consists of 118 acres. It is located approximately 4 miles from the proposed location of the Dennis WWTF.
- **Site No. 6 - S62, S117 and S71:** Located in or adjacent to the Cape Cod Rail Trail right-of-way, these parcels are state or federally-owned. Combined these parcels total 25.8 acres and the proposed length spans approximately 2 miles. The site is located approximately between 0.5 miles at the closest point to 1.5 miles at the furthest point from the proposed location of the Dennis WWTF.
- **Site No. 7 - S112, S106, and S115:** Located south of Old Chatham Road, North of Route 6 and just west of Atlantic Avenue, these three private parcels consist of 24.3 acres. The site is located approximately 1 mile from the proposed location of the Dennis WWTF.
- **Site No. 8 - S50:** Located west of Route 134 and south of Old Chatham Road, the western, unused portion of Oak Ridge Cemetery consists of approximately 31 acres. It is located approximately 1.5 miles from the proposed location of the Dennis WWTF.

3.0 Site Modeling and Recharge Potential

As part of this Evaluation of Additional Effluent Recharge Sites and in support of the development of the Dennis CWMP, effluent recharge at seven potential sites was modeled using the USGS Monomoy Flow Lens groundwater model, which includes the towns of Dennis, Harwich, Chatham, Brewster and parts of Orleans. This groundwater model was developed in the 1990s and early 2000s and was used to delineate groundwater contribution areas to embayments as part of the Massachusetts Estuaries Project (MEP). The model was created in MODFLOW, a finite-difference groundwater model code developed by the USGS and widely used for groundwater modeling applications. The simulated groundwater elevations generated by the model represent steady-state 2003 pumping and recharge conditions. Model documentation is provided in the USGS report *Simulated Water Sources and Effects of Pumping on Surface and Ground Water, Sagamore and Monomoy Flow Lenses, Cape Cod, Massachusetts* (SIR 2004-5181).

Model Updates

For this site-specific application, the model grid discretization was increased at the potential sites. Grid spacing was changed from 400 foot by 400 foot cells to 100 foot by 100 foot cells at the recharge sites to represent the recharge areas in greater detail.

No changes were made to stream stage or streamflow, hydrogeologic properties, applied rainfall recharge or pumping withdrawals as information was not readily available. While long-term average precipitation has not likely changed since 2003, pumping values may have increased,

decreased or been shifted within the vicinity of the water withdrawal locations. Therefore, CDM Smith verified the model calibration using average regional water level data from 2000 to 2015 available from the USGS NWIS database.

Geology overview

A cross-section through Dennis is provided in HA-692 (*Ground-water Resources of Cape Cod, Massachusetts, LeBlanc, et.al., 1986*) shown in Figure 3. The cross-section runs from Swan Pond in the south to Sargo Lake and Cape Cod Bay in the north. The aquifer consists of unconsolidated sediments deposited by glaciers and can be several hundred feet thick. Layers of fine silt and clay is interbedded with areas of sand and gravel. Public water supply wells in Dennis are generally located in the sand and gravels in the northern portion of Dennis.

Boring data obtained from a file review conducted in the Mass DEP Lakeville office on February 3, 2016 indicates the presences of clay in borings along the rail trail starting at depths of 20 to 35 feet below ground surface.

Recharge simulations

For this screening, seven sites were identified and an initial assessment of the recharge capacity determined using the MODFLOW groundwater flow model. For each site, the groundwater elevation beneath the site was set to five feet below the lowest estimated ground surface elevation. The MODFLOW code calculated the additional flux required to maintain the head at this location. MODPATH was used to determine the flow path and time of travel for water applied at the recharge sites and contributing areas for water supply wells.

Applied flux at locations near water supply wells is large enough to substantially change the size and orientation of the contributing areas to the public water supply wells. Even though flow was applied to locations which are outside of the 5-year time of travel based on estimated 2003 pumping rates, in some instances the change in groundwater flow velocity and direction resulted in travel to supply wells of less than five years.

Model simulations were completed to assess groundwater recharge scenarios developed for this evaluation. Recharge simulations were conducted to evaluate the total available recharge capacity of the seven sites. Results of this assessment are shown in Table 2.

Groundwater modeling at Site Nos. 1 and 2 (adjacent to the landfill and near the former DPW facility, respectively) completed as part of the August 2015 Report addressed the potential impact of groundwater mounding on vernal pools. However, this current analysis focuses on sites with groundwater levels less than 10 feet below grade, as compared to the August 2015 report, which looked at sites with groundwater levels less than 5 feet below grade. Most vernal pools do not get much deeper than five feet, thus it is not anticipated that vernal pool will be impacted in this

current conceptual level analysis. However as noted in the analysis of Site Nos. 1 and 2, more detailed site specific data on site elevations, the presence or absence of vernal pools, the installation of borings, and groundwater level sampling will be necessary on all recharge sites as part of a future hydrogeologic report and groundwater discharge permit application process. Recharge capacity from previous investigations of Site Nos. 1 and 2 are also shown in Table 2.

Based on initial review, Sites 3 and 5 were re-simulated with a flux of 4 million gallons per day (mgd) applied to northern portion of each golf courses. The flux was applied at depth of the existing water table. The north sections were targeted to that projected groundwater flow would travel to the north to either Chase Garden Creek or Sesuit Harbor watersheds, instead of south to Bass River watershed. Additional effluent flow into the Bass River watershed would require additional sewering in that watershed to meet nitrogen removal requirements. Also Site 4S and 4S were simulated together to determine a combined capacity due to their proximity to one another and being mostly town owned parcels.

Following review of the results from the 2nd model run at Sites 3 and 5, it was determined that the mounding potential was in excess of 1.5 feet at Scargo Lake. The model was rerun a 3rd time assuming a maximum mounding potential at Scargo Lake is 0.5 feet. Due to the proximity of Site 4 to Sites 3 and 5, this site was also rerun under the same scenario The results of this analysis can also be seen in Table 2.

Newly identified sites 3, 4, and 5 were prioritized as acceptable effluent recharge sites based on projected mounding, time of travel to nearby drinking water wells, subsurface soil characteristics and available recharge capacity. It is likely that Site 5 could receive a larger volume of effluent recharge due to its proximity to Scargo Lake, which has a stream that drains it but this assumption needs further investigation. The recharge potential at Site 6 is higher than the other prioritized sites but due to the known presence of clays in that area and the potential for flooding of basements, this site is less feasible. A lower flow may be able to be applied at this location upon further analysis.

The simulated increase in groundwater table elevation, or mounding, due to effluent recharge scenarios listed above, is shown in Figures 4 through 7 (corresponding to prioritized sites 3 through 6) as blue contours. The impact of water table mounding is typically evaluated by plotting the “separation distance”, or “depth-to-water” between the simulated water level with effluent loading and the ground surface. MassDEP requires a minimum vertical separation distance of 4 feet between seasonal high groundwater, with effluent recharge, and the ground surface, a standard requirement of Title 5 systems that MassDEP typically applies to all wastewater discharges to groundwater, regardless of the quality of the treated wastewater effluent. This vertical separation will be evaluated in more detail during a future phase of the project.

The magenta lines show the simulated paths for particles released at the effluent recharge site. Particle tracks, or paths, were created using MODPATH and represent the path a particle would follow based on the simulated flow field. For this simulation, particles were released at the water table at the boundary of the recharge area. The path lines from these particles indicate where effluent recharged at the site will flow and identify the final discharge location of the recharged water or downgradient receptor.

4.0 Conclusion and Next Steps

The following recommendation were made based on the limitations and outcomes of this assessment:

- The USGS model was calibrated to regional steady-state conditions based on 2003 pumping and recharge data for use in regional groundwater flow assessment. The model should be updated with recent pumping data and the proposed recharge scenarios should be tested under possible future pumping conditions including maximum pumping rates, particularly for sites located upgradient of public water supply wells. Pumping rates can have a significant impact on time of travel estimates for recharged water to reach the public water supply wells.

- Subsurface data for much of the model is limited and future field investigations including borings and well installations will be needed to fully assess these sites. Data from irrigation wells, tests wells and public water supply wells including boring logs, pump tests, and slug tests be obtained. Based on the review of data, the model should be updated and the model calibration revised.

- Inclusion of stratigraphic data and stream elevation data should be included in future model updates and calibration for the disposal scenario along the railway path. Based on previous site screening conducted in January 2016, it is suspected that the model simulated water levels are low in the Swan Pond Area.

Previously identified Site Nos. 1 and 2 remain the recommended sites for effluent recharge of scenario 6A. The additional sites identified above serve as potential alternatives for the remaining areas of concern (AOCs) within the town as well as potential recharge locations for effluent in scenario 7A.

Additionally, the other prioritized sites could serve as effluent recharge sites for the community partnership scenarios, should a community WWTF be built in the town of Dennis, and effluent recharge locations closer to the WWTF are desired.

Please do not hesitate to contact me at 617-452-6544 if you have any questions.

Very truly yours,

David F. Young, P.E.
Vice President
CDM Smith Inc.

CC: Rick White, Town Administrator
Liz Sullivan, Assistant Town Administrator
Terry Hayes, Health Director
Dan Fortier, Town Planner
Tom Andrade, Town Engineer
Ed Sanderson, CDM Smith

Appendix A

Figures

Figure 1
Effluent Recharge Site Screening
Dennis, MA - June 2016

Legend

- Parcels Remaining After Screening Criteria
- Ten Year Time of Travel
- Zone of Contribution
- Depth to Groundwater < 10ft
- Zone II
- State Owned Parcels
- Town Owned Parcels
- Dennis Water District Parcels

Protected and Recreational Open Space

- Cape Cod Land Bank
- Conservation
- Historical Cultural
- Recreation
- Recreation and Conservation
- Water Supply Protection

Areas Removed from Effluent Recharge Analysis: Zone of Contribution, Wetlands, Groundwater Depth < 10ft, and 100 year FEMA Flood Zone

Labels for Parcels (Site ID, Acres available under criteria, number of hindrance criteria intersecting parcel)

0 0.5 Miles

N

CDM Smith

Site 4N
11 ac

Site 4S
34.5 ac

Site 3
90.4 ac

Site 5
94.4 ac

Site 8
31 ac

Site 2
72.7 ac

Site 7
24.3 ac

Site 1
95.4 ac

Site 6
6.9 ac

Site 6
5.5 ac

Site 6
13.4 ac

Figure 2
Sites Selected for Effluent Recharge Modeling
Dennis, MA - June 2016

Legend

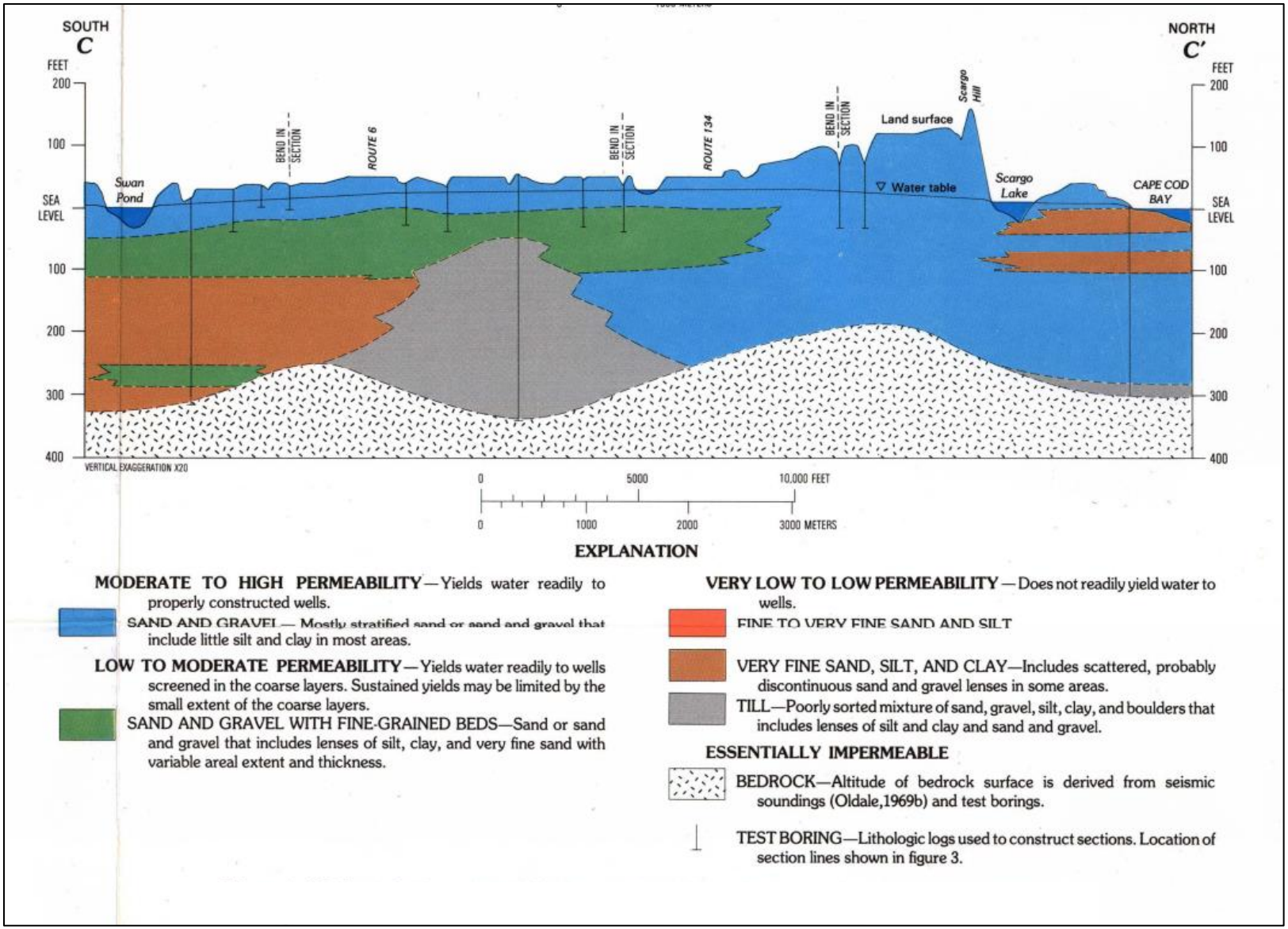
Prioritized Sites

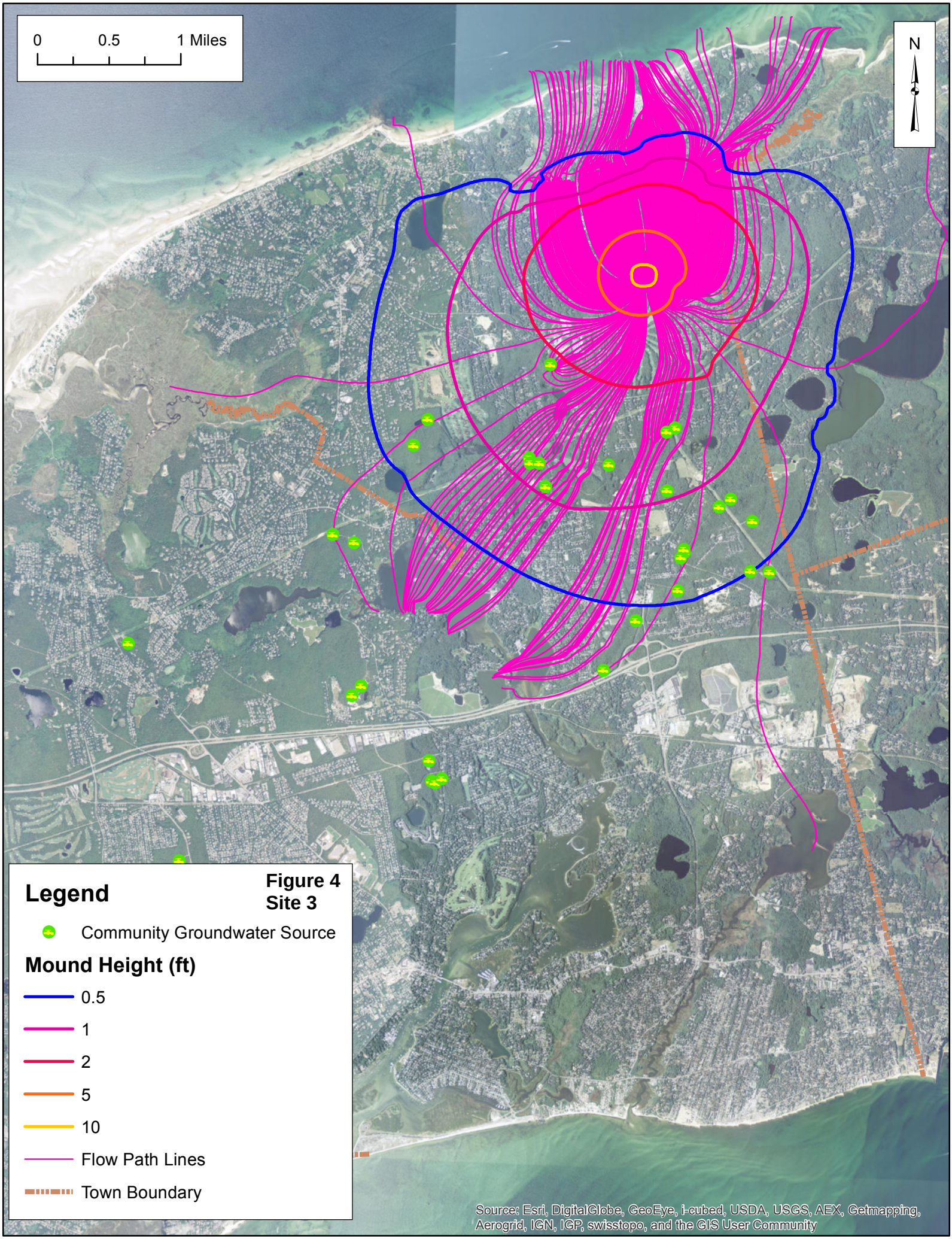
0 0.5 Miles

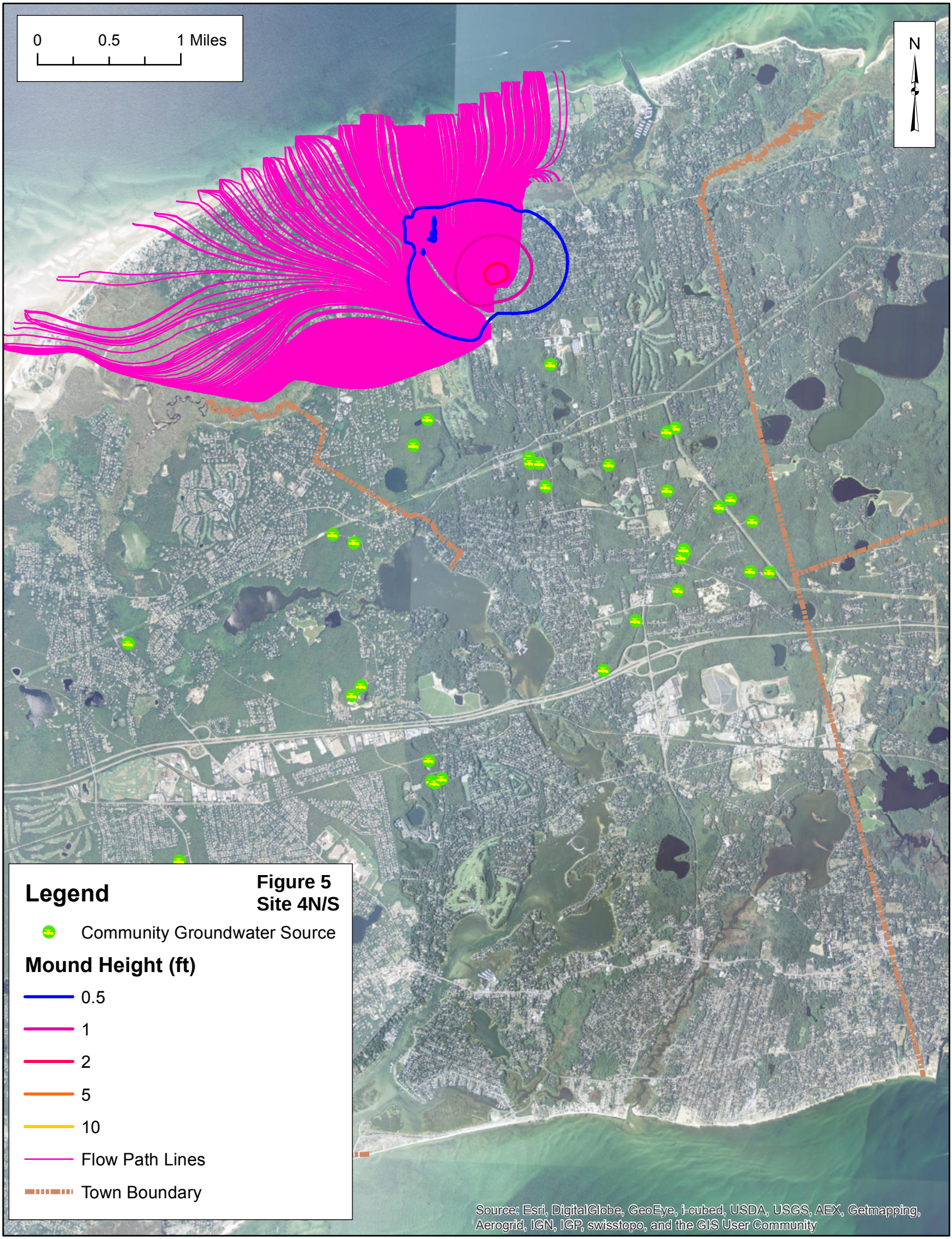
N

CDM Smith

Figure 3 – Hydrogeologic sections of the inner and mid-Cape showing typical variation in lithology (LeBlanc, et.al., 1986)




0
0.5
1 Miles
N
Legend
Figure 4
Site 3
Community Groundwater Source
Mound Height (ft)
0.5
1
2
5
10
Flow Path Lines
Town Boundary
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community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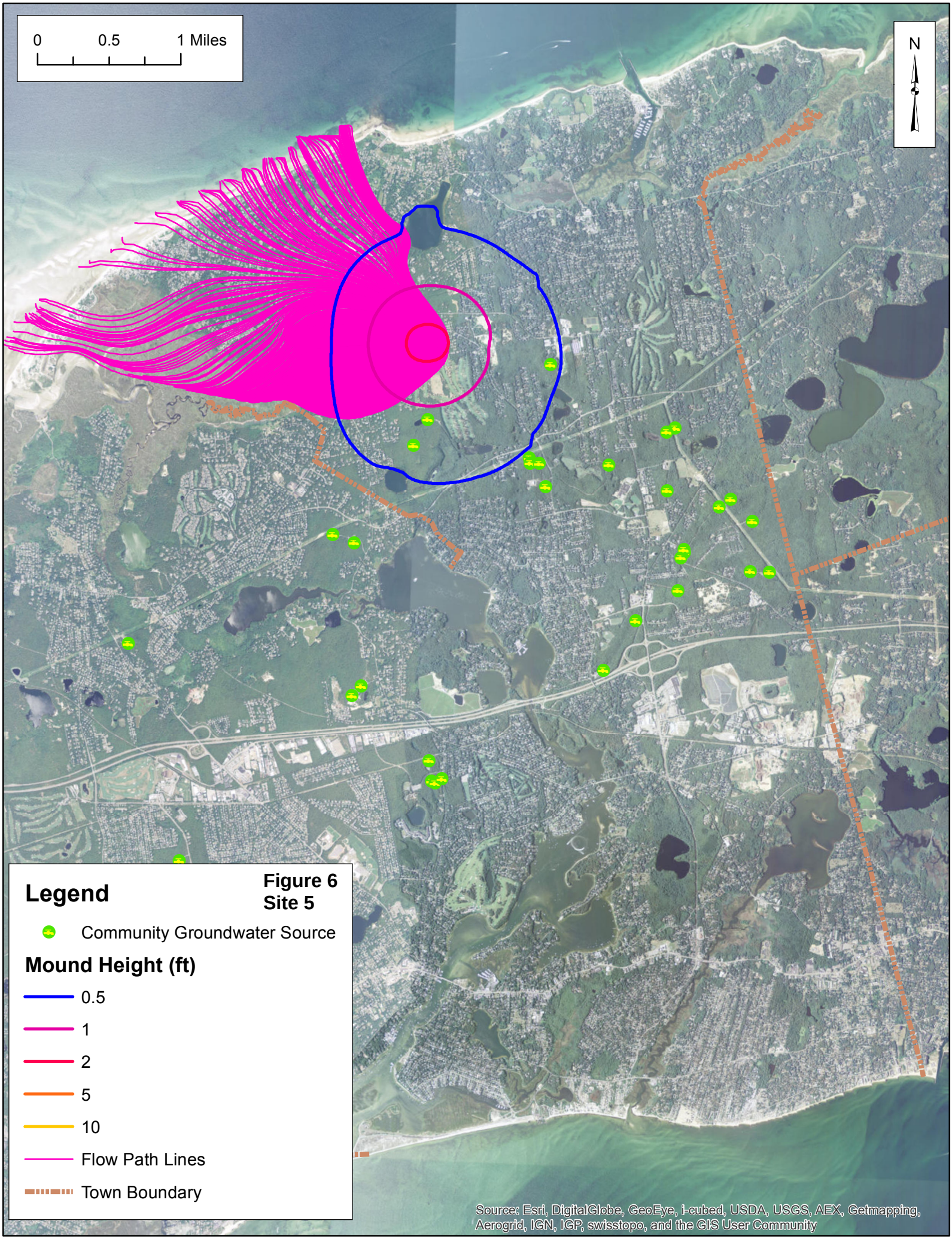
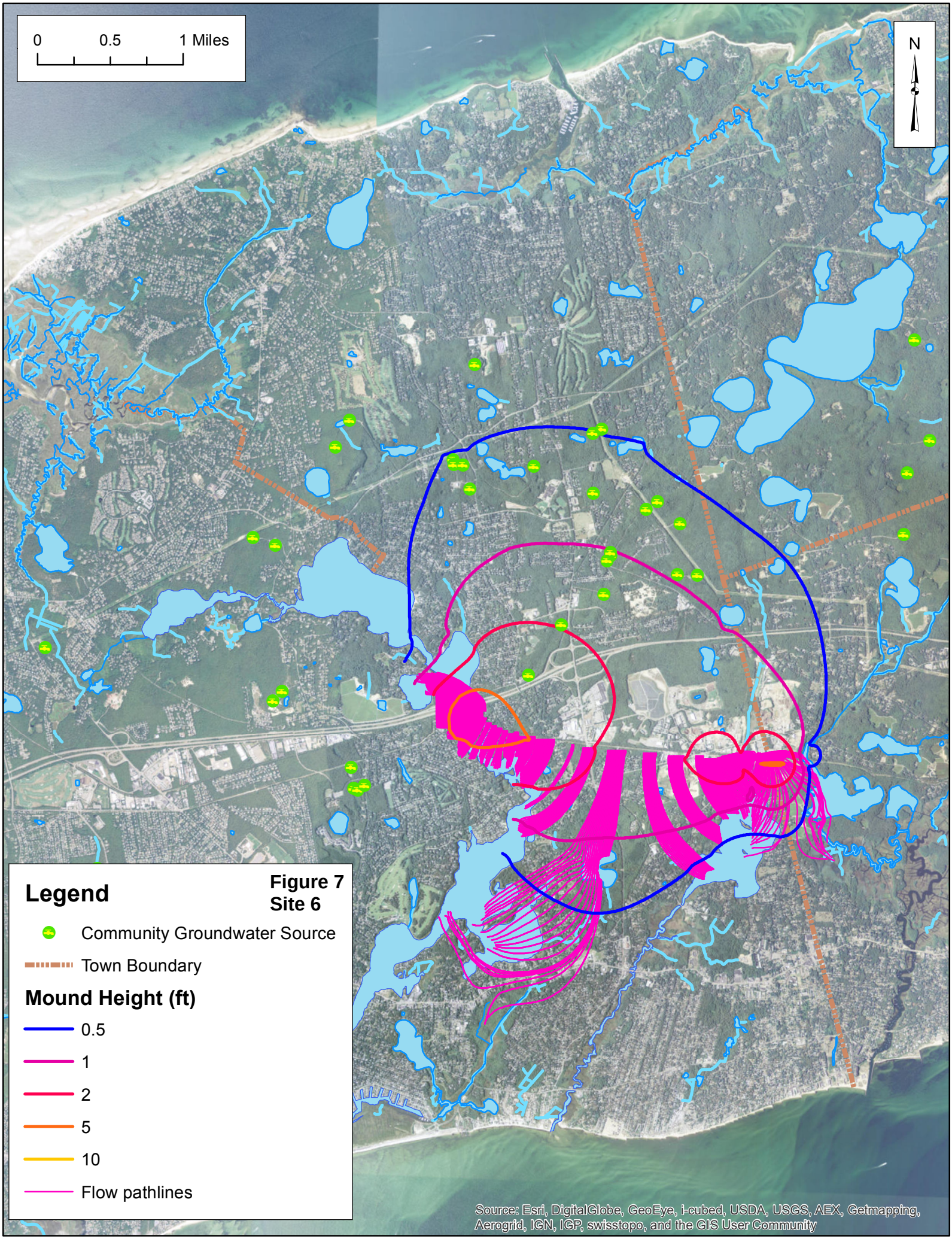
1 Miles
N
Legend
Figure 5
Site 4N/S
Community Groundwater Source
Mound Height (ft)
0.5
1
2
5
10
Flow Path Lines
Town Boundary
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community


0
0.5
1 Miles
N
Legend
Figure 6
Site 5
Community Groundwater Source
Mound Height (ft)
0.5
1
2
5
10
Flow Path Lines
Town Boundary
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community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1 Miles
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Legend
Figure 7
Site 6
Community Groundwater Source
Town Boundary
Mound Height (ft)
0.5
1
2
5
10
Flow pathlines
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Appendix B

Tables

Table 1
Preliminary Effluent Recharge Site Screening Criteria Analysis
Dennis, Massachusetts

Site ID	Parcel ID	Address	OWNER	Whole Parcel Acres	Permeable Soils	NHESP	ZoneII	Open Space Conservation	Ten Year Time of Travel	Criteria Sum	Available Acres
S1	418-1	187 BRIDGE STREET ED	J R FENNELL REALTY TRUST OF	4.96	1	0	0		0	1	4.37
S2	377-9	1447 ROUTE 6A ED	GOODE JAMES R ET UX	4.22	0	0	0		0	0	2.25
S3	349-6	46 OFF WHIG STREET DE	PERKINS ALICE B ET AL	4.38	0	0	0		0	0	3.59
S4	330-13	601 ROUTE 6A DE	PARK JAMES ET AL	5.72	0	0	0		0	0	2.68
S5	333-71	0 OFF HOKUM ROCK ROAD DE	NYBERG PETER J	3.95	1	0	0		0	1	3.95
S6	310-13	350 PADDOCKS PATH ED	TOWN OF DENNIS	13.20	1	0	1		0	2	13.20
S7	303-18	147 NEW BOSTON ROAD DE	TOWN OF DENNIS	9.02	0	0	0	Conservation	0	0	1.44
S8	257-21	0 OPEN SPACE VILLAGE GREEN DE	BETTERWOOD HOMES INC	10.29	0	0	1		0	1	10.29
S9	260-38	615 OLD BASS RIVER ROAD DE	GAGNON GEORGE C JR	10.54	0	1	1	Conservation	0	2	5.93
S10	236-7	0 WOODLAND ED	SEARS NORMAN E JR ET ALI	5.51	0	1	1		0	2	5.13
S11	231-55	12 DOTTIES PATH ED ED	LM/DM CONNORS FAMILY TRUST	10.18	0	1	1	Conservation	1	3	3.88
S12	267-3	0 WOODLAND BAKERS POND ED	R T J REALTY TRUST	3.18	0	1	1		0	2	2.55
S13	229-43	0 HOWES PATH DE	NYBERG PETER J	4.51	0	1	1		0	2	1.43
S14	230-3	244 SETUCKET ROAD DE	TOWN OF DENNIS	3.93	0	1	1	Cape Cod Land Bank	0	2	3.08
S15	225-93	0 NEAR FLAX POND DE	PINE TREE TRUST	8.45	1	0	1		1	3	3.96
S16				3.21	0	0	1		0	1	3.21
S17	208-5	37 SOUTH YARMOUTH ROAD DE	ROBERT DIANE	11.02	0	0	1		1	2	3.44
S18	211-17	73 SETUCKET ROAD SD	RAGOSA MARY MARGARET ET ALI	3.04	0	0	1		0	1	3.04
S19				7.44	0	0	0		0	0	4.75
S20	201-46	354 OPEN SPACE SD	TUCKER ESTATES HOMEOWNERS	8.14	0	0	1		0	1	8.14
S21	177-65	86 GAGES WAY SD	BEACH PLUM REALTY TRUST	4.72	0	0	1		0	1	3.10
S22	179-8	513 OLD CHATHAM ROAD SD	NICKERSON EDMOND RHODES ET ALI	9.98	0	0	1		0	1	9.98
S23	167-10	0 LAND NEAR EAGLE POND SD SD	FISHER ROBERT M	3.79	0	0	0		0	0	3.62
S24	168-2	0 EAGLE POND SD SD	VENTAS REALTY LIMITED PARTN	6.91	0	1	0		0	1	4.84
S25	167-1	0 WOODLAND SD	GORHAM JUDITH M ET AL	3.96	1	0	0		0	1	3.69
S26	164-10	41 BUSINESS PARK DRIVE SD	CHAMBERLAIN CHARLES JR ET ALI	3.20	0	1	1		0	2	3.19
S27	146-10	292 GREAT WESTERN ROAD SD	INDUSTRIAL PARK TRUST	3.98	0	1	0		0	1	0.44
S28	145-24	266 GREAT WESTERN ROAD SD	DENNIS GREAT WESTERN ROAD LLC	3.61	1	1	0		0	2	2.15
S29	141-37	10 COMMERCE STREET SD	CHAMBERLAIN CHARLES JR ET ALI	3.21	0	1	0		0	1	3.21
S30	144-2	207 GREAT WESTERN ROAD SD	JOBENS LLC	4.11	0	1	0		0	1	1.60
S31	120-6	222 UPPER COUNTY ROAD SD	OLOUGHLIN FAMILY REALTY TRUST	3.47	0	0	0		0	0	3.01
S32	121-5	328 CENTER STREET SD	POWERS TRUST	3.36	0	0	0		0	0	3.35
S33	79-33	105 COVE ROAD WD	STEIN RICHARD ET UX	4.54	0	0	0		0	0	3.24
S34	406-1	102 SESUIT NECK ROAD ED	DEERWILD REALTY TRUST	42.61	1	0	0	Conservation	0	1	23.79
S35	414-18	0 SOUTH STREET ED	TOWN OF DENNIS	9.86	0	1	0	Conservation	0	1	7.99
S36	409-47	254 SESUIT NECK ROAD ED	CROWELL BETH K	7.24	1	0	0		0	1	3.50
S37	373-6	51 PADDOCKS PATH DE	MIRANDE HOLL TRUST - 2005	11.57	0	1	0		0	1	4.16
S38	361-27	0 MAIN STREET ED	TOWN OF DENNIS	26.10	1	0	1	Conservation	0	2	25.17
S39	335-106	140 KING JAMES DRIVE ED	TOWN OF DENNIS	6.74	1	0	0		0	1	6.73
S40	414-27			4.42	1	1	0	Conservation	0	2	4.02
S41				3.68	0	0	0		0	0	1.22
S42	325-23	177 BEACH STREET DE	CICCHETTI ROBERT	3.57	0	0	0		0	0	3.21
S43	335-107	0 HOKUM ROCK ROAD ED	TOWN OF DENNIS	4.26	1	0	0		0	1	4.26

Table 1 (Cont'd)
Preliminary Effluent Recharge Site Screening Criteria Analysis
Dennis, Massachusetts

Site ID	Parcel ID	Address	OWNER	Whole Parcel Acres	Permeable Soils	NHESP	ZoneII	Open Space Conservation	Ten Year Time of Travel	Criteria Sum	Available Acres
S44	333-55	0 OPEN SPACE DE	NYBERG PETER J	5.14	1	0	0		0	1	5.14
S45	333-72-0	0 OFF HOKUM ROCK ROAD DE	OWNERS UNKNOWN	3.38	1	0	0		0	1	3.38
S46	332-29	68 HOKUM ROCK ROAD DE	COMMONWEALTH OF MASS	4.08	1	0	0	Recreation and Conservation	0	1	4.08
S47	314-47	1201 ROUTE 134 ED	SPEAR STEPHEN G	16.80	0	0	1	Conservation	0	1	16.80
S48	232-54	369 MARTIN ROAD ED	NYBERG PETER J	7.18	0	0	1		1	2	5.44
S49	203-23	812 ROUTE 134 ED	TOWN OF DENNIS	13.04	0	0	1	Cape Cod Land Bank	1	2	5.88
S50	202-1	815 ROUTE 134 SD	TOWN OF DENNIS	49.95	0	0	1	Historical Cultural	0	1	49.21
S51	191-4	0 OFF OLD CHATHAM ROAD SD SD	TOWN OF DENNIS	6.35	0	0	1	Conservation	0	1	6.33
S52	179-5	0 CYPRUS ROAD SD	TOWN OF DENNIS	5.48	0	0	1	Conservation	0	1	5.48
S53	165-4	0 GAGES WAY SD	FISHER ROBERT M	6.55	0	1	1		0	2	6.55
S54	165-8	70 BUSINESS PARK DRIVE SD	CHAMBERLAIN CHARLES E JR	12.31	0	1	1		0	2	12.23
S55	168-7	0 LAND IN DENNIS SD	BARBOUR JODIE M ET ALI	7.11	0	1	0		0	1	5.80
S56	168-1	0 WOODLAND SD	CONNORS JOHN M JR	4.97	0	0	0		0	0	4.90
S57	166-10	0 GAGES ROAD SD	LEBEL DOUGLAS W	4.15	0	1	0		0	1	4.15
S58	167-4	0 BASSET POND ROAD SD	SOUTHPOINTS DENNIS REALTY TR	6.28	0	0	0		0	0	6.28
S59	165-1	120 THEOPHILUS F SMITH ROAD SD	TOWN OF DENNIS	148.49	1	1	1		1	4	117.26
S60	167-2	0 WOODLAND SD	D V M NOMINEE TRUST	8.56	0	0	0		0	0	8.41
S61	157-2	0 WOOD & SWAMPLAND SD SD	HAMLIN RICHARD A	8.47	1	1	0		0	2	1.58
S62	148-10	0 PARKING AREA RTE 6 SD SD	COMMONWEALTH OF MASS	8.14	0	1	0		0	1	6.90
S63				4.42	0	0	0		0	0	3.98
S64				5.03	0	0	1		0	1	3.24
S65				9.42	0	0	1		0	1	9.42
S66	167-8			4.96	0	1	0		0	1	4.96
S67				3.26	0	1	0		0	1	3.26
S68				5.31	0	0	0		0	0	5.31
S69	144-10	200 GREAT WESTERN ROAD SD	GREAT WESTERN LLC	9.77	0	0	0		1	1	6.83
S70	141-38	20 COMMERCE STREET SD	CHAMBERLAIN CHARLES JR ET ALI	6.05	0	1	0		0	1	6.05
S71	141-35	0 RAIL TRAIL SD	COMMONWEALTH OF MASS	13.93	1	1	0	Recreation	1	3	13.41
S72	142-35	31 TRINITY DRIVE SD	GREAT MEADWS HMOWNERS ASSOC IN	3.31	0	1	0		0	1	3.31
S73	140-4	0 PAR A OFF ROUTE 134 SD	NICKERSON EDMOND R ET ALI	4.07	0	1	0		0	1	4.07
S74	132-21	0 OPEN SPACE SCALLOP DRIVE SD	DAVENPORT REALTY TRUST	5.46	0	1	0		0	1	5.16
S75	118-15	0 OFF MAIN ST SD SD	MASS AUDOBON SOCIETY	6.80	1	0	0	Conservation	0	1	2.80
S76	106-14	80 SHORT NECK SD SD	TOWN OF DENNIS	15.29	0	0	0	Conservation	0	0	5.60
S77	89-28	187 UPPER COUNTY ROAD DP	R C BISHOP FALL RIVER	4.30	0	0	0		0	0	0.88
S78	423-7	80 COLES POND ROAD ED	SEARS NORMAN E JR ET UX	19.27	1	0	0		0	1	12.55
S79	423-38	79 COLES POND ROAD ED	COLES POND ROAD LLC	5.20	1	0	0		0	1	3.96
S80	423-5	23 FARRINGTON ROAD ED	CRONIN BASIL F JR ET ALI	5.83	1	0	0		0	1	5.53
S81	426-3	0 COLES POND AREA ED ED	TOWN OF DENNIS	17.41	1	1	0	Conservation	0	2	11.83
S82	423-36	52 COLES POND DRIVE ED	COLES POND ROAD LLC	6.89	1	0	0		0	1	5.12
S83	424-32	82 COLES POND DRIVE ED	DENNIS CONSERVATION TRUST	6.86	1	0	0	Conservation	0	1	6.02
S84	415-1	0 LAND CROW PASTURE ED	TOWN OF DENNIS	16.06	1	1	0	Conservation	0	2	12.05
S85	413-27	13 COLES POND ROAD ED	ALBANO KENNETH J TRUSTEE ET AL	5.71	1	0	0		0	1	4.25
S86	402-1	250 CORPORATION ROAD DE	TOWN OF DENNIS	18.77	1	1	0	Recreation	0	2	10.15

Table 1 (Cont'd)
Preliminary Effluent Recharge Site Screening Criteria Analysis
Dennis, Massachusetts

Site ID	Parcel ID	Address	OWNER	Whole Parcel Acres	Permeable Soils	NHESP	ZoneII	Open Space Conservation	Ten Year Time of Travel	Criteria Sum	Available Acres
S87	371-45	0 ELM STREET DE	CROWELL WILLIAM E JR ET ALI	5.82	1	0	0		0	1	4.32
S88	374-43	0 PRINCESS BEACH D DE	TOWN OF DENNIS	32.98	1	1	0	Conservation	0	2	24.57
S89	345-156	62 HORSEFOOT PATH DE	TOWN OF DENNIS	11.20	1	1	0	Recreation	0	2	4.84
S90	359-59	23 MUSIC DRIVE ED	LACY M HAYES REVOCABLE TRUST	3.17	0	0	0		0	0	2.38
S91	352-14	0-OFF ROUTE 6A DE	SCARGO HILL REALTY TRUST	11.27	1	1	0	Conservation	0	2	8.82
S92	315-1	50 GOLF COURSE ROAD ED	TOWN OF DENNIS	157.44	1	1	1	Recreation	0	3	117.60
S93	336-71	0 OPEN SPACE ED	NYBERG PETER J	15.18	1	0	1		0	2	15.18
S94	304-14	116 NEW BOSTON ROAD DE	SUSAN E MAKOWSKI REV TR ET AL	32.54	1	0	0	Conservation	0	1	28.51
S95	311-3	0 SAND PIT HOKUM ROCK ROAD D ED	TOWN OF DENNIS	15.39	1	0	1		0	2	15.39
S96	294-16	0 OPEN SPACE ED	NORTHWIND ESTATES HOMEOWNERS	9.15	0	1	1		0	2	4.02
S97	284-4	825 OLD BASS RIVER ROAD DE	TOWN OF DENNIS	174.49	0	1	1	Recreation	1	3	118.04
S98	310-40	756 PADDOCKS PATH ED	NYBERG PETER J	5.92	0	0	1		0	1	5.92
S99	286-1	0 SIMMONS POND ED	TOWN OF DENNIS	10.97	0	0	1	Cape Cod Land Bank	0	1	4.87
S100	210-5	90 SETUCKET ROAD DE	TOWN OF DENNIS	117.43	1	1	1	Conservation	1	4	76.97
S101	213-55	0 TIFFANIES CIRCLE OP SP SD	SETUCKET WOODS HOMEOWNERS	4.66	0	0	1		0	1	4.66
S102	213-38	47 WAGER LANE SD	TOWN OF DENNIS	5.90	0	0	1	Cape Cod Land Bank	0	1	5.80
S103	212-69	0 DONNIE WAY SD	HOWES DAVID L ET AL	7.74	0	0	1		0	1	7.74
S104	187-74	53 ASACK DRIVE SD	ASACK ACRES ASSOCIATION INC	14.05	0	0	1		0	1	14.05
S105	188-42	35 PHEASANT LANE SD	TOWN OF DENNIS	22.02	0	0	1	Recreation	0	1	22.02
S106	192-6	329 OLD CHATHAM ROAD SD	LAMMERS DAVID W	9.01	0	0	1		0	1	7.51
S107	139-14	481 MAIN STREET SD	BUSH CYNTHIA A	13.13	0	1	0		0	1	5.19
S108	141-53	0 DUCK POND ROAD SD	DAVENPORT REALTY TRUST	6.99	0	1	0		0	1	6.99
S109	146-31	530 CENTER STREET SD	C S A W LLC	5.36	0	1	0		0	1	3.31
S110	131-6	141 GREAT WESTERN ROAD SD	CROWELL CONSTRUCTION INC	13.11	0	1	0		0	1	8.85
S111				6.80	0	0	1	Water Supply Protection	1	2	5.81
S112				9.65	0	0	1		0	1	7.39
S113	187-51			9.35	0	0	1		0	1	9.35
S114	179-11			7.20	0	0	1	Water Supply Protection	0	1	7.20
S115				11.01	0	0	1		0	1	9.44
S116	150-71			3.82	0	0	1		0	1	3.82
S117	138-15			6.86	0	1	0		0	1	5.54
S118				4.44	0	1	0		0	1	4.44
S119	119-6	297 ROUTE 134 SD	RENAUD VAUGHAN C	3.04	1	0	0		0	1	1.11
S120	54-60	10 SIASCONSET AVENUE DP	TOWN OF DENNIS	6.33	0	0	0		0	0	0.38
S121				7.07	0	1	0		0	1	6.52
S122	41-42	60 CHASE AVENUE DP	TOWN OF DENNIS	8.44	0	0	0	Recreation	0	0	3.01
S123	425-1			14.78	1	1	0	Conservation	0	2	10.61
S124	426-8			17.01	1	1	0	Conservation	0	2	12.21
S125	173-36	30 BOB CROWELL ROAD SD	TOWN OF DENNIS	12.01	0	0	0		0	0	3.32

Table 2
Effluent Recharge Model Simulations
Dennis, Massachusetts

Site	Watershed	Site Size (acres)	Loading Rates (gpd/ft^2)	Time of Travel (years)	Potential Effluent Flow (MGD)
1st Model Run					
1	Swan Pond River	8.7	2.8	-	1.0
2	Bass River	3.2	3.9	-	0.5
3	Sesuit Harbor	61.0	1.9	< 3	5.1
4N	Sesuit Harbor/Chase Garden Creek	8.8	4.1	~ 14	1.6
4S	Sesuit Harbor/Chase Garden Creek	14.1	8.1	< 4	5.0
5	Chase Garden Creek	48.7	3.5	< 1	7.4
6	Swan Pond	16.6	6.3	NA[1]	4.6
7	Swan Pond/Bass River	23.7	0.9	< 2	1.0
8	Bass River	16.3	3.6	< 3	2.5
2nd Model Run					
3	Sesuit Harbor	16.5	5.6	> 10	4.0
4N/S	Sesuit Harbor/Chase Garden Creek	22.9	2.1	> 10	2.1
5	Chase Garden Creek	20.2	4.5	~ 4	4.0
3rd Model Run					
3	Sesuit Harbor	16.5	1.9	Outside zone of contribution	1.4
4N/S	Sesuit Harbor/Chase Garden Creek	22.9	0.3	Outside zone of contribution	0.30
5	Chase Garden Creek	20.2	0.3	Outside zone of contribution	0.25

Notes
1. NA: Not applicable due to no nearby downstream drinking water wells

Appendix G

Public Presentations

Community Meetings

Frequently Asked Questions

Status of Water Quality Evaluation and Mitigation Alternative Study

Town of Dennis, Massachusetts

Dennis
preserving our water resources

David Young, P.E.
Vice President

Public Informational Session

June 14, 2016

CDM Smith®

Comprehensive Wastewater Management Task Force

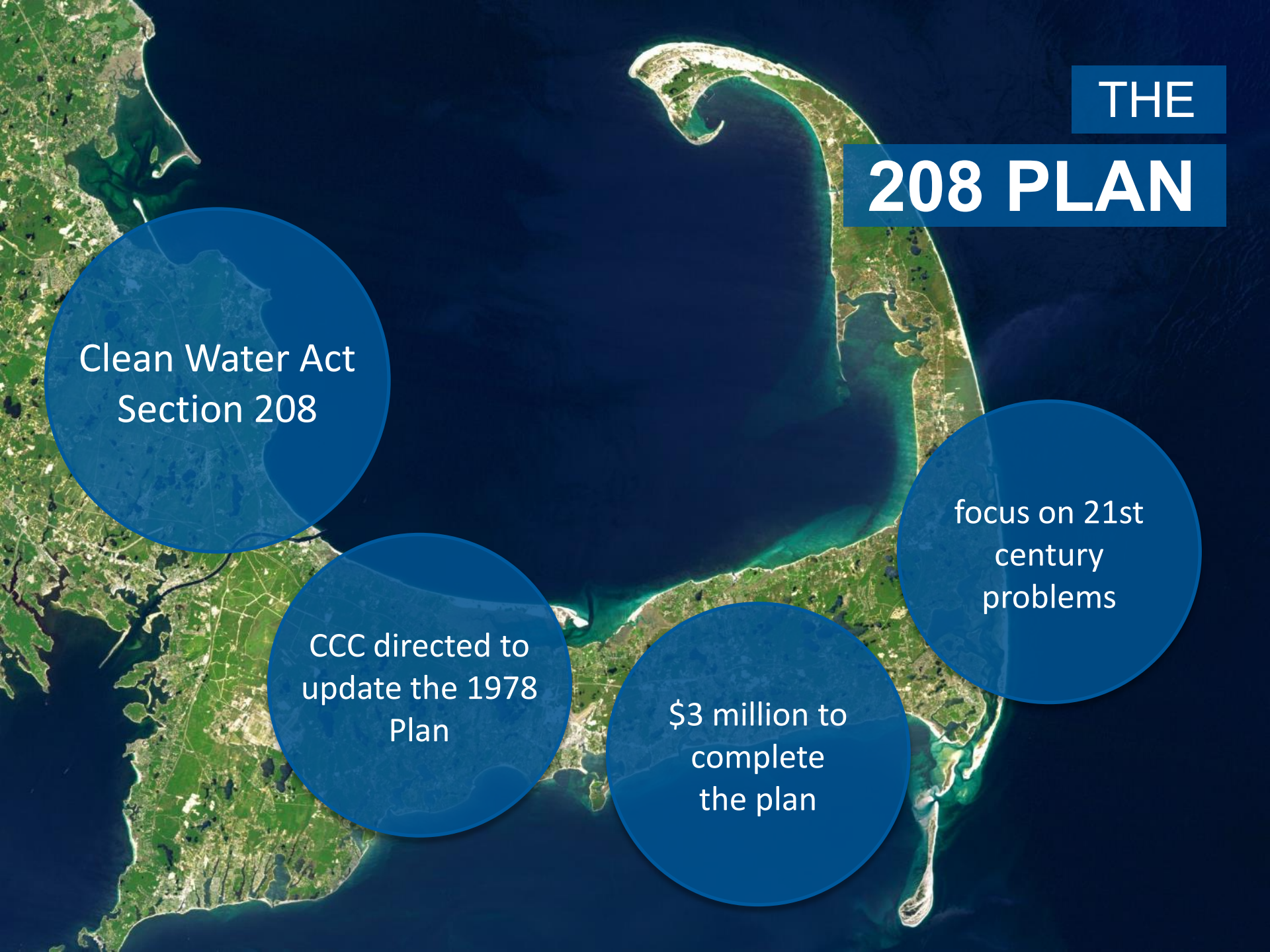
Dennis
preserving our water resources

- Task Force Members:
  - Diane Chamberlain, Chair
  - James Bonofiglio
  - Suzanne Brock
  - Stan Graveline
  - Bob Mezzadri
  - Dick O'Hearn
  - Greg Stone
- Town Staff Support: Terry Hayes, Health Department and Liz Sullivan, Assistant Town Administrator
- CDM Smith: David Young, P.E.

Meeting Purpose

Dennis
preserving our water resources

- Provide an overview of study
- Provide an update on water quality evaluation findings
- Present recommended plan selected by Task Force for implementation
- Present planning-level cost estimates
- Discuss next steps


THE
208 PLAN
Clean Water Act Section 208
CCC directed to update the 1978 Plan
$3 million to complete the plan
focus on 21st century problems

Why Dennis Needs to Control Nutrients

Water Quality

Drinking Water

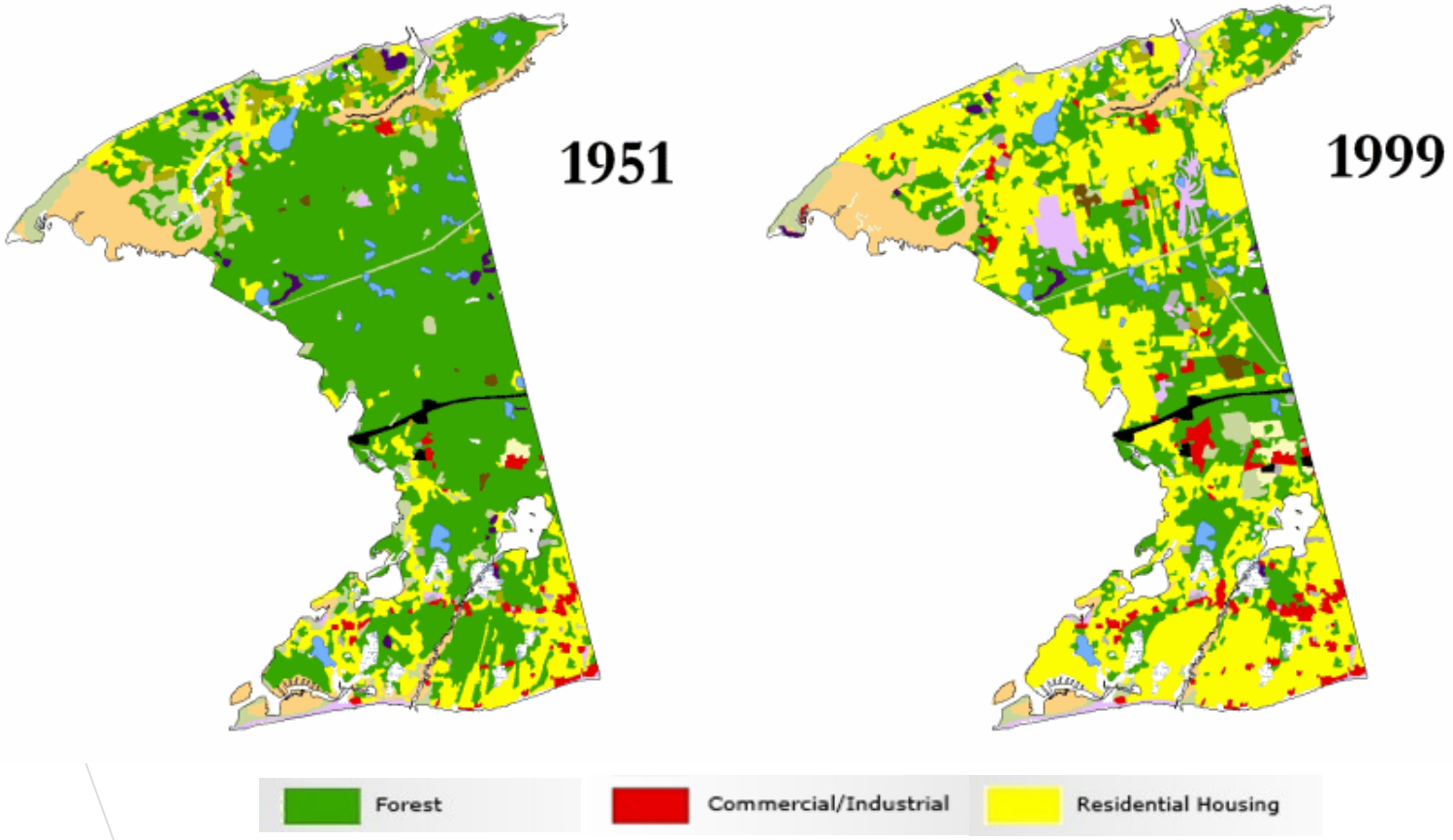
Nutrient Impacts

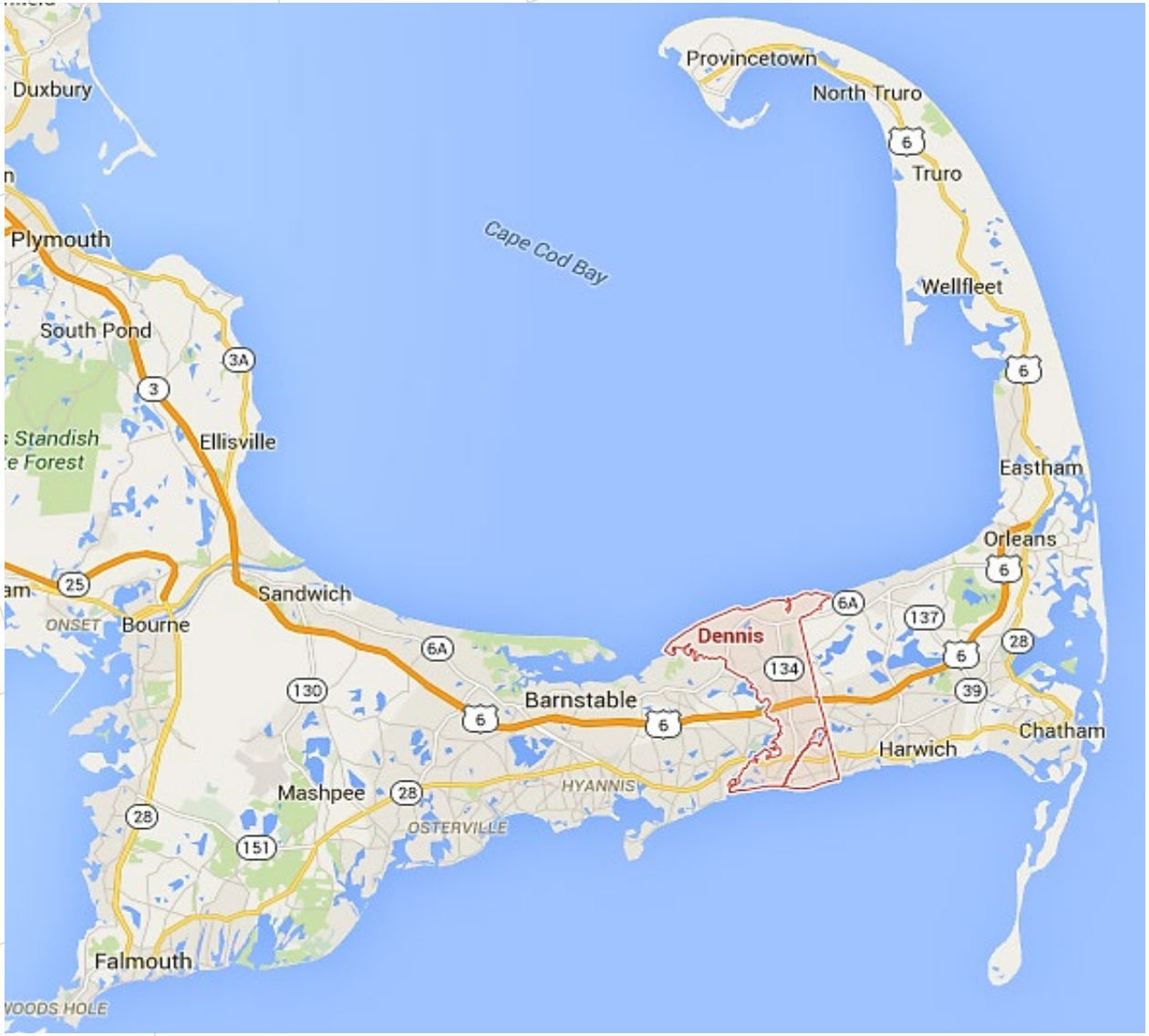
Economic Development

Beaches, Harbors, Rivers, and Ponds

Dennis

preserving our water resources

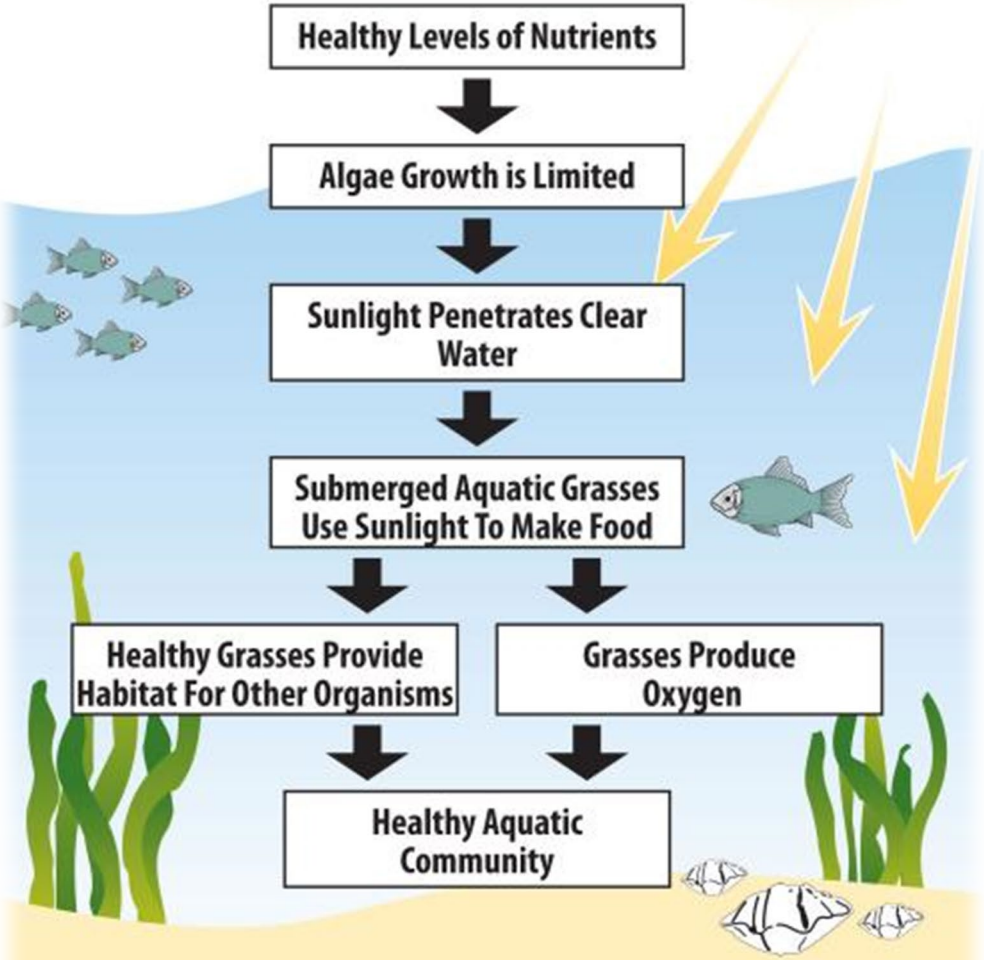




Cape Cod represents 4% of the state's population, but 20% of the state's septic systems.

Beaches, Rivers, Harbors, and Ponds Are Severely Impacted By Nutrients

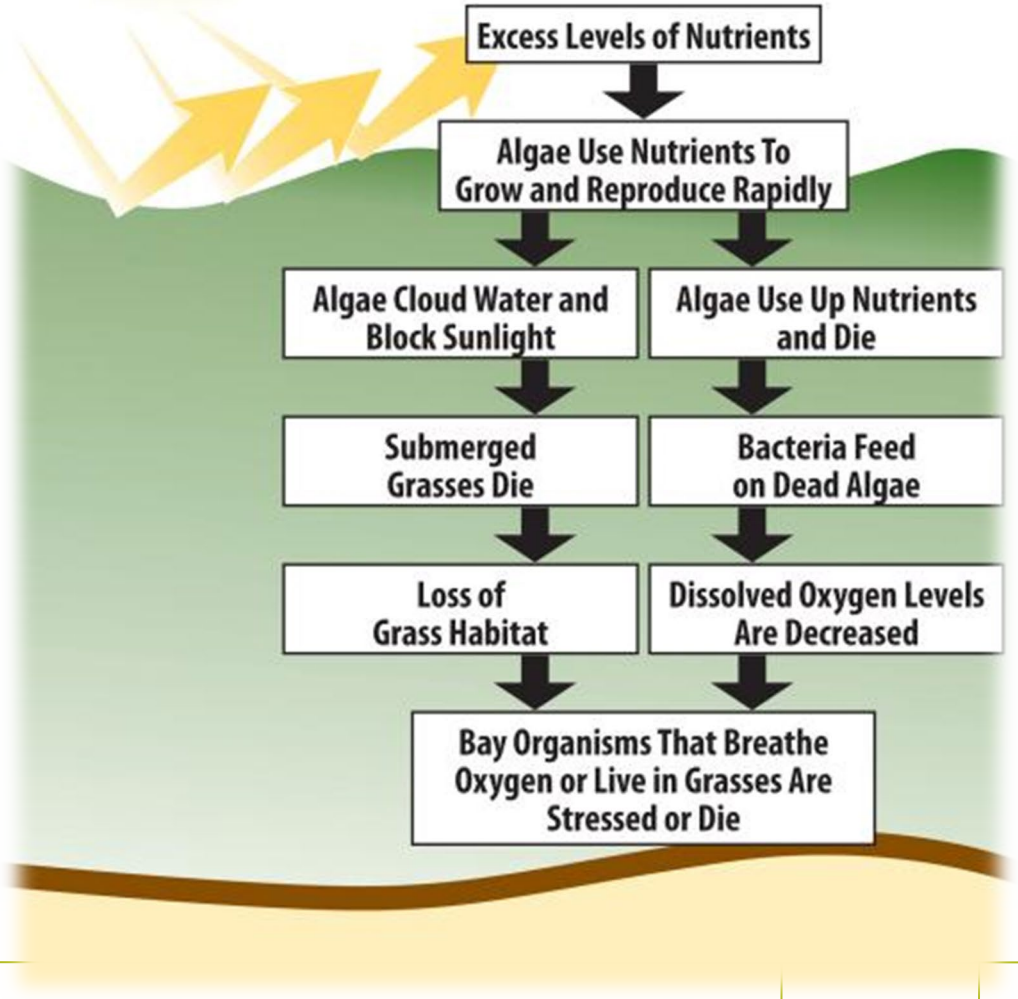
Healthy Nitrogen and Phosphorus Levels



Beaches, Rivers, Harbors, and Ponds Are Severely Impacted By Nutrients

Unhealthy Nitrogen and Phosphorus Levels

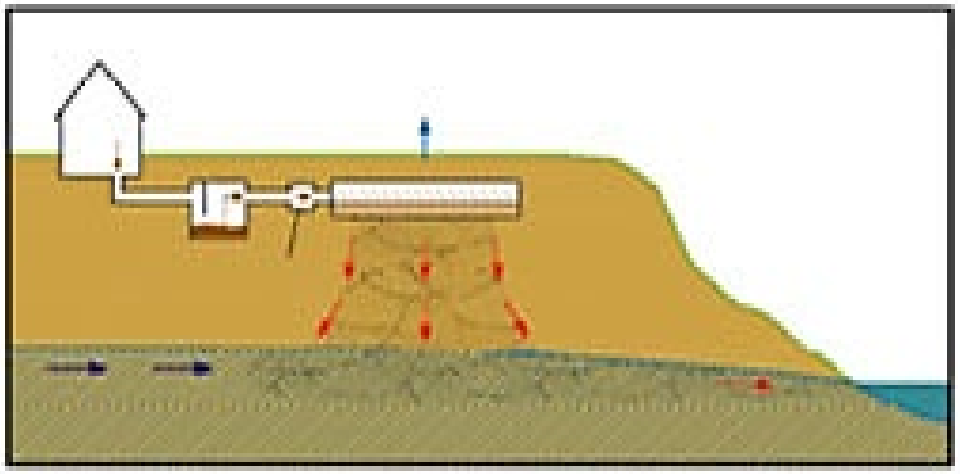
Algae in Swan Pond, Dennis



Nitrogen From Title 5 Septic Systems Is Our Biggest Issue (Designed for pathogen removal)

Septic Systems Permit Nitrogen to:

- Invade Our Ground Water
- Travel with Groundwater to the Beaches & Rivers



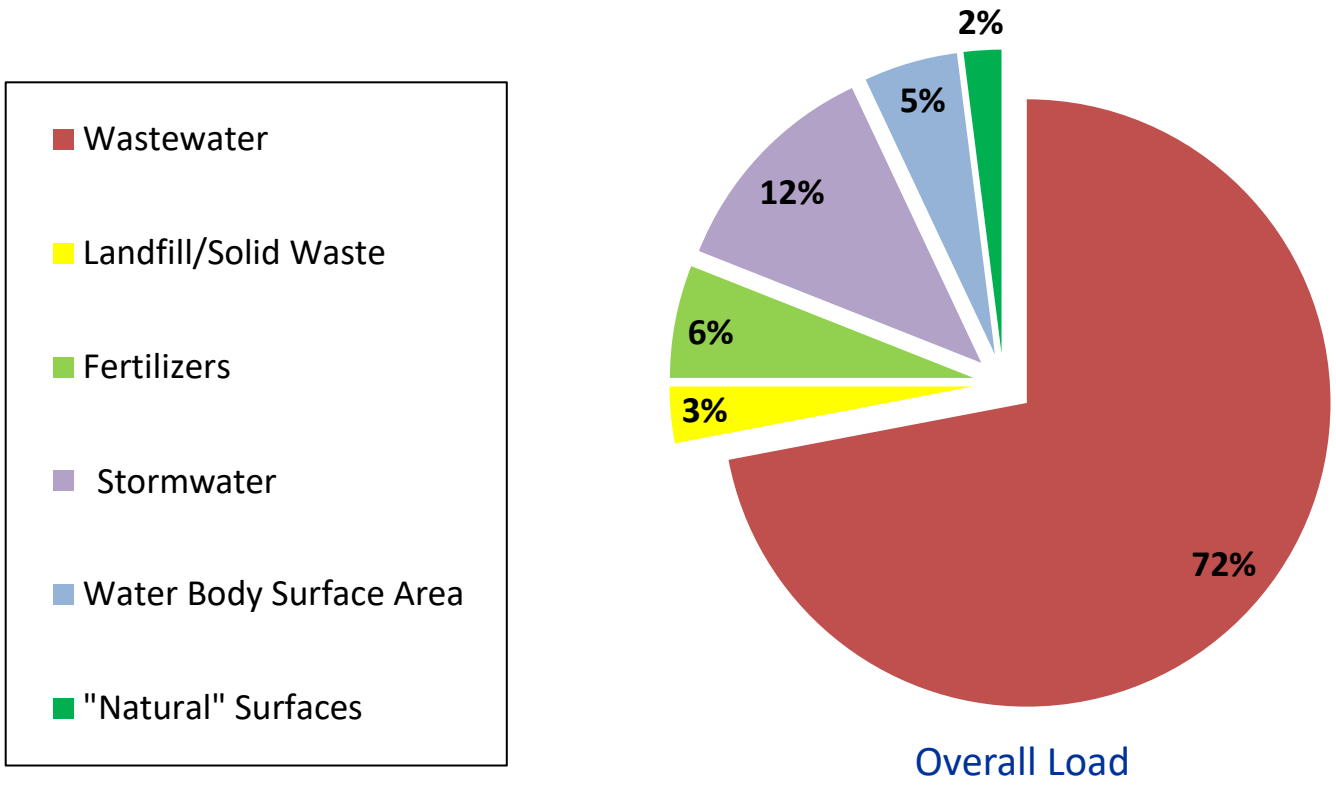
Eelgrass Loss in Dennis

1995

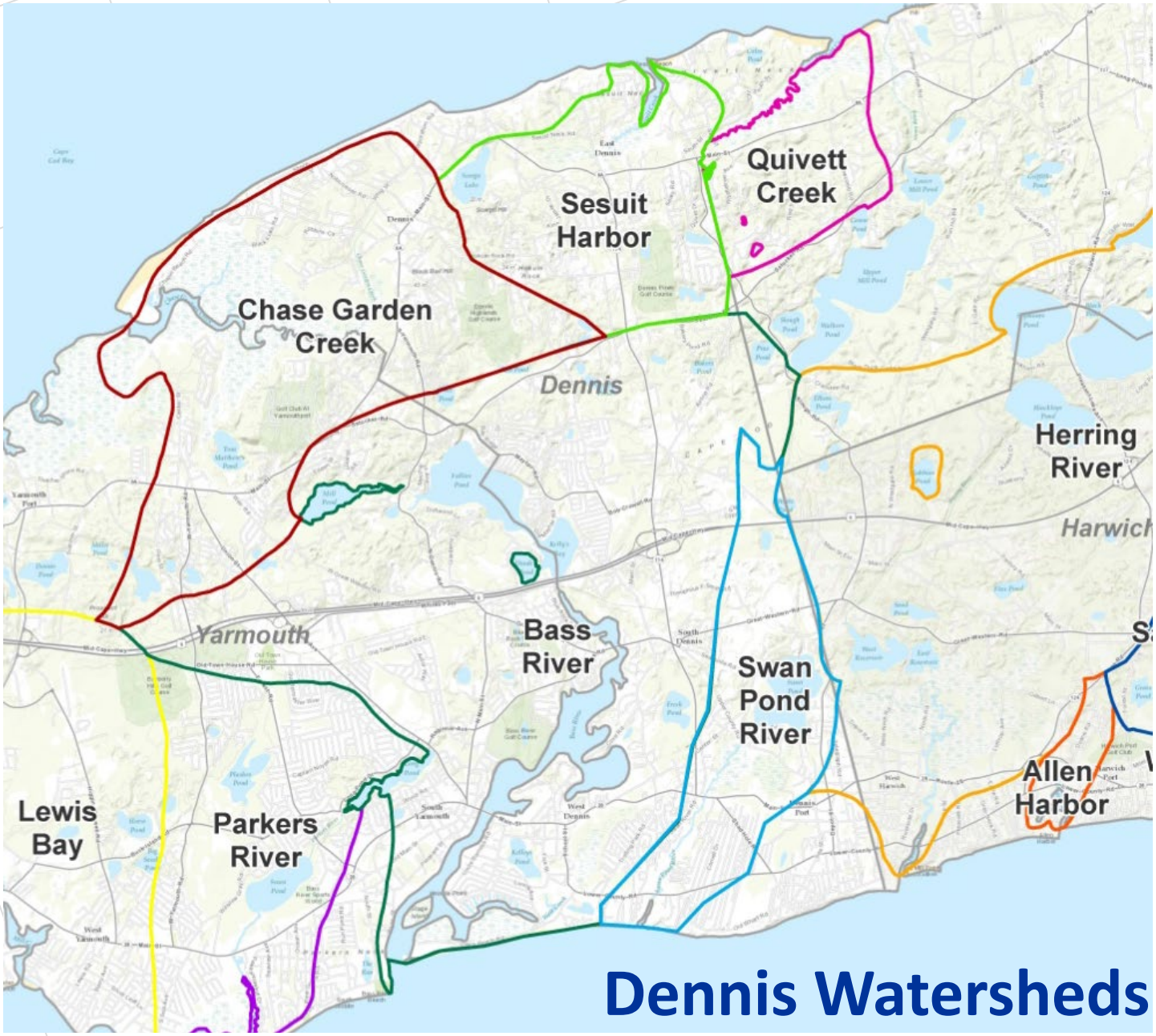
2010-13

Controllable Nitrogen Sources – Swan Pond River Watershed

Dennis
preserving our water resources



Overall Load



Dennis Watersheds

Goals for Nitrogen Management

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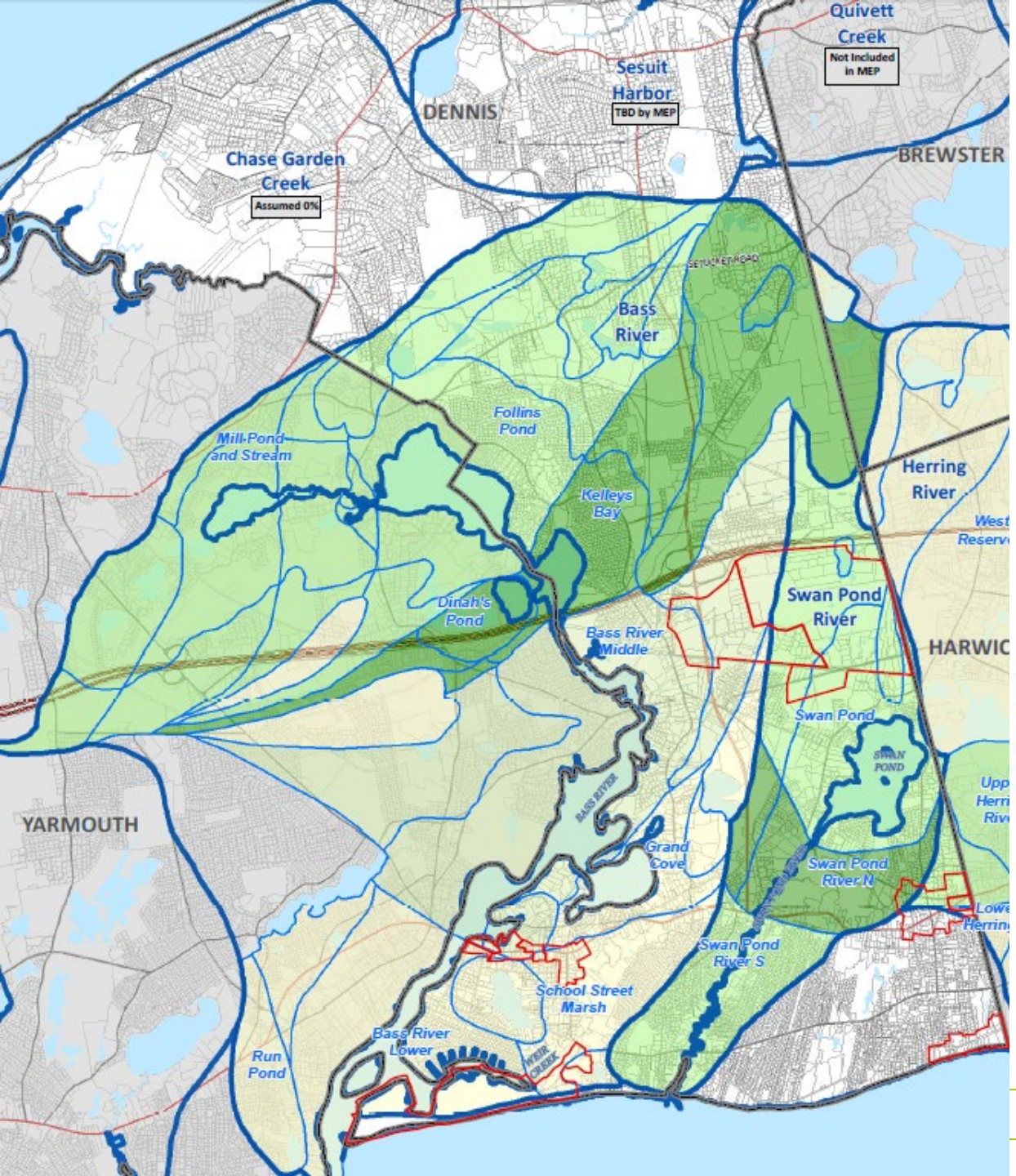
Dennis Portion of MEP Watersheds	***Septic Nitrogen ("N") Removal Rates from Wastewater to Meet TMDL Under Existing Conditions***
Swan Pond River	**-100%**
Bass River	**-60%**
Herring River	**-38%**
Sesuit Harbor	**0-25%**
Chase Garden Creek	**TBD**



MEP Summary:
Required Nitrogen Removal by Sub-watershed

Includes:

- Bass River
- Swan Pond River
- Herring River

Legend

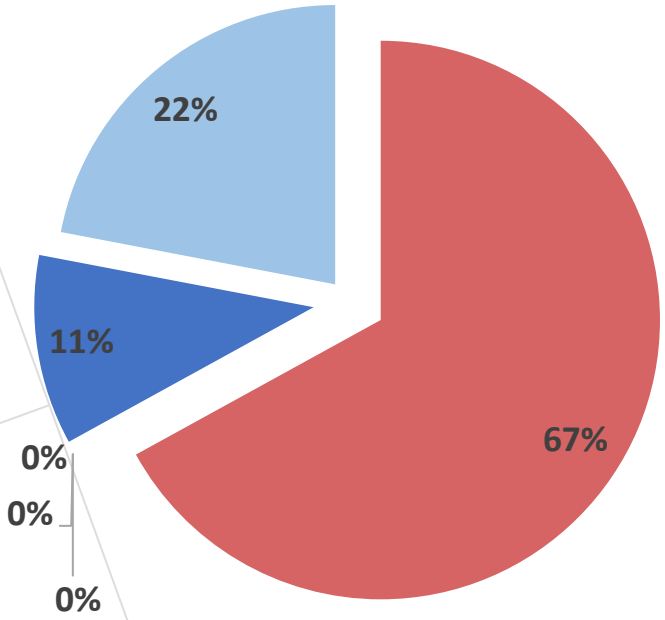
- MEP Watershed Delineations
- MEP Subwatersheds
- Planning Districts

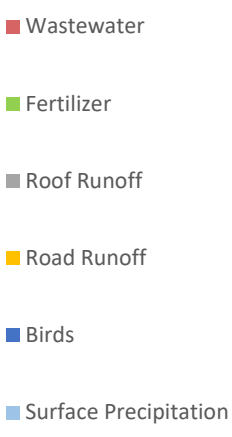
Proposed Controllable Nitrogen Removal from MEP to Meet TMDL

- 80-90%
- 70-80%
- 50-60%
- 0%

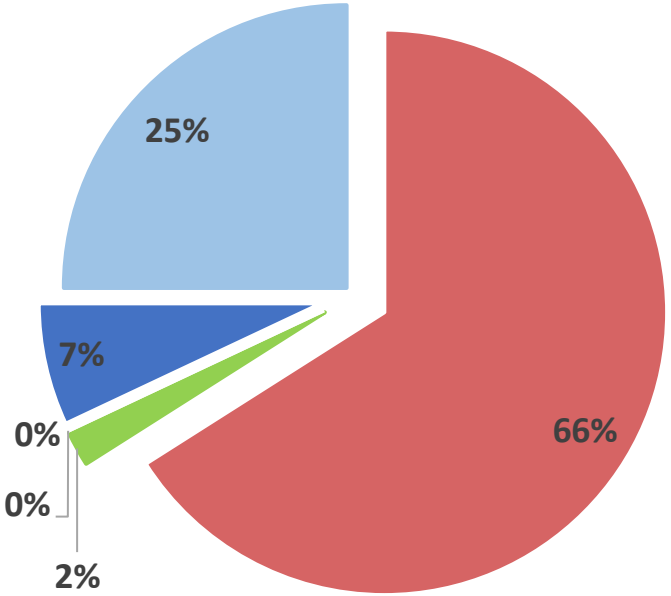
Freshwater Pond
Scargo Lake Phosphorus Loading

Low = 5.4 kg/year





High = 8.3 kg/year

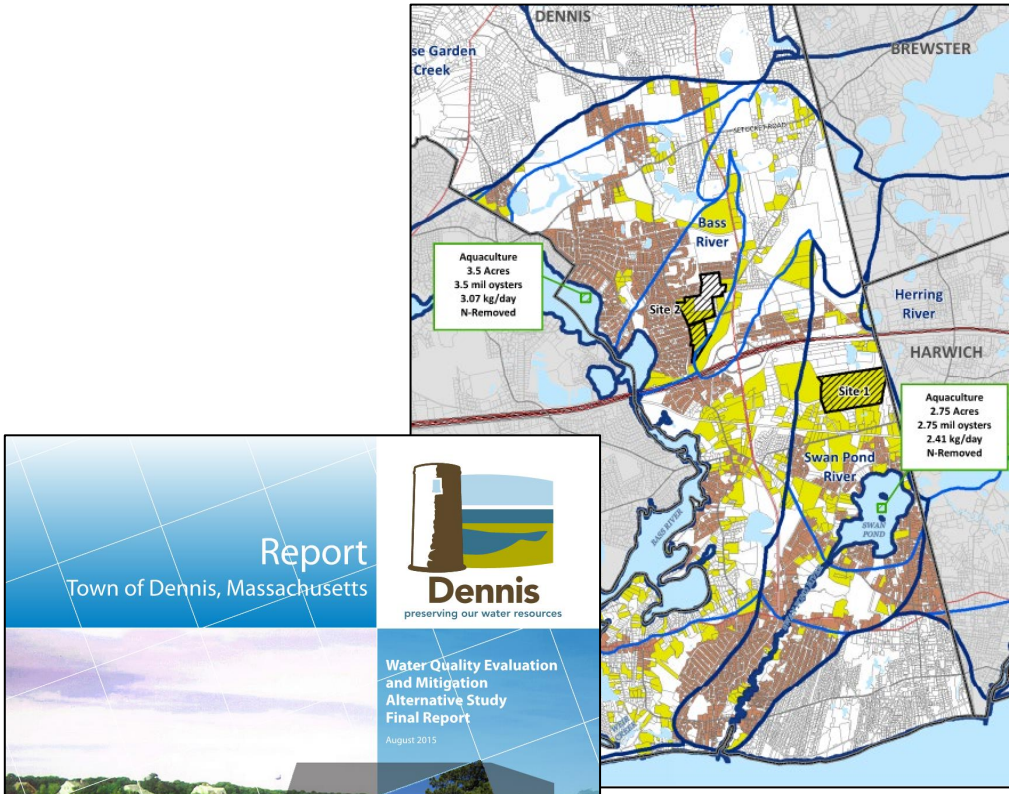


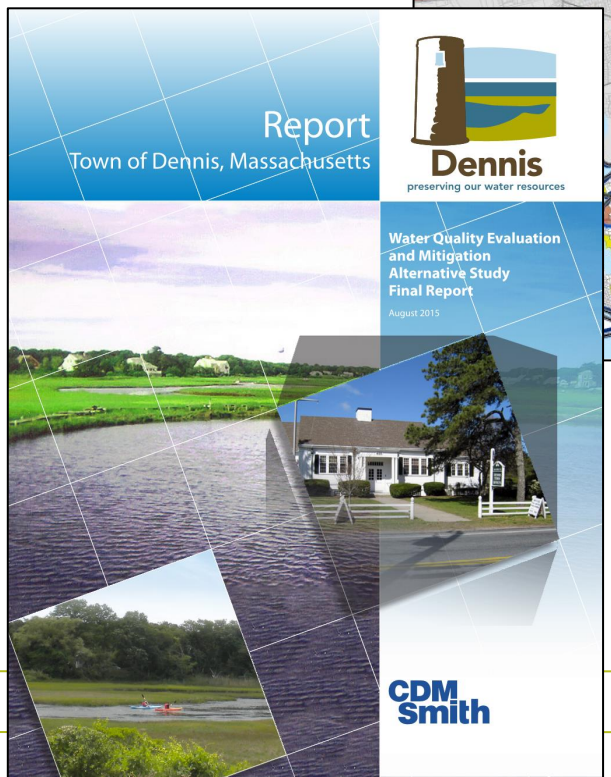
Review Definition of Need and Related Concepts

- Saltwater = nitrogen impacts
- Drinking water = nitrogen impacts
- Freshwater ponds = phosphorus impacts
- Watersheds = areas that contribute to a water body
- Title 5 septic systems = solids and pathogens removal; minimal nitrogen removal
- Inlet or bridge widening = more flushing and less residence time

Summary of Prior Work by Task Force

- Evaluation of waterbodies
- Analysis of water usage and wastewater flows
- Nitrogen balance
- Effluent recharge parcel site screening
- Water quality scenario development and assessment
- Matrix evaluation narrowed down 14 scenarios to 4
- Results summarized in August 2015 report





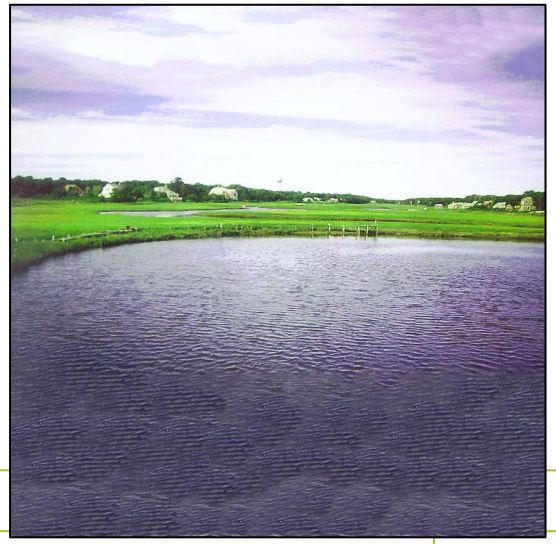
Site Scale | Neighborhood | Watershed | Cape-Wide
Prevention
Reduction
Remediation
Nitrogen Removal Possibilities
Remediation of Existing Development
Fertilizer Management
Transfer of Development Rights
Stormwater BMPs
Compact Development
Standard Title 5 Systems
Conventional Treatment
I/A Title 5 Systems
Cluster & Satellite Treatment Systems
Advanced Treatment
I/A Enhanced Systems
Wastewater Collection Systems
Effluent Disposal Systems
Toilets: Urine Diverting
Constructed Wetlands: Surface Flow
Toilets: Composting
Constructed Wetlands: Subsurface Flow
Toilets: Packaging
Stormwater: Bioretention / Soil Media Filters
Toilets: Incinerating
Stormwater: Wetlands
Phytoirrigation
Eco-Machines & Living Machines
Phytobuffers
Fertigation Wells
Permeable Reactive Barrier
Shellfish and Salt Marsh Habitat Restoration
Aquaculture/Shellfish Farming
Inlet / Culvert Widening
Pond and Estuary Dredging

Task Force's Evaluation of Nitrogen Removal Technologies

- Aquaculture
- I/A Systems
- Centralized Treatment
- Decentralized Treatment
- Inlet/Culvert Widening
- Permeable Reactive Barriers
- Stormwater Best Management Practices (BMPs)
- Fertilizer Education

Summary of this Year's Work by Task Force

- Build-out nitrogen and wastewater analysis
- Sewer collection system evaluations and layouts
- Treatment technology evaluations
- Effluent recharge and reuse technology evaluation
- Community partnership options
- Cost results and comparison of final scenarios
- Identification of recommended plan



Build-out Nitrogen and Wastewater Analysis

Scenario	Number of Parcels Being Sewered	Total Current Average Daily Flow (with I/I) (gpd)	Total Build-out Average Daily Flow (with I/I) (gpd)
3B	5,815	918,000	1,507,000
5A/5B	6,114	933,000	1,491,000
6A/6B/ 8C	6,276	966,000	1,554,000
7A	8,297	1,234,000	2,146,000

Scenario 6A Sewer Collection System: Hybrid

- Task Force evaluated vacuum, pressure, and gravity sewers
- Pumping stations, force mains
- Task Force chose a hybrid system to fit within the geography and topography of the Town

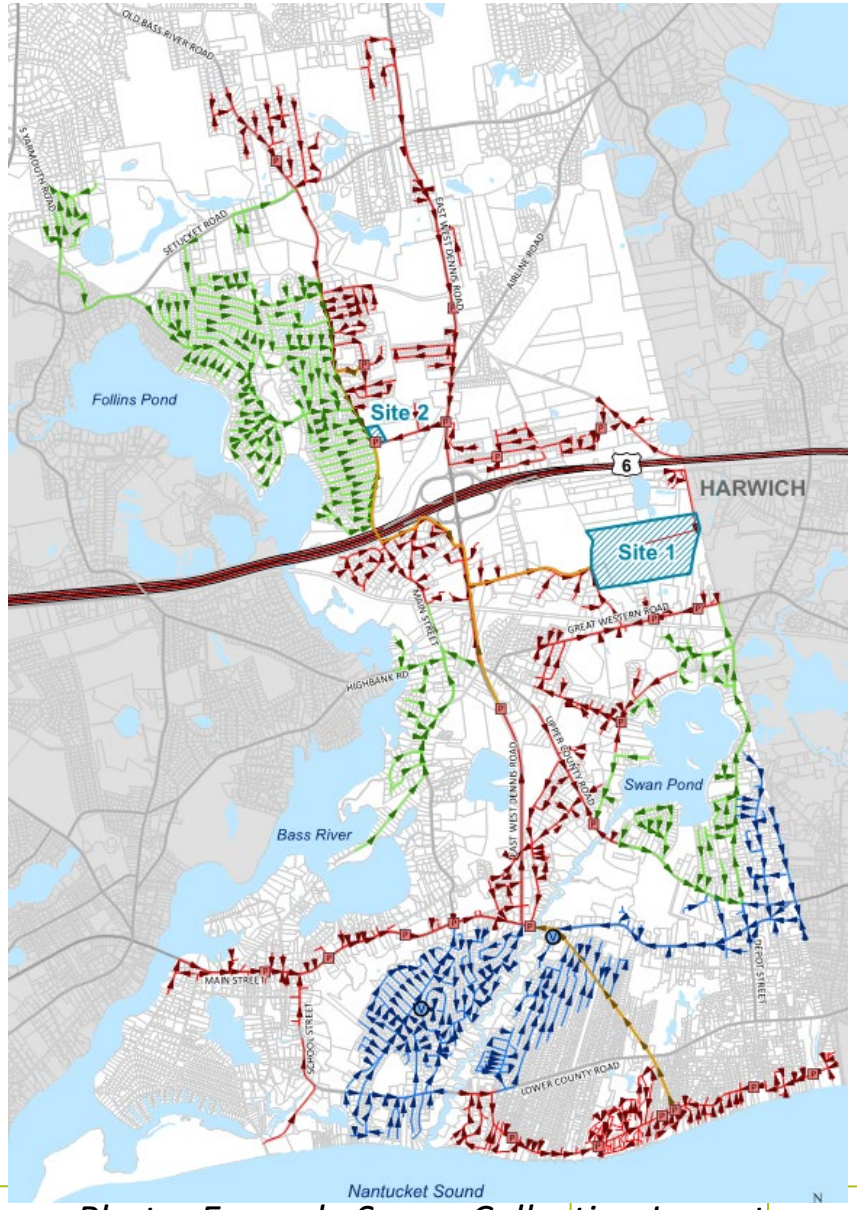


Photo: Example Sewer Collection Layout

Wastewater Infrastructure Can Be Consistent with Community Character

Treatment Technology: SBR

The Task Force chose a sequencing batch reactor (SBR) wastewater treatment process with the construction to be phased in based on coordination with collection system work.

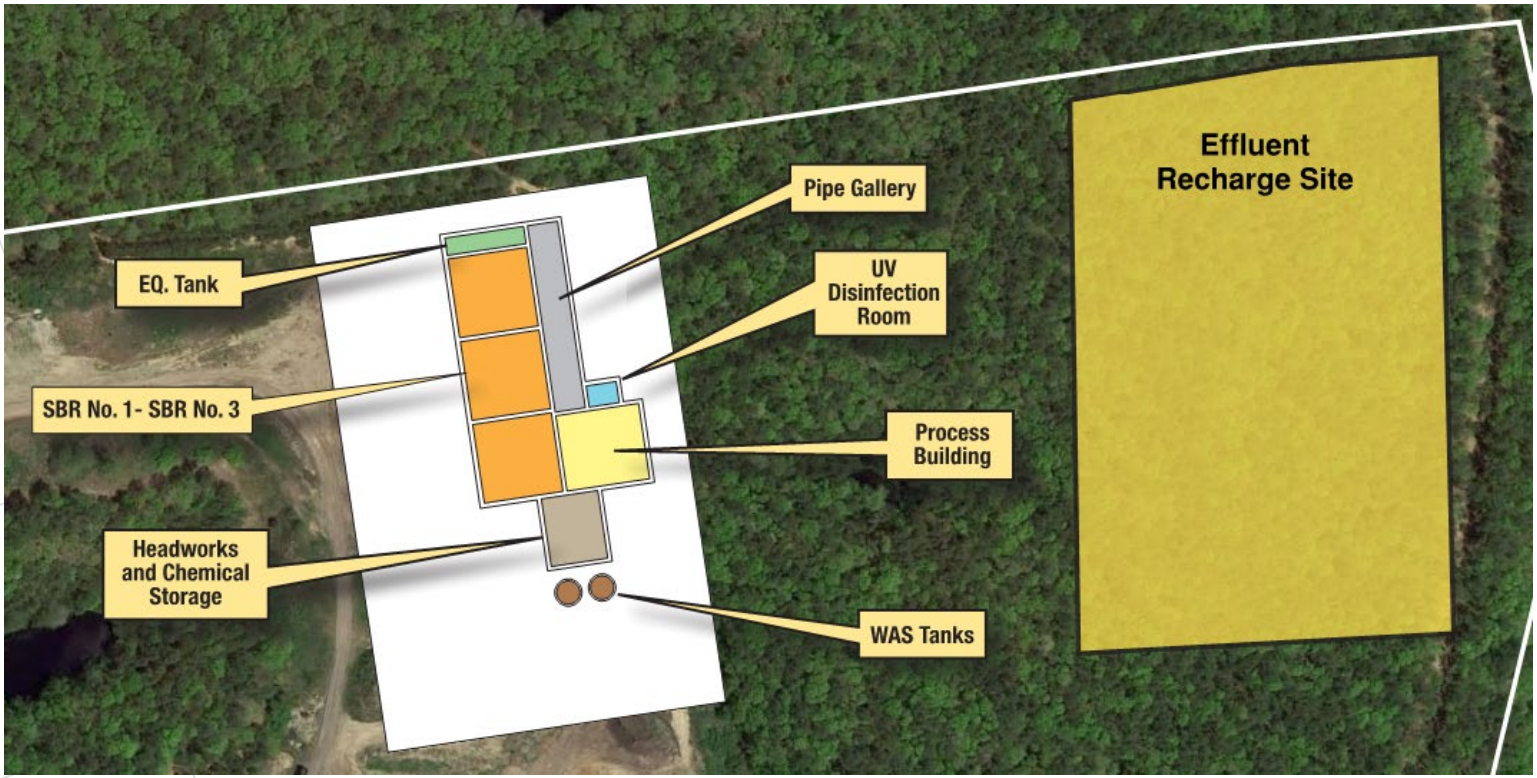
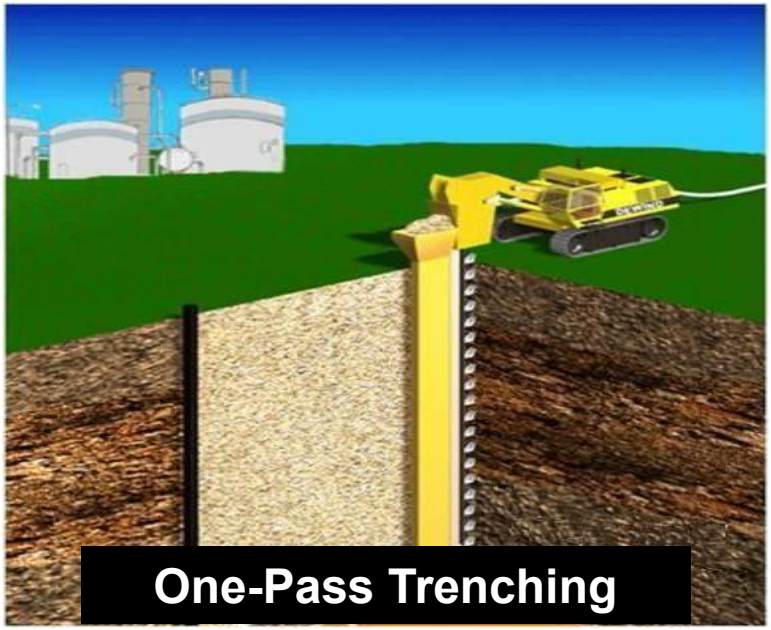


Photo: Site 1 near DPW/Landfill

SBR allows for operational flexibility and can be easily expanded

Aquaculture - Close-up of floating bag oyster culture in Bourne

PRB - Construction Techniques



Effluent Recharge Technology: Infiltration Basins

- Lower construction costs
- Requires a lower level of treatment, investigation, and permitting
- Proven successful in New England climate (Falmouth, Plymouth, Chatham)

Photo: Open infiltration basins at Chatham WWTP (1.1 MGD)

Hydrogeologic Evaluations of Potential Effluent Recharge Sites

- Task Force's prior site screening of whole town
- Site walks
- Review of site boring data
- Groundwater flow modeling (using the USGS Monomoy Flow Lens groundwater model)
- Recommendations

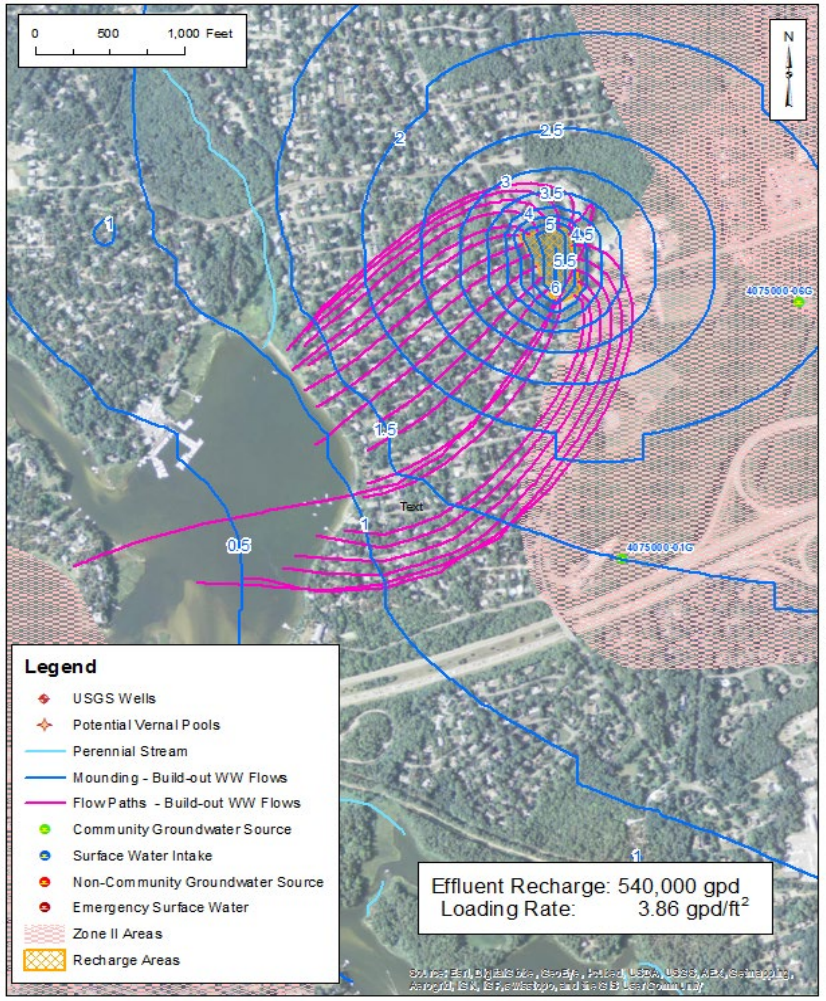
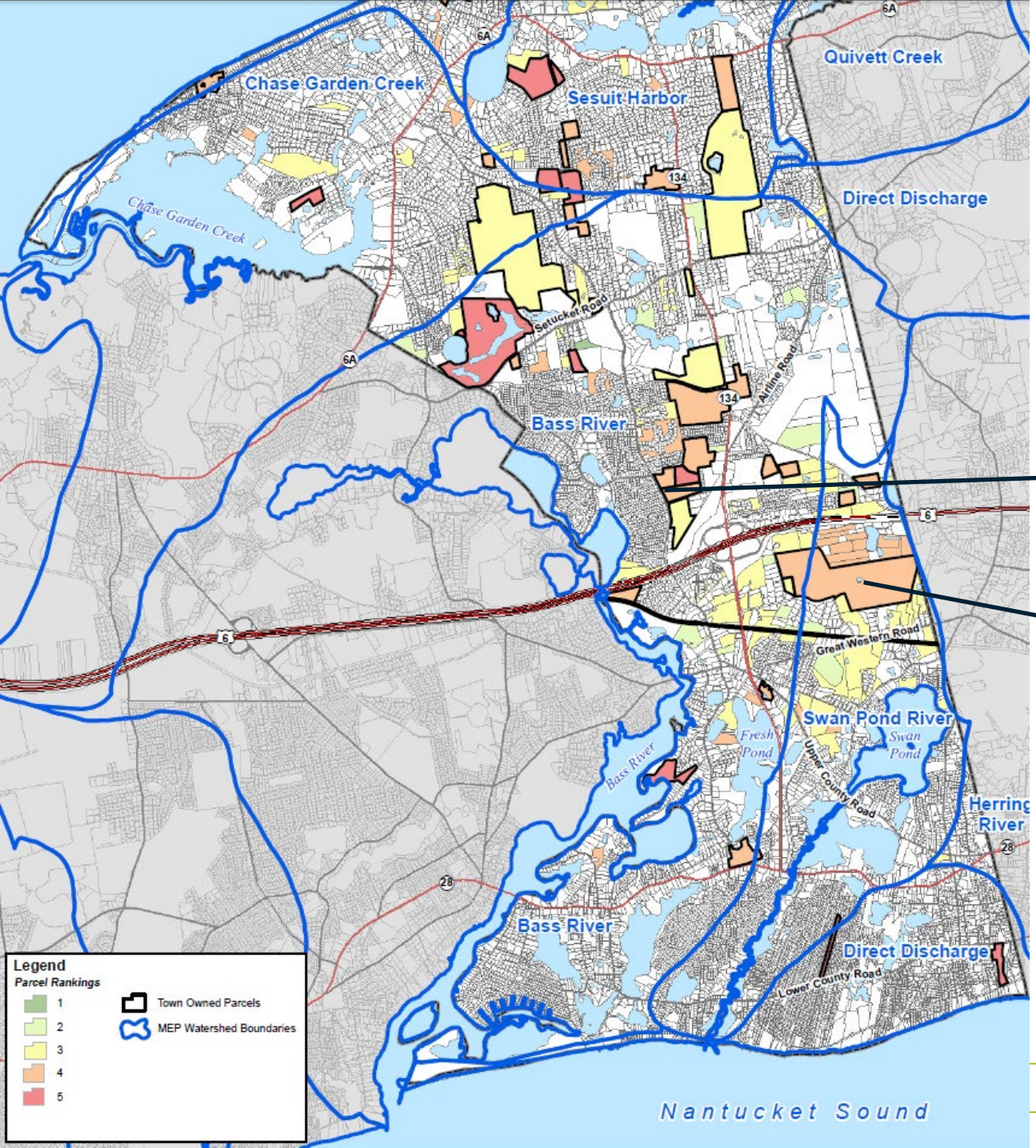


Photo: Sample Groundwater Flow Modeling

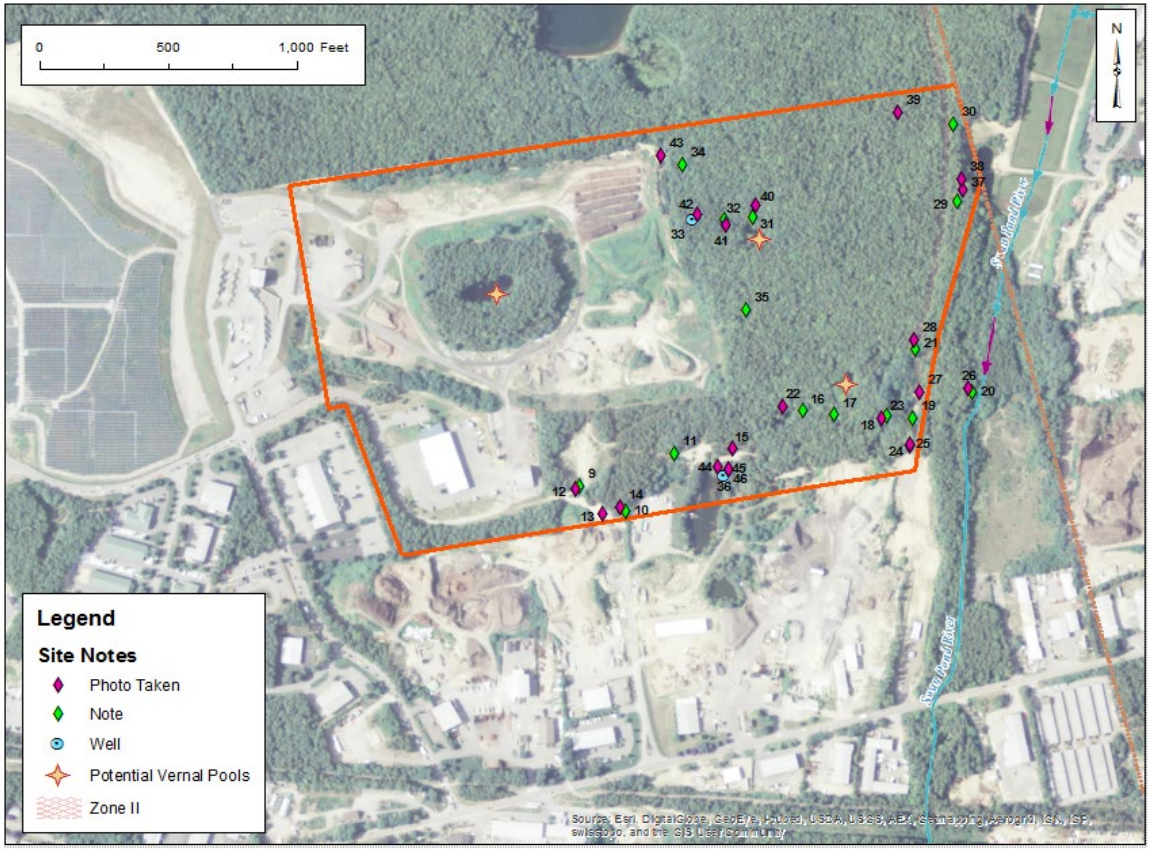
Map of Potential Effluent Recharge Sites



SITE 2

SITE 1

Site 1 – Near Current DPW Office/Landfill



- Swan Pond River Watershed
- 8.7 acres
- Depth to groundwater of around 20 feet below ground surface
- Potential vernal pools
- Maximum mounding of 6 feet for build-out wastewater flows

Site 2 – Bob Crowell Road (old DPW site)

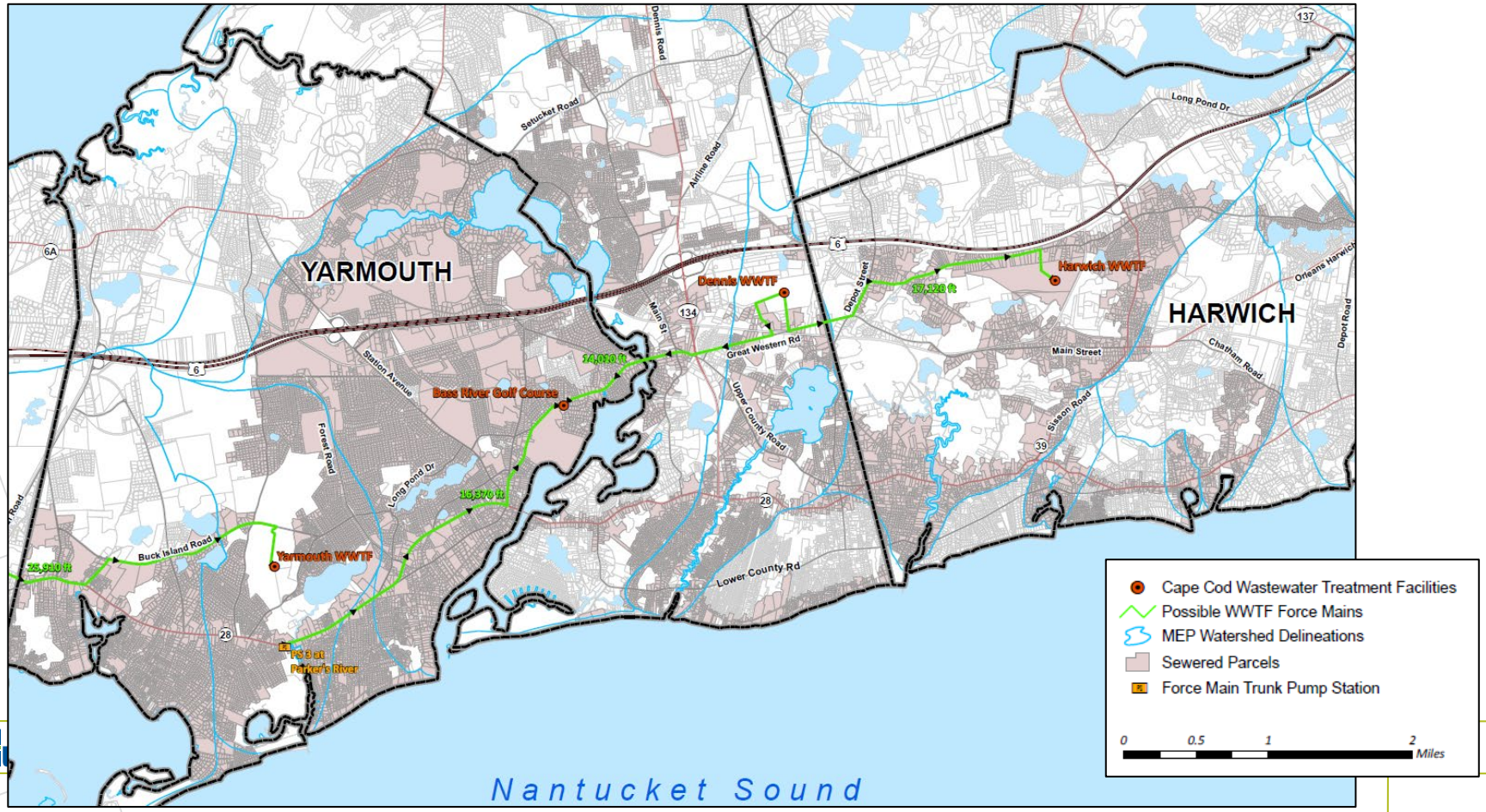
- Bass River Watershed
- 3.2 acres
- Estimated depth to groundwater of around 20-30 feet below ground surface
- Maximum mounding of 5.5 feet for build-out wastewater flows

Review Recommended Program Concepts

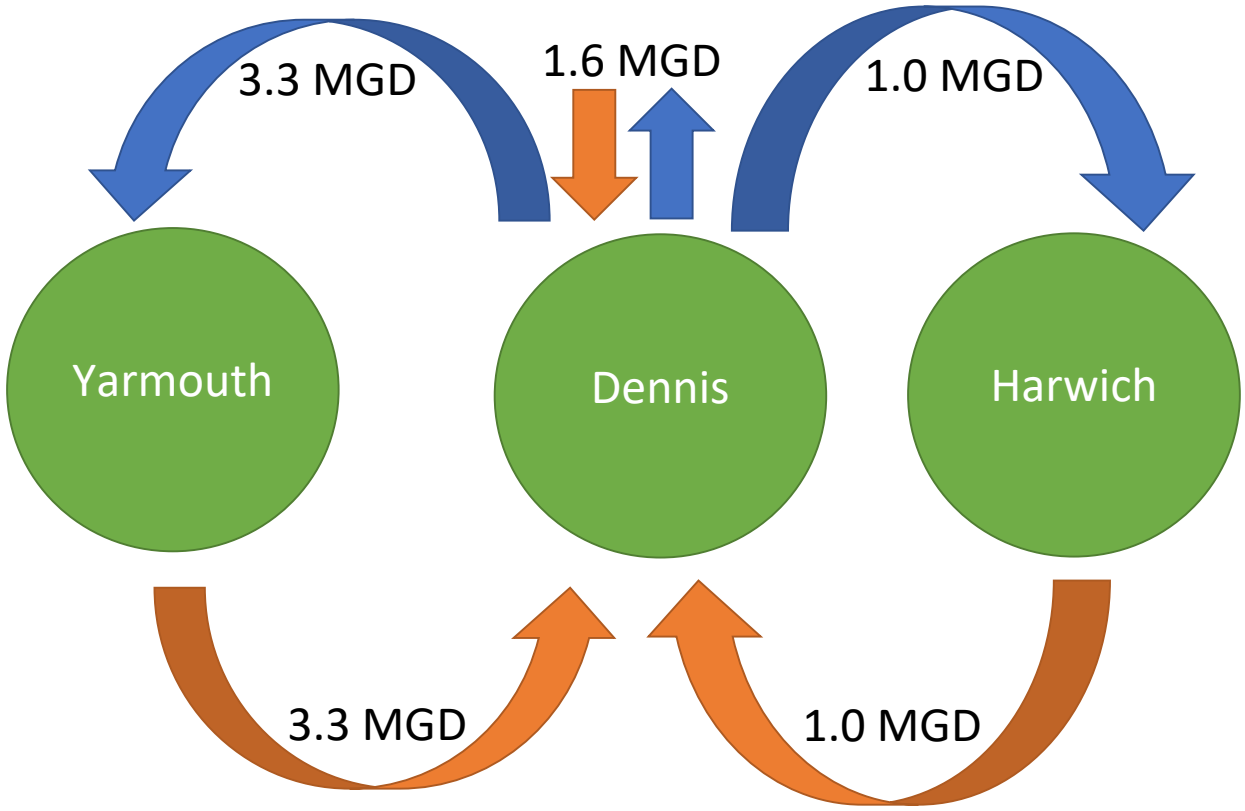
- Buildout = what could be built based on current zoning
- Effluent recharge = infiltrate highly treated wastewater back into the groundwater
- Groundwater mounding = increase in height of groundwater table resulting from additional water being infiltrated above that area (effluent being recharged)
- Permeable Reactive Barrier (PRB) = means of providing carbon source to allow conversion of nitrogen in groundwater into nitrogen gas (denitrification)
- Aquaculture = means to remove nitrogen from a degraded saltwater body via natural processes that create a product

Community Partnership Options

- Dennis, Harwich, and Yarmouth are currently evaluating the construction of one centralized treatment facility in order to save on capital and operation & maintenance costs



Community Partnership – Dennis, Harwich, and Yarmouth



MGD = million gallons per day

Summary of Wastewater Scenarios

Scenario	Description	Fertilizer/ Stormwater Credits	Aquaculture	Sewer without PRB	Sewer with PRB	I/A	WWTPs
3B	Sewer with PRB and I/A	X	X		X	X	2
5A	Sewer without PRB and Aquaculture	X	X	X			1
5B	Sewer without PRB and Aquaculture	X	X	X			2
6A/8C	Sewer with PRB and Aquaculture (includes planning districts)	X	X		X		1
6B	Sewer with PRB and Aquaculture (includes planning districts)	X	X		X		2
7A	Sewer with PRB and Aquaculture (includes planning districts and several Areas of Concern (AOCs))	X	X		X		1

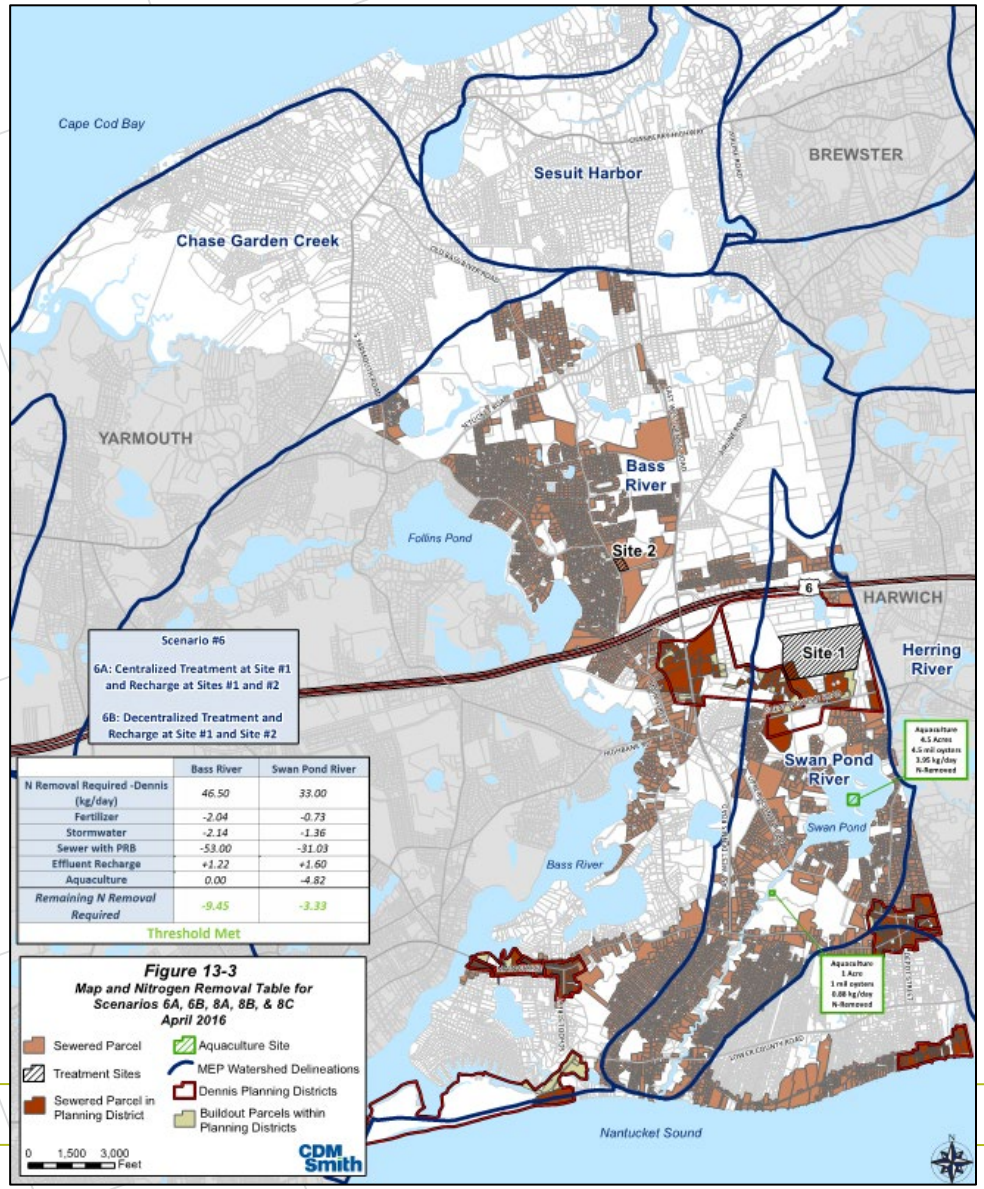
Wastewater Scenario Cost Comparison

	3B	5A	5B	6A	6B	7A	8C
Description	I/A & Sewer with PRB	Sewer without PRB	Sewer without PRB	Sewer with PRB	Sewer with PRB	Sewer with PRB	Community Partnership with Harwich & Yarmouth
Collection and Conveyance Capital Cost	$98 M	$108 M	$107 M	$119 M	$118 M	$222 M	$119 M
Treatment Capital Cost	$53 M	$39 M	$53 M	$38 M	$52 M	$41 M	$23 M
Conveyance to Recharge Cost	$1 M	$4 M	$1 M	$4 M	$1 M	$3 M	$4 M
Effluent Recharge with PRB Cost	$17 M	$3 M	$3 M	$19 M	$17 M	$19 M	$16 M
Non-Traditional Cost	$20 M	$9 M	$9 M	$9 M	$9 M	$9 M	$9 M
Total Capital Cost	$189 M	$164 M	$173 M	$188 M	$197 M	$294 M	$171 M
Total Capital Cost with Engineering & Contingency	$208 M	$180 M	$190 M	$207 M	$217 M	$323 M	$188 M
Total Annual O&M	$9.0 M	$6.7 M	$7.3 M	$7.0 M	$7.9 M	$8.3 M	$4.0 M
Equivalent Annual Cost (EAC)	$21.7 M	$17.7 M	$19.0 M	$19.7 M	$21.2 M	$22.7 M	$15.5 M
Nitrogen Removed (lbs/yr)	73,231	74,245	74,245	74,269	74,269	89,125	74,269
Annual cost per Pound Removed	$300	$240	$260	$270	$290	$255	$210

Evaluation Criteria

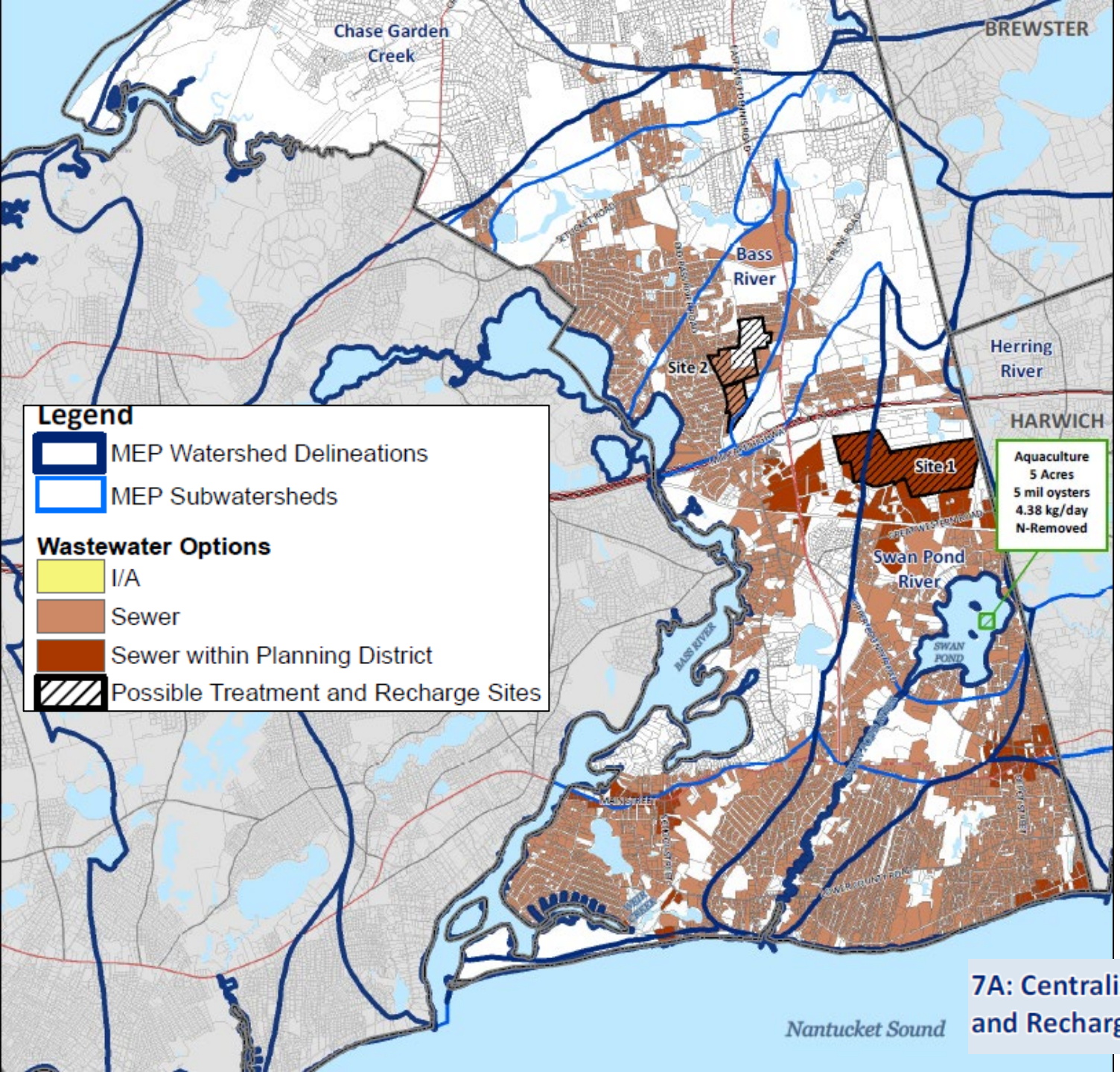
Evaluation Criteria	Criteria Weight
RELATIVE COSTS	**40%**
Capital Costs	5%
O&M Costs	5%
Equivalent Annual Cost (EAC)	20%
Cost per lb of N Removed	10%
DESIGN REQUIREMENTS AND TECHNOLOGY RELIABILITY	**14%**
Design Requirements	4%
Technology Reliability	10%
IMPLEMENTATION CONCERNS	**38%**
Regulatory Acceptance and Permitting Requirements	10%
Available Resources	4%
Governance Structure	10%
Public Acceptance	4%
Other Community and Environmental Needs	10%
CONSTRUCTION IMPACTS	**8%**
Construction Impacts	8%
TOTAL WITH WEIGHTING	100%

Recommended Wastewater Plan: Scenario 6A



- Scenario 6A was rated one of the top scenarios
- Meets MEP goals
- Meets other town goals: economic and community development
- $207 M – Capital Costs
- $ 7 M – O&M Costs
- Community partnership scenarios are built around Scenario 6A, allows for flexibility
- Consider Scenario 7A for future

Scenario 7A



7A: Centralized treatment at Site #1 and Recharge at Sites #1 and #2

Next Steps

- Submit watershed plans to Cape Cod Commission to meet 208 Plan requirements
- Determine appropriate program phasing and cost recovery plans
- Package all work completed into a Comprehensive Wastewater Management Plan (CWMP) and submit for regulatory reviews (State and Cape Cod Commission)

Schedule

Task	Cost	Date
Water Quality Evaluation and Mitigation Alternatuve Study – Phase 3	$160,000	Spring 2016 (TM passed)
Proposed Aquaculture Pilot Program	$115,000	Fall 2016/Spring 2017
File Draft CWMP with MEPA/CCC		May 2017
Water Quality Evaluation & Mitigation Alternative Study – Phase 4	$150,000	Spring 2017
File Final CWMP with MEPA/CCC		May 2018
File Development of the Regional Impact with CCC		October 2018
Request Phase 1 Design and Survey Funds	$4.9 Million	Spring 2019
Request Phase 1 Construction Funds	$60 Million	Spring 2020

Summary

- Nutrient reduction will be mandated by regulatory agencies (TMDLs issued); action now allows more town control
- This is a complex planning process that will continue indefinitely, through adaptive management – living document
- Towns need to determine how best to fund these programs
- Most properties in town contribute to the problem - not just those along a water body or those proposed for a solution
- Everyone in Dennis will benefit from improved water quality

The Consequences…

- "The cost of doing nothing is economically devastating to every Cape homeowner."
  - Cape Cod Commission – 208 Plan, 2014

Algae Bloom in Allen Harbor, Harwich, Swan Pond, Dennis and Mill Creek, Yarmouth

Questions?

Dennis
preserving our water resources

Sign up to be on the email list: www.bit.ly/DennisWaterResources

Email the Task Force at: cwmtf@town.dennis.ma.us

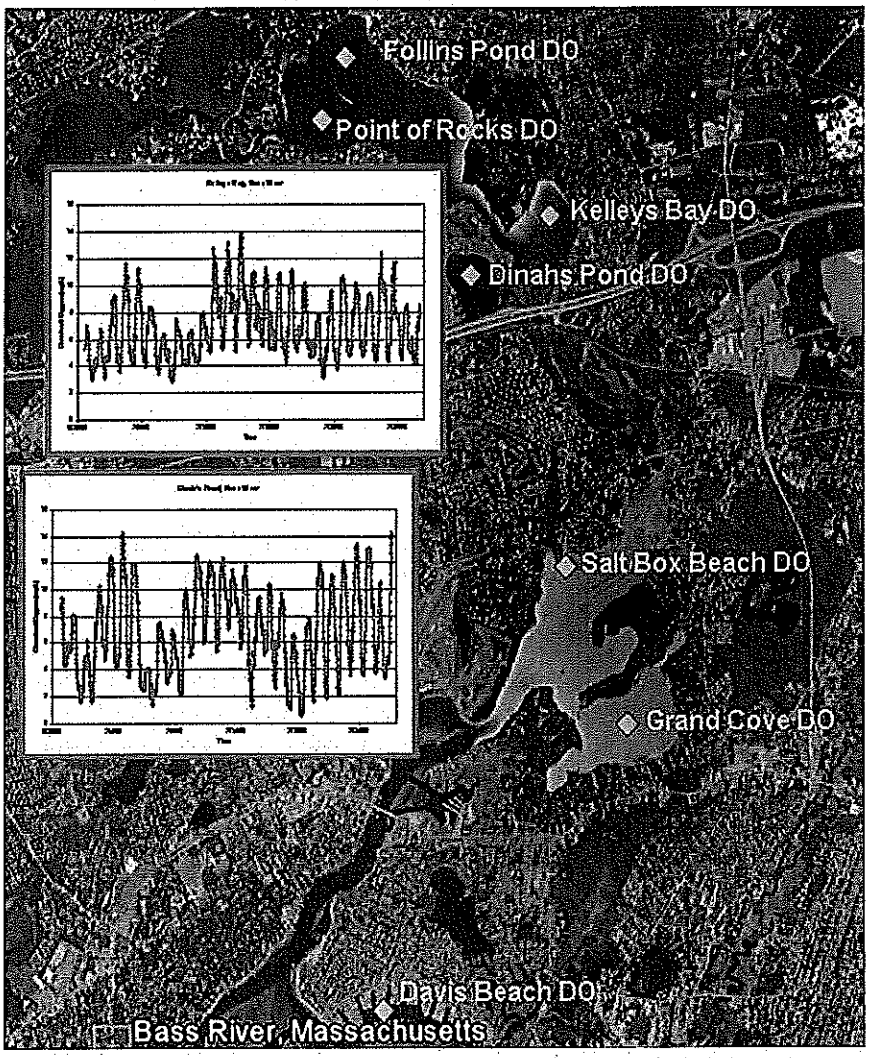
Read or download full Task 1 Report at:
http://www.town.dennis.ma.us/Pages/DennisMA_BComm/wastewater/wastewater

Terry Hayes, Dennis Health Department – thayes@town.dennis.ma.us

12-14-16

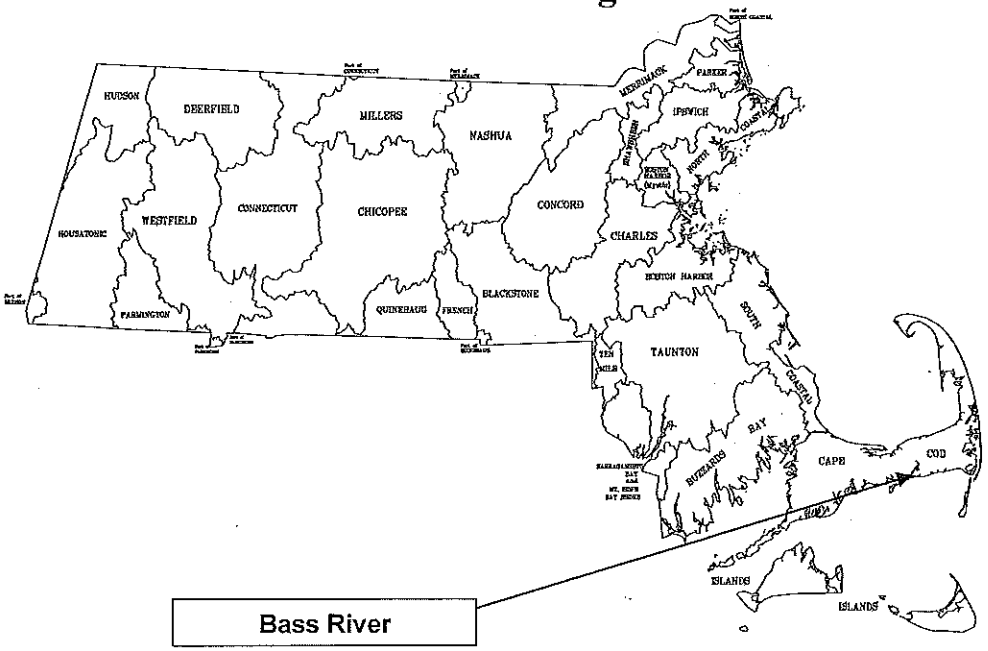
DRAFT
Bass River Estuarine System
Total Maximum Daily Load
For Total Nitrogen

(CN 392.0)



COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF ENERGY AND ENVIRONMENTAL AFFAIRS
MATTHEW A. BEATON, SECRETARY
MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION
MARTIN SUUBERG, COMMISSIONER
BUREAU OF WATER RESOURCES
DOUGLAS FINE, ASSISTANT COMMISSIONER
November 2016

Draft Bass River Estuarine System
Total Maximum Daily Loads
For Total Nitrogen



Key Feature: Total Nitrogen TMDLs for the Bass River Estuarine System

Location: US Environmental Protection Agency (EPA) Region 1, Yarmouth/Dennis, MA

Land Type: New England Coastal

303d Listing: Bass River (MA96-12) is listed in Category 5 of the 2014 Integrated List of Waters for estuarine Bioassessments and was found to be impaired for nutrients during the MEP study. Bass River has a completed TMDL for fecal coliform (EPA #36771). Segments found to be impaired for nutrients during the MEP study and will be included in a future List of Waters: Run Pond (MA96265_2018), Bass River "Grand Cove" (MA96-118_2018), Dinah's Pond (MA96-112_2018), Kelley's Bay (MA96-113_2018), Follins Pond (MA96-114_2018), Mill Pond (MA96-117_2018), Mill Pond Stream/Weir Creek (MA96-116_2018), Mill Pond Stream/Muddy Creek (MA96-115_2018).

Data Sources: University of Massachusetts – Dartmouth/School for Marine Science and Technology; US Geological Survey; Applied Coastal Research and Engineering, Inc.; Town of Dennis; Town of Yarmouth

Data Mechanism: Massachusetts Surface Water Quality Standards, Ambient Data, and Linked Watershed Model

Monitoring Plan: Town of Dennis monitoring program (technical assistance from SMAST) and Town of Yarmouth monitoring program (technical assistance from SMAST)

Control Measures: Sewering, Storm Water Management, Attenuation by Impoundments and Wetlands, Fertilizer Use By-laws, Landfill Management

Executive Summary

Problem Statement

Excessive nitrogen (N) originating from a range of sources has added to the impairment of the environmental quality of the Bass River Estuarine System. Excessive N is indicated by:

- Undesirable increases in macro algae
- Periodic extreme decreases in dissolved oxygen concentrations that threaten aquatic life
- Reductions in the diversity of benthic animal populations
- Significant loss of eelgrass habitat
- Periodic algae blooms

With proper management of N inputs these trends can be reversed. Without proper management more severe problems might develop, including:

- Periodic fish kills
- Unpleasant odors and scum
- Benthic communities reduced to the most stress-tolerant species, or in the worst cases, near loss of the benthic animal communities

Coastal communities rely on clean, productive, and aesthetically pleasing marine and estuarine waters for tourism, recreational swimming, fishing, and boating, as well as for commercial fin fishing and shellfishing. Failure to reduce and control N loadings could result in an overabundance of macro-algae, a higher frequency of extreme decreases in dissolved oxygen concentrations and fish kills, widespread occurrence of unpleasant odors and visible scum, and a complete loss of benthic macroinvertebrates throughout most of the embayments. As a result of these environmental impacts, commercial and recreational uses of the Bass River System will be greatly reduced.

Sources of Nitrogen

Nitrogen enters the waters of coastal embayments from the following sources:

- The watershed
  - Natural background
  - Septic Systems
  - Runoff
  - Fertilizers
  - Agricultural activities
  - Landfills
  - Wastewater treatment facilities
- Atmospheric deposition
- Nutrient-rich bottom sediments in the embayments

Figure ES-A and Figure ES-B illustrate the percent contribution of all the sources of N and the controllable N sources to the estuary system, respectfully. Values are based on Table IV-3 and

Figure IV-7 from the Massachusetts Estuaries Project (MEP) Technical Report. As evident, most of the present *controllable* load to this system comes from septic systems.

Figure ES-A: Percent Contributions of All Nitrogen Sources to the Bass River Estuarine System

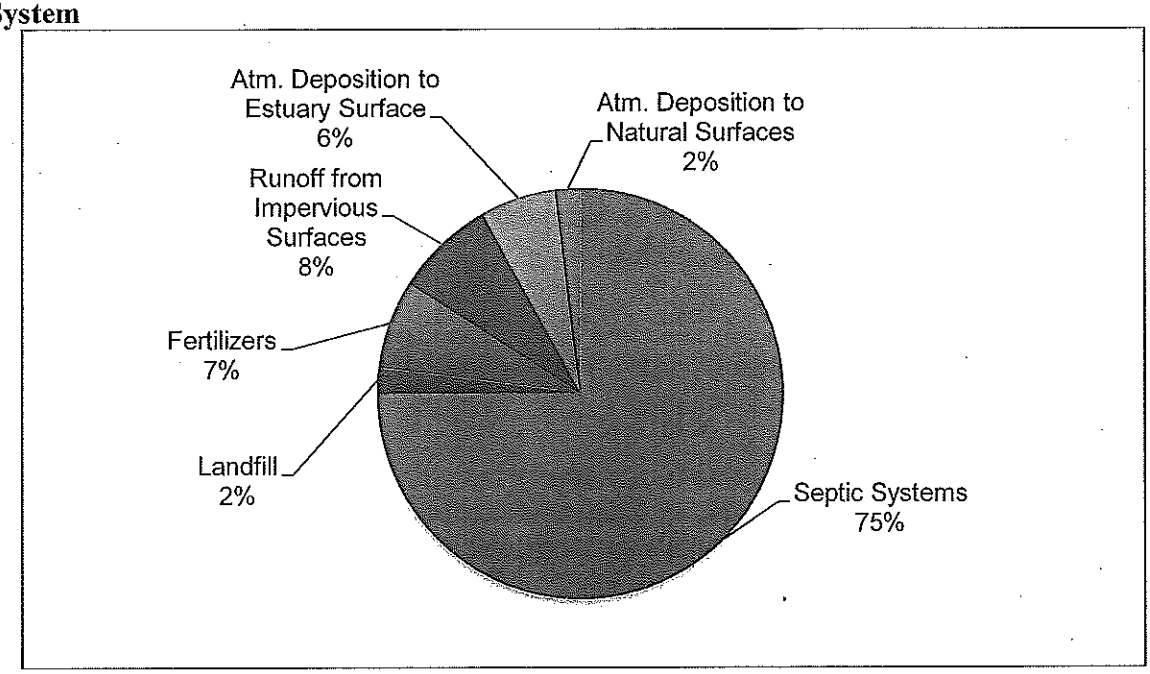
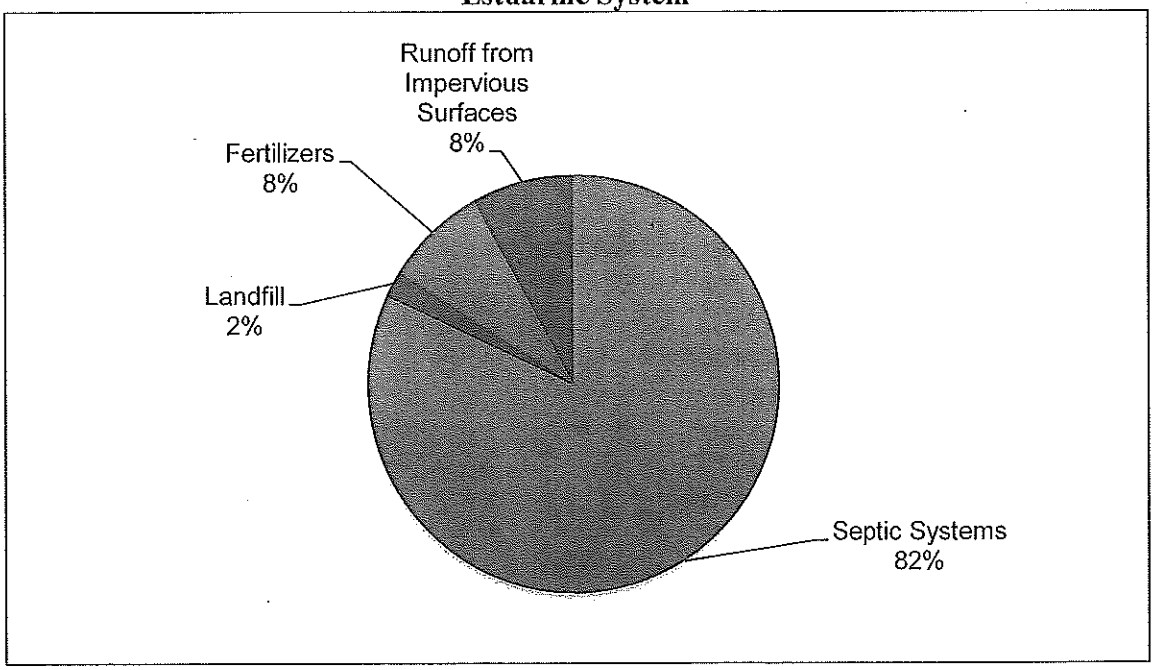


Figure ES-B: Percent Contributions of Controllable Nitrogen Sources to the Bass River Estuarine System



Target Threshold N Concentrations and Loadings

The watershed of the Bass River estuarine system is located on Cape Cod, Massachusetts and lies within the towns of Yarmouth and Dennis and also extends into a small portion of the southwest corner of Brewster. The total N loading (the quantity of N) to this system is 338 kg N/day with the majority of the load originating from the subwatersheds of Bass River-Middle (101 kg N/), Follins Pond (76 kg N/day) and Kelleys Bay (49 kg N/day). The resultant concentrations of N ranged from 0.310-1.129 mg/L in the entire system (range of annual means collected from 13 stations during 2003-2008 as reported in Table VI-1 of the MEP Technical Report, and included in Appendix A of this report).

In order to restore and protect this estuarine system, N loadings, and subsequently the concentrations of N in the water, must be reduced to levels below those that cause the observed environmental impacts. This N concentration will be referred to as the *target threshold N concentration*. The Massachusetts Estuaries Project (MEP) has determined that by achieving a total N concentration of 0.42 mg/L near sentinel station BR-7 in the mid reach of Bass River (see Figure 5), water and habitat quality will be restored in these systems. The mechanism for achieving the target threshold N concentrations is to reduce the N loadings to the watershed of the harbor estuarine system. Based on the MEP sampling and modeling analyses and their Technical Report, the MEP study has determined that the Total Maximum Daily Load (TMDL) of N that will meet the target threshold N concentration of 0.42 mg/L is 206 kg N/day (note: this number is different from the tech report, as negative benthic flux was set to zero in the TMDL). To meet the TMDL this report suggests that a 47% reduction of the total watershed nitrogen load for the entire system will be required. This document presents the TMDL for the Bass River system and suggests possible options to both Yarmouth and Dennis on how to reduce the N loadings to meet the recommended TMDL and protect the waters of this embayment system.

Implementation

The primary goal of TMDL implementation will be lowering the concentrations of N by targeting loadings from on-site subsurface wastewater disposal (septic) systems. The MEP Technical Report for the Bass River system indicated that by reducing septic loads by 97% to 100% in the Dinahs Pond, Follins Pond, Kelleys Bay and Mill Pond and Stream (Weir Creek and Muddy Creek) subwatersheds along with a 69% reduction of septic load in the Bass River-Middle subwatershed the target thresholds can be met. However, there are other loading reduction scenarios that could achieve the target threshold N concentrations and could be verified through additional modeling. The MEP Technical Report also evaluated other options such as widening the culvert at the railroad bridge; however, such options were not considered effective for this particular system.

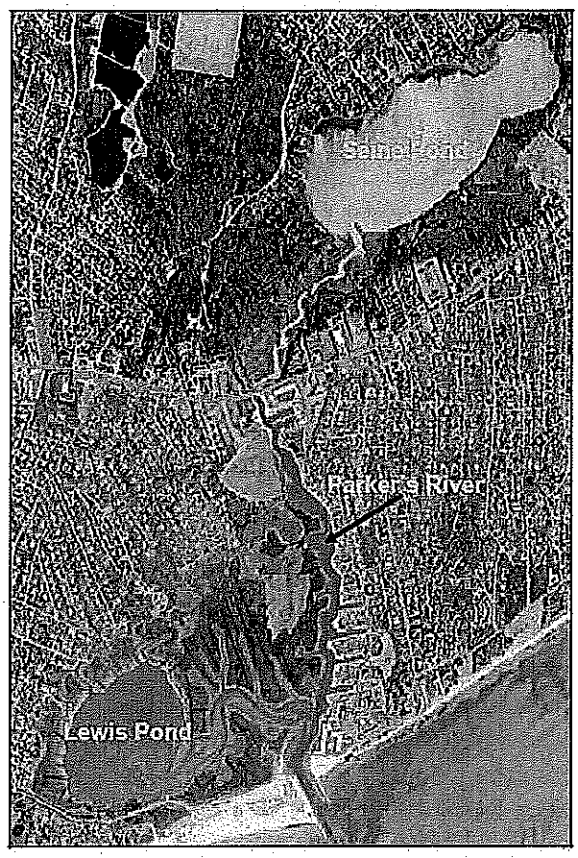
Local officials can explore other loading reduction scenarios through additional modeling as part of their Comprehensive Wastewater Management Plan (CWMP). Implementing best management practices (BMPs) to reduce N loadings from fertilizers and runoff where possible will also help to lower the total N load to the system. Methods for reducing N loadings from these sources are explained in detail in the "MEP Embayment Restoration Guidance for Implementation Strategies" which is available on the MassDEP website

http://www.mass.gov/eea/docs/dep/water/resources/a-thru-m/mepmain.pdf The appropriateness of any of the alternatives will depend on local conditions and will have to be determined on a case-by-case basis using an adaptive management approach. This adaptive management approach will incorporate the priorities and concepts included in the updated area wide management plan established under Clean Water Act Section 208. Finally, growth within the communities of Dennis and Yarmouth, that would exacerbate the problems associated with N Loadings, should be guided by considerations of water quality associated impacts.

12-14-16

DRAFT
Parkers River Embayment System
Total Maximum Daily Loads
For Total Nitrogen

(CN 335.0)



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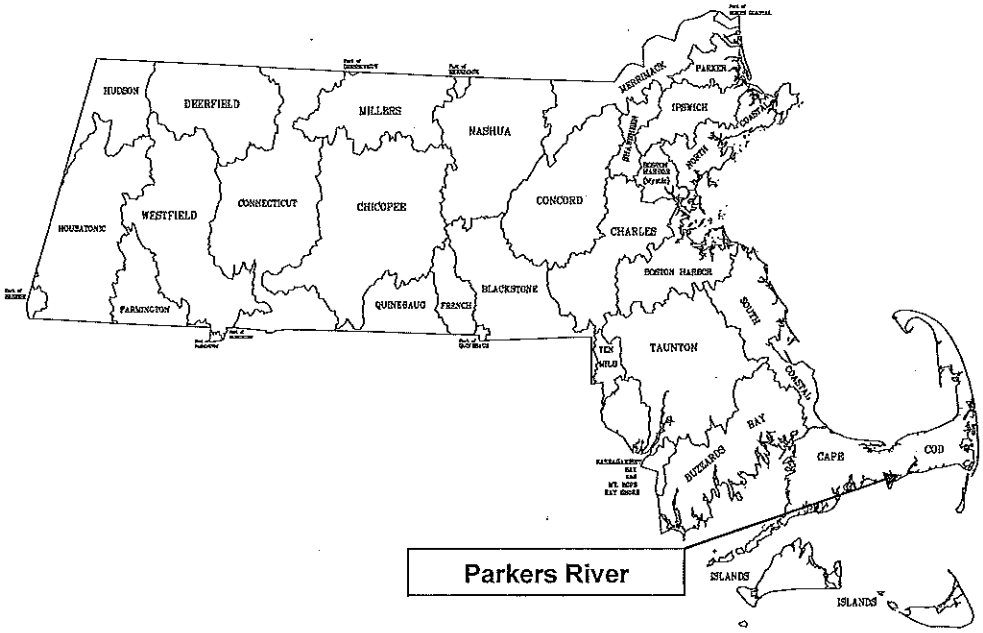
BUREAU OF WATER RESOURCES
DOUGLAS FINE, ASSISTANT COMMISSIONER

November 2016

Draft Parkers River Embayment System
Total Maximum Daily Loads
For Total Nitrogen



Key Feature:	Total Nitrogen TMDL for Parkers River Embayment System
Location:	US Environmental Protection Agency (EPA) Region 1, Yarmouth, MA
Land Type:	New England Coastal
303d Listing:	Parkers River (Segment MA96-38) is on the Category 4a list 2014 MA Integrated List of Waters with a completed TMDL for fecal coliform. Parkers River, Seine Pond (Segment MA96-110_2018), and Lewis Pond (Segment MA96-109_2018) were found to be impaired for nutrients during the MEP study and will be listed in a future List of Waters as impaired.
Data Sources:	University of Massachusetts – Dartmouth/School for Marine Science and Technology; US Geological Survey; Applied Coastal Research and Engineering, Inc.; Cape Cod Commission; Town of Yarmouth
Data Mechanism:	Massachusetts Surface Water Quality Standards, Ambient Data, and Linked Watershed Model
Monitoring Plan:	Town of Yarmouth monitoring program with assistance from SMAST
Control Measures:	Sewering, hydrodynamic modifications to Rt. 28 culvert, and implementation of best management practices for the control of non-point sources.

Executive Summary

Problem Statement

Excessive nitrogen (N) originating from a wide range of sources has added to the impairment of the environmental quality of the Parkers River Embayment System. In the Parkers River estuary, the most significant impairments are the loss of eelgrass in the lower Parkers River basin and impaired benthic infauna in Seine Pond. In general, excessive N in these waters is indicated by:

- Undesirable increases in macroalgae;
- Periodic extreme decreases in dissolved oxygen concentrations that threaten aquatic life;
- Reductions in the diversity of benthic animal populations;
- Significant loss of eelgrass habitat;
- Periodic algae blooms.

With proper management of nitrogen inputs, these trends can be reversed. Without proper management more severe problems might develop, including:

- Periodic fish kills;
- Unpleasant odors and scum;
- Benthic communities reduced to the most stress-tolerant species, or in the worst cases, near loss of the benthic animal communities.

Coastal communities rely on clean, productive and aesthetically pleasing marine and estuarine waters for tourism, recreational swimming, fishing and boating, as well as for commercial fin fishing and shellfishing. Failure to reduce and control N loadings could result in an overabundance of macroalgae, a higher frequency of extreme decreases in dissolved oxygen concentrations and fish kills, widespread occurrence of unpleasant odors and visible scum, and a complete loss of benthic macroinvertebrates throughout most of the embayments. As a result of these environmental impacts, commercial and recreational uses of the Parkers River estuarine system will be greatly reduced.

Sources of Nitrogen

Nitrogen enters the waters of coastal embayments from the following sources:

- The watershed
    - Natural background
    - Septic systems
    - Runoff
    - Fertilizers
    - Agricultural activities
    - Landfills
    - Wastewater treatment facilities;
- Atmospheric deposition
- Nutrient-rich bottom sediments in the embayments

Figure ES-1 illustrates the percent contribution of all the sources of N ("overall load") and the controllable N sources to the estuary system ("local control load"). Values are from Table IV-3 and Figure IV-5 from the Massachusetts Estuaries Project (MEP) Parkers River Embayment

System Technical Report (Howes *et. al*, 2010). As evident, most of the present overall load and most of the controllable load of nitrogen to this system comes from wastewater (septic systems).

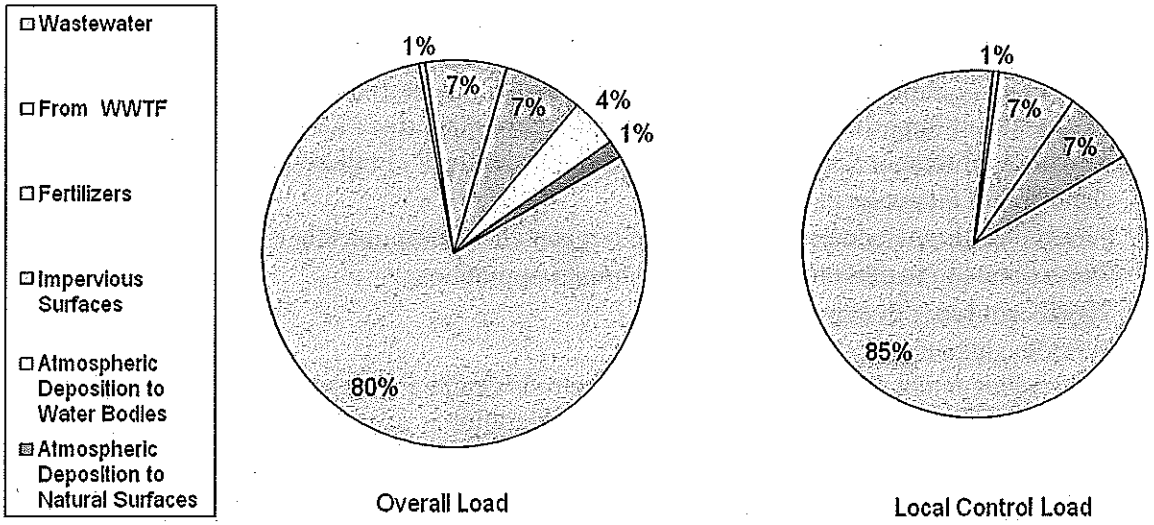


Figure ES-1- Relative Contribution of All Nitrogen Sources (Uncontrollable and Controllable) in the Parkers River Embayment System

Target Threshold Nitrogen Concentrations and Loadings

The Parkers River estuary lies entirely within the Town of Yarmouth on Cape Cod, Massachusetts. The total attenuated watershed N loading (the quantity of N) to the system is approximately 67 kg N/day. The overall total nitrogen load to the embayment system including direct atmospheric deposition of nitrogen to the embayment surfaces and the net benthic flux of nitrogen from the sediments is approximately 98 kg N/day. Current water column concentrations of N in the embayment system ranged from 0.663-0.994 mg/L throughout the entire system (range of annual means collected from 5 stations during 2002-2008 as reported in Table VI-1 of the MEP Parkers River Embayment System Technical Report, Howes *et. al*, 2010 and Appendix A).

In order to restore and protect this estuarine system, N loadings and subsequently, the concentrations of N in the water must be reduced to levels below those that cause the observed environmental impacts. This N concentration will be referred to as the target threshold N concentration. The Massachusetts Estuaries Project (MEP) has determined that by achieving a total N concentration of 0.42 mg/L at the sentinel station located between stations PR-2 and PR-3 in the lower reach of the Parkers River, located at the uppermost extent of the historical eelgrass coverage, water and habitat quality will be restored in this system (see Figures 6 and 7). The mechanism for achieving the target threshold N concentration is to reduce the N loadings to the watershed of the estuarine system.

Based on the MEP sampling and modeling analyses (Howes *et. al.*, 2010), the Massachusetts Department of Environmental Protection (MassDEP) has adopted a range of Total Maximum

Daily Loads (TMDLs) of N throughout the embayment system. The values of the TMDLs range from 5.18 to 18.02 kg/day for the different subembayments with a total Parkers River Embayment System TMDL of 35.47 kg N/day. (Note: this number is slightly different from the technical report as negative benthic flux was set to zero in the TMDL.). For the Parkers River Embayment System an overall approximately 80% reduction in watershed N loads is required to meet target threshold N concentrations and restore this embayment system.

This document presents the TMDLs for the Parkers River estuarine system and suggests possible options to Yarmouth on how to reduce the N loadings to meet the recommended TMDLs and protect the waters of this embayment system.

Implementation

The primary goal of implementation will be to lower the concentrations of N by greatly reducing the loadings from on-site subsurface wastewater disposal systems through a variety of centralized or decentralized methods such as sewering and treatment with nitrogen removal technology, advanced treatment of septage, and/or installation of N-reducing on-site systems. There may be other loading reduction scenarios that could achieve the target threshold N concentrations than were explored in the MEP Technical Report. These options would require additional modeling to verify their effectiveness.

These strategies, plus ways to reduce N loadings from stormwater runoff and fertilizers, are explained in detail in *The Massachusetts Estuaries Project: Embayment Restoration and Guidance for Implementation Strategies* (MassDEP 2003). The appropriateness of any of the alternatives will depend on local conditions, and will have to be determined on a case-by-case basis, using an adaptive management approach. This adaptive management approach will incorporate the priorities and concepts included in the updated area wide management plan established under the Clean Water Act Section 208.

Finally, growth within the community of Yarmouth that would exacerbate the problems associated with N loadings, should be guided by considerations of water quality-associated impacts.

12-14-16

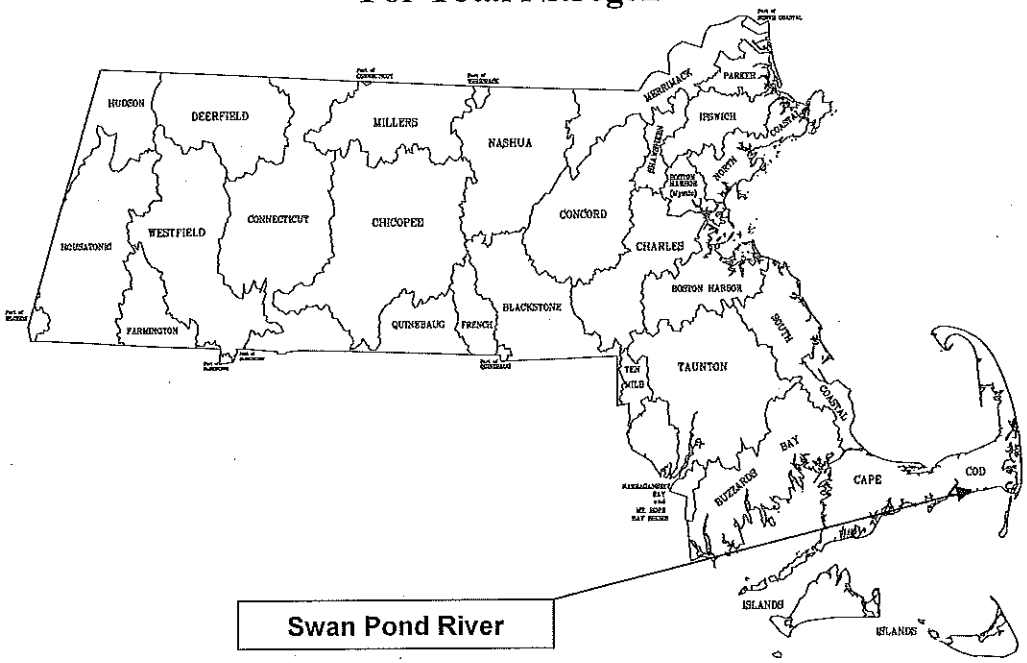
DRAFT
Swan Pond River Estuarine System
Total Maximum Daily Load
For Total Nitrogen
CN 393.0

COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF ENERGY AND ENVIRONMENTAL AFFAIRS
MATTHEW A. BEATON, SECRETARY
MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION
MARTIN SUUBERG, COMMISSIONER
BUREAU OF WATER RESOURCES
DOUGLAS FINE, DEPUTY ASSISTANT COMMISSIONER

November 2016

DRAFT

Swan Pond River Estuarine System Total Maximum Daily Load For Total Nitrogen



Key Feature:	Total Nitrogen TMDL for the Swan Pond River Estuarine System
Location:	US Environmental Protection Agency (EPA) Region 1, Dennis, MA
Land Type:	New England Coastal
303d Listing:	The Swan Pond River (MA 96-14) is impaired and listed in Category 5 of the 2014 Integrated List of Waters as impaired for aquatic life (loss of eelgrass and benthic habitat) and shellfishing (fecal coliform). The Swan Pond River estuarine system was found to be impaired for nutrients during the MEP study. Swan Pond will be listed as impaired for nutrients in a future List of Waters.
Data Sources:	University of Massachusetts – Dartmouth/School for Marine Science and Technology, US Geological Survey, Applied Coastal Research and Engineering, Inc., Town of Dennis
Data Mechanism:	Massachusetts Surface Water Quality Standards, Ambient Data, and Linked Watershed Model
Monitoring Plan:	Town of Dennis, Dennis Water District Water Quality Monitoring Program (with technical assistance from SMAST)
Control Measures:	Sewering, Stormwater Management, Attenuation by Impoundments and Wetlands, Fertilizer Use By-laws

Executive Summary

Problem Statement

Excessive nitrogen (N) originating from a range of sources has added to the impairment of the environmental quality of the Swan Pond River estuarine system. Excessive N is indicated by:

- Undesirable increases in macro algae
- Periodic extreme decreases in dissolved oxygen concentrations that threaten aquatic life
- Reductions in the diversity of benthic animal populations
- Significant loss of eelgrass habitat
- Periodic algae blooms

With proper management of N inputs these trends can be reversed. Without proper management more severe problems might develop, including:

- Periodic fish kills
- Unpleasant odors and scum
- Benthic communities reduced to the most stress-tolerant species, or in the worst cases, near loss of the benthic animal communities

Coastal communities rely on clean, productive and aesthetically pleasing marine and estuarine waters for tourism, recreational swimming, fishing and boating, as well as for commercial fin fishing and shellfishing. Failure to reduce and control N loadings could result in an overabundance of macro-algae, a higher frequency of extreme decreases in dissolved oxygen concentrations and fish kills, widespread occurrence of unpleasant odors and visible scum, and a complete loss of benthic macroinvertebrates throughout most of the embayments. As a result of these environmental impacts, commercial and recreational uses of the Swan Pond River estuarine system will be greatly reduced.

Sources of Nitrogen

Nitrogen enters the waters of coastal embayments from the following sources:

- The watershed
    - Natural background
    - Septic Systems
    - Runoff
    - Fertilizers
    - Agricultural activities
    - Landfills
    - Wastewater treatment facilities;
- Atmospheric deposition;
- Nutrient-rich bottom sediments in the embayments.

Figure ES-A and Figure ES-B illustrate the percent contribution of all the sources of N and the controllable N sources to the estuary system, respectfully. Values are based on Table IV-3 and Figure IV-5 from the Massachusetts Estuaries Project (MEP) Swan Pond River Embayment System Technical Report. As evident, most of the present *controllable* load to this system comes from septic systems.

Figure ES-A: Percent Contributions of All Nitrogen Sources to the Swan Pond River Estuarine System

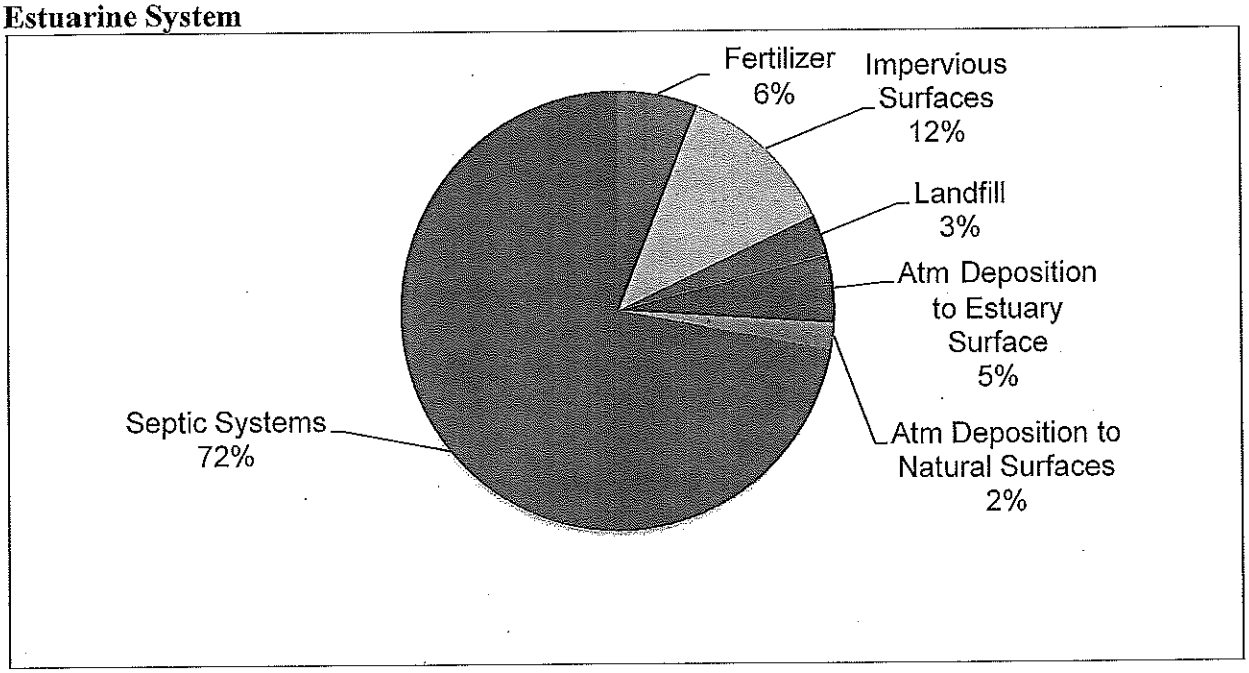
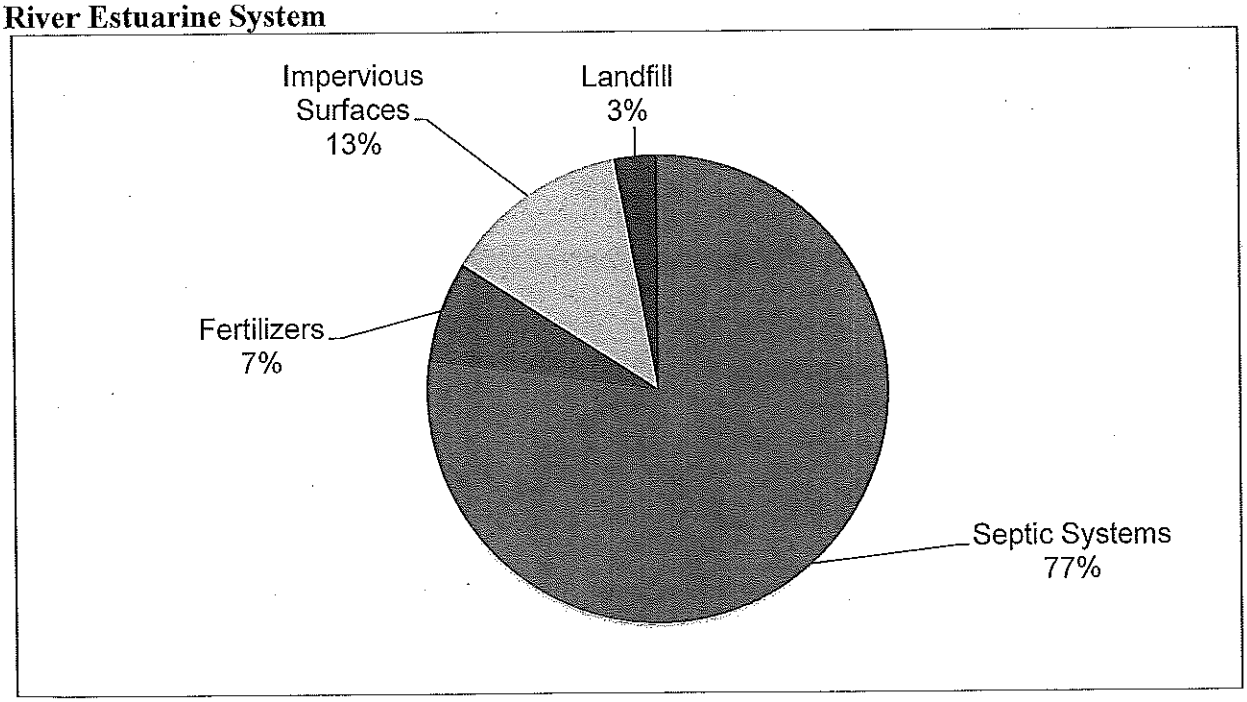


Figure ES-B: Percent Contributions of Controllable Nitrogen Sources to the Swan Pond River Estuarine System



Target Threshold N Concentrations and Loadings

The Swan Pond River and Swan Pond lie entirely within the Town of Dennis on Cape Cod, Massachusetts. The watershed of this system is predominately in Dennis but very small portions are shared between the Towns of Harwich and Brewster. The total N loading (the quantity of N) to this system is 46 kg N/day from the combined three major subwatersheds (Swan Pond, Swan Pond River North and Swan Pond River South). The resultant concentrations of N ranged from 0.449-1.547 mg/L in the entire system (range of annual means collected from 7 stations during 2005-2010 as reported in Table VI-1 of the MEP Technical Report, and included in Appendix A of this report).

In order to restore and protect this estuarine system, N loadings, and subsequently the concentrations of N in the water, must be reduced to levels below those that cause the observed environmental impacts. This N concentration will be referred to as the *target threshold N concentration*. The Massachusetts Estuaries Project (MEP) has determined that by achieving a total N concentration of 0.40 mg/L near sentinel station SWP-2 in the middle of the lower reach of the Swan Pond River (see Figure 5), water and habitat quality will be restored in these systems. The mechanism for achieving the target threshold N concentrations is to reduce the N loadings to the watershed of the estuarine system. Based on the MEP sampling and modeling analyses and their Technical Report, the MEP study has determined that the Total Maximum Daily Load (TMDL) of N that will meet the target threshold N concentration of 0.40 mg/L is 13.1 kg N/day (note: this number is slightly different from the technical report, as negative benthic flux was set to zero in the TMDL). To meet the TMDL this report suggests that a 77% reduction of the total watershed nitrogen load for the entire system will be required.

This document presents the TMDL for the Swan Pond River Estuarine System and suggests possible options to Dennis as well as the watershed towns of Harwich and Brewster on how to reduce the N loadings to meet the recommended TMDL and protect the waters of this embayment system.

Implementation

The primary goal of TMDL implementation will be lowering the concentrations of N by targeting loadings from on-site subsurface wastewater disposal (septic) systems. The MEP Technical Report for the Swan Pond River Estuarine System indicated that by reducing septic loads by 100% throughout the watershed, the target thresholds can be met. However, there may be other loading reduction scenarios that could achieve the target threshold N concentrations. These options would require additional modeling to verify their effectiveness.

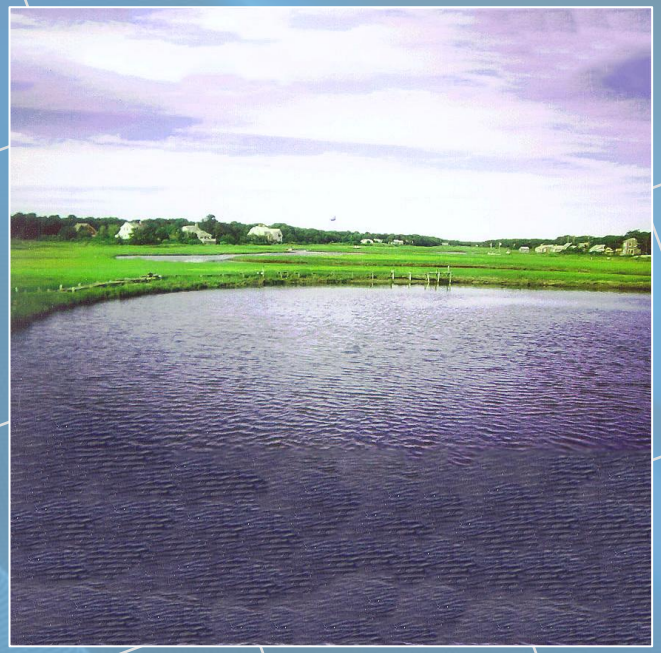
Local officials can explore other loading reduction scenarios through additional modeling as part of their Comprehensive Wastewater Management Plan (CWMP). Implementing best management practices (BMPs) to reduce N loadings from fertilizers and runoff where possible will also help to lower the total N load to the system. Methods for reducing N loadings from these sources are explained in detail in the "MEP Embayment Restoration Guidance for Implementation Strategies" which is available on the MassDEP website

http://www.mass.gov/eea/agencies/massdep/water/watersheds/coastal-resources-and-estuaries.html The appropriateness of any of the alternatives will depend on local conditions and will have to be determined on a case-by-case basis using an adaptive management approach. This adaptive management approach will incorporate the priorities and concepts included in the updated area wide management plan established under Clean Water Act Section 208.

Finally, growth within the communities of Dennis, Harwich, and Brewster that would exacerbate the problems associated with N loadings should be guided by considerations of water quality-associated impacts.

Dennis, Harwich, and Yarmouth

Community Partnership Evaluation Project



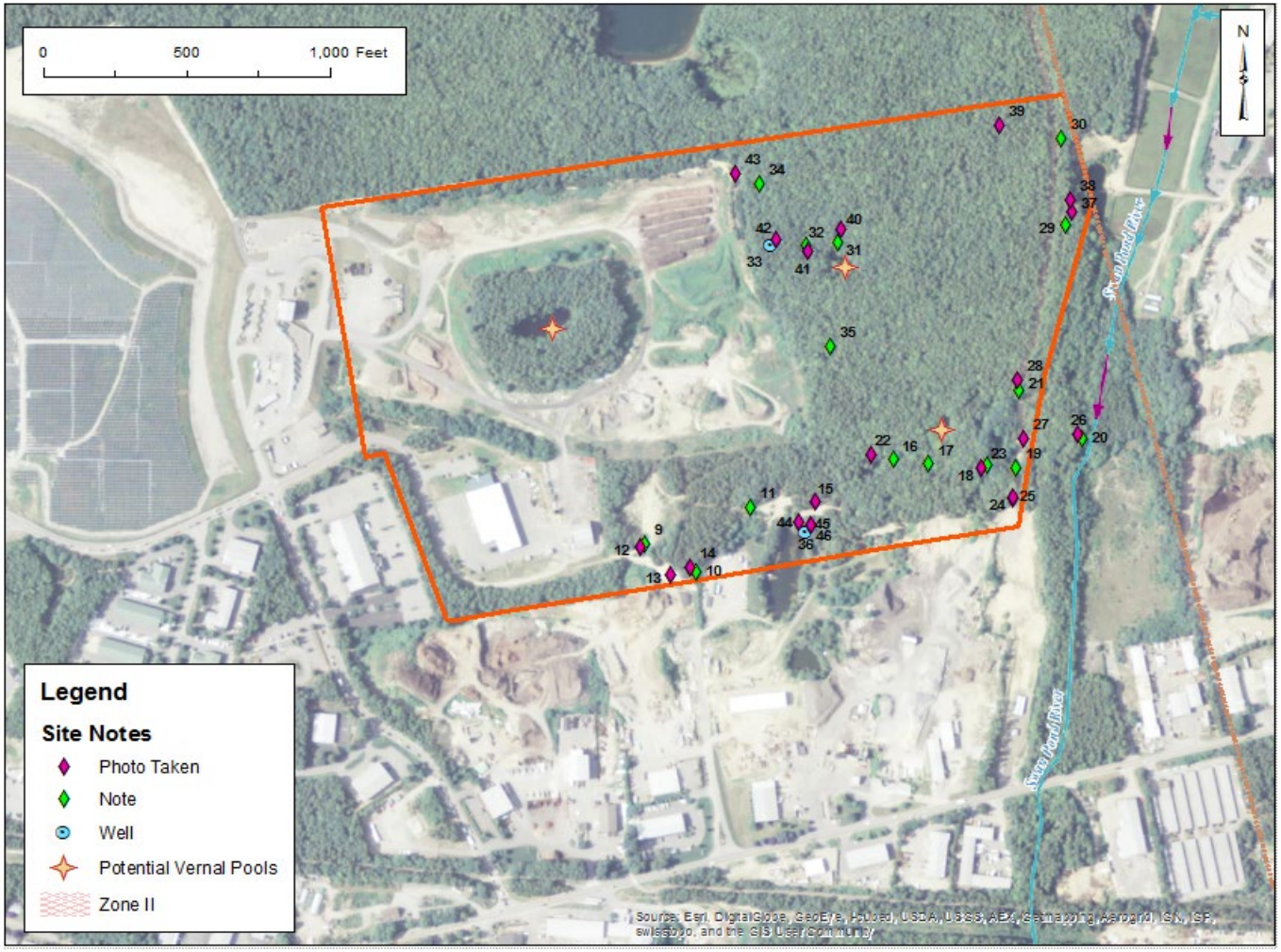
David Young, P.E.
Vice President

September 21, 2016

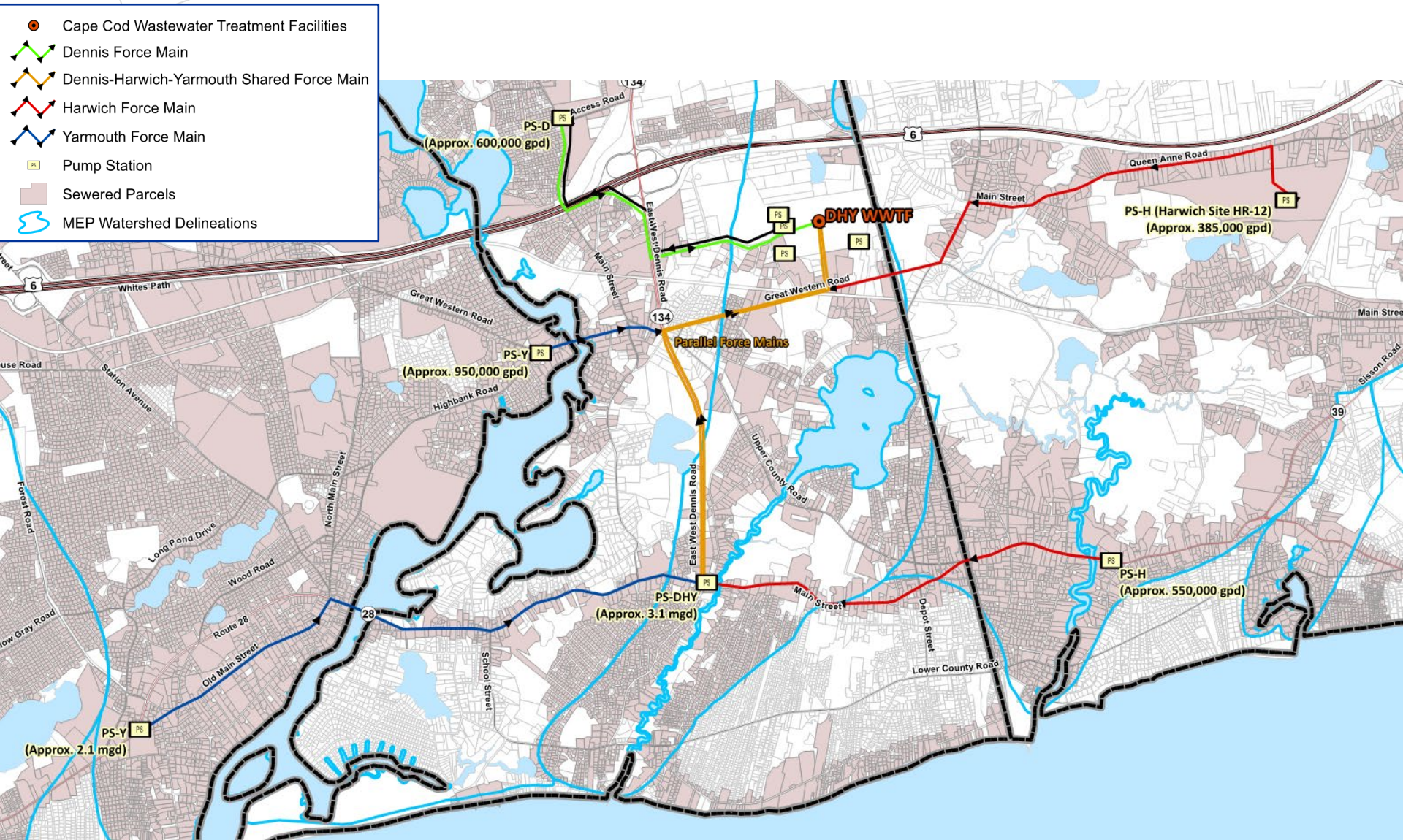
Wastewater Flow by Town at Buildout

	Wastewater Flow at Buildout	% of D-H-Y WWTF
Dennis	1.5 MGD	28%
Harwich	0.9 MGD	17%
Yarmouth	3.0 MGD	56%
Total	5.4 MGD	

D-H-Y WWTF at 120 Theophilis Smith Road, Dennis



Regional Conveyance: North and South Connections for Dennis, Harwich, and Yarmouth



D-H-Y Regional Phasing Timeline

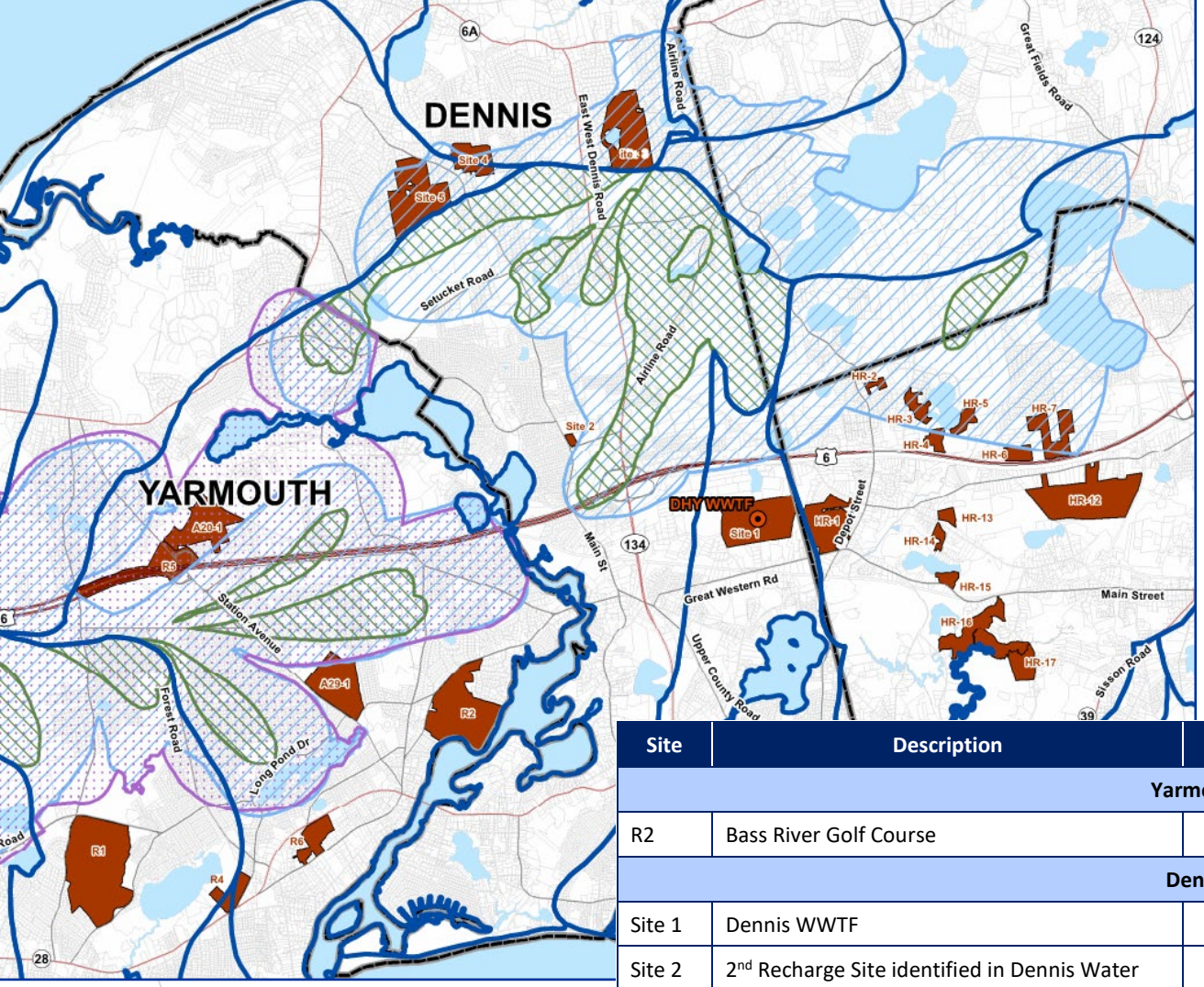
- Phase 1
  - Regional D-H-Y WWTF Construction
  - Regional Pumping Station at Intersection of Route 28/Route 134
  - Regional Dual Force Mains to D-H-Y WWTF
  - Dennis sewer system backbone on Route 28 West
  - Harwich Pleasant Bay sewer service area (to Chatham WWTP)
  - Yarmouth South Connection: Force Main along Route 28 in Dennis to connect Yarmouth's Rt28 sewer service area
- Phase 2
  - Dennis sewer system expansion
  - Harwich Pleasant Bay sewer service area (to Chatham WWTF)
  - Yarmouth sewer system expansion

D-H-Y Regional Phasing Timeline (continued)

- Phase 3
  - Dennis and Yarmouth sewer system expansion
  - Harwich South Connection: PS & Force Main along Route 28 in Dennis to connect southern Harwich's sewer service area
- Phase 4
  - Regional D-H-Y WWTF Expansion
  - Dennis sewer system expansion (north of Route 6)
  - Harwich sewer system backbone on Route 28 in Harwich
  - Yarmouth sewer system expansion

D-H-Y Regional Phasing Timeline (continued)

- Phase 5
  - Dennis, Harwich, and Yarmouth sewer system expansion
- Phase 6
  - Dennis sewer system expansion
  - Harwich North Connection: PS & Force Main on Great Western Road
  - Harwich sewer service expansion
  - Yarmouth North Connection: Force Main on Highbank Road
  - Yarmouth sewer service expansion
- Phases 7 and 8
  - Harwich sewer service expansion
  - Potential for Dennis/Yarmouth sewer service expansion



Regional Effluent Recharge

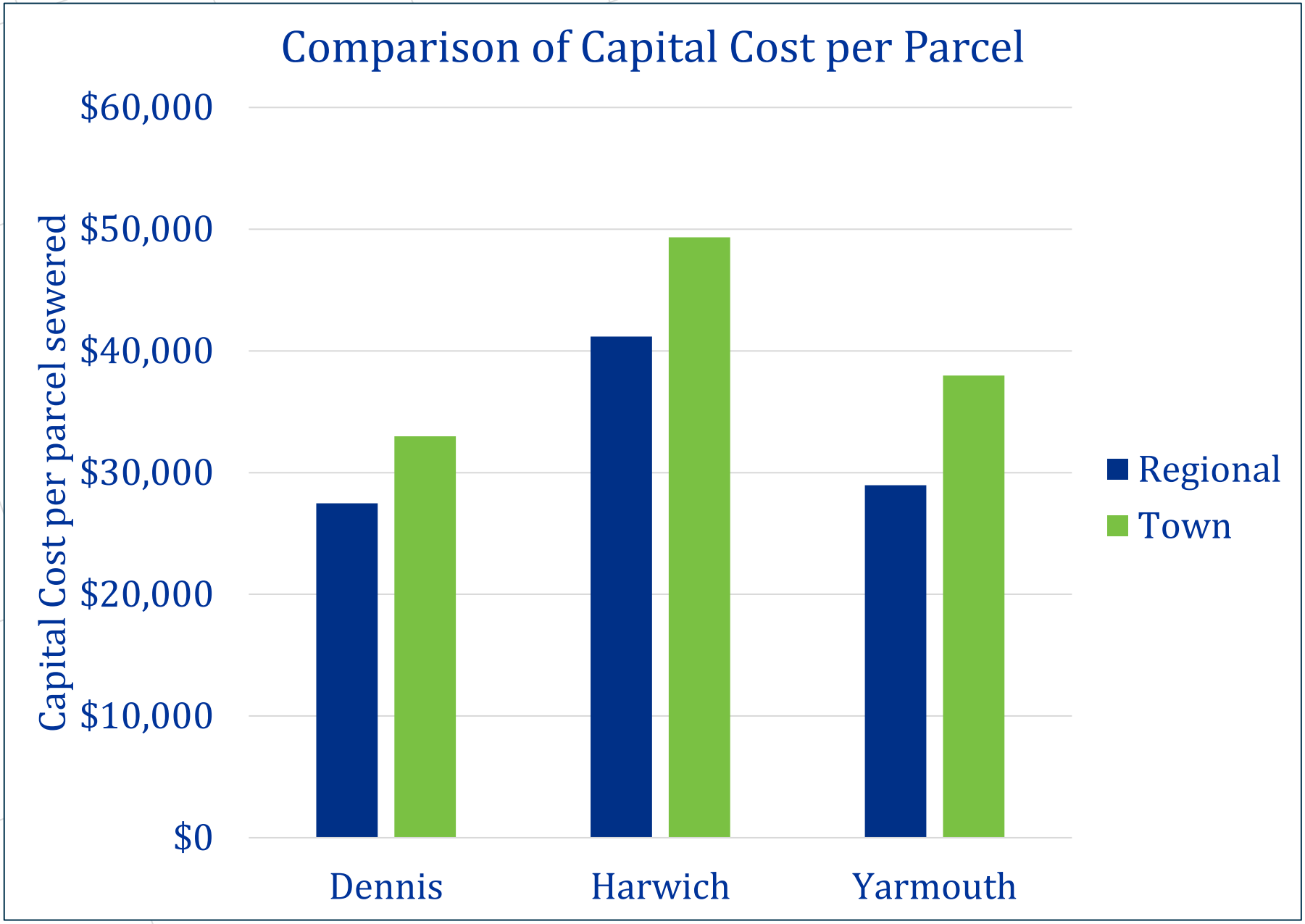
Site	Description	Effluent Recharge Capacity Range (MGD)	
Yarmouth			
R2	Bass River Golf Course	0.4	0.75
Dennis			
Site 1	Dennis WWTF	1.0	
Site 2	2nd Recharge Site identified in Dennis Water Quality Evaluation and Mitigation Alternative Study Final Report	0.5	
Site 3	Northern section of Dennis Pines Golf Course	1.4	4.0
Site 4	Parcels north and south of Hokum Rock Road	0.3	2.1
Site 5	Northern section of Highland Golf Course	0.25	4.0
Harwich			
HR-12	Proposed Location of Harwich WWTF	1.2	
	Total	5.1	13.6

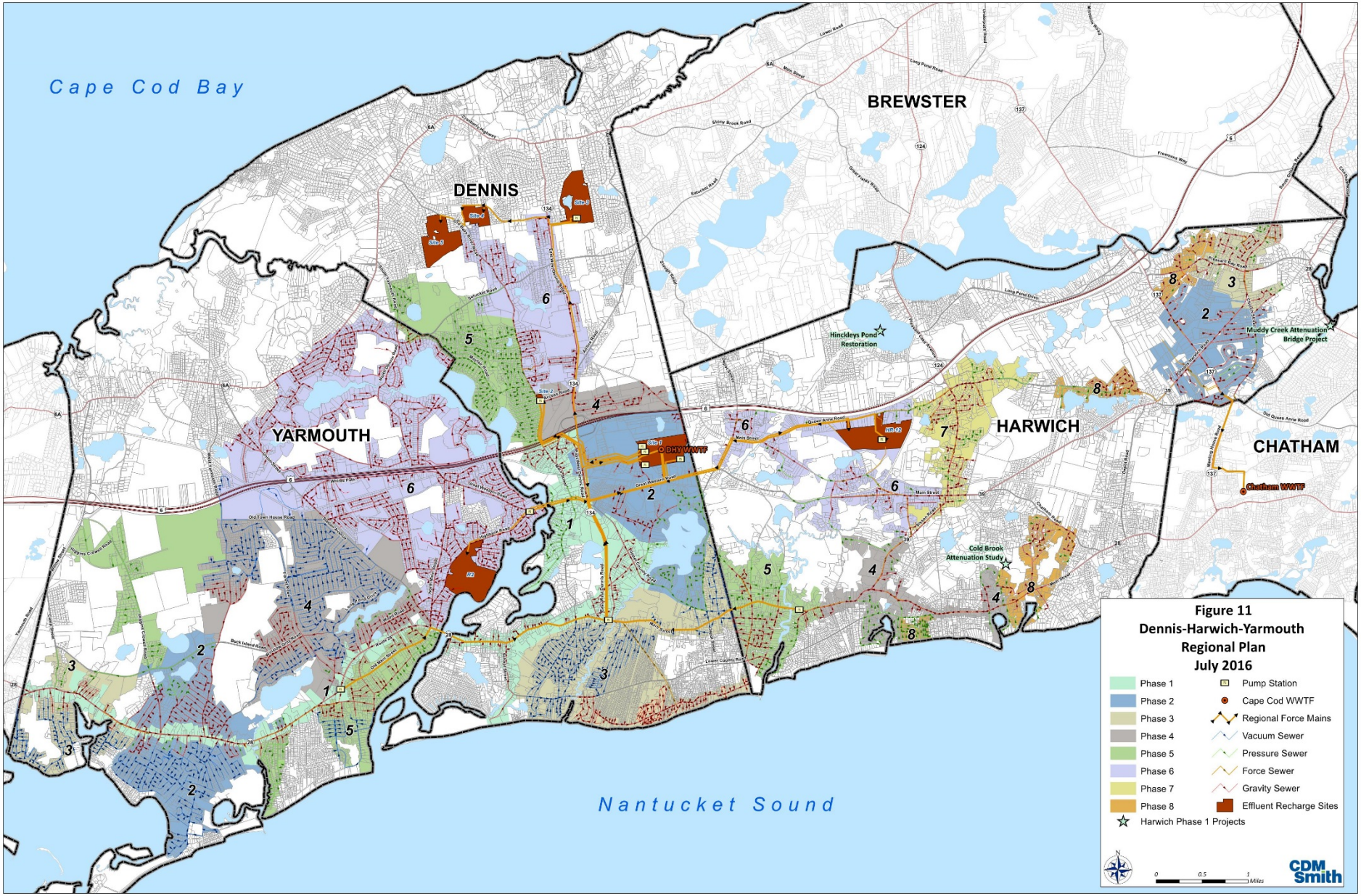
Summary of Shared Utilities

- A regional pumping station at the intersection of Route 28 and Route 134 in Dennis
- Dual 20-inch force mains from the intersection of Route 28 and Route 134 into the D-H-Y WWTF
- D-H-Y WWTF
- Piping to convey to recharge sites
- Regional effluent recharge sites:
  - Dennis Site Nos. 1 and 2
  - Yarmouth Bass River Golf Course
  - Harwich Site HR-12
  - Dennis Pines Golf Course (Site No. 3)
  - Dennis Highland Golf Course (Site No. 5)
  - Dennis Parcels north and south of Hokum Rock Road (Site No. 4)

Regional and Town Scenario Cost Comparison At Buildout Flow

	Capital Costs		O&M Costs		Equivalent Annual Costs		Annual Savings	
	Regional	Town	Regional	Town	Regional	Town	$ Mil/year	%
Dennis	$172 M	$207 M	$3.8 M	$7 M	$11 M	$20 M	$8 M	42%
Harwich	$204 M	$244 M	$2.5 M	$3 M	$12 M	$17 M	$5 M	31%
Yarmouth	$330 M	$432 M	$6.2 M	$12 M	$21 M	$31 M	$10 M	33%


Comparison of Capital Cost per Parcel
$60,000
$50,000
$40,000
$30,000
$20,000
$10,000
$0
Capital Cost per parcel sewered
Dennis
Harwich
Yarmouth
Regional
Town


Cape Cod Bay
BREWSTER
DENNIS
YARMOUTH
HARWICH
CHATHAM
Nantucket Sound
Hinckleys Pond Restoration
Muddy Creek Attenuation Bridge Project
Cold Brook Attenuation Study
DNY WWTF
Chatham WWTF
Figure 11
Dennis-Harwich-Yarmouth
Regional Plan
July 2016
Phase 1
Phase 2
Phase 3
Phase 4
Phase 5
Phase 6
Phase 7
Phase 8
Harwich Phase 1 Projects
Pump Station
Cape Cod WWTF
Regional Force Mains
Vacuum Sewer
Pressure Sewer
Force Sewer
Gravity Sewer
Effluent Recharge Sites
CDM Smith

Status of Water Quality Evaluation and Mitigation Alternative Study

Town of Dennis, Massachusetts

Dennis
preserving our water resources

David Young, P.E.
Vice President

Town Workshop
November 17, 2015

CDM Smith®

Comprehensive Wastewater Management Task Force

Dennis
preserving our water resources

- Task Force Members:
  - Diane Chamberlain, Chair
  - Stan Graveline
  - John Harper
  - Bob Mezzadri
  - Dick O'Hearn
  - Greg Stone
  - Frank Verny
  - Suzanne Brock
  - Jay Thrasher
- Town Staff Support: Terry Hayes, Health Department and Liz Sullivan, Assistant Town Administrator
- CDM Smith: David Young, P.E.

Meeting Purpose

Dennis
preserving our water resources

- Provide an overview of study
- Update on water quality evaluation findings
- Show possible sites for wastewater treatment components (facilities and/or effluent recharge basins)
- Present four scenarios selected by Task Force for further detailed evaluation in next phase
- Present planning-level cost estimates
- Discuss next steps

Why Dennis Needs to Control Nutrients

Water Quality

Drinking Water

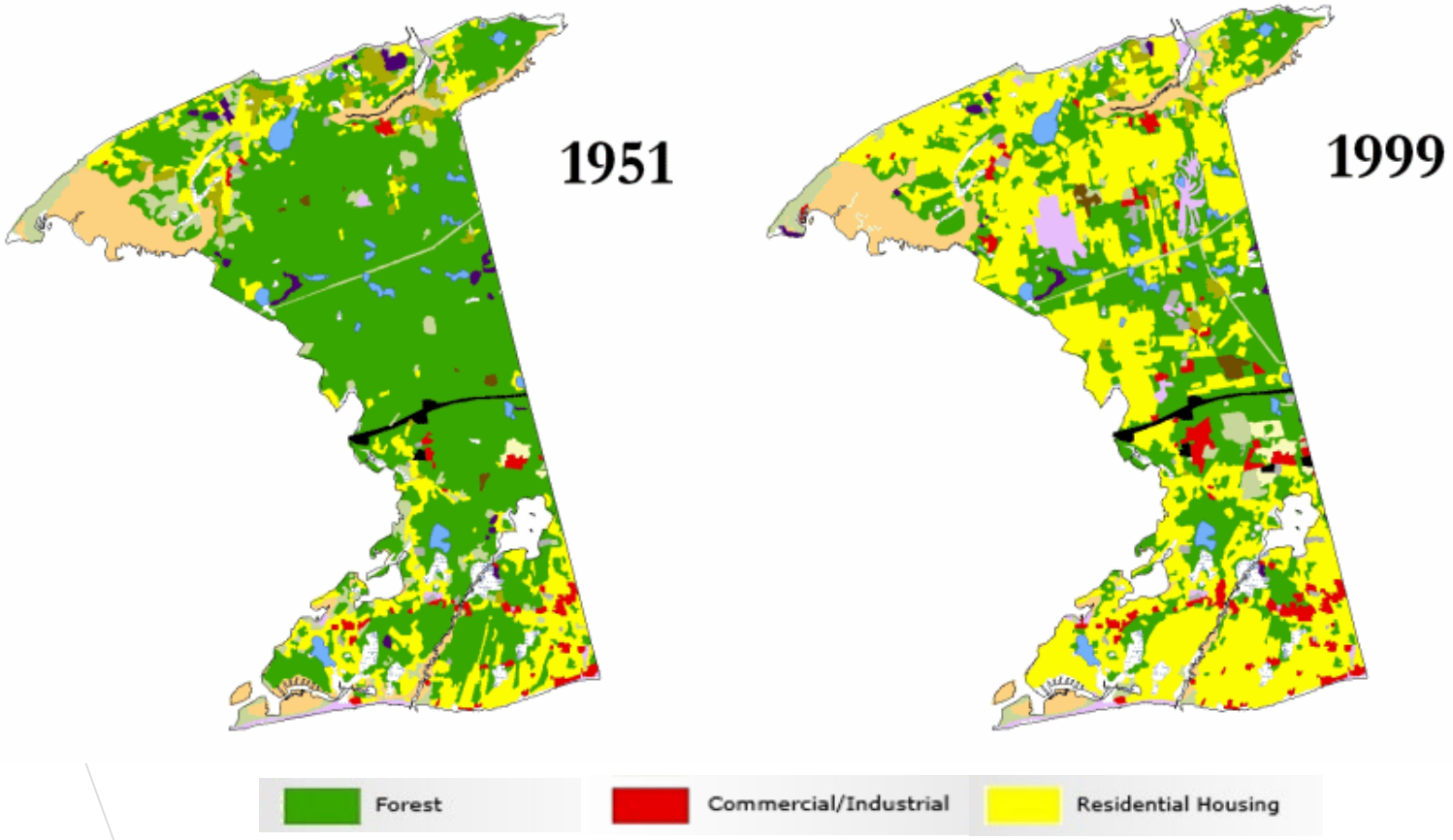
Nutrient Impacts

Economic Development

Beaches, Harbors, Rivers, and Ponds

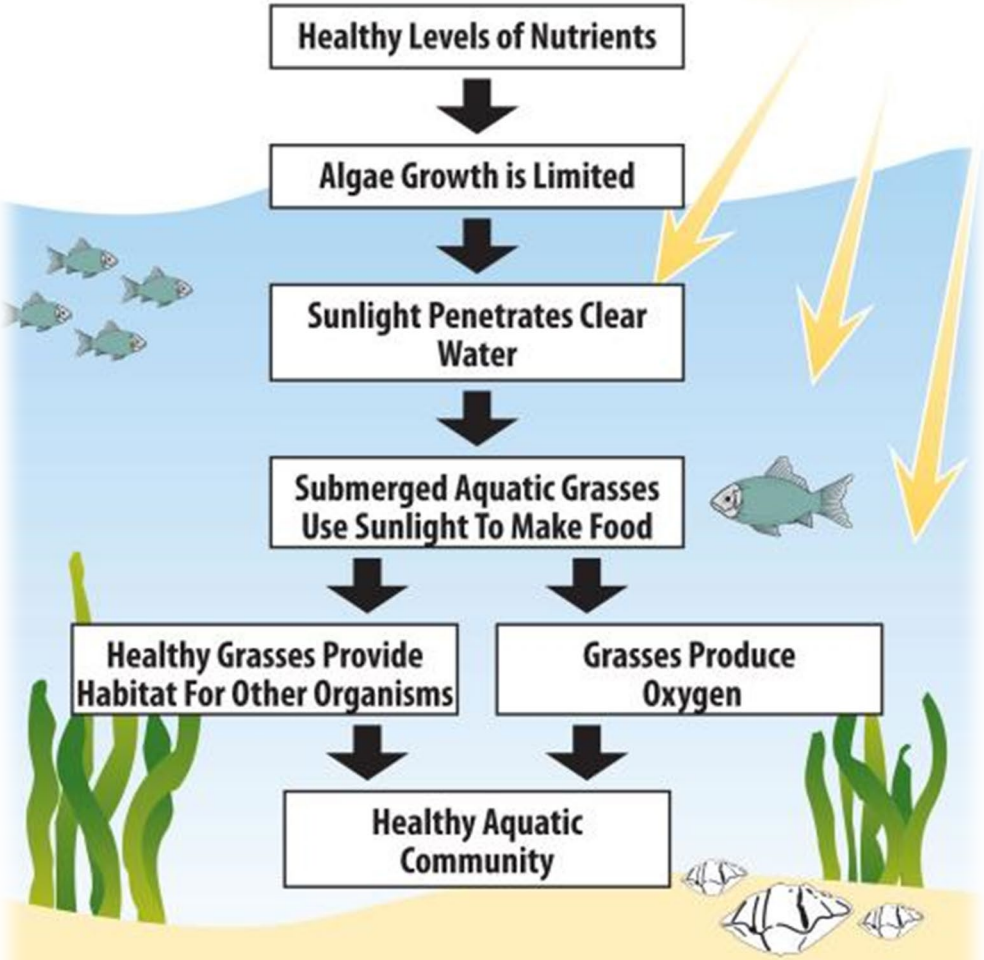
Dennis

preserving our water resources



Beaches, Rivers, Harbors, and Ponds Are Severely Impacted By Nutrients

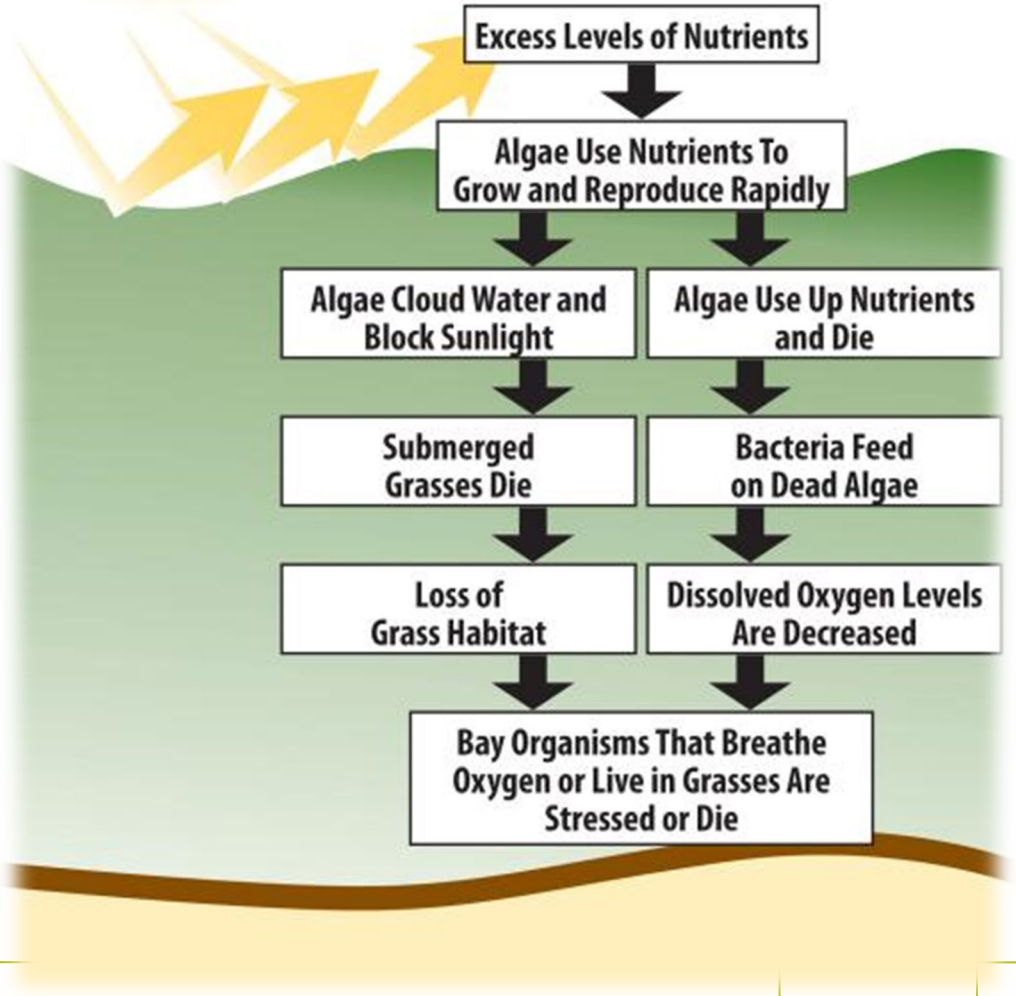
Healthy Nitrogen and Phosphorus Levels

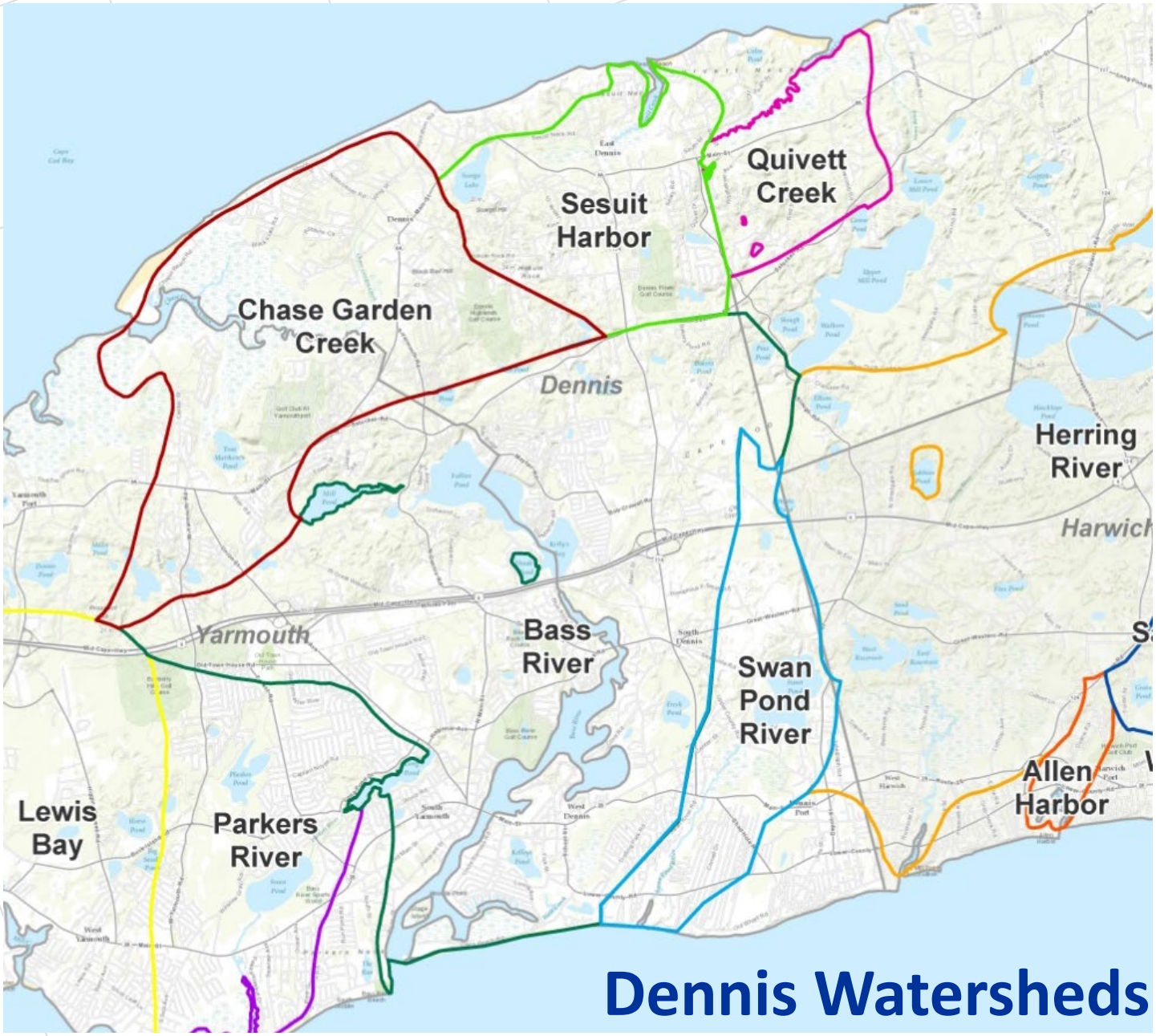


Beaches, Rivers, Harbors, and Ponds Are Severely Impacted By Nutrients

Unhealthy Nitrogen and Phosphorus Levels

Algae in Mill Pond, Yarmouth

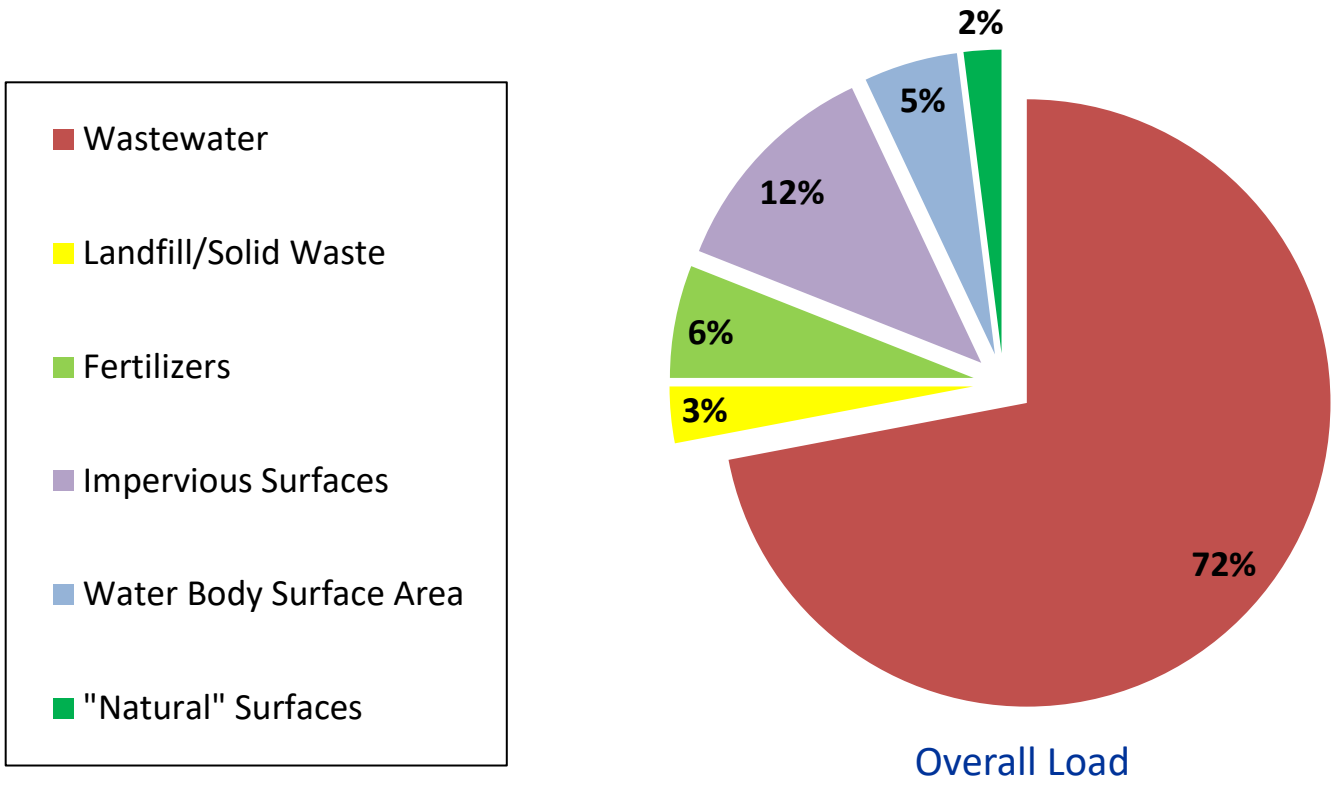




Dennis Watersheds

Controllable Nitrogen Sources – Swan Pond River Watershed

Dennis
preserving our water resources



Overall Load

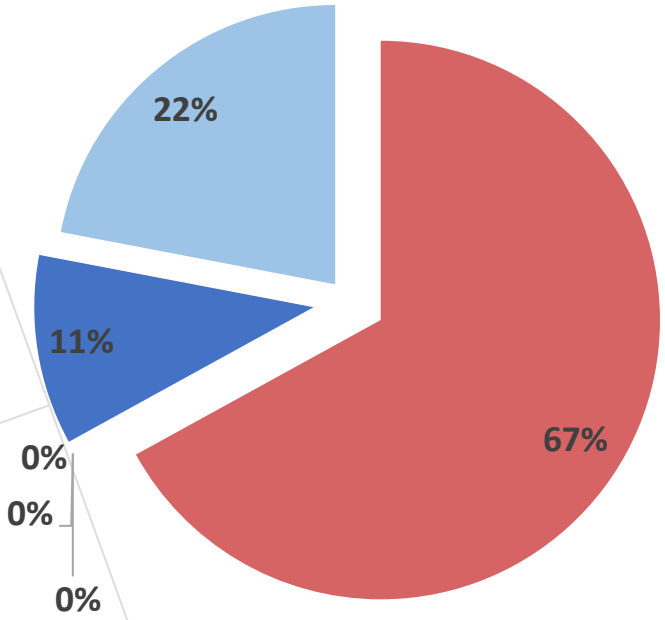
Goals for Nitrogen Management

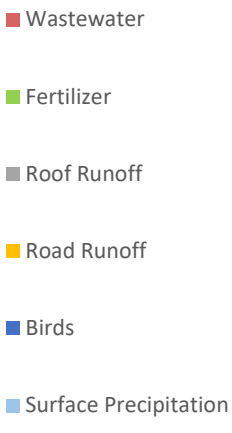
Dennis
preserving our water resources

Dennis Portion of MEP Watersheds	***Septic Nitrogen ("N") Removal Rates from Wastewater to Meet TMDL Under Existing Conditions***
Swan Pond River	**-75.5%**
Bass River	**-47.4%**
Herring River	**-100%**

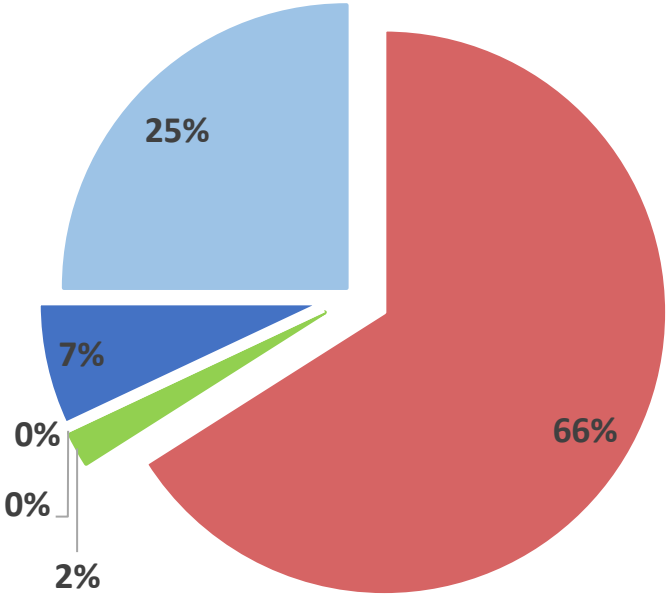
Scargo Lake Phosphorus Loading

Low = 5.4 kg/year

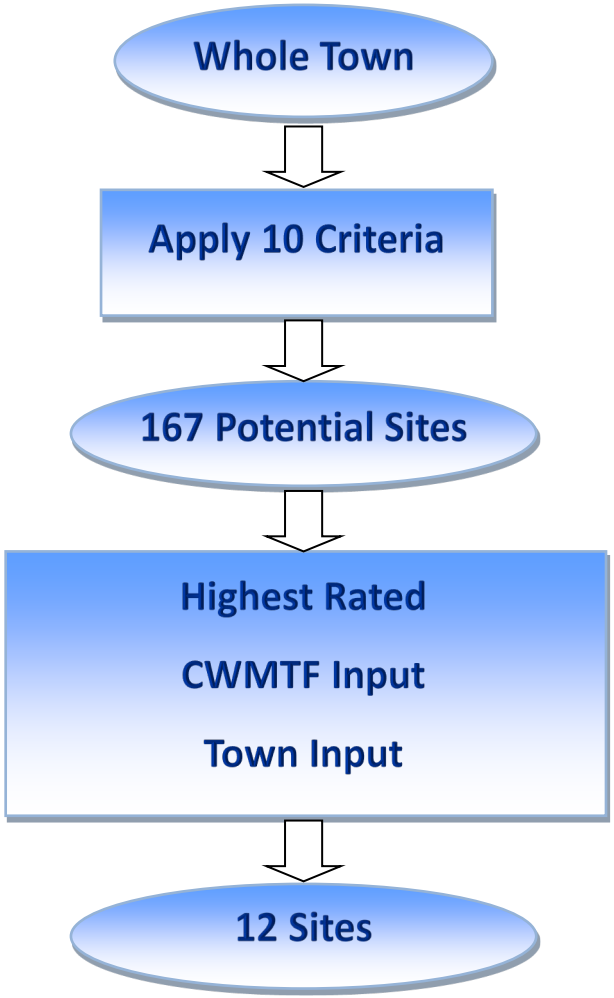




High = 8.3 kg/year



Treatment Site Screening Process



Treatment Site Screening Criteria

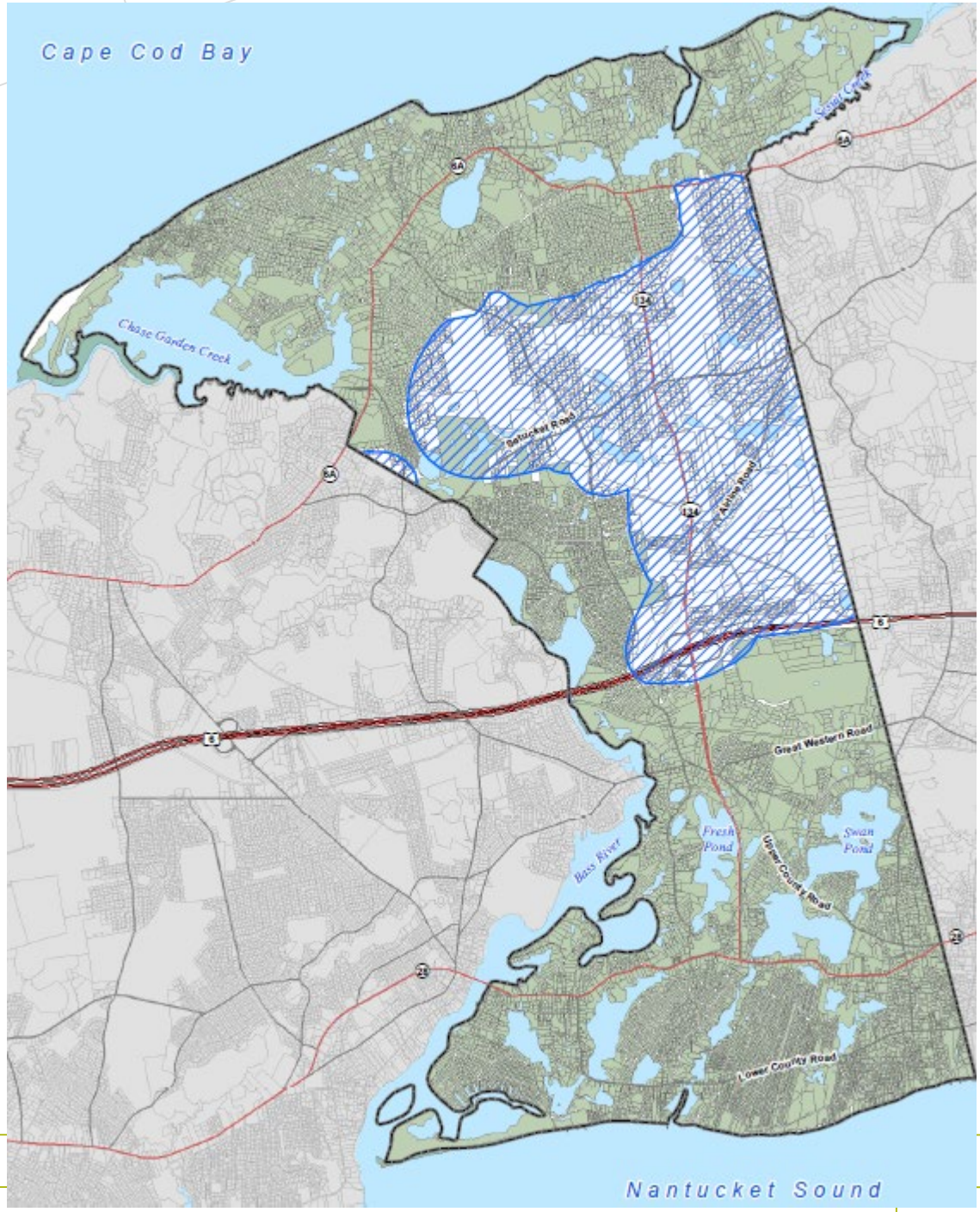
Exclusion Criteria

1. Parcel Size Greater than Three Acres
2. Outside Zone of Contribution
3. Outside Special Flood Hazard Areas
4. Outside of Wetlands
5. Favorable Depth to Groundwater

Points Criteria

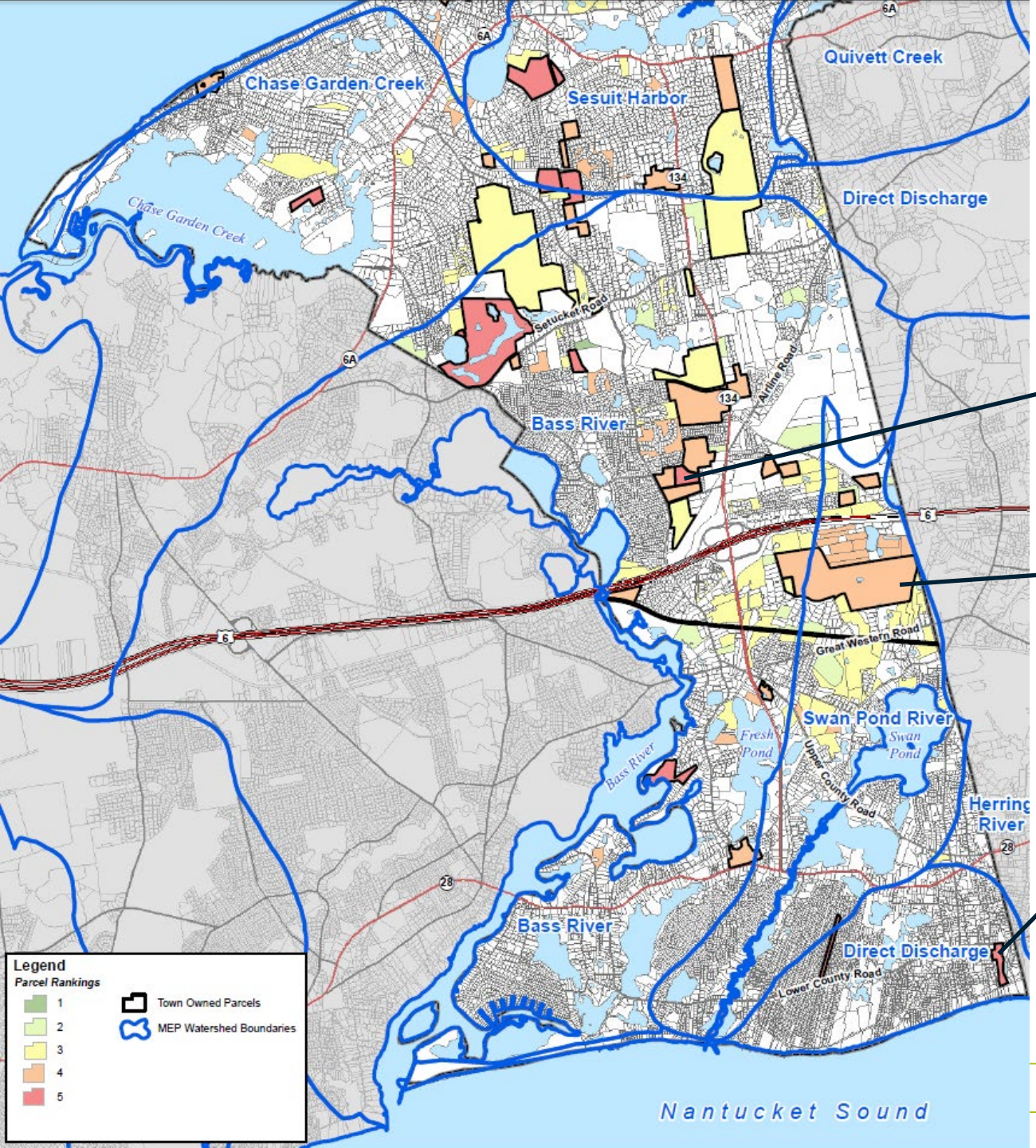
1. Permeable Soils
2. Favorable Development Status
3. Outside Priority Habitat Areas
4. Outside Municipal Wellhead Protection Zone II
5. Town-owned Property

Sample Screening Map: Zone II Areas



CDM Smith

Map of Final Sites



SITE 2

SITE 1

SITE 3

Wastewater Infrastructure Can Be Consistent with Community Character

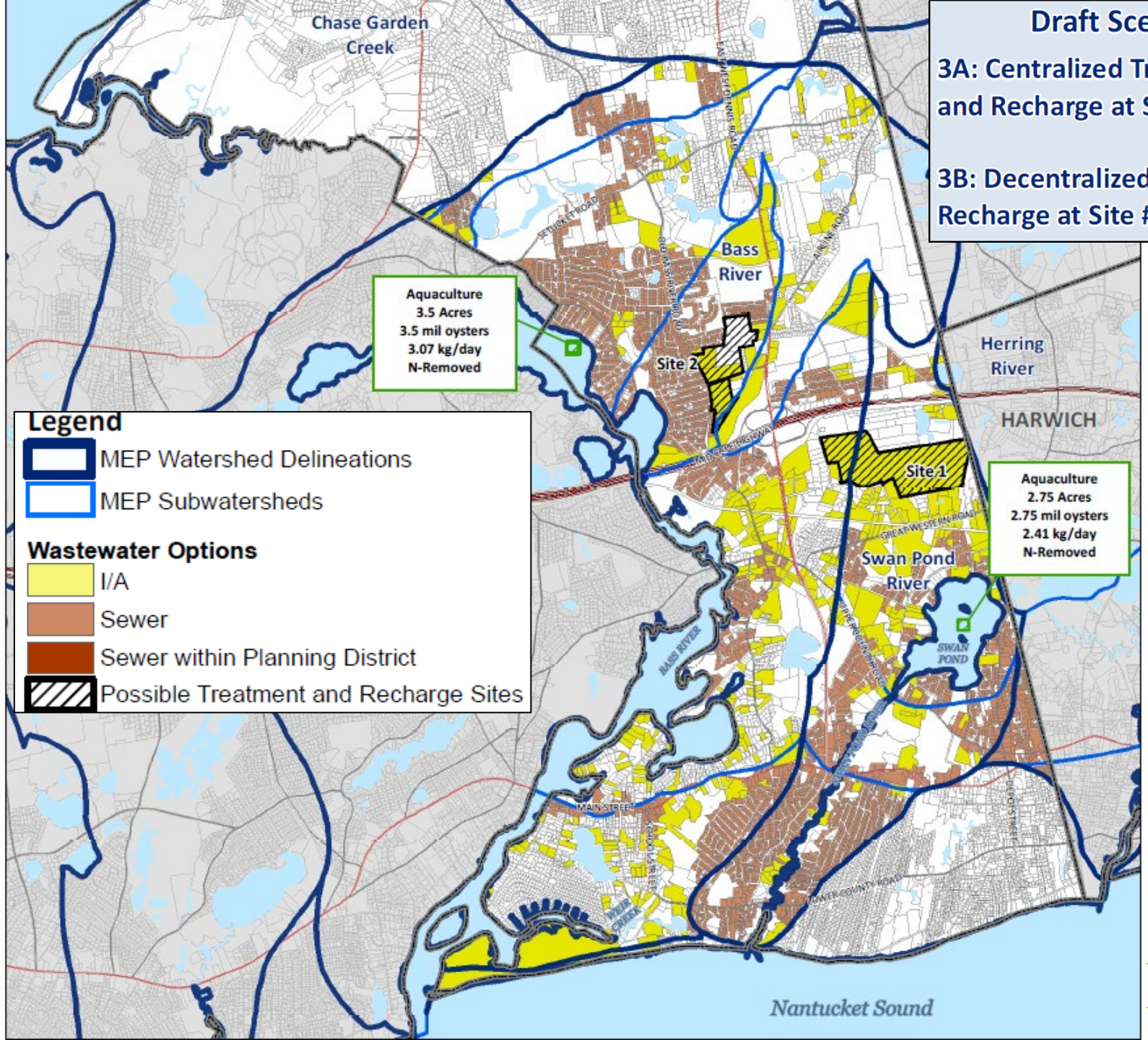
Chatham Wastewater Treatment Plant (1.1 million gallon per day average flow with open infiltration basins)

Water Reuse - Kingston Massachusetts

Indian Pond Golf Course – 325,000 gpd subsurface effluent recharge site

Summary of Wastewater Scenarios

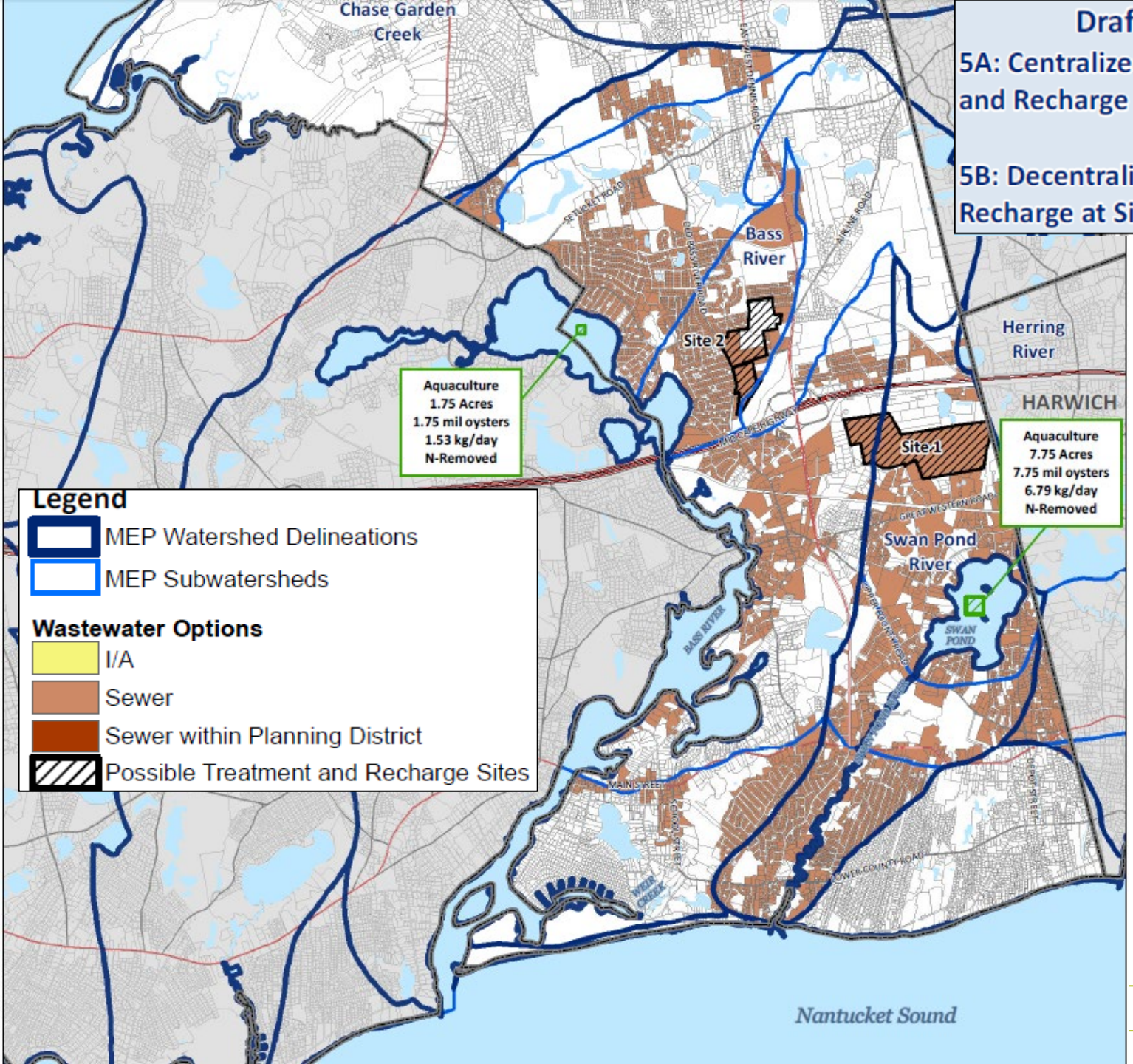
Scenario	Description	Fertilizer/ Stormwater Credits	Aquaculture	Sewer without PRB	Sewer with PRB	I/A	WWTPs
1	All Innovative/Alternative (I/A) Onsite Systems	X				X	0
2A	All I/A with Aquaculture	X	X			X	0
3A	Sewer with PRB and I/A	X	X		X	X	1
3B	Sewer with PRB and I/A	X	X		X	X	2
4A	Sewer with PRB	X			X		1
4B	Sewer with PRB	X			X		2
5A	Sewer without PRB and Aquaculture	X	X	X			1
5B	Sewer without PRB and Aquaculture	X	X	X			2
6A	Sewer with PRB and Aquaculture (includes planning districts)	X	X		X		1
6B	Sewer with PRB and Aquaculture (includes planning districts)	X	X		X		2
7A	Sewer with PRB and Aquaculture (includes planning districts and several Areas of Concern (AOCs))	X	X		X		1
7B	Sewer with PRB and Aquaculture (includes planning districts and several AOCs)	X	X		X		2
7C	Sewer with PRB and Aquaculture (includes planning districts and several AOCs)	X	X		X		3
7D	Sewer with Ocean Outfall (includes planning districts and several AOCs)	X					1



Draft Scenario #3

3A: Centralized Treatment at Site #1 and Recharge at Sites #1 and #2

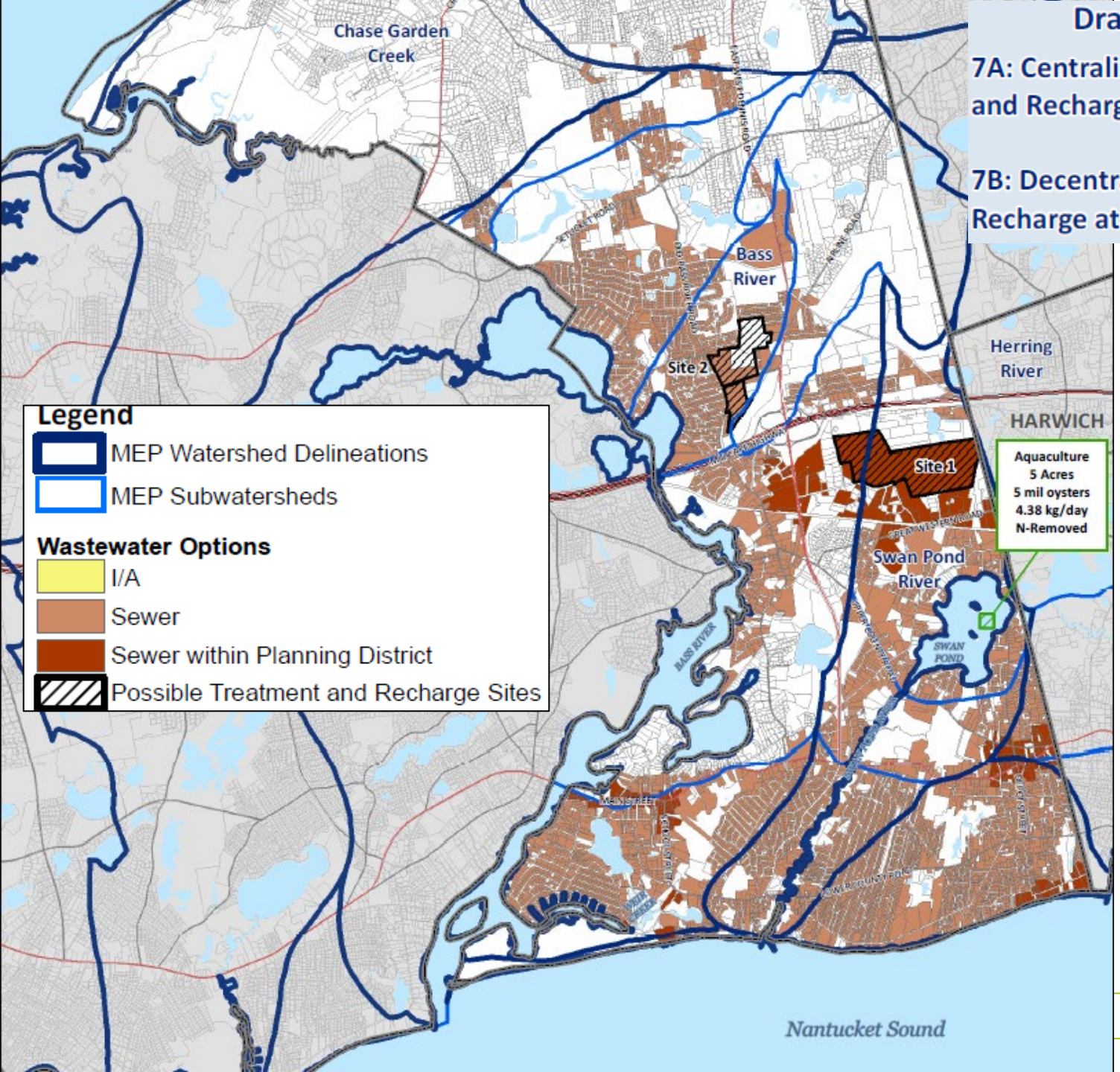
3B: Decentralized Treatment and Recharge at Site #1 and Site #2



Draft Scenario #5

5A: Centralized Treatment at Site #1 and Recharge at Sites #1 and #2

5B: Decentralized Treatment and Recharge at Site #1 and Site #2



Draft Scenario #7A/7B

7A: Centralized treatment at Site #1 and Recharge at Sites #1 and #2

7B: Decentralized Treatment and Recharge at Site #1 and Site #2

Scenario Screening Results

Evaluation of Alternatives															
Evaluation Criteria	Criteria Weight	1	2	3A	3B	4A	4B	5A	5B	6A	6B	7A	7B	7C	7D
TOTAL WITH WEIGHTING	500	204	206	367	355	394	395	419	402	394	370	307	316	296	262

- Scenarios 5A and 5B were selected because they rated the highest
- Scenario 3B was selected to evaluate an option with minimal sewers, decentralized treatment systems, and I/A systems on large lots
- Scenario 6B was selected to include an option with a decentralized approach and aquaculture that provides infrastructure to economic growth areas

Summary of 4 Selected Scenarios

	3B	5A	5B	6B
Description	Aquaculture, I/A and Sewer with PRB	Aquaculture and Sewer without PRB	Aquaculture and Sewer without PRB	Aquaculture and Sewer with PRB (includes planning districts)
Fertilizer/Stormwater Credits	X	X	X	X
Number of Parcels with I/A Systems	395			
Acres of Aquaculture	6.25	9.5	9.5	3.25
Number of Parcels Sewered	4,826	5,234	5,234	5,471
Number of WWTPs	2	1	2	2
Number of Effluent Recharge Sites	2	2	2	2
PRB at Recharge Site	X			X
Average Daily Flow to WWTP #1 (Swan Pond)	367,000	756,000	463,000	584,000
Average Daily Flow to WWTP #2 (Bass River)	268,000		293,000	289,000
Annual Pounds Nitrogen Removed	67,179	66,422	66,422	71,184
Cost per Pound Nitrogen Removed	$ 280	$ 250	$ 270	$ 280

- Capital Cost Ranges: $186M- $217M
- Annual O&M Cost Ranges: $5.22M-$6.98M
- Equivalent Annual Cost Ranges: $17M-$20M
  - For Comparison: Dennis appropriated $16M for FY15 Dennis/Yarmouth Regional School budget

Community Partnership Options

- Harwich and Yarmouth in planning process
- Share watersheds
- Economy of scale

Next Steps

- Finalize effluent recharge modeling and evaluate potential impacts
- Evaluate collection system types and treatment technologies
- Gather more information on non-traditional technologies (aquaculture, permeable reactive barriers, floating wetlands)
- Refine life cycle costs for each scenario
- Develop criteria and ratings system to compare four final wastewater scenarios
- Select final recommended program
- Determine appropriate phasing and cost recovery plan
- Future: Package all into a CWMP and regulatory reviews

Summary

- Nutrient reduction will be mandated by regulatory agencies (TMDLs issued); action now allows more town control
- This is a complex planning process that will continue indefinitely, through adaptive management – living document
- Towns need to determine how best to fund these programs
- Most properties in town contribute to the problem - not just those along a water body or those proposed for a solution
- Everyone in Dennis will benefit from improved water quality

Questions?

Dennis
preserving our water resources

Sign up to be on the email list: www.bit.ly/DennisWaterResources

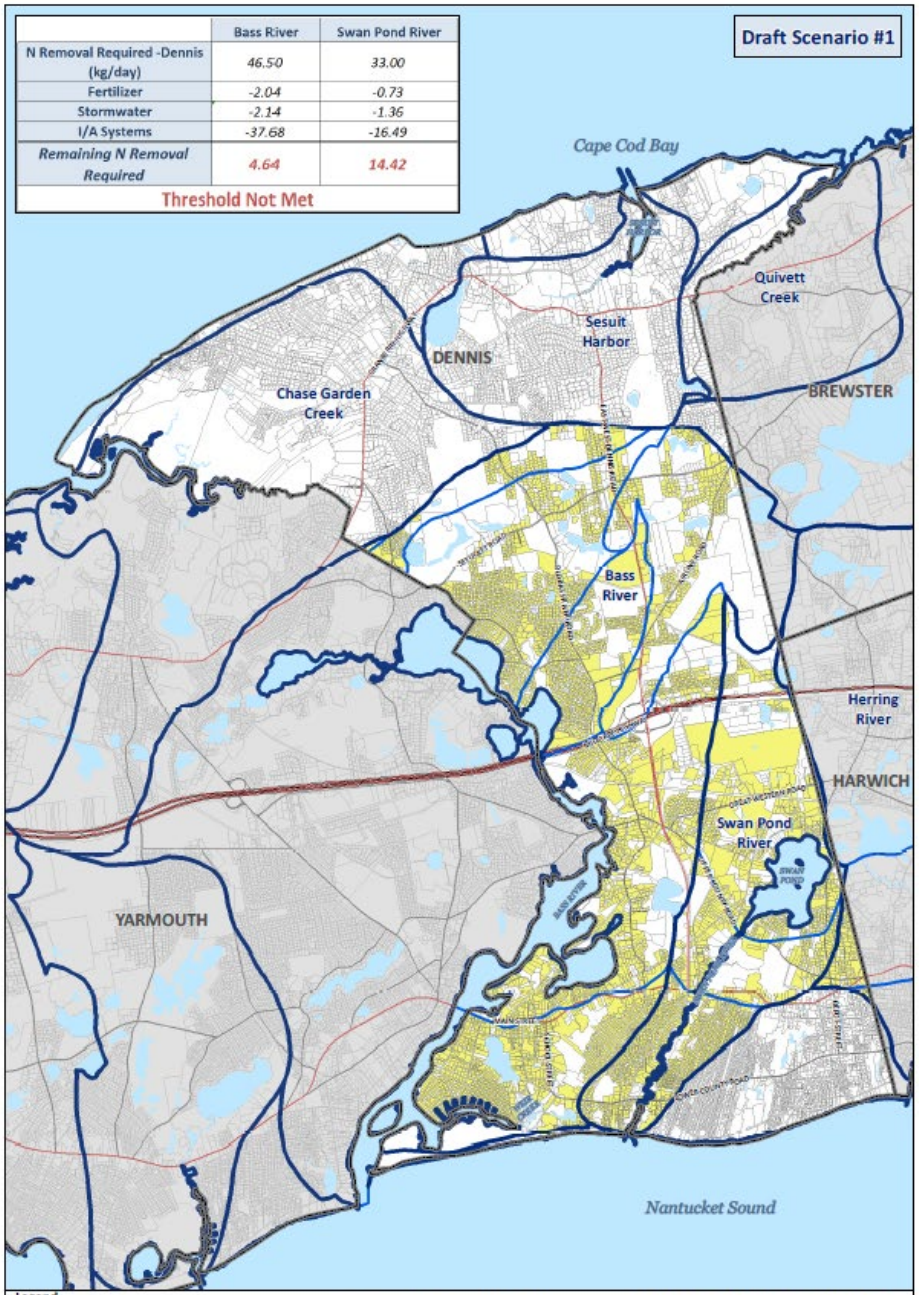
Email the Task Force at: cwmtf@town.dennis.ma.us

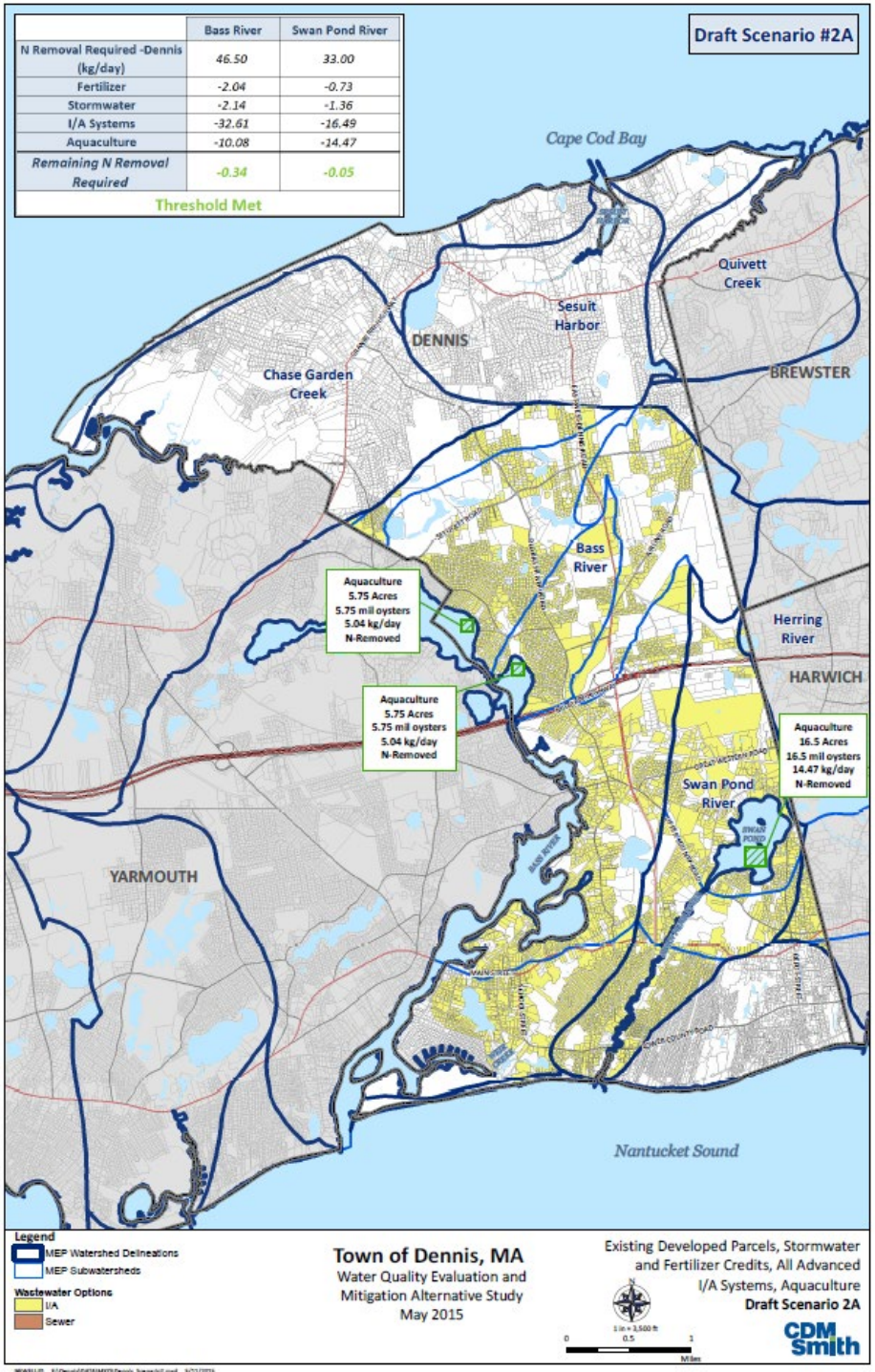
Read or download full Task 1 Report at:
http://www.town.dennis.ma.us/Pages/DennisMA_BComm/wastewater/wastewater

Terry Hayes, Dennis Health Department – thayes@town.dennis.ma.us

All Scenario Maps

	Bass River	Swan Pond River
N Removal Required -Dennis (kg/day)	46.50	33.00
Fertilizer	-2.04	-0.73
Stormwater	-2.14	-1.36
I/A Systems	-37.68	-16.49
Remaining N Removal Required	4.64	14.42
Threshold Not Met		



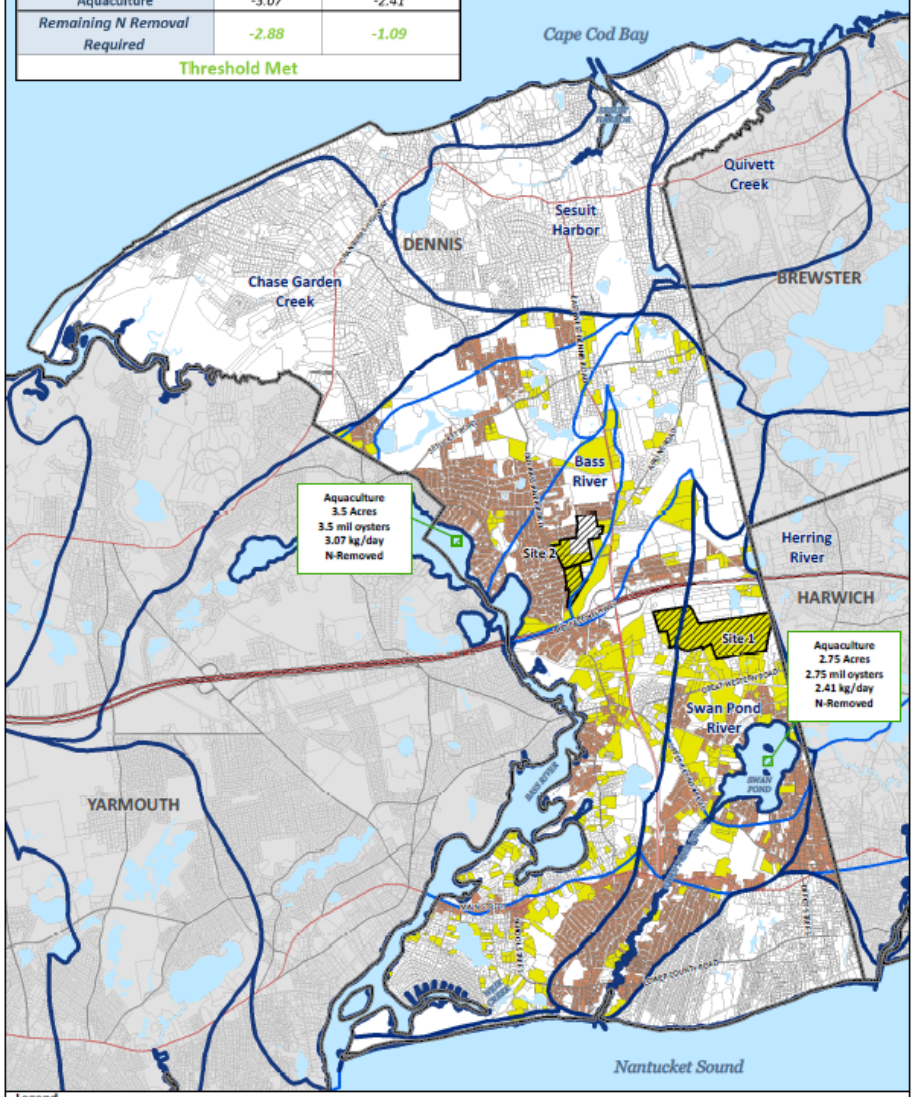

Draft Scenario #2A
Bass River
Swan Pond River
N Removal Required -Dennis (kg/day) 46.50 33.00
Fertilizer -2.04 -0.73
Stormwater -2.14 -1.36
I/A Systems -32.61 -16.49
Aquaculture -10.08 -14.47
Remaining N Removal Required -0.34 -0.05
Threshold Met
Cape Cod Bay
Quivett Creek
Sesuit Harbor
DENNIS
BREWSTER
Chase Garden Creek
Bass River
Herring River
HARWICH
Aquaculture 5.75 Acres 5.75 mil oysters 5.04 kg/day N-Removed
Aquaculture 5.75 Acres 5.75 mil oysters 5.04 kg/day N-Removed
Aquaculture 16.5 Acres 16.5 mil oysters 14.47 kg/day N-Removed
Swan Pond River
YARMOUTH
Nantucket Sound
Legend
MEP Watershed Delineations
MEP Subwatersheds
Wastewater Options
I/A
Sewer
Town of Dennis, MA
Water Quality Evaluation and Mitigation Alternative Study
May 2015
Existing Developed Parcels, Stormwater and Fertilizer Credits, All Advanced I/A Systems, Aquaculture
Draft Scenario 2A
0 0.5 1
Miles
CDM Smith

	Bass River	Swan Pond River
N Removal Required -Dennis (kg/day)	46.50	33.00
Fertilizer	-2.04	-0.73
Stormwater	-2.14	-1.36
I/A Systems	-2.16	-1.55
Sewer with PRB	-41.13	-29.53
Effluent Recharge	+1.16	+1.49
Aquaculture	-3.07	-2.41
Remaining N Removal Required	-2.88	-1.09
Threshold Met		

Draft Scenario #3

3A: Centralized Treatment at Site #1 and Recharge at Sites #1 and #2

3B: Decentralized Treatment and Recharge at Site #1 and Site #2



Legend
- MEP Watershed Delineations
- MEP Subwatersheds

Wastewater Options
- I/A
- Sewer
- Possible Treatment and Recharge Sites

Town of Dennis, MA
Water Quality Evaluation and Mitigation Alternative Study
May 2015

Stormwater and Fertilizer Credits, Existing Developed Parcels, Sewer with PRB All Advanced I/A Systems, and Aquaculture - **Draft Scenario 3**

1 in = 3,500 ft
0 0.5 1 Miles

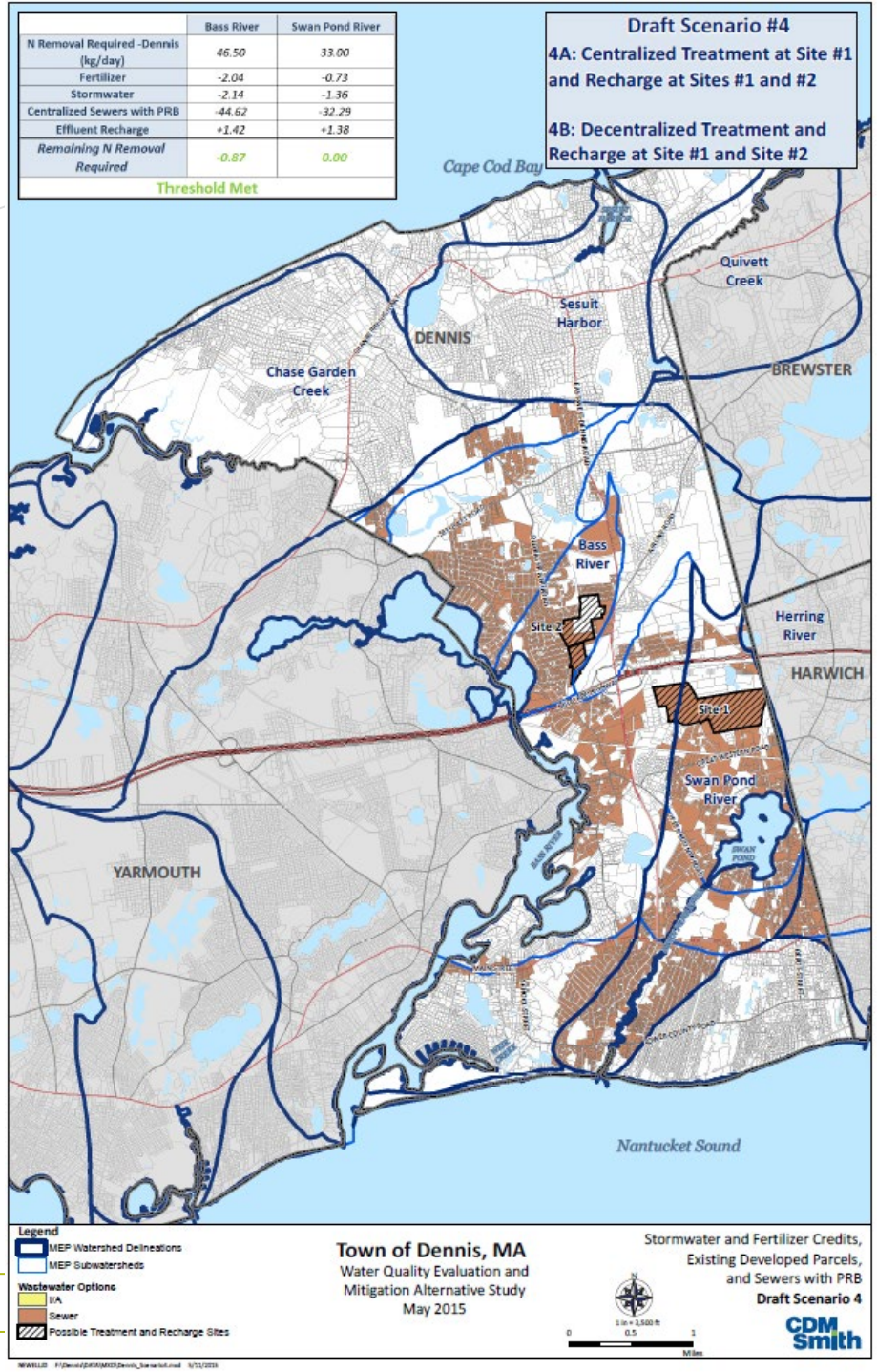
CDM Smith

	Bass River	Swan Pond River
N Removal Required -Dennis (kg/day)	46.50	33.00
Fertilizer	-2.04	-0.73
Stormwater	-2.14	-1.36
Centralized Sewers with PRB	-44.62	-32.29
Effluent Recharge	+1.42	+1.38
Remaining N Removal Required	-0.87	0.00
Threshold Met		

Draft Scenario #4

4A: Centralized Treatment at Site #1 and Recharge at Sites #1 and #2

4B: Decentralized Treatment and Recharge at Site #1 and Site #2



Legend
- MEP Watershed Delineations
- MEP Subwatersheds

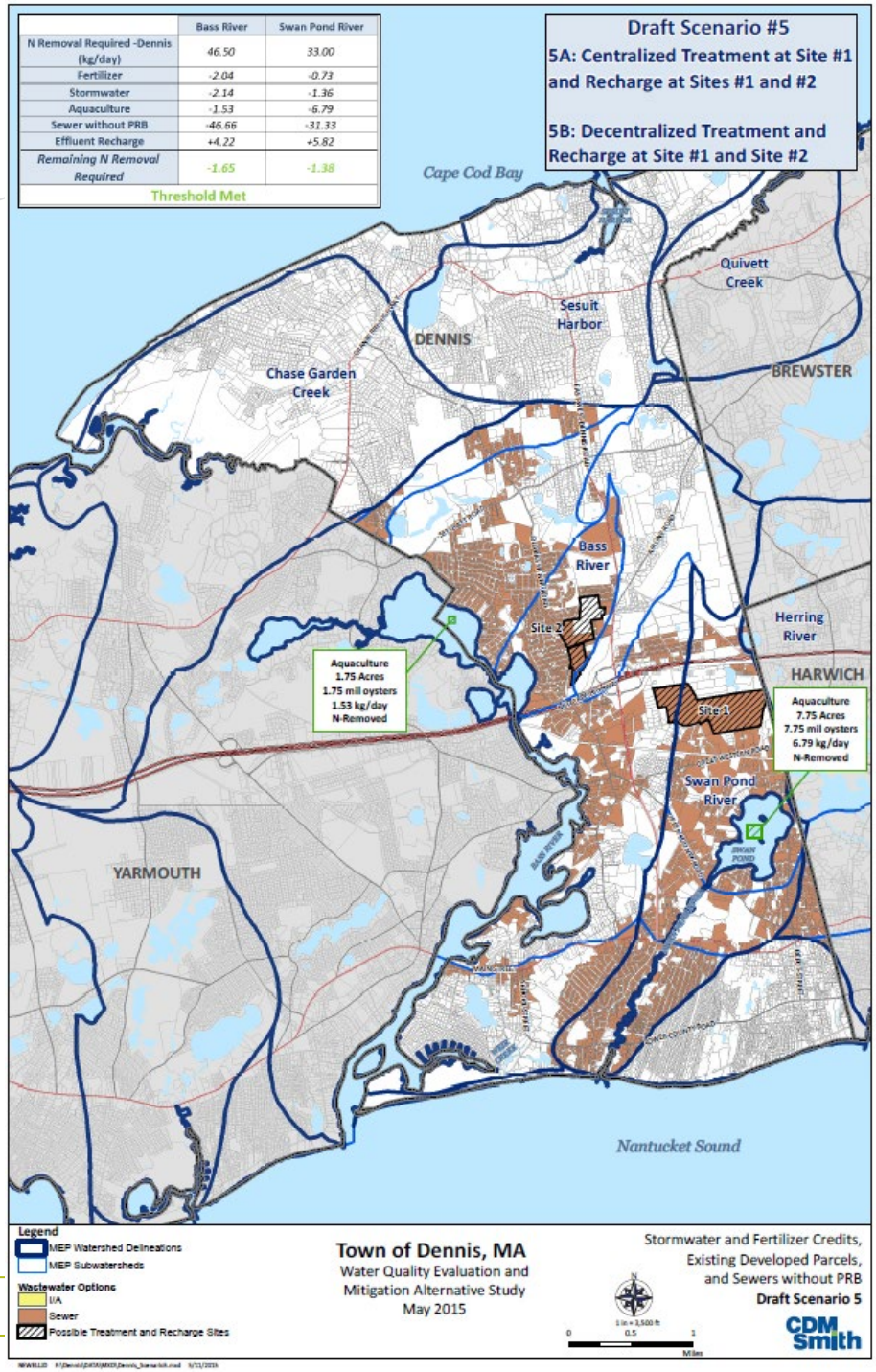
Wastewater Options
- I/A
- Sewer
- Possible Treatment and Recharge Sites

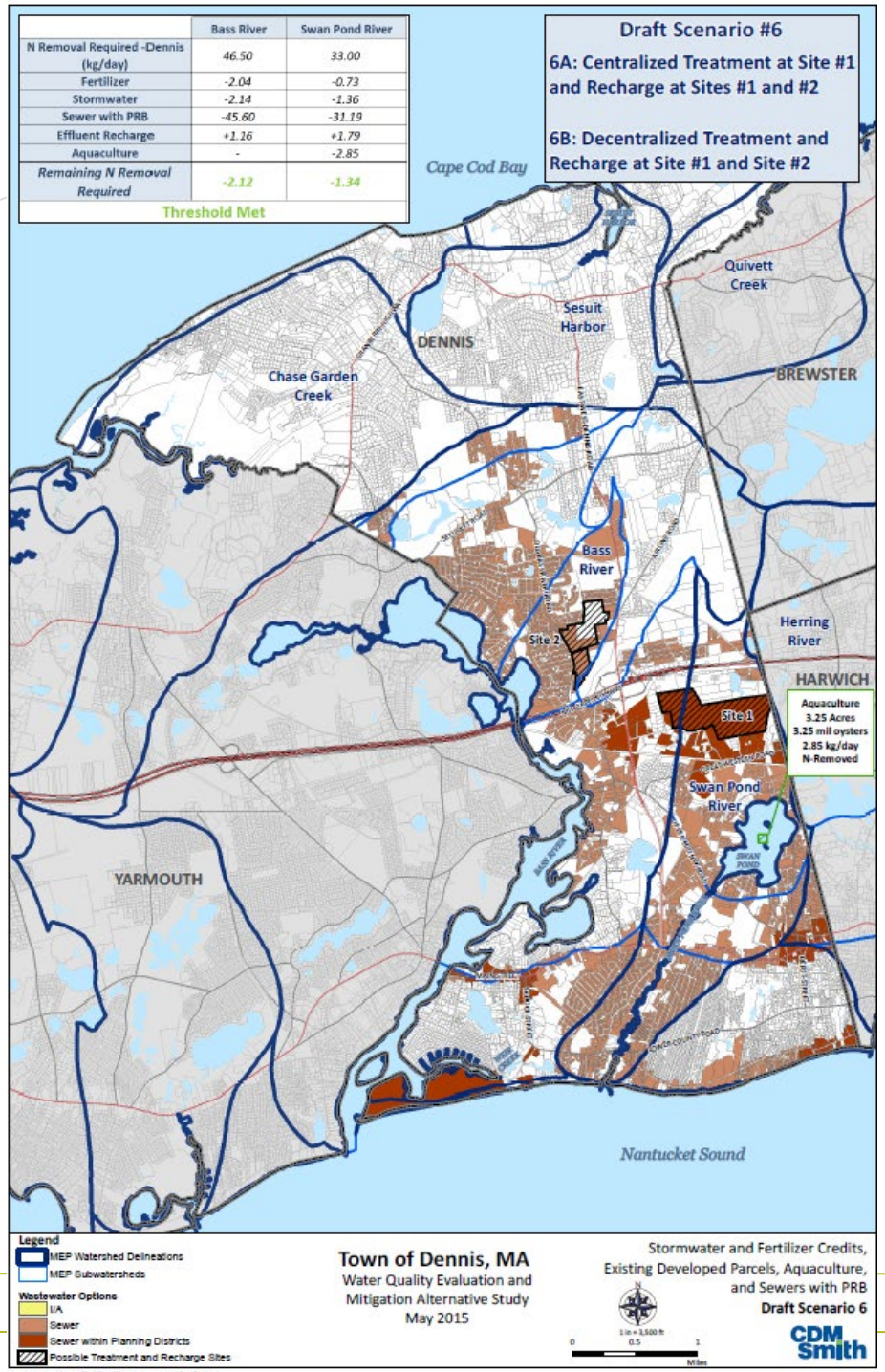
Town of Dennis, MA
Water Quality Evaluation and Mitigation Alternative Study
May 2015

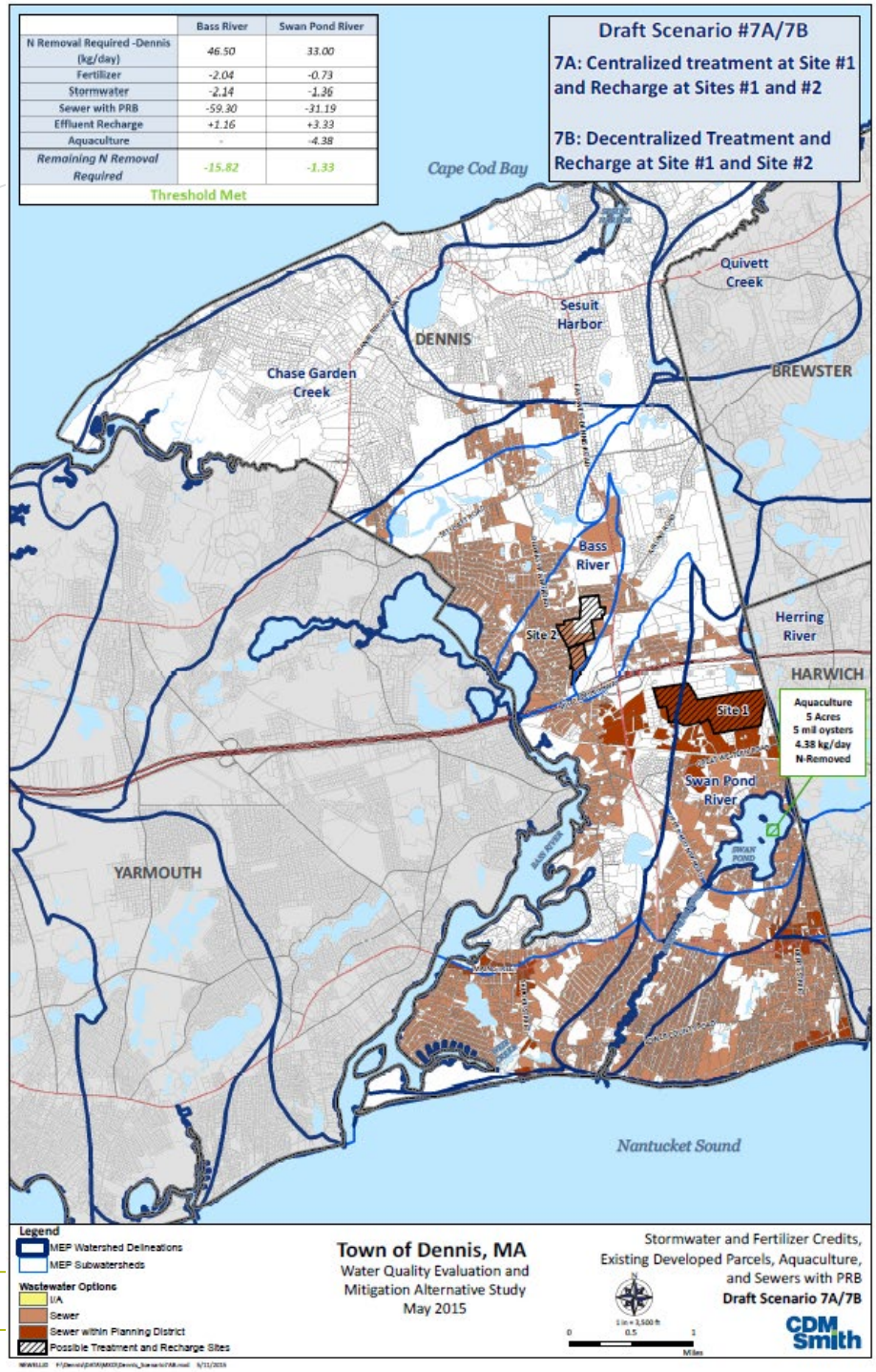
Stormwater and Fertilizer Credits, Existing Developed Parcels, and Sewers with PRB
Draft Scenario 4

1 in = 1,500 ft
0 0.5 1 Miles

CDM Smith


Draft Scenario #5
5A: Centralized Treatment at Site #1 and Recharge at Sites #1 and #2
5B: Decentralized Treatment and Recharge at Site #1 and Site #2
Bass River
Swan Pond River
N Removal Required -Dennis (kg/day) 46.50 33.00
Fertilizer -2.04 -0.73
Stormwater -2.14 -1.36
Aquaculture -1.53 -6.79
Sewer without PRB -46.66 -31.33
Effluent Recharge +4.22 +5.82
Remaining N Removal Required -1.65 -1.38
Threshold Met
Cape Cod Bay
Quivett Creek
Sesuit Harbor
DENNIS
BREWSTER
Chase Garden Creek
Bass River
Herring River
Site 2
Site 1
HARWICH
Aquaculture 1.75 Acres 1.75 mil oysters 1.53 kg/day N-Removed
Aquaculture 7.75 Acres 7.75 mil oysters 6.79 kg/day N-Removed
Swan Pond River
YARMOUTH
Nantucket Sound
Legend
MEP Watershed Delineations
MEP Subwatersheds
Wastewater Options
I/A
Sewer
Possible Treatment and Recharge Sites
Town of Dennis, MA
Water Quality Evaluation and Mitigation Alternative Study
May 2015
Stormwater and Fertilizer Credits, Existing Developed Parcels, and Sewers without PRB
Draft Scenario 5
CDM Smith
Miles


Draft Scenario #6
6A: Centralized Treatment at Site #1 and Recharge at Sites #1 and #2
6B: Decentralized Treatment and Recharge at Site #1 and Site #2
Bass River
Swan Pond River
N Removal Required -Dennis (kg/day) 46.50 33.00
Fertilizer -2.04 -0.73
Stormwater -2.14 -1.36
Sewer with PRB -45.60 -31.19
Effluent Recharge +1.16 +1.79
Aquaculture - -2.85
Remaining N Removal Required -2.12 -1.34
Threshold Met
Cape Cod Bay
Quivett Creek
Sesuit Harbor
DENNIS
BREWSTER
Chase Garden Creek
Bass River
Herring River
Site 2
Site 1
HARWICH
Aquaculture
3.25 Acres
3.25 mil oysters
2.85 kg/day
N-Removed
Swan Pond River
YARMOUTH
Nantucket Sound
Legend
MEP Watershed Delineations
MEP Subwatersheds
Wastewater Options
I/A
Sewer
Sewer within Planning Districts
Possible Treatment and Recharge Sites
Town of Dennis, MA
Water Quality Evaluation and Mitigation Alternative Study
May 2015
Stormwater and Fertilizer Credits, Existing Developed Parcels, Aquaculture, and Sewers with PRB
Draft Scenario 6
CDM Smith


Draft Scenario #7A/7B
7A: Centralized treatment at Site #1 and Recharge at Sites #1 and #2
7B: Decentralized Treatment and Recharge at Site #1 and Site #2
Bass River
Swan Pond River
N Removal Required -Dennis (kg/day)
46.50
33.00
Fertilizer
-2.04
-0.73
Stormwater
-2.14
-1.36
Sewer with PRB
-59.30
-31.19
Effluent Recharge
+1.16
+3.33
Aquaculture
-
-4.38
Remaining N Removal Required
-15.82
-1.33
Threshold Met
Cape Cod Bay
Quivett Creek
Sesuit Harbor
DENNIS
BREWSTER
Chase Garden Creek
Bass River
Herring River
Site 2
Site 1
HARWICH
Aquaculture
5 Acres
5 mil oysters
4.38 kg/day
N-Removed
Swan Pond River
YARMOUTH
Nantucket Sound
Legend
MEP Watershed Delineations
MEP Subwatersheds
Wastewater Options
I/A
Sewer
Sewer within Planning District
Possible Treatment and Recharge Sites
Town of Dennis, MA
Water Quality Evaluation and Mitigation Alternative Study
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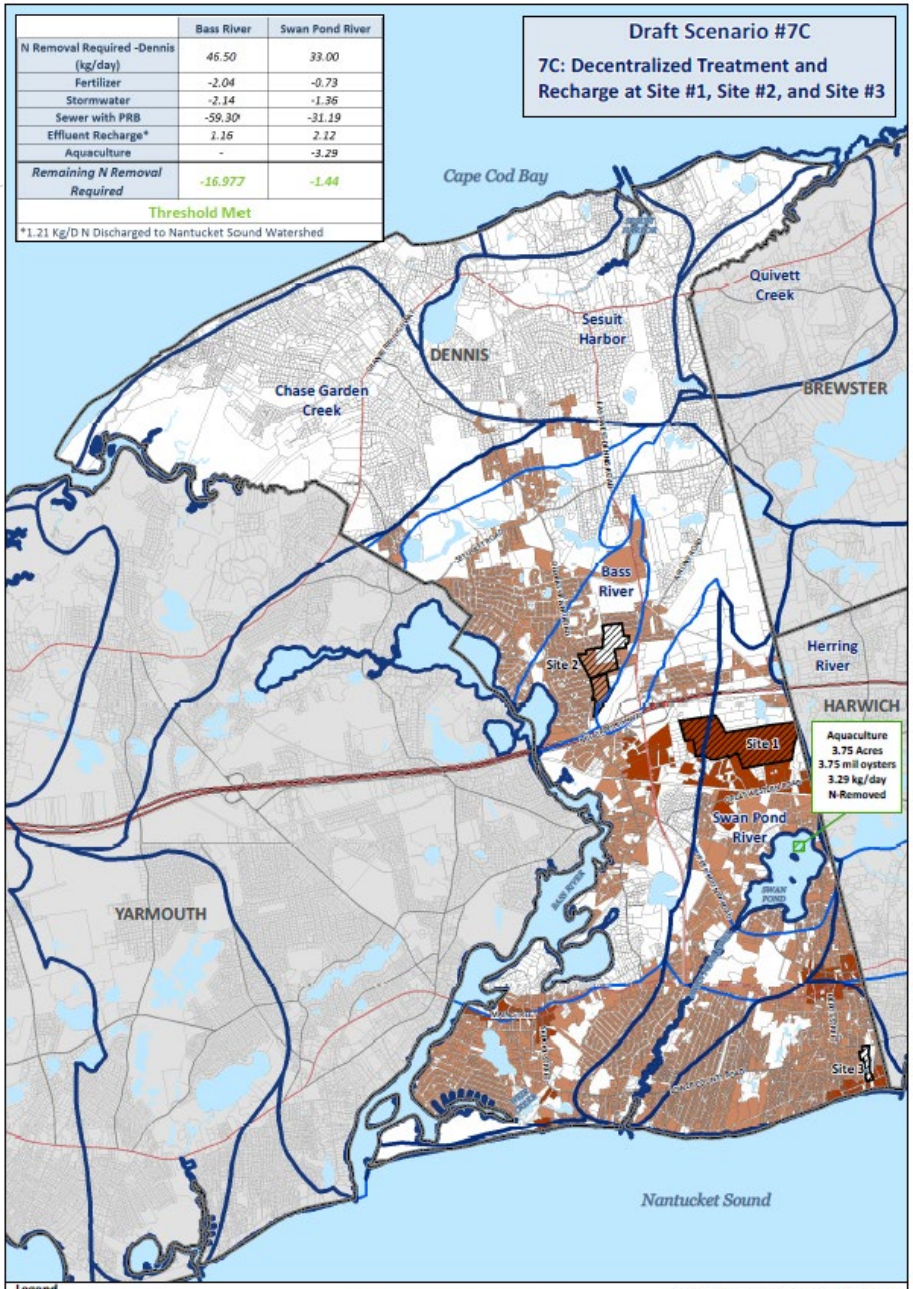
Stormwater and Fertilizer Credits, Existing Developed Parcels, Aquaculture, and Sewers with PRB
Draft Scenario 7A/7B
CDM Smith
Miles

	Bass River	Swan Pond River
N Removal Required -Dennis (kg/day)	46.50	33.00
Fertilizer	-2.04	-0.73
Stormwater	-2.14	-1.36
Sewer with PRB	-59.30	-31.19
Effluent Recharge*	1.16	2.12
Aquaculture	-	-3.29
Remaining N Removal Required	-16.977	-1.44
Threshold Met		

*1.21 Kg/D N Discharged to Nantucket Sound Watershed

Draft Scenario #7C

7C: Decentralized Treatment and Recharge at Site #1, Site #2, and Site #3



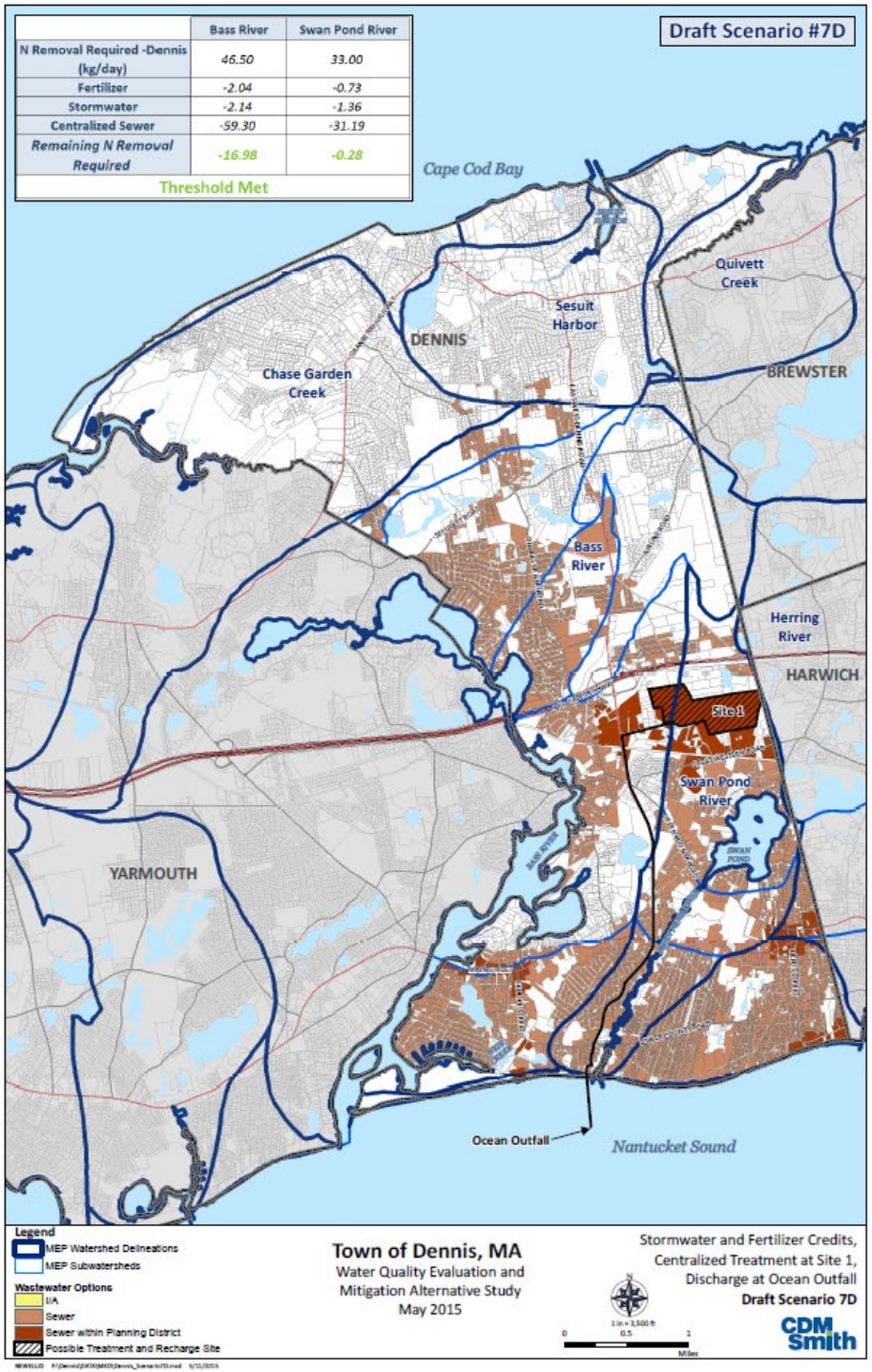
Legend
- MEP Watershed Delineations
- MEP Subwatersheds

Wastewater Options
- I/A
- Sewer
- Sewer within Planning District
- Possible Treatment and Recharge Sites

Town of Dennis, MA
Water Quality Evaluation and Mitigation Alternative Study
May 2015

Stormwater and Fertilizer Credits, Existing Developed Parcels, Aquaculture, and Sewers with PRB
Draft Scenario 7C

CDM Smith


Draft Scenario #7D
Bass River
Swan Pond River
N Removal Required -Dennis (kg/day)
46.50
33.00
Fertilizer
-2.04
-0.73
Stormwater
-2.14
-1.36
Centralized Sewer
-59.30
-31.19
Remaining N Removal Required
-16.98
-0.28
Threshold Met
Cape Cod Bay
Quivett Creek
Sesuit Harbor
DENNIS
BREWSTER
Chase Garden Creek
Bass River
Herring River
HARWICH
Site 1
Swan Pond River
YARMOUTH
Ocean Outfall
Nantucket Sound
Legend
MEP Watershed Delineations
MEP Subwatersheds
Wastewater Options
I/A
Sewer
Sewer within Planning District
Possible Treatment and Recharge Site
Town of Dennis, MA
Water Quality Evaluation and Mitigation Alternative Study
May 2015
Stormwater and Fertilizer Credits, Centralized Treatment at Site 1, Discharge at Ocean Outfall
Draft Scenario 7D
Miles

MEETING MINUTES

Community Partnership – Dennis, Harwich, and Yarmouth

Date: January 11, 2017
Time: 11:00 AM
Location: Dennis Town Hall

Attendees: MaryAnne Gibbs, Paul McCormick, Elizabeth Sullivan – Town of Dennis

Christopher Clark – Town of Harwich

Jeff Colby, Robert Lawton, Ed Senteio – Town of Yarmouth

Kara Johnston, Dave Young – CDM Smith

Meeting Summary:

- Overview of each town's stage in wastewater planning process
- Overview of community partnership draft plan and memos completed to date
- Discussion of community partnership among the towns:
    - Cost savings are so significant
    - Three town option is more favorable than a two town scenario
    - Potential future requirement of treatment of CECs would require an upgrade at each facility. Would be more cost effective to only have to upgrade one community plant.
    - Effluent is a product (golf courses, wash stations, etc.)
    - Eelgrass is a good way of demonstrating the problem (relatable images)
    - Potential for real estate transfer tax
    - Communities seem to like the idea of a tax deduction through debt exclusion
    - Aesthetics was #1 reason why young professionals come to the Cape
    - Example smell of Herring River
- Discussion of recent MassDEP meeting:
    - E.Sullivan, JC, CC, and DY met with Commissioner Martin Suuberg of MassDEP
    - Discussed what would happen if communities did not begin wastewater program
    - DEP said they would respond
    - DEP developing a response letter which will say they will revise Title V regulations requiring any septic system in a nitrogen sensitive watershed to be replaced with an I/A system
        - DY: Millie Garcia-Serrano (MassDEP) asked what would the towns would like to hear about in the letter:
            1. Timeline- when Title V system would need to be changed (at home sale, when Title V needs to be replaced, even if the system is ok)
            2. Not meeting TMDLs with I/A systems would still need to install sewers/WWTF
            3. Future treatment of CECs would require sewers/WWTF

4. Incentives – 0% loans, Principle Forgiveness

- Harwich adopted similar Chatham rule saying no expansion past current Title V regulations
- Land use controls are a requirement for 0% loans
- Discussion of current Water Districts in each town- Dennis has a separate Water District, Harwich and Yarmouth BOS act as Water District
- **Next Steps:**
    - **Create a 1 pager of why the communities are teaming up**
        - **Highlight percent savings, tax rate with and without community partnership, average house cost in each town**
    - **Agreement discussion document with points from MFN and spread to the three towns**
    - **Discuss letter with MassDEP**
    - **Schedule meeting with BOS from the 3 towns in Dennis to discuss community partnership plan**
    - **Schedule a meeting the week prior to BOS meeting with administrators**

Dennis, Harwich, and Yarmouth

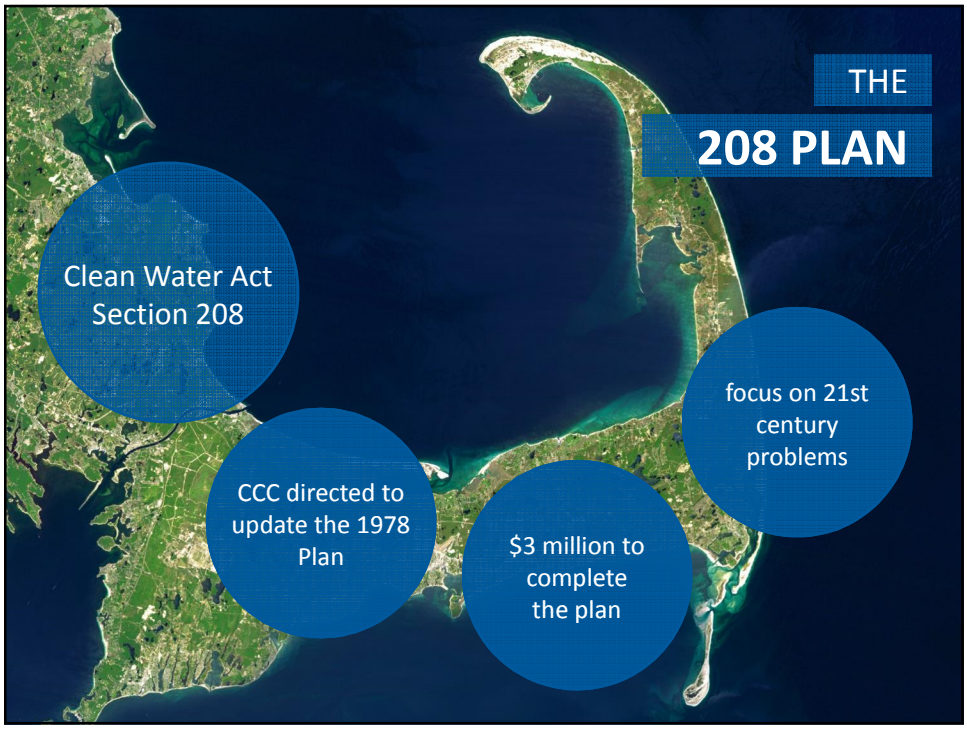
Community Partnership for Wastewater

David F. Young, P.E.
Vice President

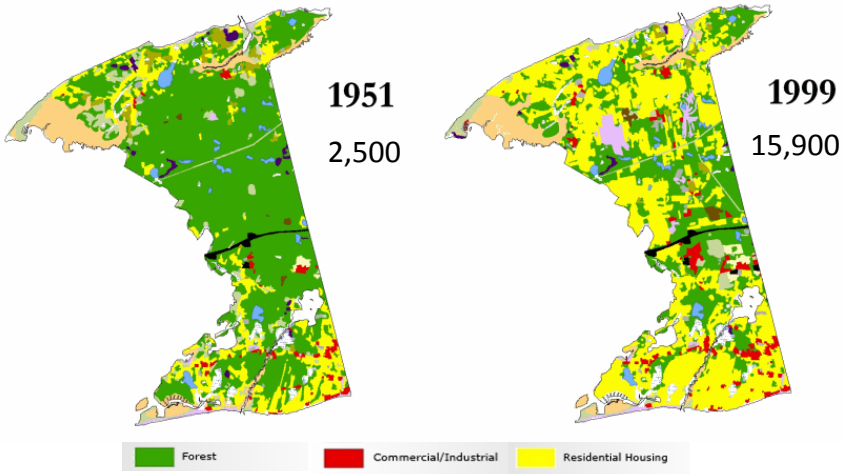
March 8, 2017

Presentation

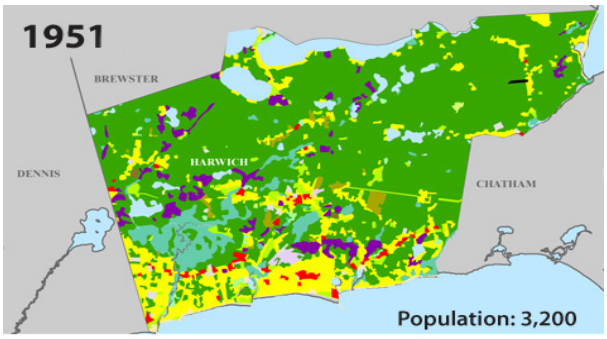
- Background on wastewater planning and 208 Plan
- Status of wastewater planning in each community.
- Community partnership concept.
- Preliminary results.
- Timeline for implementation.
- Summary.
- Questions/ Comments?

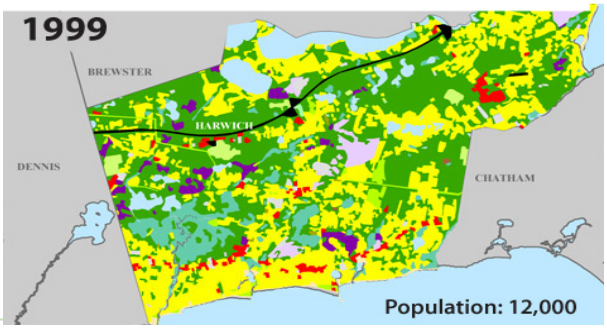


Dennis Population Increase: 600% over 50 years



Harwich Population Increase: 400% over 50 years





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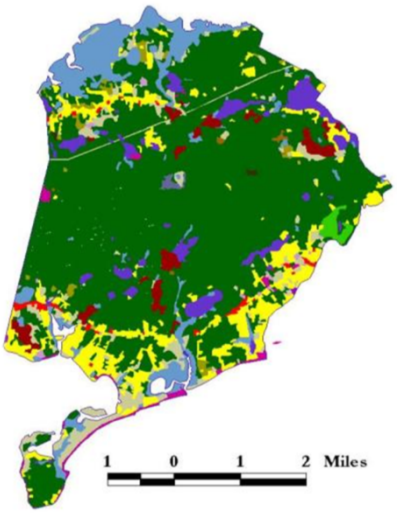
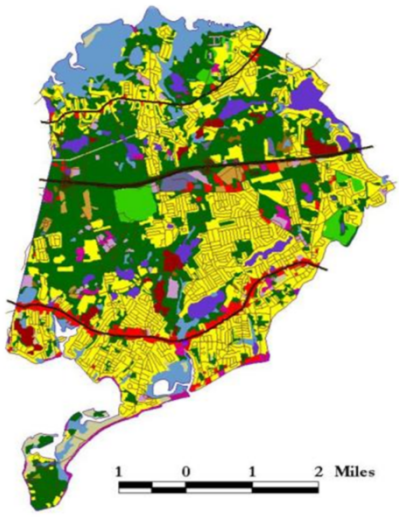
Yarmouth Population Increase: 700% over 50 years



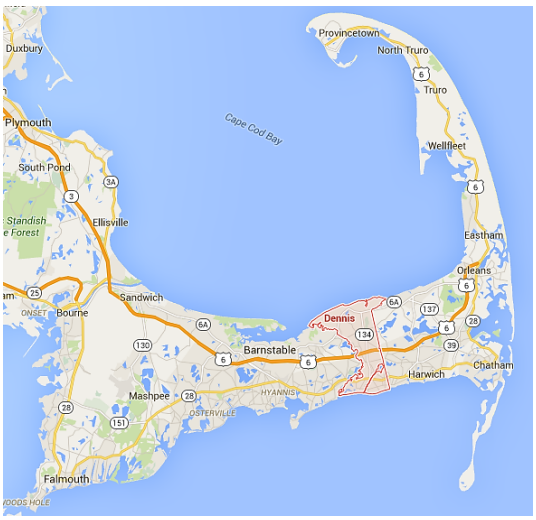
1951 – Pop. 3,297



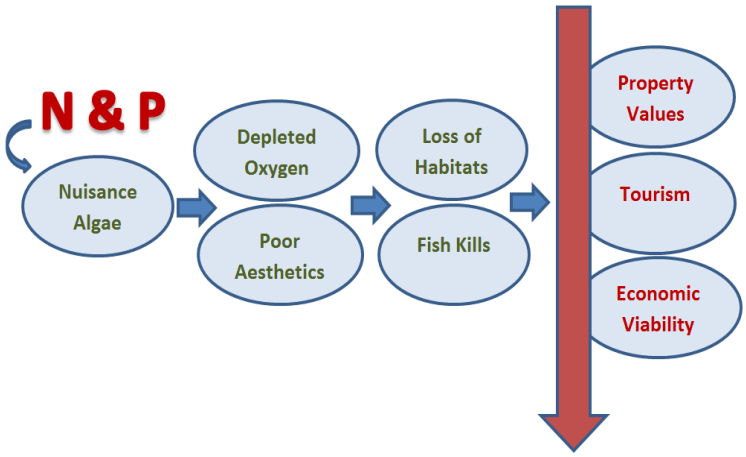
2010 – Pop. 23,793

6

Cape Cod represents 4% of the state's population, but 20% of the state's septic systems.

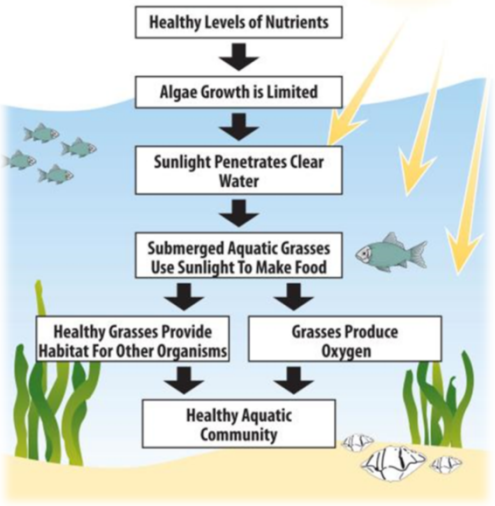


The Issue…



Beaches, Rivers, Harbors, and Ponds Are Severely Impacted By Nutrients

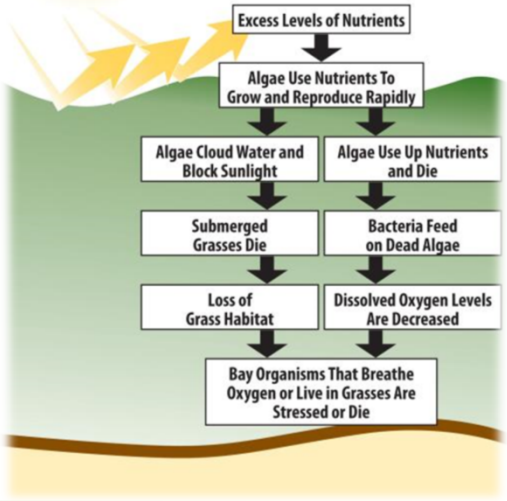
Healthy Nitrogen and Phosphorus Levels



Beaches, Rivers, Harbors, and Ponds Are Severely Impacted By Nutrients

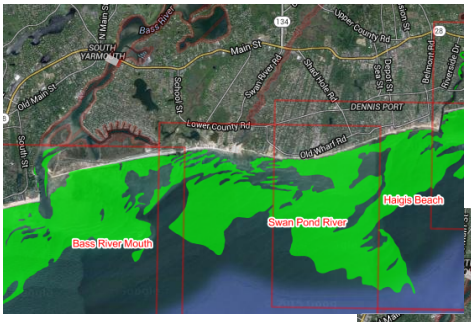
Unhealthy Nitrogen and Phosphorus Levels

Algae in Swan Pond, Dennis



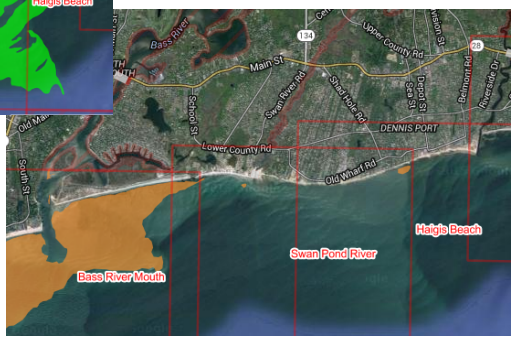
CDM Smith

Eelgrass Loss in Dennis



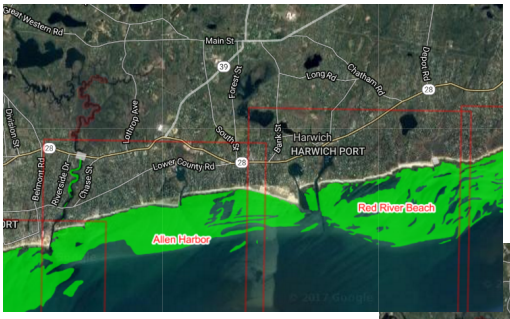
1995

2010-13



MassDEP Eelgrass Mapping Project Viewer

Eelgrass Loss in Harwich



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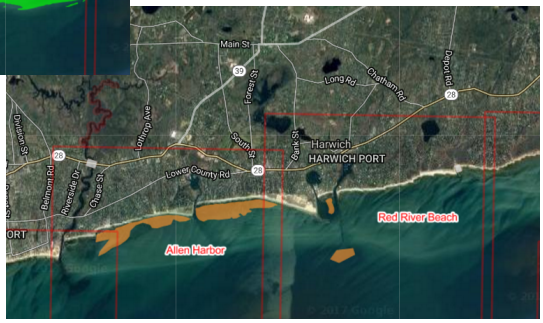
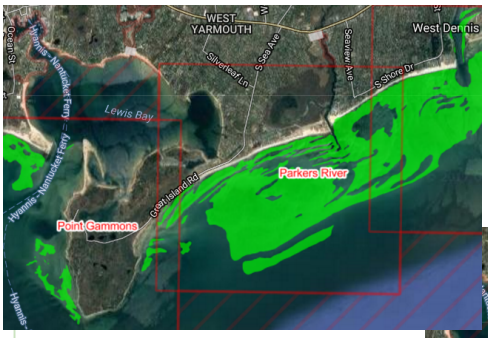


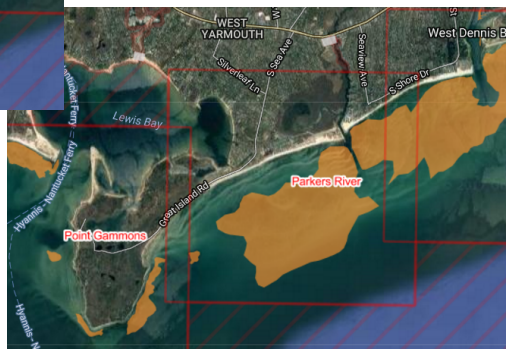
MassDEP Eelgrass Mapping Project Viewer

Eelgrass Loss in Yarmouth



1995

2010-13



MassDEP Eelgrass Mapping Project Viewer

Dennis – Swan Pond Algae Bloom (Summer 2009)

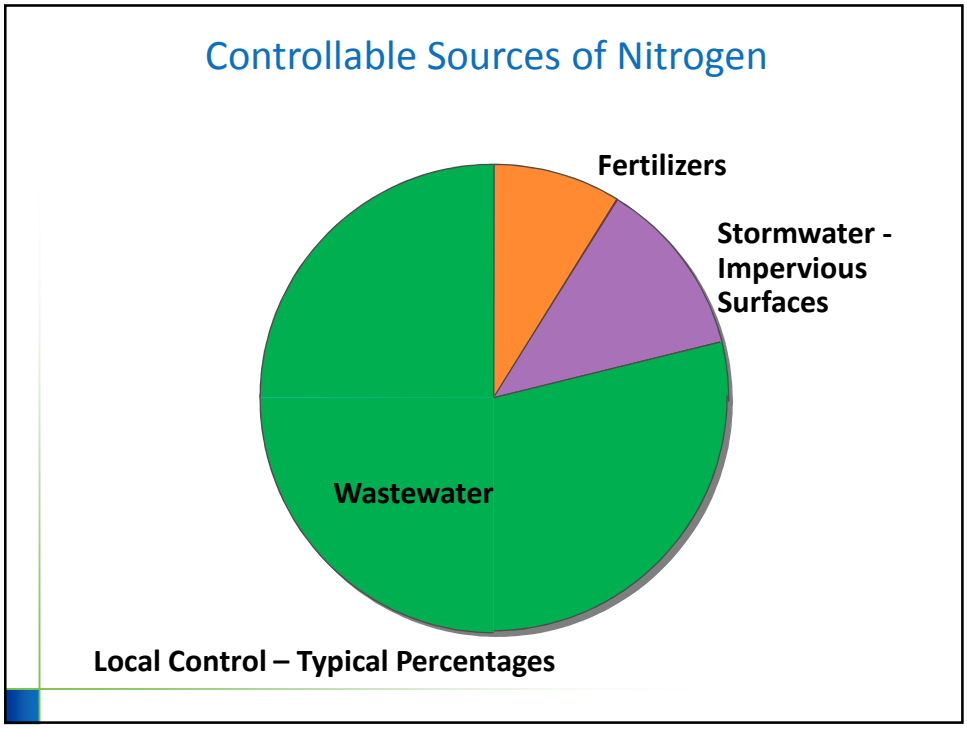
Harwich – Allen Harbor Algae Bloom (Summer 2007)

Yarmouth – Mill Creek Algae Bloom (2011) and Parkers River Fish Kill (2009)

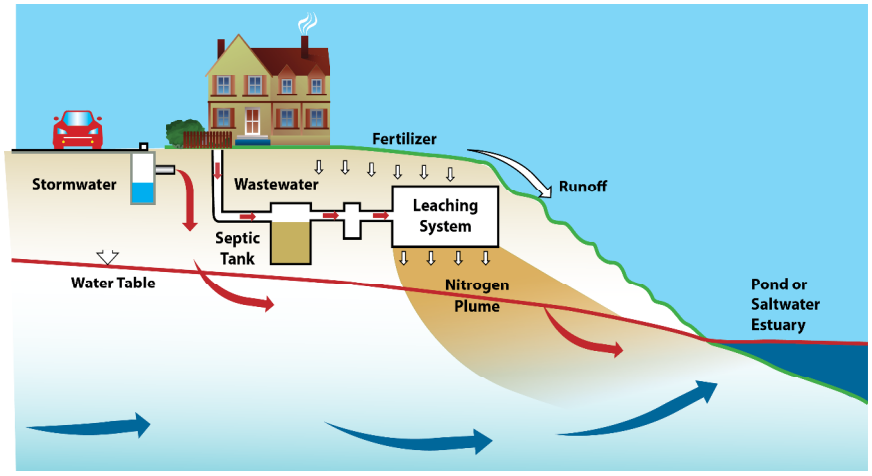
Mill Creek Algae Bloom May 2011

Parkers River Fish Kill July 2009

Site Scale | Neighborhood | Watershed | Cape-Wide
Nitrogen Removal Possibilities
Prevention
Reduction
Remediation
Remediation of Existing Development
Fertilizer Management
Transfer of Development Rights
Stormwater BMPs
Compact Development
Standard Title 5 Systems
Conventional Treatment
I/A Title 5 Systems
Cluster & Satellite Treatment Systems
Advanced Treatment
I/A Enhanced Systems
Wastewater Collection Systems
Effluent Disposal Systems
Toilets: Urine Diverting
Constructed Wetlands: Surface Flow
Toilets: Composting
Constructed Wetlands: Subsurface Flow
Toilets: Packaging
Stormwater: Bioretention / Soil Media Filters
Toilets: Incinerating
Stormwater: Wetlands
Phytoirrigation
Eco-Machines & Living Machines
Phytobuffers
Fertigation Wells
Permeable Reactive Barrier
Shellfish and Salt Marsh Habitat Restoration
Aquaculture/Shellfish Farming
Inlet / Culvert Widening
Pond and Estuary Dredging


Controllable Sources of Nitrogen
Fertilizers
Stormwater - Impervious Surfaces
Wastewater
Local Control – Typical Percentages

Nitrogen Entering Our Groundwater from Title 5 Septic Systems is Our Biggest Issue



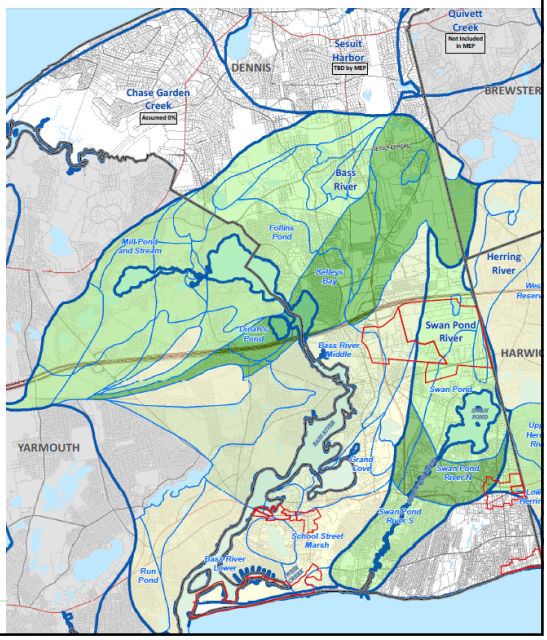
Dennis – Septic Nitrogen Removal Required

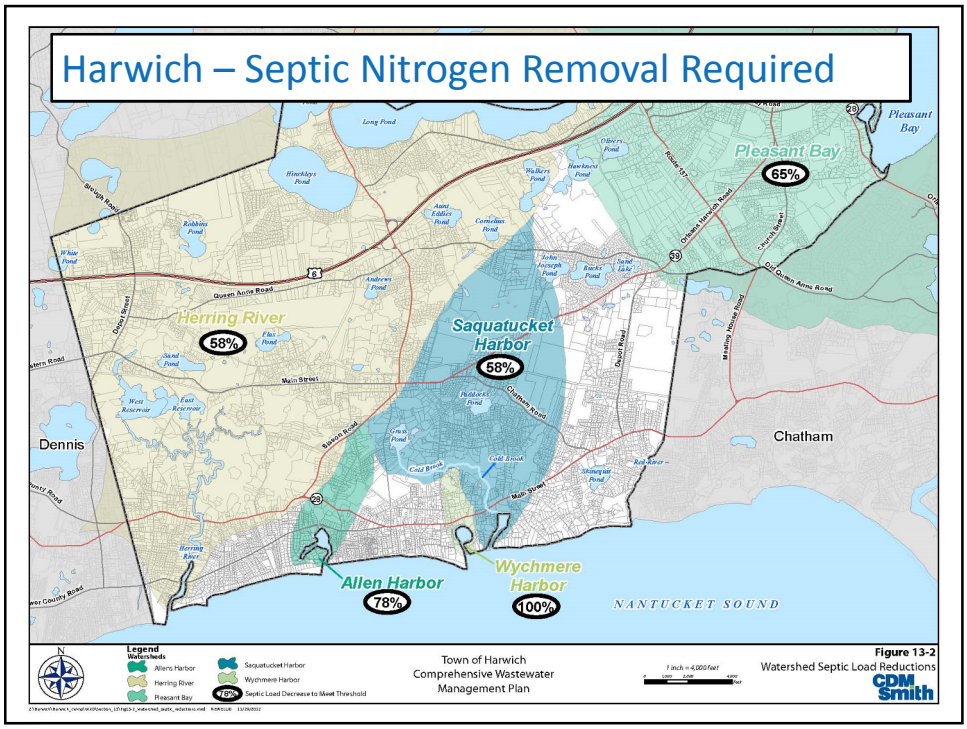
MEP Summary:
Required Nitrogen Removal by Sub-watershed

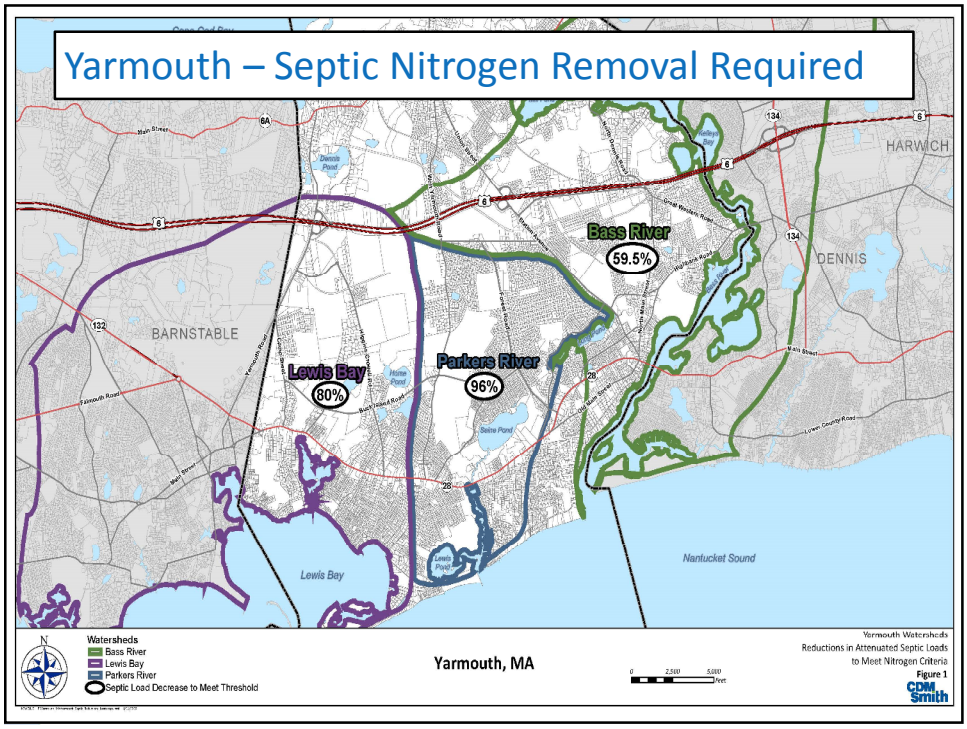
Includes:
- **Bass River**
- **Swan Pond River**
- **Herring River**

Legend
- MEP Watershed Delineations
- MEP Subwatersheds
- Planning Districts

Proposed Controllable Nitrogen Removal from MEP to Meet TMDL
- 80-90%
- 70-80%
- 50-60%
- 0%

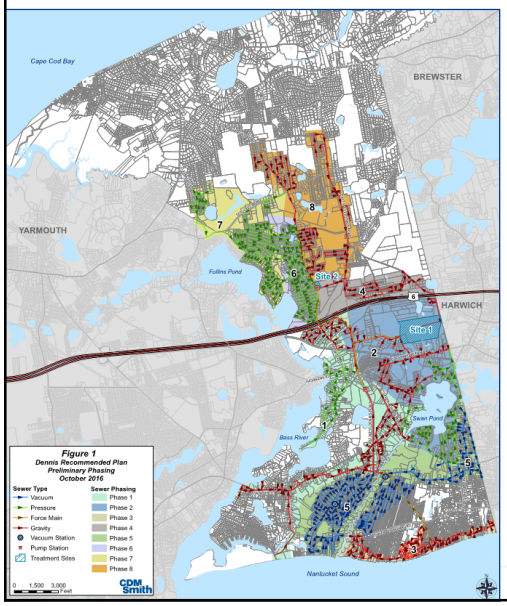



Harwich – Septic Nitrogen Removal Required
Pleasant Bay
65%
Herring River
58%
Saquatucket Harbor
58%
Allen Harbor
78%
Wychmere Harbor
100%
Dennis
Chatham
NANTUCKET SOUND
Legend
Watersheds
Allens Harbor
Herring River
Pleasant Bay
Saquatucket Harbor
Wychmere Harbor
Septic Load Decrease to Meet Threshold
Town of Harwich
Comprehensive Wastewater
Management Plan
Figure 13-2
Watershed Septic Load Reductions
CDM Smith

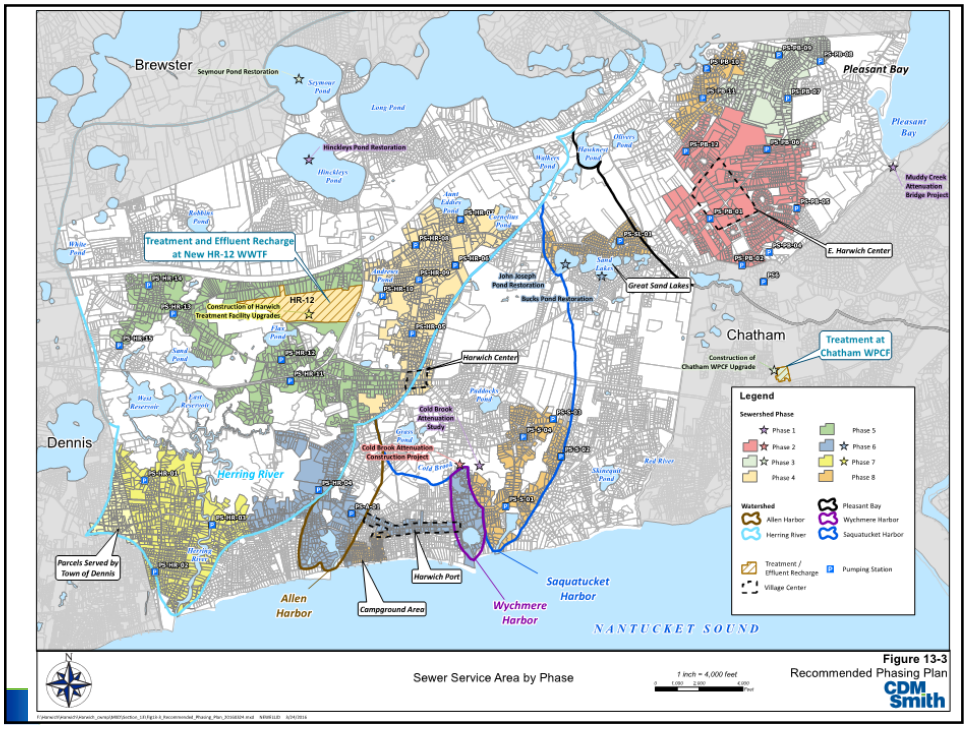

Yarmouth – Septic Nitrogen Removal Required
Bass River
59.5%
Lewis Bay
80%
Parkers River
96%
HARWICH
DENNIS
BARNSTABLE
Lewis Bay
Nantucket Sound
Watersheds
Bass River
Lewis Bay
Parkers River
Septic Load Decrease to Meet Threshold
Yarmouth, MA
Yarmouth Watersheds
Reductions in Attenuated Septic Loads
to Meet Nitrogen Criteria
Figure 1
CDM Smith

CDM Smith

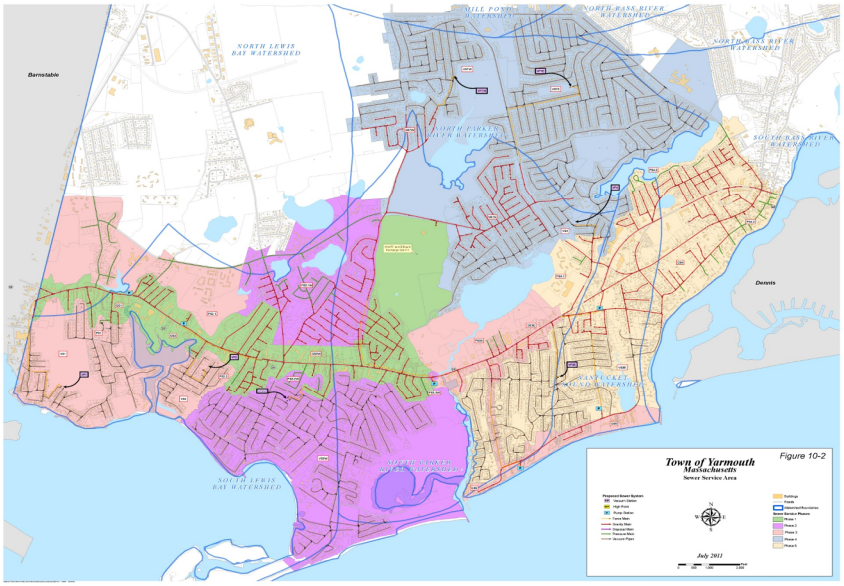
Dennis Recommended Wastewater Plan: Scenario 6A



- Scenario 6A was rated one of the top scenarios
- Meets MEP goals
- Meets other town goals: economic and community development
- $207 M – Capital Costs
- $ 7 M – O&M Costs
- Community partnership scenarios are built around Scenario 6A, allows for flexibility
- Consider Scenario 7A for future

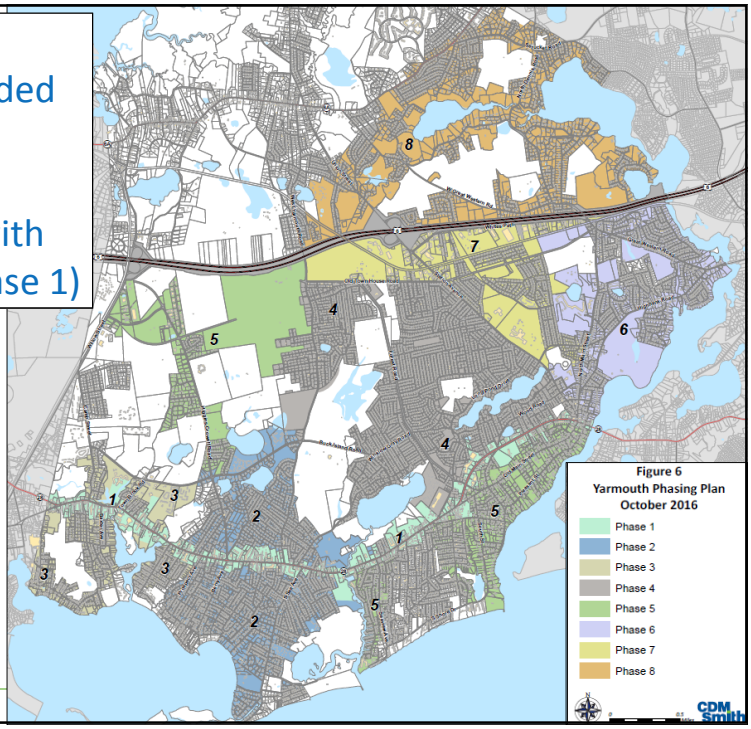


CWMP Recommended Program
Yarmouth Phasing



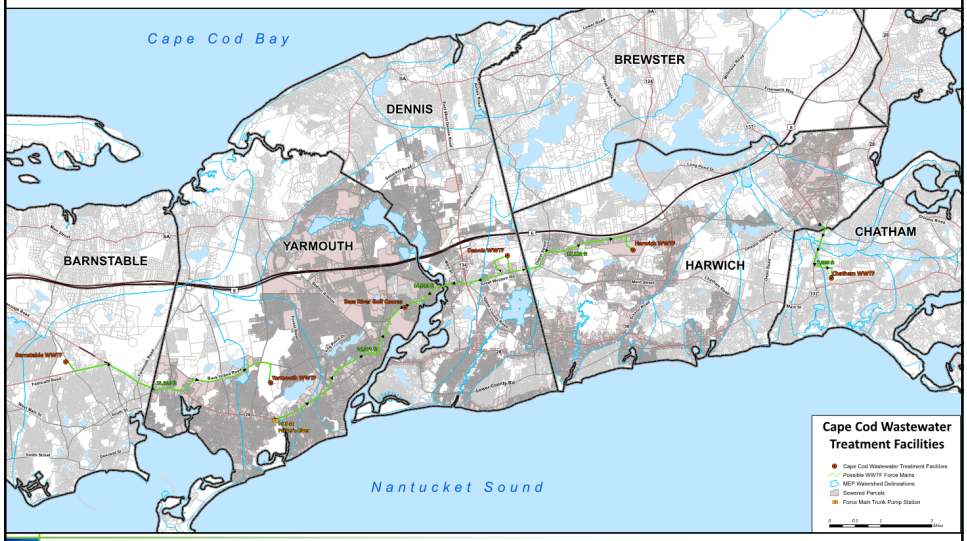
Yarmouth Recommended Program

(8 Phases with Revised Phase 1)



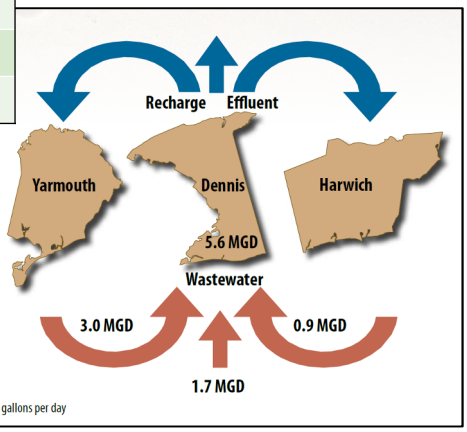
CDM Smith

Potential Mid/Lower-Cape WWTFs: Hyannis, Yarmouth, Dennis, Harwich, Chatham

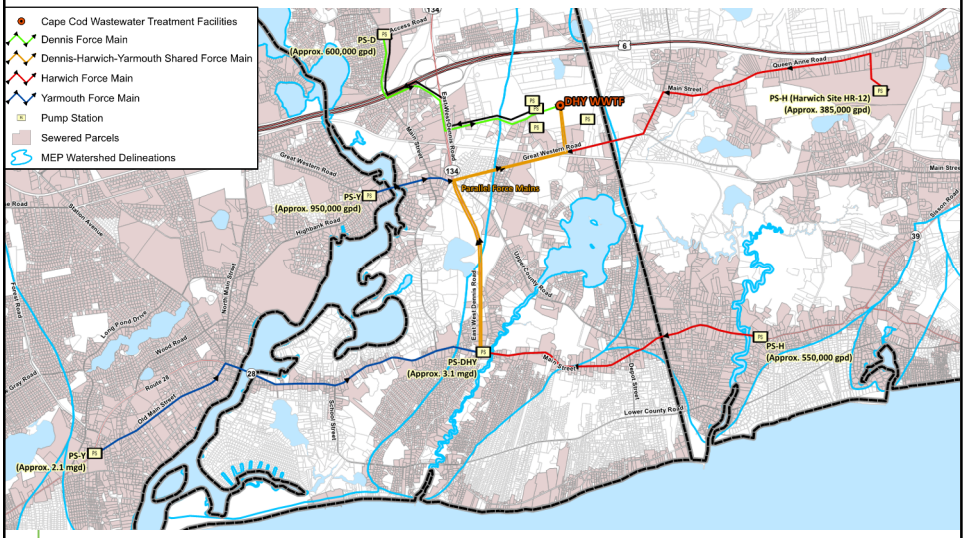


Wastewater Flow by Town

	Wastewater Flow at Buildout	% of DHY WWTF
Dennis	1.7 MGD	31%
Harwich	0.9 MGD	16%
Yarmouth	3.0 MGD	53%
Total	5.6 MGD	



Regional Conveyance: North and South Connections

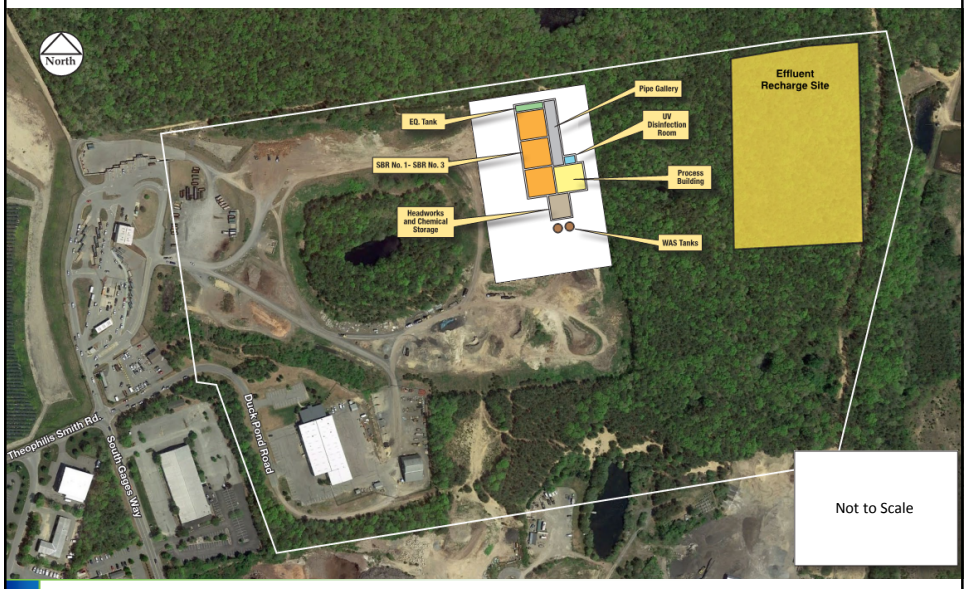


Summary of Shared Utilities

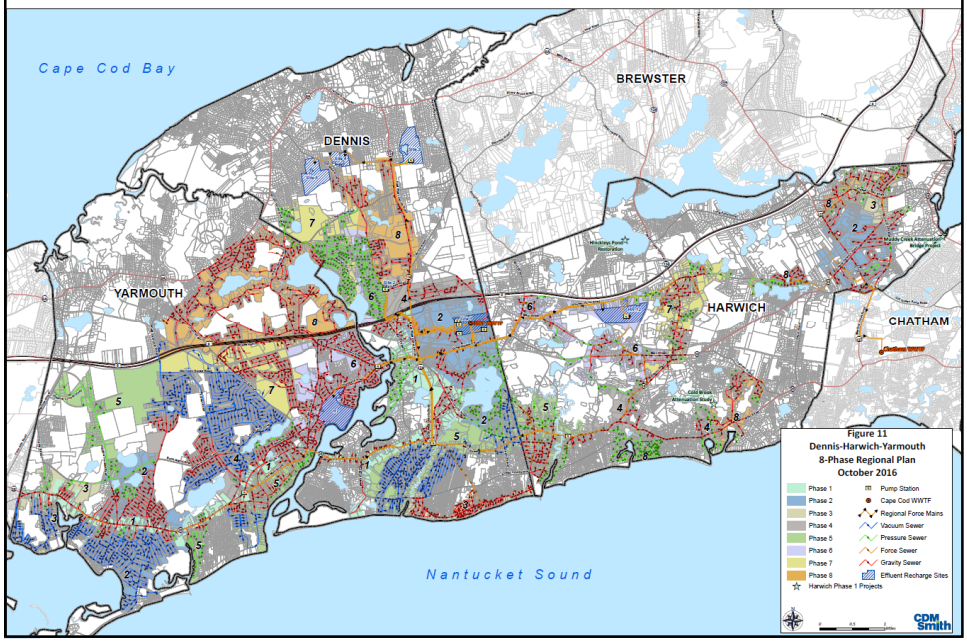
- A regional pumping station near the intersection of Route 28 and Route 134 in Dennis
- Dual 20-inch force mains from the intersection of Route 28 and Route 134 into the DHY WWTF
- DHY WWTF
- Piping to convey to multiple recharge sites
- Regional effluent recharge sites:
  - Dennis Site Nos. 1 and 2
  - Yarmouth Bass River Golf Course
  - Harwich Site HR-12
  - Dennis Pines Golf Course (Site No. 3)
  - Dennis Highland Golf Course (Site No. 5)
  - Dennis Parcels north and south of Hokum Rock Road (Site No. 4)

CDM Smith

DHY WWTF at 120 Theophilis Smith Road, Dennis



DHY Community Partnership - Wastewater



DHY Regional Phasing Timeline

- Phase 1
  - Regional DHY WWTF Construction
  - Regional Pumping Station near Intersection of Route 28/Route 134
  - Regional Dual Force Mains to DHY WWTF
  - Dennis sewer system backbone on Route 28 West
  - Harwich Pleasant Bay sewer service area (to Chatham WPCF)
  - Yarmouth South Connection: Force Main along Route 28 in Dennis to connect Yarmouth's Rt28 sewer service area
- Phase 2
  - Dennis sewer system expansion
  - Harwich Pleasant Bay sewer service area (to Chatham WPCF)
  - Yarmouth sewer system expansion

DHY Regional Phasing Timeline (continued)

- Phase 3
  - Dennis and Yarmouth sewer system expansion
  - Harwich South Connection: PS & Force Main along Route 28 in Dennis to connect southern Harwich's sewer service area
- Phase 4
  - Regional DHY WWTF Expansion
  - Dennis sewer system expansion (north of Route 6)
  - Harwich sewer system backbone on Route 28 in Harwich
  - Yarmouth sewer system expansion

CDM Smith

DHY Regional Phasing Timeline (continued)

- Phase 5
  - Dennis, Harwich, and Yarmouth sewer system expansion
- Phase 6
  - Dennis sewer system expansion
  - Harwich North Connection: PS & Force Main on Great Western Road
  - Harwich sewer service expansion
  - Yarmouth North Connection: Force Main on Highbank Road
  - Yarmouth sewer service expansion
- Phases 7 and 8
  - Harwich sewer service expansion
  - Potential for Dennis/Yarmouth sewer service expansion

Town and Regional Preliminary Cost Comparison at Buildout

	Capital Costs		O&M Costs		Equivalent Annual Costs		Annual Savings	
	Town	Regional	Town	Regional	Town	Regional	$ Mil/year	%
Dennis	$207 M	$170 M	$7.0 M	$4.1 M	$16.3 M	$11.7 M	$4.6 M	28%
Harwich	$251 M	$211 M	$3.4 M	$2.4 M	$14.6 M	$11.8 M	$2.7 M	19%
Yarmouth	$342 M	$325 M	$9 M	$6.3 M	$24.2 M	$20.8 M	$3.4 M	14%

CDM Smith

Preliminary Costs for First Three Phases at Buildout

Fiscal Year	Dennis		Harwich		Yarmouth	
2017			Phase 1:	$2,600,000		
2018	Phase 0:	$375,000	Phase 2:	$34,150,000	Phase 0:	$200,000
2019	Phase 1:	$29,200,000			Phase 1:	$24,200,000
2019	Phase 1A:	$20,800,000	Phase 2A:	$9,000,000	Phase 1A:	$38,100,000
2023			Phase 3:	$13,700,000		
2024	Phase 2:	$21,900,000			Phase 2:	$38,300,000
2028	Phase 3:	$13,200,000	Phase 4:	$25,200,000	Phase 3:	$13,900,000

Cost Categories
Harwich completed natural nitrogen attenuation programs (Muddy Creek Bridge Widening and Cold Brook Study)
Dennis and Yarmouth Final CWMP Planning and Pilot Programs
Multiple services – Pleasant Bay sewer design and construction; Cold Brook
Design and Construction

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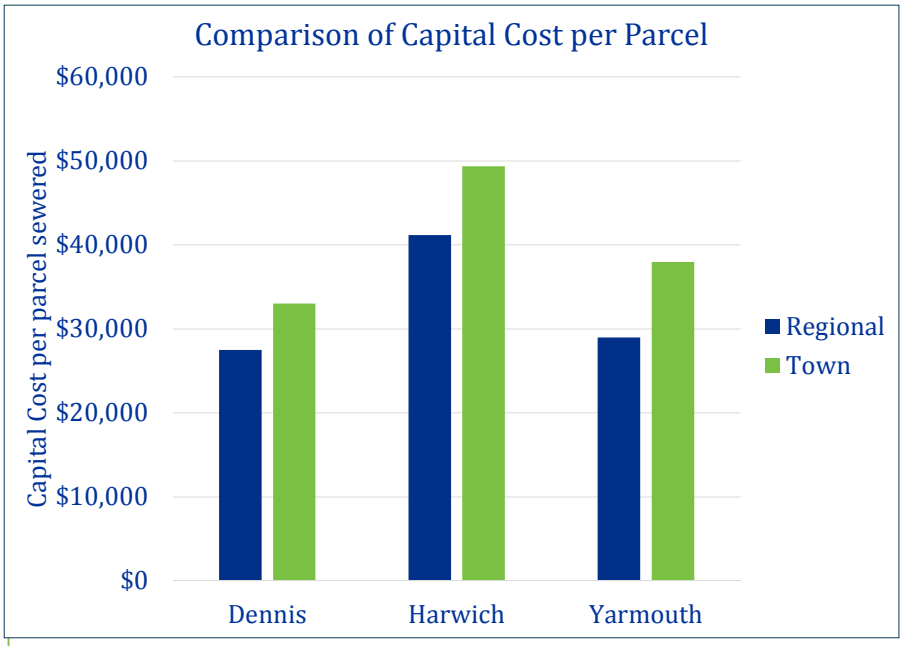

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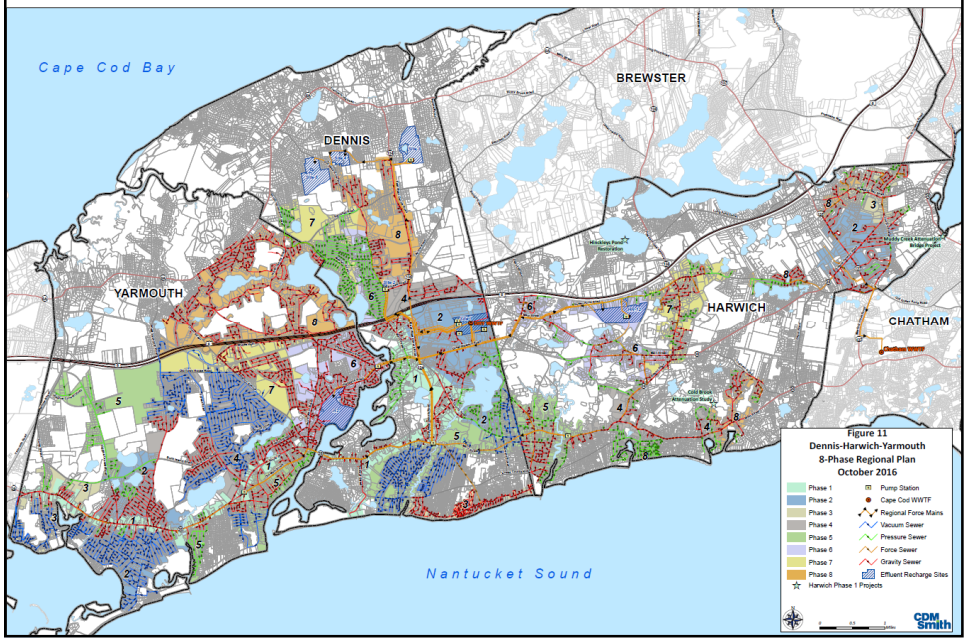
DHY Community Partnership - Wastewater



Summary: Advantages of Community Partnership Option

- Cost savings;
- Improve water bodies and overall aesthetics on the Cape;
- Work with regulators to meet watershed Total Maximum Daily Loads (TMDLs);
- Recharge effluent in beneficial locations (i.e., golf courses, washing stations);
- Operate and maintain the treatment facility and shared infrastructure with one staff;
- Address potential future treatment of contaminants of emerging concern (CECs);
- Simplifies governance for wastewater operations;
- Construction of sewers in commercial areas to promote desired economic development and smart growth; and
- Gain more points for State Revolving Fund (SRF) loan program to access low interest rates.

CDM Smith

It's been done before…

- Drinking Water Systems in Dennis, Harwich, and Yarmouth all cost about what it will cost to implement the wastewater solution.
- Recent formation (2014) of the MFN Regional Wastewater District for the towns of Mansfield, Foxborough and Norton.

MassDEP Response Strategy

- Designation of Nitrogen Sensitive Areas ("NSAs")
  - Revise Title 5 Regulations.
  - Would require homeowners to install enhanced I/A septic systems (twice the cost of sewers per pound of nitrogen removed) if located in an NSA.
- Changes to Ground Discharge Permits and Regulations
  - Tighten current permit limits.
  - Remove Title 5 Exemption, requiring enhanced I/A septic systems.
- Formation of Water Pollution Abatement Districts ("WPADs")
  - DEP could form WPADs and require implementation of wastewater plans.

CDM Smith

The Consequences

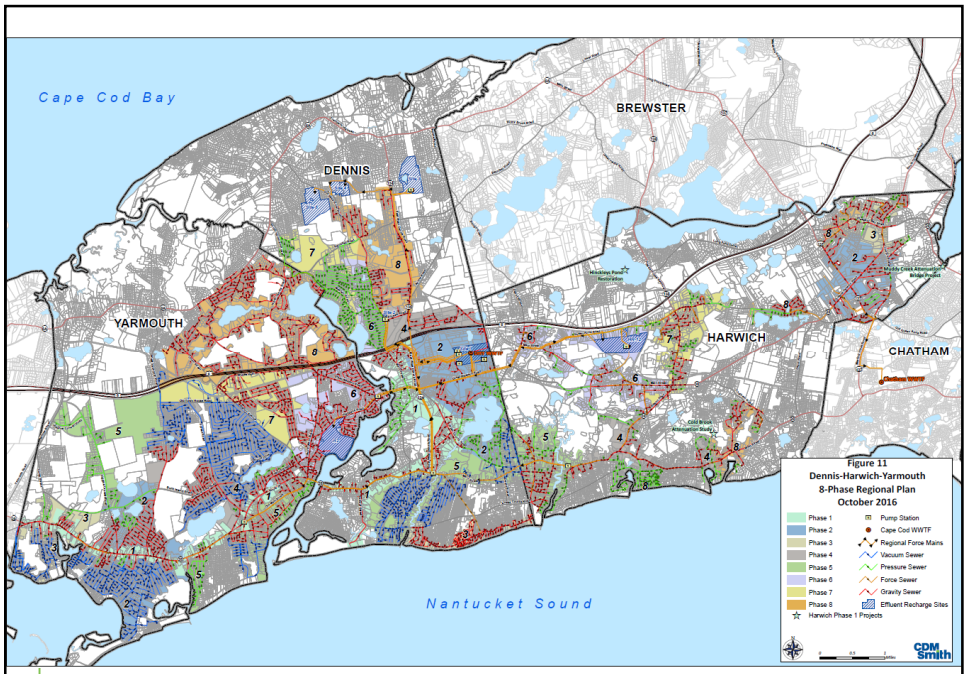
- "The cost of doing nothing is economically devastating to every Cape homeowner."

  -Cape Cod Commission, 208 Plan, 2014

- "A 1% decline in water quality led to an average loss in home value of 0.61%"

  -Cape Cod Commission, Three Bays Study, 2015

Questions/Comments?


Cape Cod Bay
BREWSTER
DENNIS
YARMOUTH
HARWICH
CHATHAM
Nantucket Sound
Figure 11
Dennis-Harwich-Yarmouth
8-Phase Regional Plan
October 2016
Phase 1
Phase 2
Phase 3
Phase 4
Phase 5
Phase 6
Phase 7
Phase 8
Harwich Phase 1 Projects
Pump Station
Cape Cod WWTF
Regional Force Mains
Vacuum Sewer
Pressure Sewer
Force Sewer
Gravity Sewer
Effluent Recharge Sites
CDM Smith

DHY Clean Waters Community Partnership Meeting

Between

Board of Selectmen

From

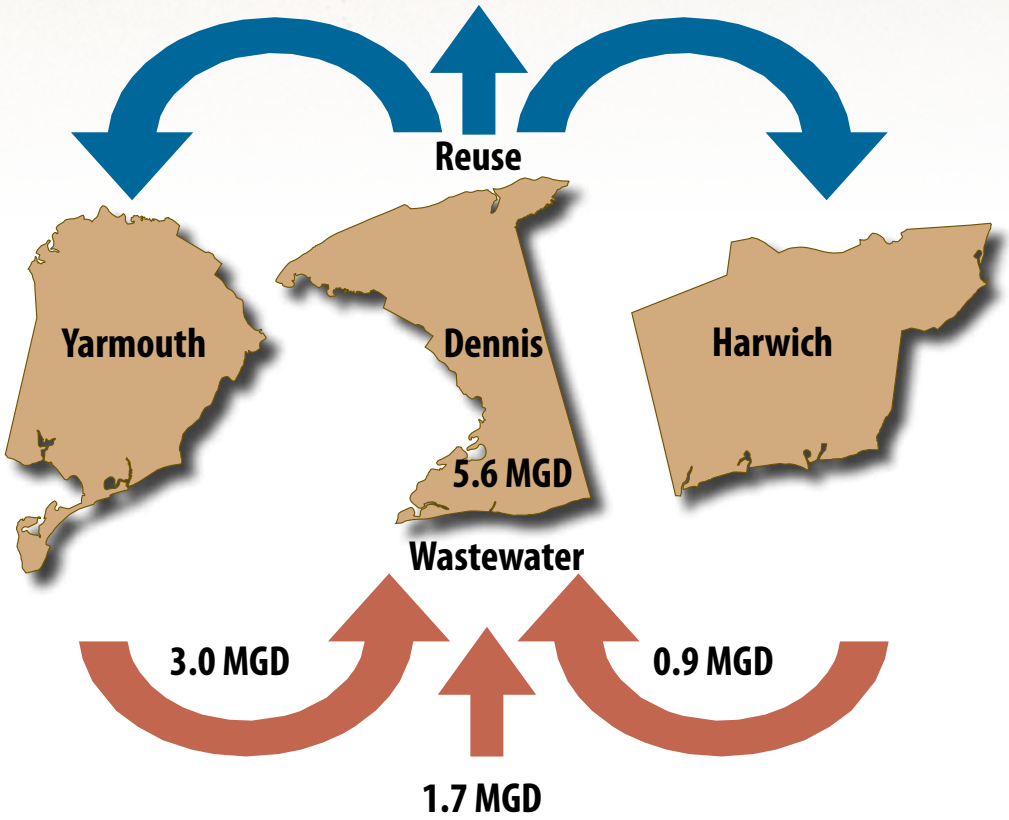
Dennis, Harwich and Yarmouth to Discuss DHY Clean Waters Community Partnership

March 22, 2018 - 6:00 pm

Dennis Council on Aging & Senior Center
1045 Route 134, South Dennis, MA 02660

March

22



MGD – million gallons per day

Agenda

Agenda

Meeting of Board of Selectmen from Dennis, Harwich and Yarmouth to Discuss DHY Clean Waters Community Partnership

March 22, 2018 – 6:00 pm

1. **Welcome Comments**
2. **Overview of Efficiency and Regionalization Grant Awarded to DHY Clean Waters Community Partnership from the Community Compact Program**
3. **Review MassDEP Input to Date**
4. **CWMP and Program Status Update from Dennis, Harwich, and Yarmouth**
5. **Overview of DHY Discussions and Preliminary Cost Savings**
6. **Proposed Project Schedule**
7. **Proposed Town Meeting Article(s) for Special Legislation**
8. **Board of Selectmen Discussion and Potential Vote for Town Meeting Article**
9. **Closing Remarks**
10. **Discussion of topics not reasonably anticipated by the Board Chairs 48 hours before the meeting.**

David F. Young, P.E.
Vice President

July 31, 2018

Dennis CWMP Update
2018 Residents Meeting

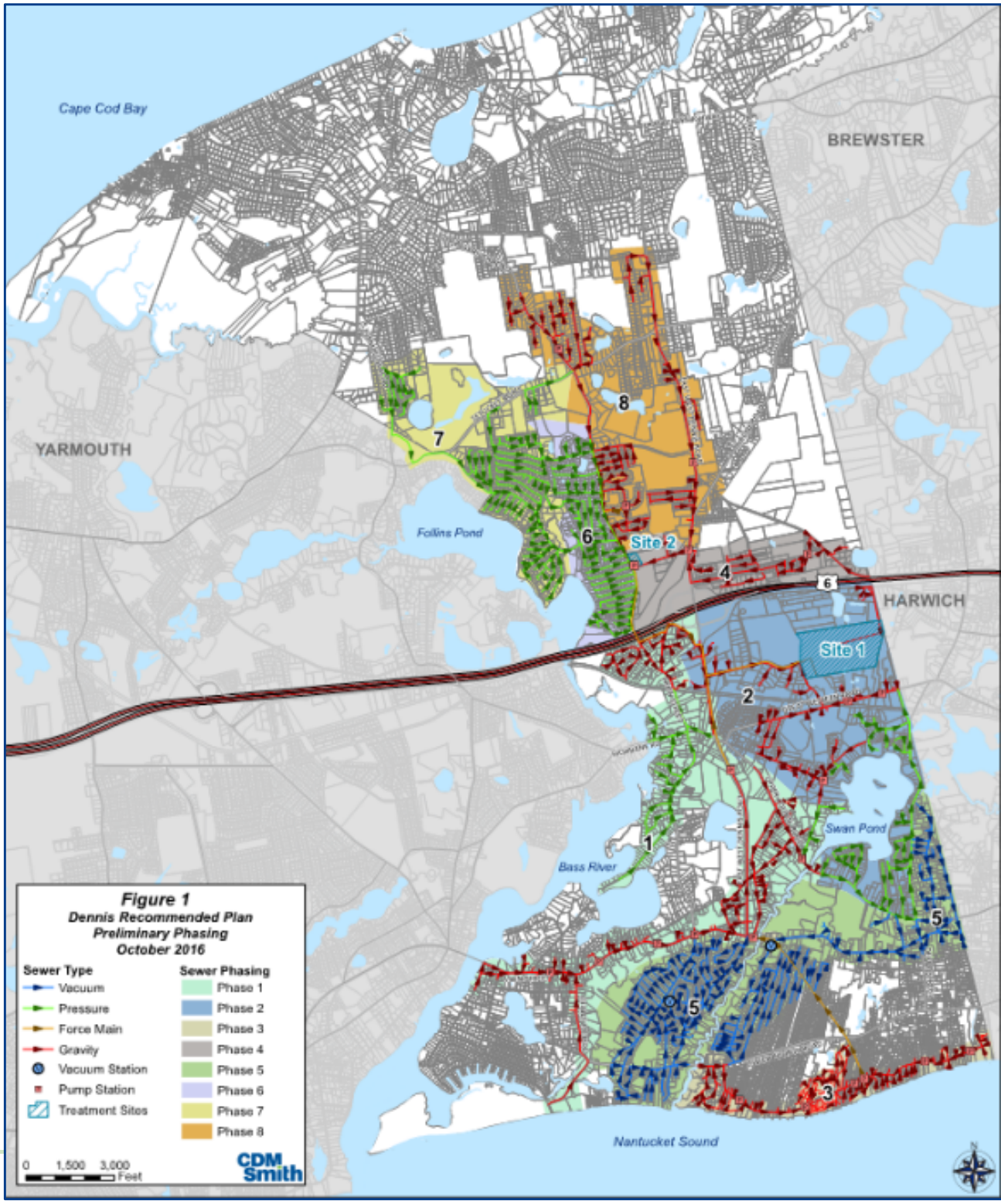
CDM Smith

CWMP and Program Status Update: Town of Dennis

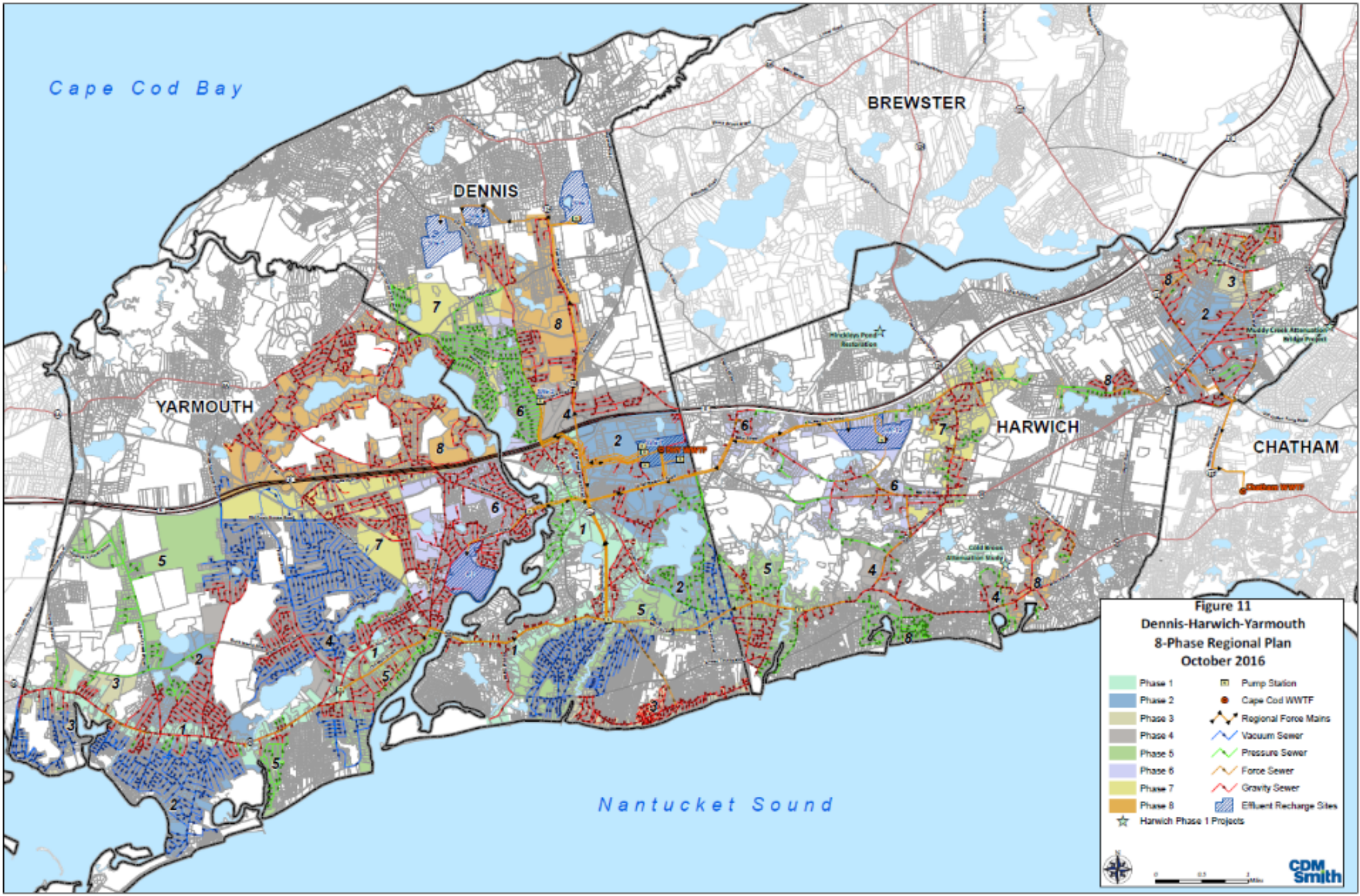
- Draft CWMP submitted to Commonwealth of Massachusetts Environmental Policy Act (MEPA) Office and the Cape Cod Commission (CCC) (Summer 2017)
- Bass River Railroad/Cape Cod Rail Trail Bridge Abutment Widening (2016-2017)
- Economic Study conducted
- Aquaculture Pilot Project in Swan Pond (starting in Summer 2018)
- Final CWMP to be submitted (Fall 2018)

Watershed	Septic Load Reduction Required
Bass River	60%
Herring River	58%
Swan Pond	100%
Chase Garden Creek	+24%
Sesuit Harbor	Awaiting MEP Report

Dennis Recommended Program

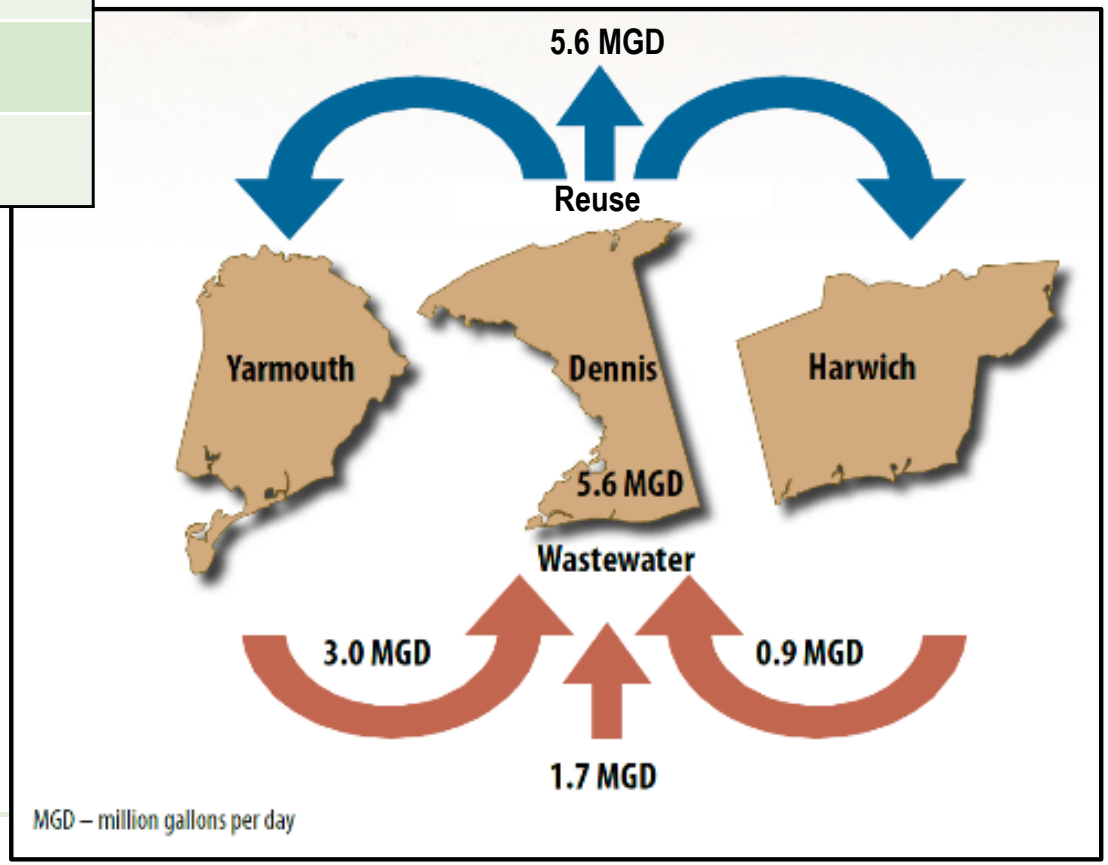


DHY Community Partnership - Wastewater

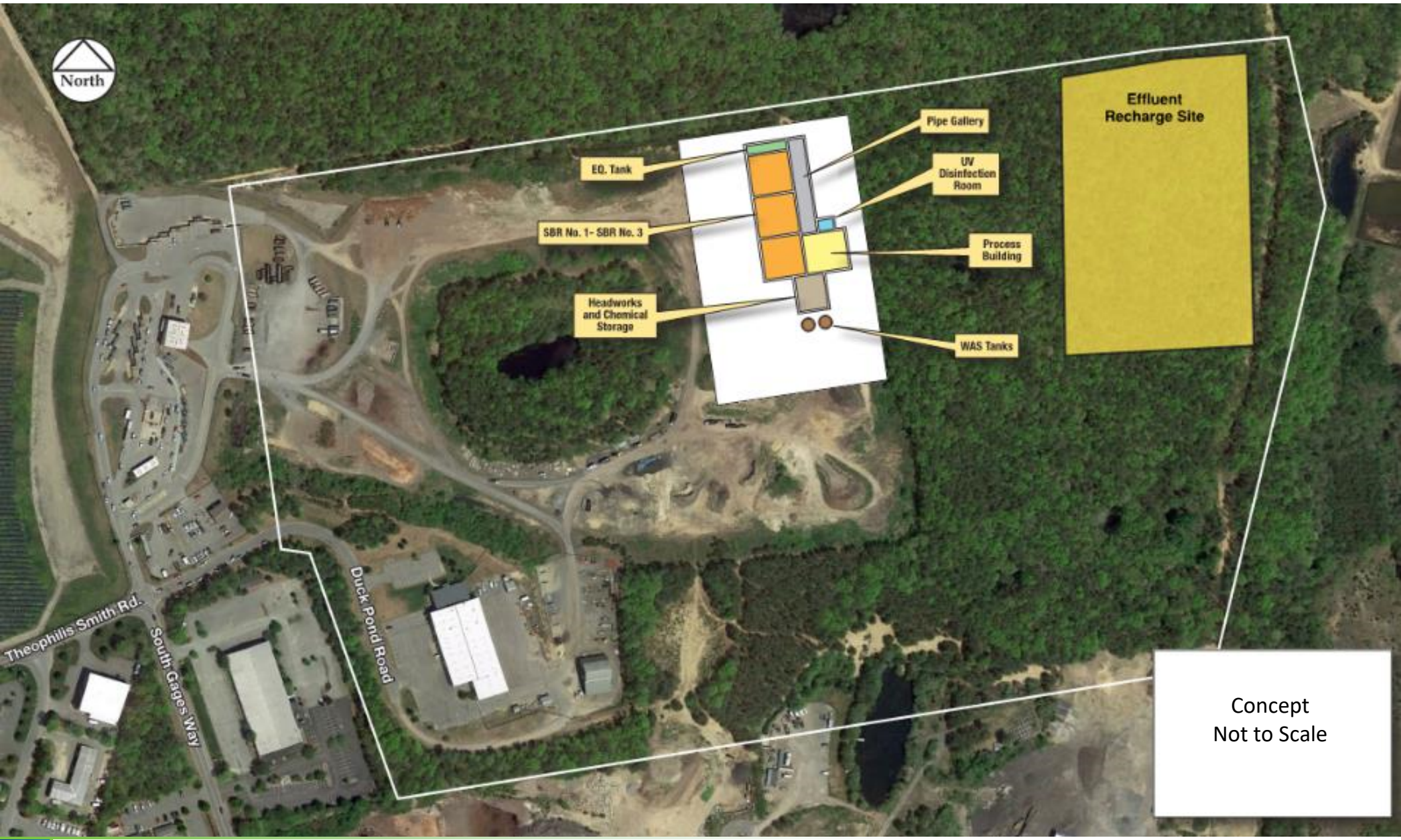


Estimated Wastewater Flow by Town

	Wastewater Flow at Buildout	% of DHY WWTF
Dennis	1.7 MGD	31%
Harwich	0.9 MGD	16%
Yarmouth	3.0 MGD	53%
Total	5.6 MGD	



DHY WWTF at Dennis DPW Site



3 Ways Shellfish Remove Nitrogen

Nitrogen in water

Phytoplankton

IN the system

Harvest ~ 0.3gN /oyster

3

Sequestration tissue & shell

Excretion

2

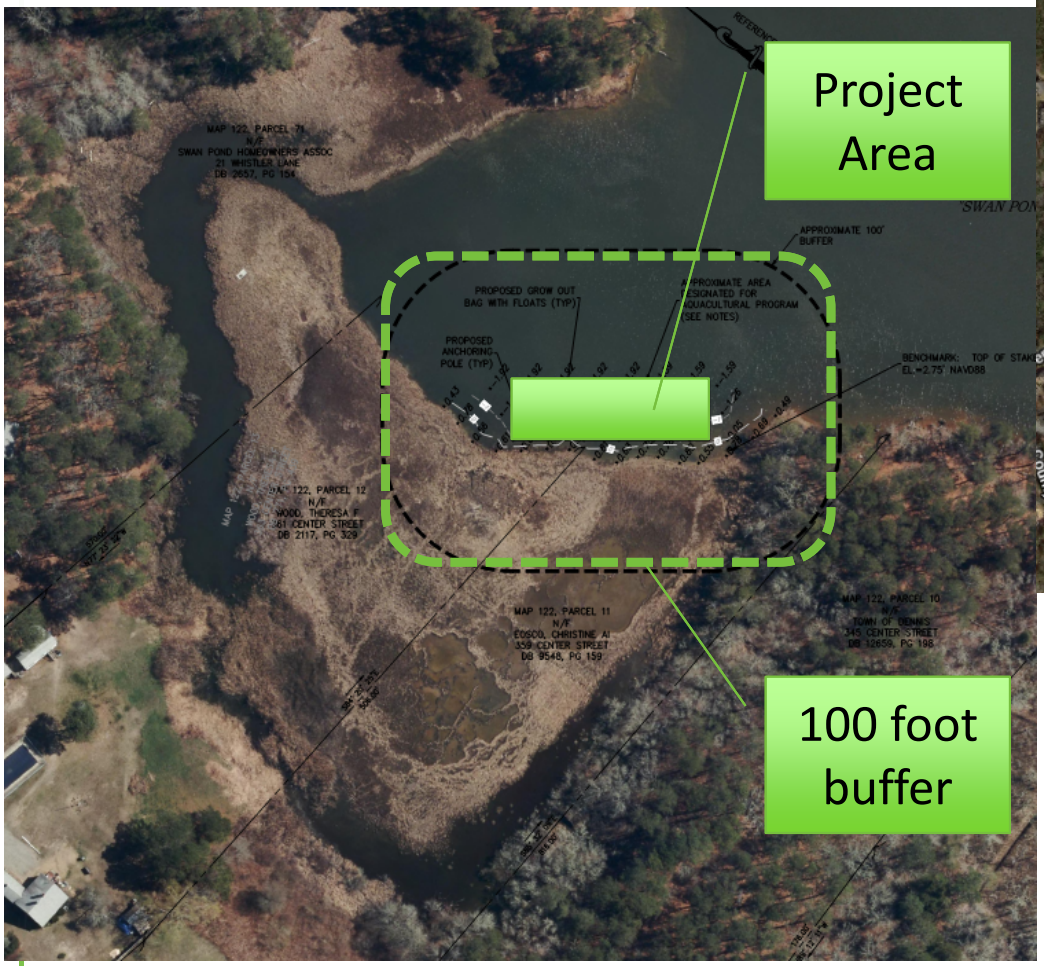
Denitrification N_2 gas

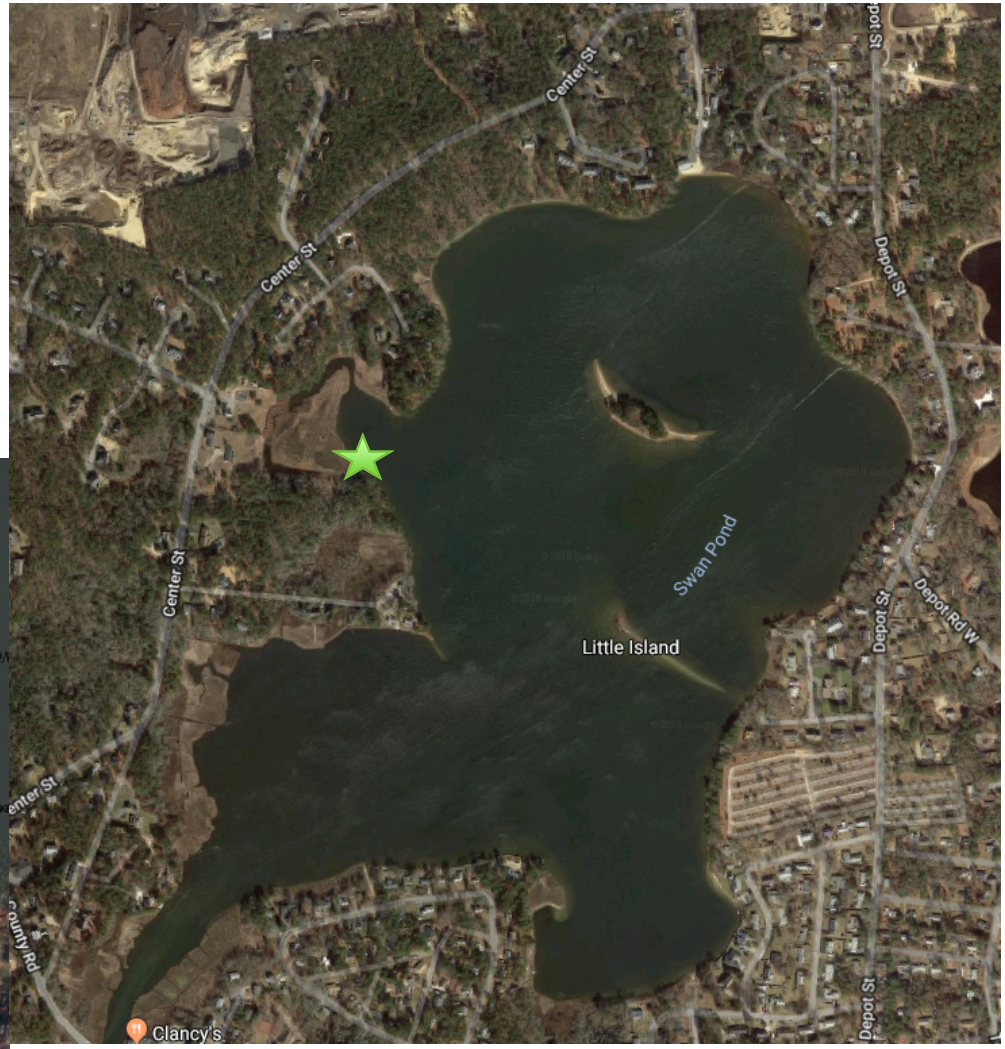
1

Burial into sediment

OUT of the system

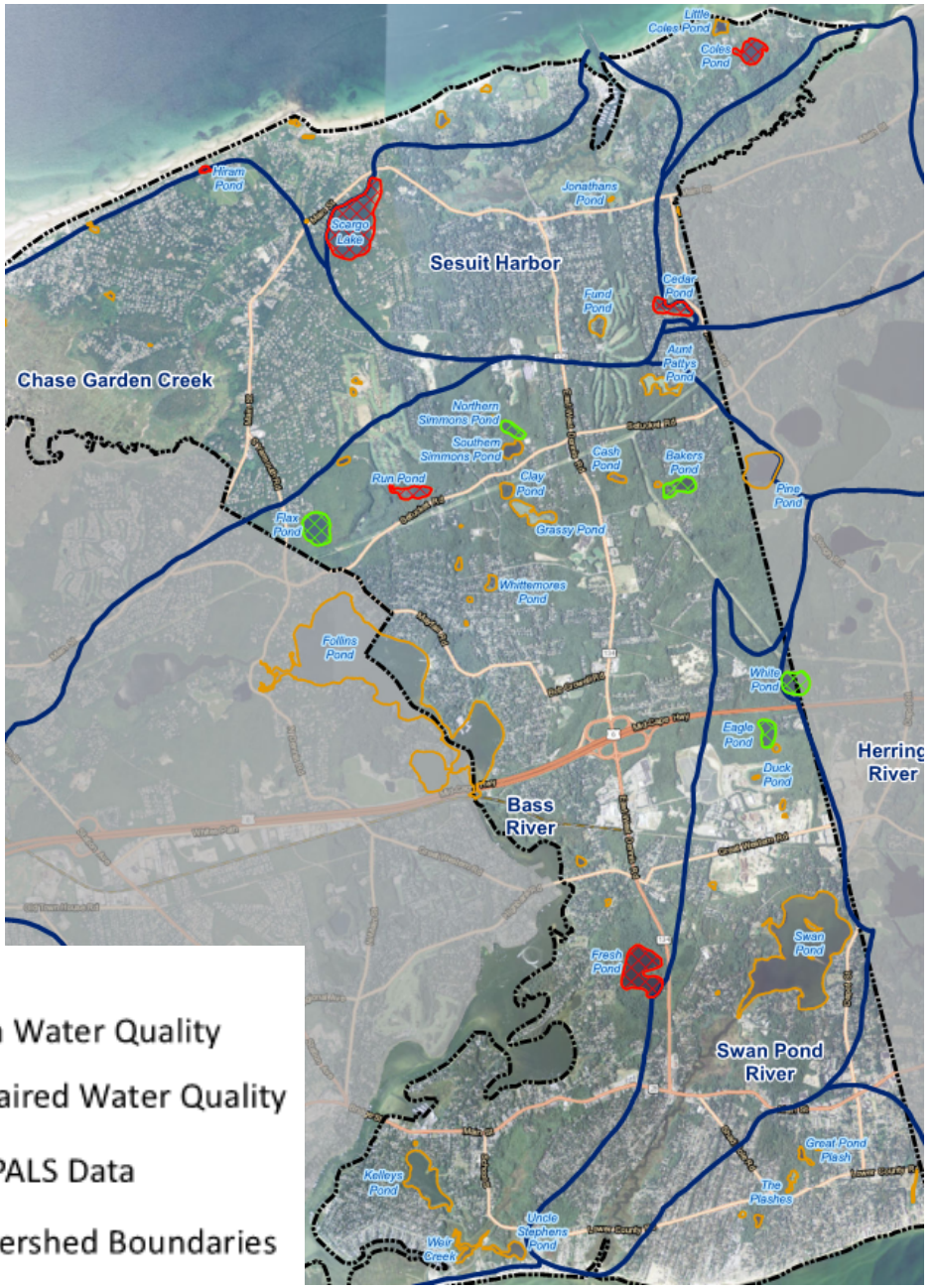
Aquaculture Pilot





Freshwater Ponds

- October 2016 Final Water Quality Report Issued by the School for Marine Science and Technology
- CDM Smith assessing the need for sampling at ponds that have limited data
- Monitoring and potential restoration included in Final CWMP



Next Steps

- Continued DHY Discussions through the rest of the year
  - Presentation on Community Partnership being included in the program at the One Cape Summit in August 2018
- Dennis to submit Final CWMP in the fall of 2018

David F. Young, P.E.
Vice President

August 11, 2020

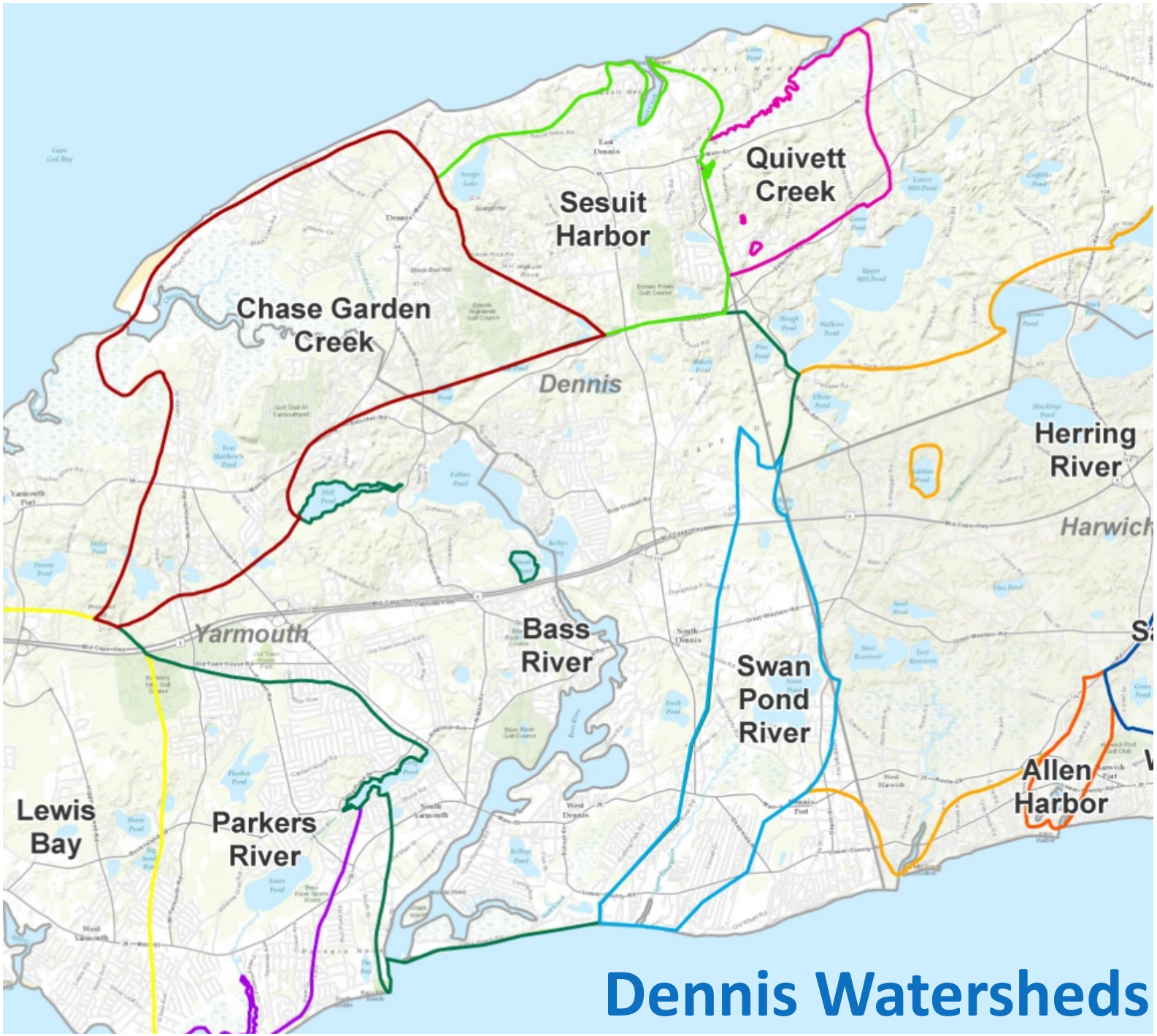
Dennis CWMP Update
2020 Summer Resident Meeting

CDM Smith

Comprehensive Wastewater Management Plan (CWMP) – Status Update

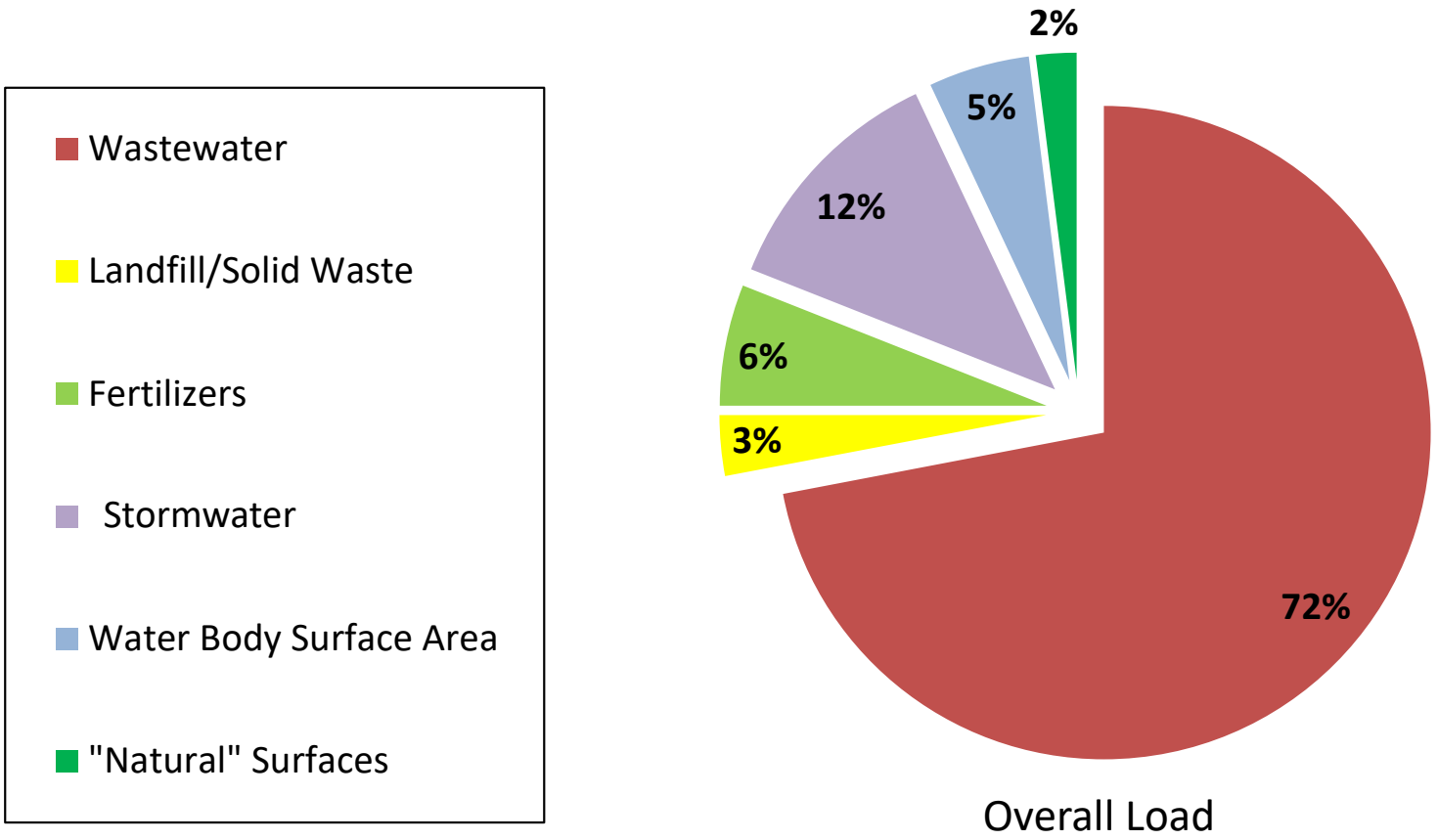
- Draft CWMP submitted to Commonwealth of Massachusetts Environmental Policy Act (MEPA) Office and the Cape Cod Commission (CCC) (Summer 2017)
- Aquaculture Pilot Project in Swan Pond (field work completed 2018-2019)
- Initial Archeological Surveys of future pumping stations completed
- Effluent recharge field investigations (Aug. & Oct. 2020)
- Final CWMP to be submitted (TBD)

Watershed	Septic Load Reduction Required
Bass River	60%
Herring River	58%
Swan Pond	100%
Chase Garden Creek	+24%
Sesuit Harbor	Awaiting MEP Report

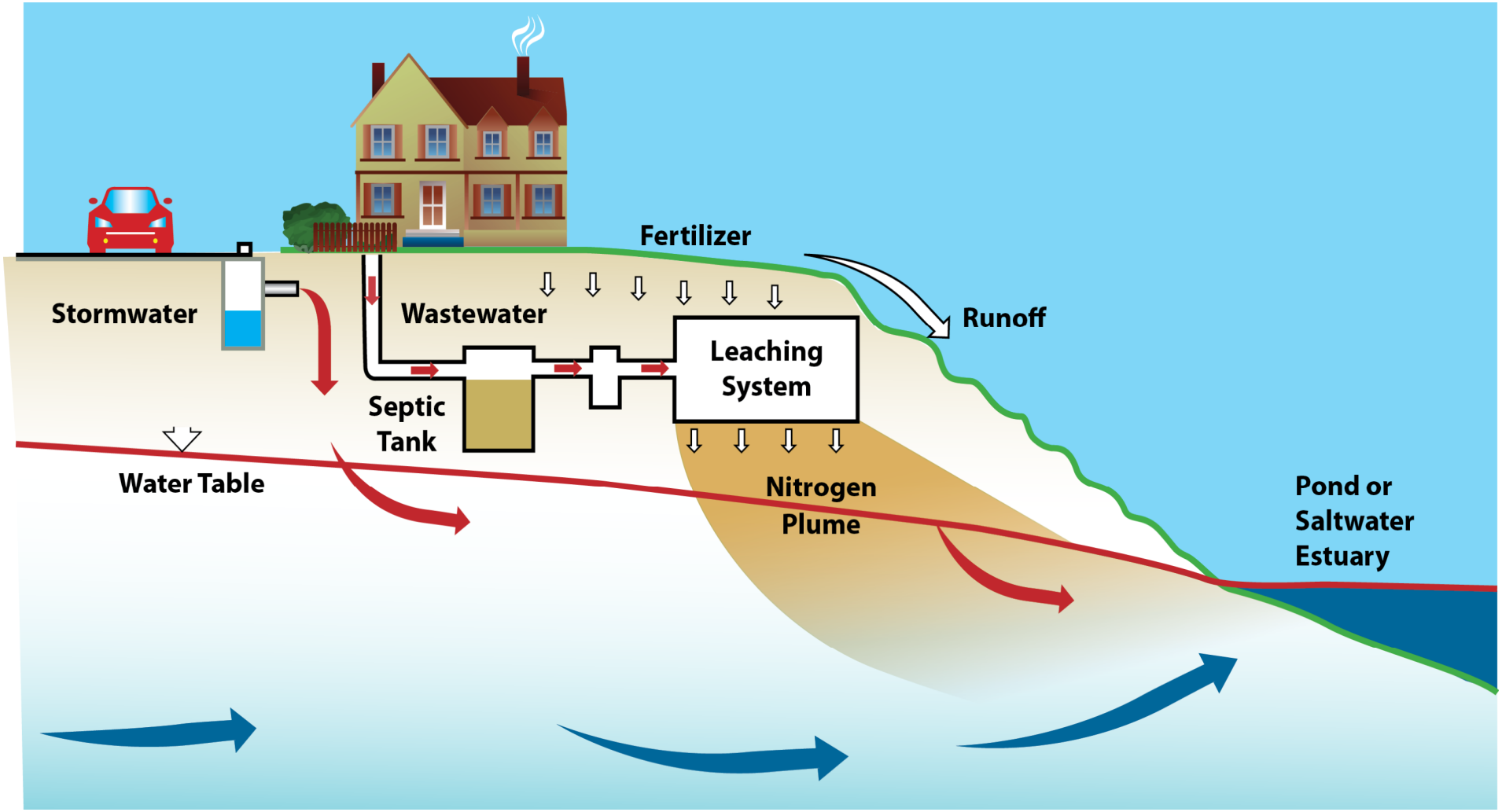

Quivett Creek
Sesuit Harbor
Chase Garden Creek
Dennis
Herring River
Harwich
Yarmouth
Bass River
Swan Pond River
Allen Harbor
Lewis Bay
Parkers River
Dennis Watersheds

Controllable Nitrogen Sources – Swan Pond River Watershed

Dennis
preserving our water resources

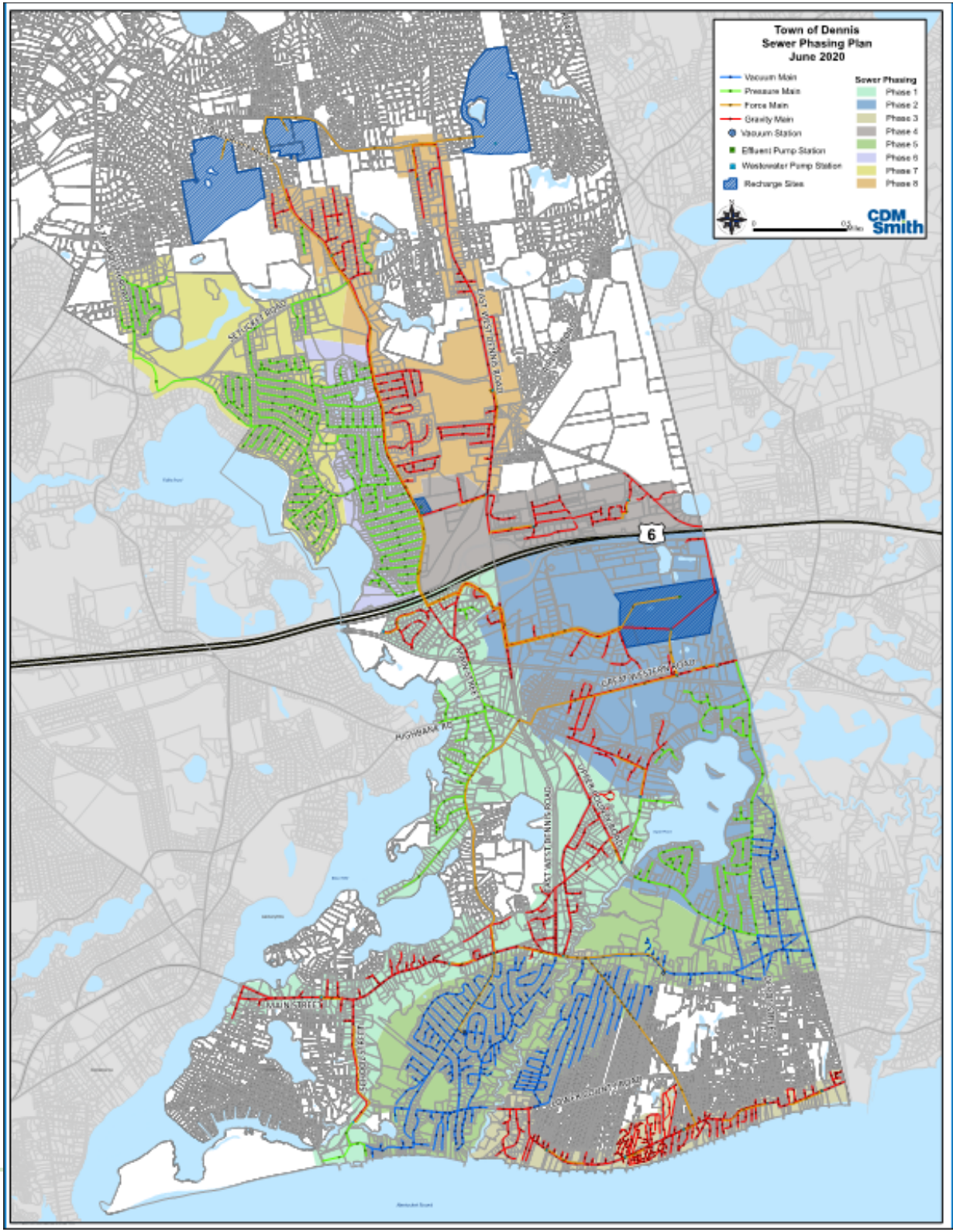


Nitrogen Entering Our Groundwater from Title 5 Septic Systems **Is Our Biggest Issue**

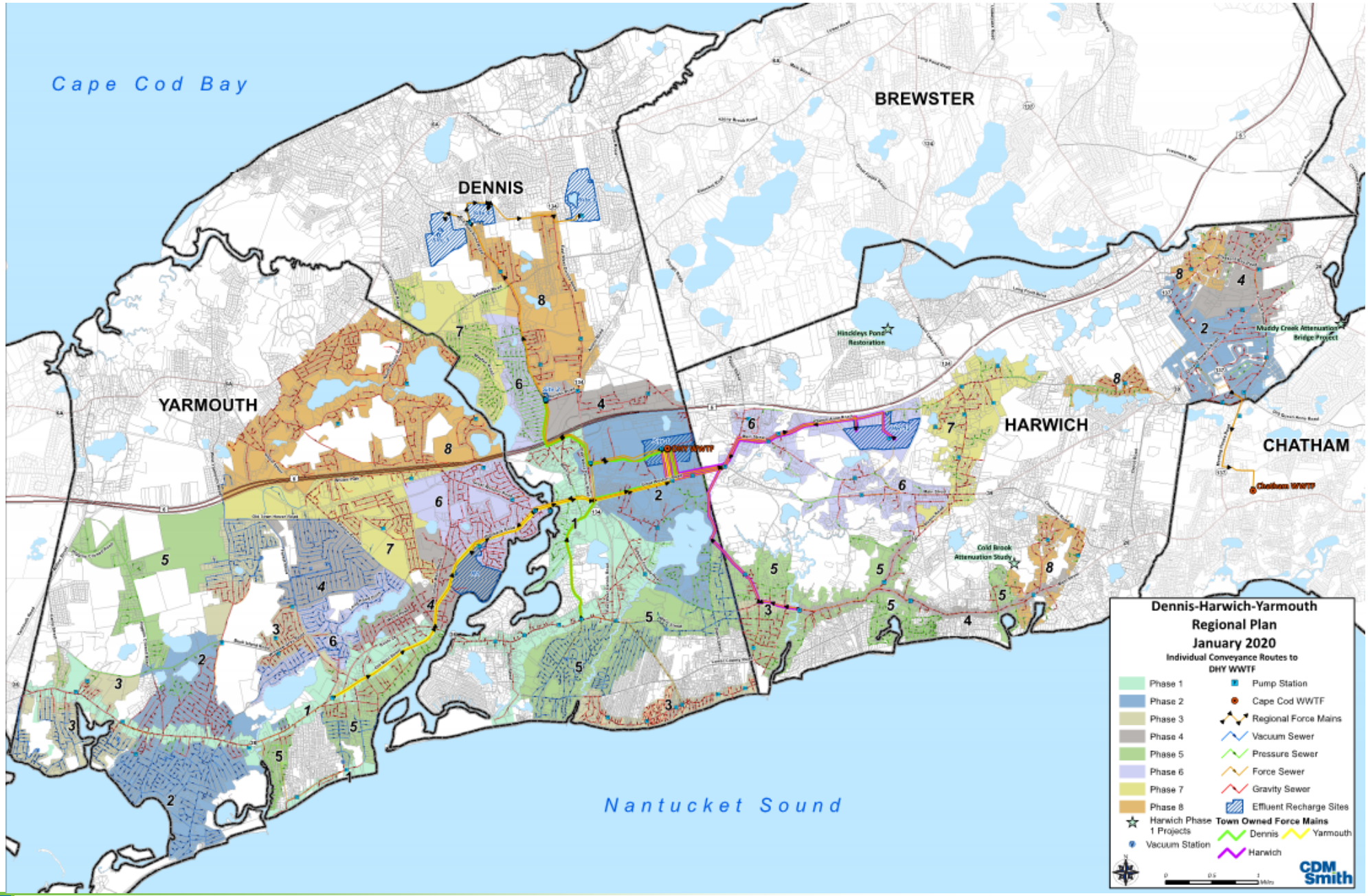


Dennis Recommended Program

- Sewer line routing and pump station locations revaluated in early 2020



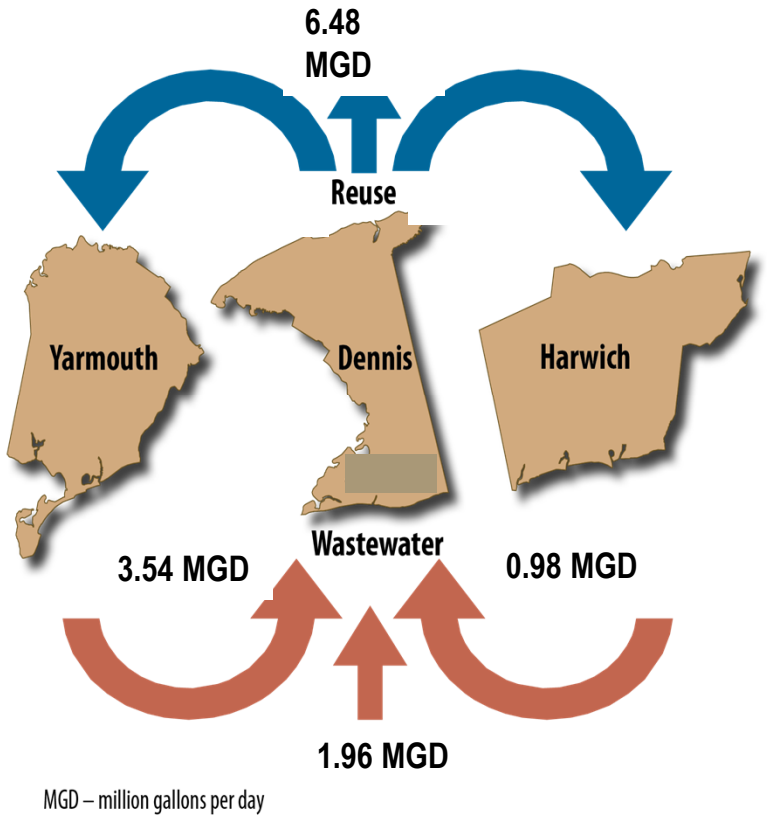
DHY Clean Waters Community Partnership



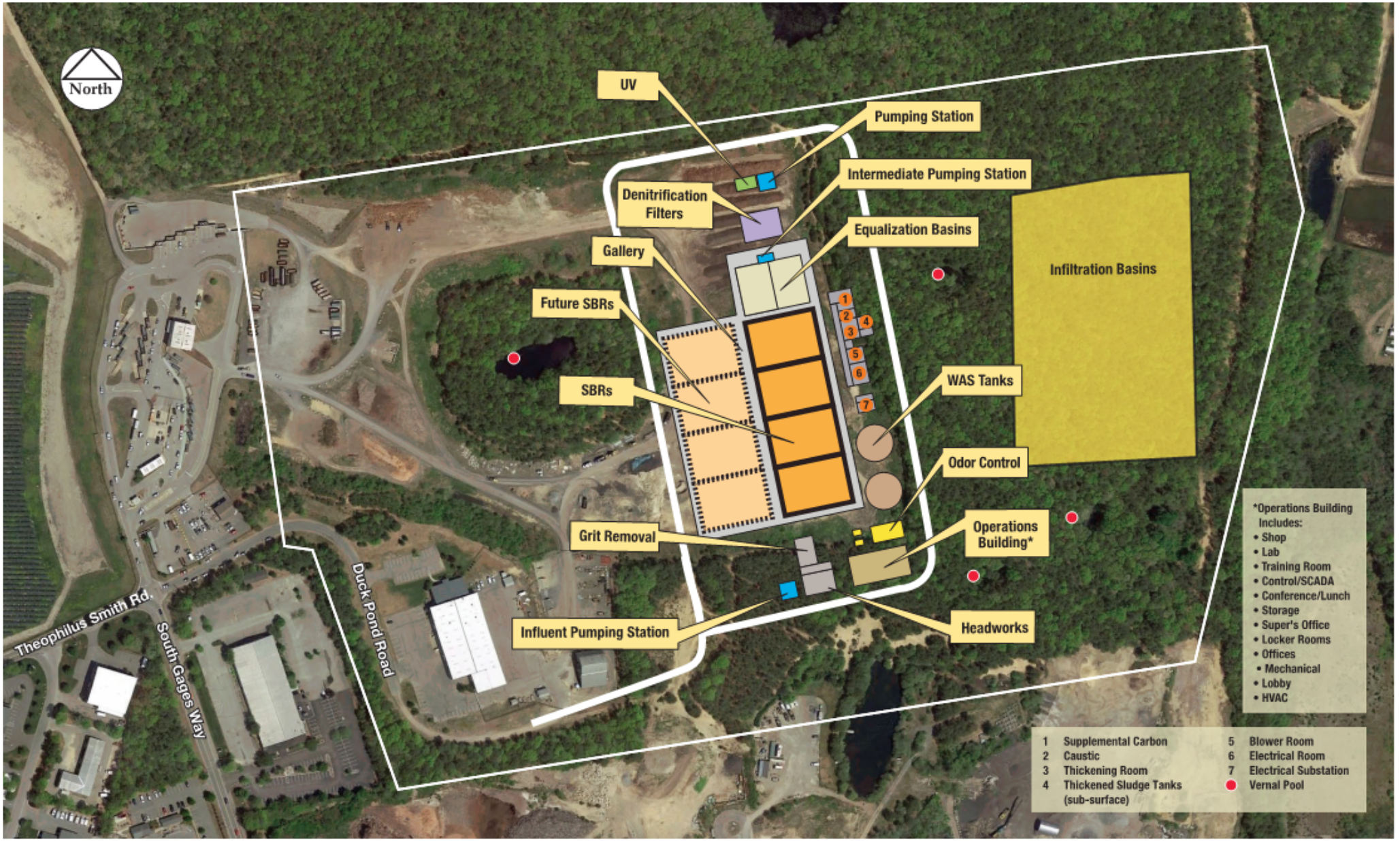
DHY - Estimated Wastewater Flow by Town

	Wastewater Flow at Buildout	% of DHY WWTF
Dennis	1.96 MGD	30%
Harwich	0.98 MGD	15%
Yarmouth	3.54 MGD	55%
Total	6.48 MGD	(Buildout)

Community Partnership – Dennis, Harwich, and Yarmouth



MGD – million gallons per day



Town of Dennis, Massachusetts

April 1, 2020

Site 1 WWTF and Effluent Recharge Conceptual Layout

DHY Facility

CDM Smith

Swan Pond Aquaculture Demonstration Project

Fertilizer Educational Resources

- PowerPoint presentation
- Fertilizer brochure

Comprehensive Wastewater Management Planning for

Dennis

Town of Dennis

Wastewater Implementation Committee

Fertilizer Education Subcommittee

Joe Martins, Chairman

Sue Brock

Jim Bonofiglio

Dennis
preserving our water resources

CORRECT FERTILIZER USE PROTECTS OUR WATER QUALITY

Information for homeowners regarding lawn care and fertilizer use

Proposed Funding Methods

- Solar Fund Revenues
- Portion of rooms tax
- Water Infrastructure Investment Fund (WIIF)
- Town-wide Property Tax
- Cape Cod Water Protection Fund
- Zero interest State Revolving Fund loans
- Coordination with MassDOT projects on Route 28
- Other?

Next Steps

- Finalize Draft DHY Agreement/Discussions
- Coordinate with planned MassDOT projects
- Approve DHY Agreement at Town Meeting
- Appropriate funds to begin initial design phase
- Submit Final CWMP once determination on DHY is made
- Start two year design phase followed by three year construction and facility start-up.

Summary

- Nutrient reduction will be mandated by regulatory agencies (TMDLs issued); action now allows more town control;
- This is a complex planning process that will continue indefinitely, through adaptive management – living document;
- Need to continue to work to implement DHY Partnership;
- Most properties in town contribute to the problem - not just those along a water body or those proposed for a solution; and
- Everyone in Dennis will benefit from improved water quality.

Questions?

Dennis
preserving our water resources

Sign up to be on the email list: www.bit.ly/DennisWaterResources

Email the Task Force at: cwmtf@town.dennis.ma.us

Read or download past wastewater related planning reports:
https://www.town.dennis.ma.us/wastewater-implementation-committee/pages/reports

Access the DHY Clean Waters Community Partnership Website:
https://www.dhycleanwaters.org/

Wastewater Committee
Frequently Asked Questions (FAQs)

1. *Why all the talk about wastewater?*
    a. *What is the problem?*
        i. In recent years, excessive levels of nutrients, specifically nitrogen and phosphorus, have resulted in eutrophication (i.e. algal blooms) in several of the town's surface water bodies. These events are predominately caused by nitrogen originating from onsite wastewater systems (fully functioning Title 5 septic systems, cesspool systems, etc.) in the areas that contribute groundwater to saltwater estuaries or harbors known as a watershed. Similarly, watersheds that contribute surface water or ground water to ponds can convey too much phosphorus to freshwater ponds. Excessive amounts of these nutrients causes the algal blooms resulting in an unhealthy environment.
    b. *What proof is there that a problem exists?*
        i. In some instances, waters are periodically covered with mats of algae, smell like decaying fish, and therefore do not support the ecology of the Cape. For example, in 2009, an algal bloom occurred in Swan Pond creating aesthetically displeasing waters, fish kills due to depleted oxygen levels in the pond, and an odor that permeated the neighborhood for weeks. Shellfish crops also continue to decline.
    c. *Why is the problem arising now and a bigger issue on Cape Cod than other communities?*
        i. Cape Cod has less than four percent of the Massachusetts population but 20 percent of the septic systems in the state. The rapid population growth on the Cape over the past 50 years has resulted in excessive nutrient loading in surface and groundwater, largely from man-made sources, has migrated to the region's estuaries, particularly those downstream of highly developed or populated areas. Over time, nutrients build up within an estuary as a result of limited flushing.
    d. *If our drinking water is safe, what's the problem?*
        i. Public health-related nitrate thresholds (10 mg/l) are ten times higher than the thresholds established for healthy estuarine ecosystems (typically 0.5 mg/l or lower); therefore, it is common to meet drinking water standards while still greatly exceeding the nitrogen levels in groundwater required to protect the saltwater environment. Fresh water bodies and groundwater supply wells are more resilient to nitrogen impacts than salt water embayments.

ii. The freshwater shorelines are classified as "coastal plain pondshores," which provide habitat to rare and endangered plants and animals.

iii. As water quality declines, the tourist industry will decline as well. Property values and tax revenues in coastal areas will decline, and the burden of maintaining town services will shift inland, to those who can least afford it.

e. What if our town sticks with the status quo and does nothing?

i. We have seen a decline in the quality of our water resources and we cannot ignore this situation any longer. Our quality of life is being impacted. Our tourist economy will be impacted. The cost to address the issues will only increase and should not be left solely to future generations to address. If the town does not initiate this project on its own terms, the project could be forced upon us by regulators, such as the Cape Cod Commission. In this case, local residents will have less say on important issues regarding cost, traffic disruption, the timeline and economic redevelopment.

2. *I thought Title 5 septic systems solved the issue of increased nutrient loading from wastewater on groundwater?*

a. Why don't they?

i. Typically over 85% of the controllable nitrogen comes from water leaching from fully compliant Title 5 septic systems down to the groundwater table, which ultimately surfaces in our streams and estuaries. This type of system was designed to remove solids and bacteria. Title 5 systems only remove about 10 to 15 percent of the nitrogen in waste discharged to them. It is important to understand that effluent leaving a Title 5 septic system on a lot 300 feet or 3 miles from an estuary can still affect the water quality of the receiving estuary. The septic system effluent infiltrates down to the groundwater table where the groundwater then conveys it as it flows toward an estuary before daylighting in the open water body.

b. My septic works fine. Why should I have to pay for another solution?

i. All septic systems contribute to the nitrogen loading in some capacity. It is in the town's interest to retain local control of this future large capital project. The state and federal environmental regulatory authorities are under pressure from a lawsuit to enforce the water quality standards of the federal Clean Water Act. If the town does not initiate this project on its own terms, there is a real possibility that the project will be forced upon us by an outside agency in which case local

residents will have less say on important issues regarding cost, traffic disruption, the timeline and economic redevelopment.

c. *Why don't septic systems impact our drinking water?*
    i. Septic systems are designed such that they are located at an appropriate distance from drinking water sources and convey wastewater away from drinking water sources. Dennis' drinking water supply is well protected through a combination of maximizing land ownership and control within the Zone IIs (the area of an aquifer that contributes water to a well under the most severe pumping conditions) to its wells, maintaining a town Wellhead Protection District, and conducting annual household hazardous waste collection days. Historically, the Dennis Water District has been very proactive by purchasing land to protect the town's drinking water areas. Additionally, as stated above, drinking water threshold values are higher than those values which may impact a healthy estuarine ecosystem.

d. *Does keeping my septic system pumped help? What if I don't have it pumped?*
    i. Performing regular maintenance on your septic system, such as pumping out the solids, is recommended to allow the system to function as intended and help prevent back-ups or solids overflow into the leaching field. Portions of the town are likely to always utilize Title 5 or related on-site systems.

e. *I just installed a new septic system-if everyone knew there was a problem, why didn't I have a better alternative?*
    i. The town is actively working to develop a town wide plan to combat the nitrogen contamination issue. It is likely that homeowners that newly installed Title 5 septic systems will be given a grace period to comply with the selected implementation scenario. The town wide plan is also likely to take 30 plus years to fully implement.

3. *What are the nitrogen levels?*
    a. *Current levels in our watersheds vs. allowable levels*
        i. The table below provides the current attenuated nitrogen load in each of the watersheds within the Town of Dennis compared to the threshold nitrogen load. The threshold load is the amount of a substance that can be assimilated into a natural environmental to maintain the water body's designated uses:

Dennis
preserving our water resources

Wastewater Committee
Frequently Asked Questions (FAQs)

Watershed	Current Attenuated Total Loading (kg/day)	Threshold Total Loading (kg/day)
Bass River	217.8	114.5
Swan pond	43.7	10.7
Herring River	62.8	47.9
Chase Garden Creek	Results pending release of final MEP report	
Sesuit Harbor	Results pending release of final MEP report	

b. *Healthy drinking water*
    i. 2013 Annual Range of nitrate as N found in drinking water supply wells: *Non detect up to 2.07 mg/L* vs. a Maximum Contaminant Level (MCL): *10 mg/L.*
c. *Title 5 septic system output*
    i. Effluent from a Title 5 septic system contributes approximately 6.2 kg of nitrogen/yr/parcel, leaving a nitrogen concentration in the recharged effluent at a concentration of about 35 mg/L.
d. *I/A system output*
    i. Effluent from an advanced innovative and alternative (I/A) wastewater treatment system contributes approximately 3.1 kg of nitrogen/yr/parcel, leaving a nitrogen concentration in the recharged effluent at a concentration of 13 to 19 mg/L.
e. *PRB attenuation*
    i. Permeable reactive barriers (PRBs) will most likely be installed around effluent recharge basins as a polishing step, but could also be used elsewhere in town. Effluent from wastewater collected by sewering and subsequent treatment at a treatment plant combined with a PRB surrounding the effluent recharge basin will contribute approximately 0.2 kg of nitrogen/yr/parcel, leaving a nitrogen concentration in the recharge effluent at a concentration of 1.0 mg/L.
f. *Natural attenuation*
    i. Values of natural nitrogen attenuation vary greatly depending on the media the wastewater travels through, including ponds, streams and marshes. Natural attenuation can account for anywhere between 30 to greater than 50 percent nitrogen attenuation depending on the path the groundwater travels prior to entering the estuaries.
g. *Allowable levels of nitrogen to restore our estuaries are defined above. Is there value in seeking interim values that could be more affordable but only achieve some fraction of the total reduction needed?*

i. The rate at which the estuaries are deteriorating will already take many years to slow down and ultimately reverse the impacts, even if immediate action is taken; therefore is it recommended that the full threshold values be targeted. However, the town wide plan is likely to be implemented in phases within each watershed and the water quality monitored between phases to determine progress in meeting the targeted values.

4. *What solutions to wastewater contamination are being considered for Dennis?*
    a. *What is the role of the Comprehensive Wastewater Management Task Force (CWMTF) and what have they accomplished?*
        i. The CWMTF is a committee of residents whose aim is to address the wastewater contamination concerns within the Town of Dennis. In recognition of the importance of preserving, restoring, and maintaining high-quality water resources, the Town of Dennis' CWMTF has undertaken this Water Quality Evaluation and Mitigation Alternative Study. This project builds on prior work and, in the next phase of study, will culminate in the development of a town-wide plan to guide future decision making as it pertains to water quality initiatives.
    b. *Will decentralized sewer systems help and are there alternatives to sewers?*
        i. Decentralized sewer treatment systems consist of collection, treatment and dispersal of wastewater from individual homes, larger industrial or commercial facilities, clusters of homes or entire communities. These systems can be stand alone or be tied into existing centralized systems and can therefore be seen as an alternative to town wide sewering. On-site I/A systems are also being considered.
    c. *What will happen to sludge from any proposed centralized sewer treatment facility?*
        i. The sludge generated from a centralized wastewater treatment facility will be treated and either beneficially reused or disposed of in an existing approved landfill.
    d. *What are Advanced Innovative and Alternative (I/A) systems. What are the pros and cons of such systems?*
        i. I/A systems are onsite advanced septic systems designed for nutrient reduction. These are more sophisticated than a Title 5 system and must be monitored by a licensed operator.

ii. Pros: I/A systems are more efficient in removing contaminants such as nitrogen and solids from the wastewater over conventional technologies.

iii. Cons: Regulatory hurdles due to the new technology. The Department of Environmental protection (MassDEP) will need to approve the plan for a I/A technology prior to implementation.

e. What is a Permeable Reactive Barrier (PRB)?

i. A PRB is a subsurface permeable barrier, comprised of either inorganic or organic material, chosen to target the reduction of specific contaminates. This material provides a carbon source for denitrification to occur.

f. Why all the talk about oysters?

i. Oysters have the ability to uptake and remove nitrogen from impaired water bodies. On Cape Cod, there are at least three examples where oyster aquaculture demonstration projects have been employed to help restore water quality and remove nitrogen from coastal estuaries. The Town of Dennis is intending to pilot this process and is considering it's use longterm as a polishing step to further remove nitrogen.

5. Do septic systems impair our fresh water bodies?

a. What is the impact of nitrogen on fresh water? What are the impacts of Phosphorous?

ii. Currently, MassDEP does not have a numerical criterion for nitrogen unless the water body is subject to a Total Maximum Daily Load (TMDL) or site-specific criterion; however, discharges that result in excessive aquatic plant or algal growth (eutrophication) need to be controlled. In some highly eutrophic lakes (which have excess phosphorus – more than plants need to grow), nitrogen can become the limiting nutrient for plant productivity. In these cases, an ecological advantage is afforded to certain blue-green algae that have the ability to obtain nitrogen from the atmosphere (called fixing nitrogen) and use this nitrogen as a nutrient source to fuel algal growth. Thus nitrogen limitation in ponds with excess phosphorus concentrations can be a factor in blue-green algal blooms. However, most freshwater ponds on Cape Cod are phosphorus limited.

iii. Similarly, there is no numerical criterion for phosphorous unless the water body is subject to a TMDL or site-specific criterion. Phosphorus is a key nutrient influencing plant growth in ponds. Phosphorus is usually the limiting nutrient to

freshwater ponds here in New England, such that increasing its concentration alone will result in greater plant productivity.

b. *Scargo Lake looks great-is there a problem?*
    i. Conditions of Scargo Lake have worsened and the pond is becoming impaired. The Scargo Lake Memo, written by The Cape Cod Pond and Lake Stewardship (PALS) program, recommends that the town consider hypolimnetic aeration as a remediation measure for Scargo Lake. This entails providing aeration to the bottom layer of the lake during the period of the year when the lake is stratified (May through September). This and other methods will be considered in the town wide water resources program.
c. *How many fresh water bodies do we have?*
    i. The Town of Dennis has approximately 29 ponds with a total area of 749 acres, including three ponds shared with neighboring towns.

6. *What is the Cape Cod Commission 208 plan?*
    a. *What are the plan elements and how are they of value to Dennis?*
        i. The Cape Cod Commission's Area-wide Water Quality Management Plan Update ("the 208 Plan") has been developed to address federal regulatory requirements. The 208 Plan discusses the nitrogen problem Cape-wide and presents a suite of options towns can consider in solving their nitrogen loading issues. The 208 Plan's recommendations are based on meeting the goals outlined in each Massachusetts Estuaries Project (MEP) report. The Cape Cod Commission has designated each Cape Cod town as the Waste Management Agency responsible for meeting the Clean Water Act requirements for water resource protection. 208 refers to the section of the Federal Clean Water Act requiring a regional plan to be developed.
    b. *The 208 plan advocates use of purportedly lower cost I/A systems and consideration of centralized sewer systems as the last approach. Is Dennis following this guidance?*
        i. Yes, to distinguish between proposed scenarios in the Dennis Water Quality Evaluation and Mitigation Alternative Study, a detailed evaluation matrix was developed. Within the matrix, I/A systems were given a higher rating and centralized sewer was given a lower rating value.

7. *What are funding impacts?*
    a. *What are the short and long term cost projections to home owners?*

Wastewater Committee
Frequently Asked Questions (FAQs)

i. Once the final scenario is chosen, projected costs per homeowner will be defined.

b. This is a lot of money. Can the town afford this?

i. This will be an expensive program but it will be implemented over a 30 year period. This is similar to the Dennis Water District public water supply which has already been implemented.

c. Is state, federal or other funding sources possible?

i. CDM Smith prepared a memorandum which includes potential funding sources for consideration today. Typical funding mechanisms for wastewater programs include general taxes, betterments, connection fees, infrastructure investment funds and user fees. In addition, more innovative funding mechanisms must also be considered in the development of a comprehensive funding approach that spreads the financial burden of such a program across all benefactors in an affordable way.

Appendix H

MEPA Certificate and Comments including other agency comments on Draft CWMP/EENF

The Commonwealth of Massachusetts
Executive Office of Energy and Environmental Affairs
100 Cambridge Street, Suite 900
Boston, MA 02114

Charles D. Baker
GOVERNOR

Karyn E. Polito
LIEUTENANT GOVERNOR

Matthew A. Beaton
SECRETARY

Tel: (617) 626-1000
Fax: (617) 626-1081
http://www.mass.gov/eea

July 14, 2017

CERTIFICATE OF THE SECRETARY OF ENERGY AND ENVIRONMENTAL AFFAIRS
ON THE
EXPANDED ENVIRONMENTAL NOTIFICATION FORM

PROJECT NAME	: Comprehensive Wastewater Management Plan
PROJECT MUNICIPALITY	: Dennis
PROJECT WATERSHED	: Cape Cod
EEA NUMBER	: 15707
PROJECT PROPONENT	: Town of Dennis
DATE NOTICED IN MONITOR	: June 7, 2017

Pursuant to the Massachusetts Environmental Policy Act (MEPA; M.G. L. c. 30, ss. 61-62I) and Section 11.06 of the MEPA regulations (301 CMR 11.00), I have reviewed the Expanded Environmental Notification Form (EENF) and hereby determine that this project **requires** the submission of an Environmental Impact Report (EIR). The EENF was submitted to support the Proponent's request to file a Single EIR, rather than a Draft and Final EIR, pursuant to Section 11.06(8) of the MEPA regulations. The Proponent should submit a Single EIR in accordance with the Scope included in this Certificate.

Project Background

The EENF/Comprehensive Wastewater Management Plan (CWMP) described the Town of Dennis's plan to address water quality management concerns resulting from population growth and increased development. It included a comprehensive review of existing water quality in the town's coastal waters, freshwater ponds, and groundwater sources of drinking water. The analysis in the CWMP focused on water quality impacts and management options related to nitrogen. Nitrogen has become the focus of water management on Cape Cod through the data and analysis prepared by the Massachusetts Estuaries Project (MEP) conducted by the Massachusetts Department of Environmental Protection (MassDEP), the establishment of Total

Maximum Daily Loads (TMDL) by MassDEP and the Environmental Protection Agency (EPA), and the Cape Cod Commission's (CCC) Area-Wide Water Quality Management Plan ("208 Plan"). The MEP established nitrogen removal requirements of 47.4 percent in the Bass River watershed, 75.5 percent in the Swan Pond River watershed, and 23.6 percent in the Herring River watershed.

The CWMP documented that wastewater discharges from septic systems are the most significant source of nitrogen. It outlined a long-term, multi-phase approach to reducing nitrogen by managing wastewater through a variety of traditional means, such as sewering and wastewater treatment, and non-traditional methods including the control of fertilizer use and stormwater, public education, land use and open space changes, potential implementation of innovative and alternative (I/A) technologies, permeable reactive barriers (PRB) and aquaculture. The CWMP consists of the following components to meet the Town's long-term water quality goals and TMDL limits:

- A wastewater treatment facility (WWTF) with a capacity of 1.7 million gallons per day (mgd), two effluent recharge areas with PRB, a wastewater collection system consisting of 92 miles of new sewer mains and 21 pump stations;
- Public education regarding wastewater management and the appropriate use of fertilizers;
- Water conservation and inflow prevention to reduce the volume of wastewater;
- Implementation of stormwater Best Management Practices (BMPs), including deep sump catch basins, infiltration and retention systems, porous pavement, and catch basin cleaning, upstream of sensitive water sources to reduce pollutants from runoff;
- Monitoring and protection of water quality in freshwater ponds;
- Establishment of an Innovative and Alternative Technologies Committee to continue to explore the feasibility of new technologies;
- Land use controls, such as increasing the minimum lot size through zoning and acquisition of public open space;
- Maintain and potentially expand boat pump-out services managed by the Dennis Harbormaster; and
- Initiate a pilot oyster aquaculture program in Swan Pond to determine whether a healthy oyster population can be supported that results in water quality improvements.

In addition, the widening of the Route 6 Bridge currently being undertaken by MassDOT as part of its extension of the Cape Cod Rail Trail and the proposed widening of Route 6 over the Bass River are expected to relieve flow restrictions and improve water quality by increasing tidal flushing.

A key component of the CWMP is an Adaptive Management Plan (AMP) that will include the reassessment and adjustment of the CWMP as phases of the plan are implemented. The AMP will be informed by the findings of a Wastewater Implementation Committee (WIC) that will monitor the progress of the CWMP, the results of on-going water quality monitoring in the Bass River, Swan Pond, Sesuit Harbor, Herring River and Chase Garden Creek watersheds, MassDEP's eelgrass mapping, WWTF water quality reports, and population growth data. The AMP will assist the Town in evaluating its progress in attaining water quality goals, including

compliance with the TMDLs, and adjusting the design or phasing of structural and non-structural components of the CWMP.

The Preferred Alternative identified in the CWMP will be implemented in eight phases:

- Phase 1: Construct the WWTF and one of the effluent recharge areas with PRB, install a "spine" of sewer mains from the WWTF to commercial districts along Route 28 on the western side of town, add sewer mains to residential areas adjacent to Bass River and East-West Dennis Road;
- Phase 2: Install sewer mains in areas adjacent to the WWTF and north and west of Swan Pond;
- Phase 3: Install sewer mains to the southeast coastal planning districts and in Dennis Port;
- Phase 4: Expand the WWTF and construct the second effluent recharge area with PRB and install sewer mains in areas adjacent to Route 6;
- Phase 5: Install sewer mains in the area south of Swan Pond;
- Phase 6: Install sewer mains north of Route 6 and west of Old Bass River Road;
- Phase 7: Install sewer mains northwest of Route 6 adjacent to Follins Pond; and
- Phase 8 Install sewer mains north of the second effluent recharge site.

Non-structural components of the CWMP, including aquaculture, stormwater management, and education programs will commence in Phase 1 and continue through all project phases. The phases will be implemented in five-year intervals over 40 years.

Project Site

The Town of Dennis is located in the central section of Cape Cod and has shorelines on both Cape Cod Bay and Nantucket Sound. In 2010, the year-round population of Dennis was 14,207 residents which increased to 63,000 residents in the summer. The Town-wide average daily wastewater flow is 2,694,899 gpd, which fluctuates between an average low of 1,183,665 gpd in the winter and average high of 5,407,084 gpd in the summer. The town does not have a wastewater collection system or municipal treatment facility and wastewater flow is currently directed primarily to septic systems on each lot.

The town is divided into six watersheds: Bass River, Chase Garden Creek, Herring River, Quivett Creek, Sesuit Harbor, and Swan Pond River. In addition, several areas along the town's northern and southern coasts directly discharge into Cape Cod Bay and Nantucket Sound, respectively.

The Federal Emergency Management Agency (FEMA) prepared a series of Flood Insurance Rate Maps (FIRM), effective July 16, 2014, that depict flood zones across the town. Coastal Flood Zones with Velocity Hazard (VE zone) are located along the Town's northern and southern coasts and the 100-year flood plain extends landward from the coasts with varying Base Flood Elevations (BFE).

Permitting and Jurisdiction

The project is undergoing MEPA review and is subject to preparation of a mandatory EIR pursuant to 301 CMR 11.03(3)(a)(1)(b) and 301 CMR 11.03(5)(a)(3) of the MEPA regulations because it requires State Agency Actions and involves the alteration of ten or more acres of LSCSF and BLSF and the construction of one or more new sewer mains of ten or more miles in length, respectively. The project also exceeds the ENF threshold at 301 CMR 11.03(5)(b)(1) because it involves the construction of a new wastewater treatment and/or disposal facility with a capacity of 100,000 gpd or more. It requires a Groundwater Discharge Permit from MassDEP and Construction Access Permits from MassDOT and/or DCR. The project may require a Conservation and Management Permit (CMP) from the Division of Fisheries & Wildlife's NHESP. It is subject to review under the May 2010 MEPA Greenhouse Gas (GHG) Emissions Policy and Protocol ("the Policy").

The project will require an Order of Conditions (OC) from the Dennis Conservation Commission (or in the case of an appeal, a Superseding Order of Conditions (SOC) from MassDEP). It may require review by the Massachusetts Historical Commission (MHC) under Section 106 of the National Historic Preservation Act of 1966 and M.G.L. Chapter 9, sections 26-27C (950 CMR 70-71).

The Town will receive Financial Assistance from the Commonwealth through the State Revolving Fund (SRF). Therefore, MEPA jurisdiction is broad and extends to all aspects of the project that are likely, directly or indirectly, to cause Damage to the Environment, as defined in the MEPA regulations.

Environmental Impacts

As described in the EENF, implementation of the CWMP Recommended Plan will add six acres of impervious area and impact 508,290 sf (11.7 acres) of Land Subject to Coastal Storm Flowage (LSCSF) and 25,710 sf (0.6 acres) of Bordering Land Subject to Flooding (BLSF). The pilot aquaculture project may impact up to one-half acre of Land Under Salt Ponds.

The project is intended to improve aquatic health and water quality by providing more effective wastewater treatment. Measures to avoid minimize, and mitigate project impacts include the use of erosion and sediment control measures during construction, limiting areas of disturbance by locating work within previously disturbed areas where possible, and designing the system to limit extraneous infiltration and inflow (I/I). Additional mitigation commitments should be identified in the Single EIR.

Single EIR Request

The Town requested that it be allowed to file a Single EIR in lieu of a Draft and Final EIR. The MEPA regulations indicate a Single EIR may be allowed, provided I find that the EENF:

a) describes and analyzes all aspects of the project and all feasible alternatives, regardless of any jurisdictional or other limitation that may apply to the Scope;

b) provides a detailed baseline in relation to which potential environmental impacts and mitigation measures can be assessed; and,

c) demonstrates that the planning and design of the Project use all feasible means to avoid potential environmental impacts.

The Proponent submitted an EENF to satisfy the requirements for a Single EIR and, as required, the EENF was subject to an extended comment period. It provided a detailed project description, a baseline for evaluating environmental impacts and a comprehensive alternatives analysis. The EENF identified how the project is designed to achieve consistency with regulatory standards, including water quality standards and measures to avoid, minimize and mitigate project impacts. Comments from MassDEP, the Massachusetts Office of Coastal Zone Management (CZM) and the Cape Cod Commission (CCC) identify issues that can be addressed in a Single EIR.

Conclusion

Based on review of the EENF, consultation with State Agencies and review of comment letters, I have determined that the Proponent may submit a Single EIR. The Single EIR should be prepared in accordance with the following Scope.

SCOPE

General

The Single EIR/CWMP should follow Section 11.07 of the MEPA regulations for outline and content, as modified by this Scope. The Single EIR should identify and describe any changes to the project since the filing of the EENF and provide an update on State, local and federal permitting.

Project Description

The Single EIR should include an executive summary, it should identify significant environmental benefits and impacts, and measures that will be taken to avoid, minimize and mitigate adverse impacts. The Single EIR should describe the planning process that has occurred to date, and the proposed schedule for the remaining phases of planning, design, environmental permitting and review, and construction. Detailed information should be provided for each area where construction is proposed, including maps that show where sewer lines, cross-country easements, pumping stations, and other facilities will be located.

The Single EIR should discuss the state permitting process for this project and describe how it will meet all applicable performance standards. I encourage early coordination with MassDEP during preparation of the Single EIR/CWMP as requested in the agency's comments.

Growth Management

Executive Order #385 requires that State and local agencies engage in protective and coordinated planning oriented towards resource protection and sustainable economic development. For reasons of both environmental protection and fiscal prudence, investments in public infrastructure should be carefully targeted toward those areas for which clear existing needs have been established and for areas where denser development is appropriate, thereby relieving development pressures on open space, agricultural lands, and other valuable natural resources.

The Single EIR should identify parcels located within the proposed sewer service areas that are undeveloped or that have development constraints due to the lack of sewers, and compare the potential secondary growth impacts that may be induced by public sewers with local and regional growth management policies and zoning. It should examine what regulatory or physical constraints would remain on home expansions after sewers are constructed, and whether such expansions might have unanticipated impacts on estimated wastewater flows and water use.

CWMP

The CWMP provided a summary of wastewater planning that has occurred to date, described existing conditions and land uses in the project area, identified future needs, and evaluated system alternatives to meet identified wastewater treatment demand and water quality objectives. The Single EIR should address the comments of MassDEP, CZM and the CCC and incorporate the requested data and analysis.

Needs Assessment

The CWMP included an updated needs assessment that identified Areas of Concern (AOC). The Town completed a needs assessment in 2005 that was based on the presence of Zone II water supply protection zones, soil characteristics, density of lots, high groundwater, location within flood zones, septic system failures, shellfish closure areas, industrial land uses and filled wetlands. The needs assessment presented in the CWMP was based on updated data related to the original criteria and new information on I/A septic systems, rare species habitat, and areas with established TMDLs. The needs assessment also considered the absence of infrastructure in areas targeted for economic and residential development, including five economic Growth Districts, seasonal cottages and additional affordable housing units. The CWMP identified fifteen AOC, which were further designated as primary, secondary, tertiary, and newly designated areas. The primary areas include: Dennis Port (Swan Pond River watershed); Dennis Port Shore (partially in Swan Pond River watershed); Follins Pond (Bass River watershed); Swan Pond (Swan Pond River watershed); Trotting Park (partially in the Swan Pond River watershed); and West Dennis (Bass River watershed). Secondary areas include Route 6A East (Sesuit Harbor watershed); Route 6A west (Chase Garden Creek watershed); and Taunton Avenue (direct discharge to Cape Cod Bay). The tertiary AOCs include Dennis North Shore

(direct discharge to Cape Cod Bay); Hokum Rock Commercial (Sesuit Harbor); South Dennis Industrial (Swan Pond River and Bass River watersheds); and District of Critical Planning Concern (direct discharge to Cape Cod Bay). The newly designated AOCs are Route 134 North (Bass River watershed) and Shore Road (Chase Garden Creek watershed).

As detailed below, the Single EIR should include analysis of an additional alternative consisting of a sewer/treatment-only scenario with effluent recharge outside nitrogen-sensitive watersheds within Dennis and in neighboring communities as part of a regional wastewater system.

Alternatives Analysis

The CWMP developed 14 water quality management scenarios to meet nitrogen removal goals identified in the needs assessment and the MEP studies. The scenarios reflect a broad array of options, including combinations of sewering, treatment facilities (including regional treatment facilities), effluent recharge sites, discharge of treated wastewater outside the watershed, and various levels of non-structural components such as I/A septic systems, permeable reactive barriers (PRB), and aquaculture. The 14 scenarios were intended to provide a screening-level analysis from which a subset would be selected, refined, and further analyzed. In the initial 14 scenarios, all of the infrastructure would have been located within the Town of Dennis. The Town determined that five of these scenarios warranted further analysis. Three additional scenarios were developed to evaluate regional wastewater alternatives.

The following eight scenarios were selected for further analysis:

- Scenario 3B: Includes I/A systems on parcels over one acre in size, sewering parcels of smaller size in high-density neighborhoods, two treatment facilities and two effluent recharge sites with PRBs;
- Scenario 5A: Includes sewering parcels in the Bass River and Swan Pond River watersheds, one treatment facility, two effluent recharge sites without PRBs, and aquaculture in the Bass River and Swan Pond River watersheds;
- Scenario 5B: This option is the same as Scenario 5A but would include two treatment facilities and two effluent recharge sites;
- Scenario 6A: Includes sewering in the Bass River and Swan Pond River watersheds, additional sewering on the southern part of the Town including the southern coast, one treatment facility, two effluent recharge sites with PRB, and aquaculture in the Swan Pond watershed;
- Scenario 6B: This option is the same as Scenario 6A but would include two treatment facilities and two effluent recharge sites;
- Scenario 8A: This option is a variation of Scenario 6A except that the treatment facility would be located in Yarmouth and serve both towns, with effluent recharge in each community;
- Scenario 8B: This option is a variation of Scenario 6A except that the treatment facility would be located in Dennis but shared with Harwich, with effluent recharge in each community; and,

- Scenario 8C: This option is a variation of Scenario 6A, but the treatment facility would be located in Dennis but shared with Yarmouth and Harwich, with effluent recharge in each of the three communities.

The alternatives were evaluated and compared on the basis of cost, design requirements and reliability of technology, construction impacts, and implementation concerns, such as the ability to permit the projects and public acceptance. Three effluent recharge sites were evaluated based on initial hydrogeological modelling. Two sites were selected to be incorporated into the Preferred Alternative: Site 1 is located adjacent to the proposed WWTF off of Theophilis Smith Road in the Swan Pond River watershed and Site 2 is located on Bob Crowell Road in the Bass River watershed. The Town selected Scenario 6A as the Preferred Alternative because it will collect wastewater from a sufficient number of developed parcels in the Swan Pond River and Bass River watersheds to meet nitrogen removal requirements and provide sewer infrastructure to economic growth districts. It will meet MEP and TMDL nitrogen reduction thresholds, includes effluent recharge in both the Bass River and Swan Pond River watersheds and can be phased in a manner that provides implementation flexibility. The Preferred Alternative could potentially be expanded to serve additional AOCs and collect wastewater from the neighboring communities of Yarmouth and Harwich.

Preferred Alternative

The Preferred Alternative has been designed to treat an average daily flow of 1.7 million gallons expected from the areas to be sewered. It will be capable of operating under seasonal flow conditions, which are expected to range from 0.74 million gpd in the winter to 3.43 million gpd in the summer. The collection system will use gravity sewers to the extent possible, but pump stations, low pressure sewers and vacuum sewers will be required for some areas. The WWTF will use the sequencing batch reactor (SBR) process, which will effectively remove nitrogen and has a great deal of flexibility for future expansion. The facility could add more SBRs or add membranes downstream of the SBRs to function as a hybrid SBR/Membrane Bioreactor (MBR) facility capable of even greater nitrogen removal. The WWTF will be constructed initially to handle flows from Phases 1 through 3 and will be expanded as part of Phase 4 to add capacity for the remaining phases.

The WWTF effluent will achieve the 3 milligrams per liter (mg/l) limit identified in the MEP reports. Effluent recharge Site 1 will have the capacity to recharge an average annual flow of 1.05 mgd to the Swan Pond River watershed and Site 2 will recharge the remainder of the flow into the Bass River watershed. According to the EENF, the use of PRBs will reduce this concentration to 1.0 mg/l. The Single EIR should confirm that 1.0 mg/l is an achievable treatment level. MassDEP and CZM note that the calculations regarding nitrogen loading to the Swan Pond River and Bass River watersheds may be incorrect. The Single EIR should provide revised calculations and summarize any changes to nitrogen treatment and loading levels. As recommended by MassDEP, the Single EIR should evaluate the potential for disposing of effluent outside of the Swan Pond River watershed using drip irrigation in open spaces areas such as golf courses.

The Preferred Alternative relies on a 25 percent nitrogen removal credit for the non-structural components of the CWMP, including aquaculture, land use controls and open space

acquisition, and stormwater management and fertilizer use reduction programs. As noted by CCC, Dennis is preempted by state law from adopting a fertilizer use by-law. The Single EIR should provide additional information on how the Town will administer the fertilizer and stormwater management programs to the extent necessary to achieve reduction goals. It should provide more detail about the monitoring program including the general approach to be used, how it will be implemented, monitoring locations, and water quality parameters to be measured. It should address how the monitoring program will be designed to evaluate the effectiveness of non-structural treatment options. The Single EIR should identify the process the Town will use to identify open space parcels for acquisition and its efforts to implement the necessary land use controls.

The CWMP relies on non-traditional nitrogen reduction measures that must be implemented successfully in order to achieve the necessary nitrogen removal. The Single EIR should develop a contingency alternative to achieve required nitrogen levels without relying on non-traditional methods. It should be based on sewering and treatment only with effluent recharge areas outside of nitrogen-sensitive areas such as the Swan Pond River watershed. As noted by CCC, a third effluent recharge area identified in the CWMP has limited capacity; the Single EIR should identify other potential recharge sites. A regional wastewater facility should also be reviewed in detail in the Single EIR. The regional scenarios studied in the CWMP were the most cost-effective and efficient nitrogen-removal solutions and are encouraged by MassDEP and CCC. A regional solution would also expand the number of potential recharge areas outside of nitrogen-sensitive areas.

Wetlands

According to the EENF, the project will impact 508,290 sf (11.7 acres) of LSCSF and 25,710 sf (0.6 acres) of BLSF. The project qualifies as a limited project pursuant to 310 CMR 10.53(3)(d) for the construction of underground public utilities (sewer lines). Construction of wastewater treatment plants and related structures is exempt from the requirements for Riverfront Area pursuant to 310 CMR 10.58(6)(h). According to the EENF, the majority of work within these areas will occur within paved right-of-way, will be temporary in nature, and will be restored to original conditions following completion of construction. The Single EIR should identify areas of impacts to wetland resource areas and describe mitigation measures. It should address the project's compliance with appropriate standards of the Wetlands Regulations (310 CMR 10.00).

Rare Species

According to the EENF, Effluent Recharge site 1 is located within the Priority Habitat for the Plymouth Gentian (*Sabatia kennedyana*) and the Long-Beaked Bald-Sedge (*Rhynchospora scirpoides*) and within Priority Habitat and Estimated Habitat for the Eastern Box Turtle (*Terrapene carolina*). All three species are designated as species of Special Concern under the Massachusetts Endangered Species Act (MESA). NHESP notes that rare species habitat is located throughout Dennis and any changes to the Preferred Alternative or adoption of other measures studied in the CWMP may also be subject to review by NHESP. Portions of roadways that would be sewered in the Preferred Alternative appear to be located within rare species

habitat, but sewer systems within 10 feet of the edge of existing paved roads may be exempt from MESA review. The Single EIR should report on its consultation with NHESP, identify any impacts to rare species habitat and propose mitigation measures. The Town should continue to consult with NHESP as the design of the Preferred Alternative is finalized.

Climate Change

Executive Order 569: Establishing an Integrated Climate Change Strategy for the Commonwealth (EO 569) was issued on September 16, 2016. EO 569 recognizes the serious threat presented by climate change and directs agencies within the administration to develop and implement an integrated strategy that leverages state resources to combat climate change and prepare for its impacts. The Order seeks to ensure that Massachusetts will meet GHG emissions reduction limits established under the Global Warming Solution Act of 2008 (GWSA) and will work to prepare state government and cities and towns for the impacts of climate change.

The GHG Policy and requirements to analyze the effects of climate change through EIR review is an important part of this statewide strategy. These analyses advance proponents' understanding of a project's contribution and vulnerability to climate change. I strongly encourage the Proponent to consider complementary approaches – such as incorporation of renewables and inclusion of low impact development in site design - which can improve the project's resiliency, reduce GHG emissions and conserve and sustainably employ the natural resources of the Commonwealth.

Adaptation and Resiliency

The Single EIR should include a chapter that addresses the capacity of the wastewater collection and treatment systems under projected levels of precipitation and sea level conditions and the resiliency of the system to the effects of climate change. Components of the wastewater collection infrastructure appear to be located within coastal AE and VE flood zones. CZM recommends that the Town consider alternative locations for the infrastructure proposed to be sited in these locations, or to otherwise implement climate change adaptation measures to protect the pump station. The Single EIR should review alternative locations for system components, such as pump stations, including locations outside the floodplain. It should identify design features that could increase the resiliency of the proposed infrastructure under future sea level conditions. Prior to preparing this analysis, the Town should consult with the MEPA office regarding precipitation data that will be used.

Greenhouse Gas Emissions

This project is subject to review under the May 5, 2010 MEPA GHG Policy. The Policy requires Proponents to quantify carbon dioxide (CO_2) emissions and identify measures to avoid, minimize or mitigate such emissions. The analysis should quantify the direct and indirect CO_2 emissions of the project's energy use. Direct emissions include on-site stationary sources, which typically emit GHGs by burning fossil fuel for heat, hot water, steam and other processes. Indirect emissions result from the consumption of energy, such as electricity, that is generated off-site by burning of fossil fuels, and from emissions from vehicles used by employees, vendors, customers and others. The Policy directs proponents to use applicable building codes to

establish a project emissions baseline that is "code-compliant." However, there is no building energy code equivalent that applies specifically to WWTFs or energy use models (such as eQUEST) designed to estimate the projected energy use of the WWTF processing energy loads.

The EENF included a commitment to design the WWTF to use high-efficiency motors that are optimized for the expected wastewater flows as an energy conservation measure. It did not include a GHG analysis because the design of the WWTF is in a preliminary stage and has not been finalized. During the review period, the Town submitted a proposed method for evaluating energy-efficiency alternatives for the WWTF. The proposed method would use the EPA's Energy Star Portfolio Manager (ESPM) computer modeling program to compare the energy use of the planned wastewater treatment technologies to the energy use of a baseline treatment facility achieving an ESPM Energy Performance Rank of 50, which reflects the average energy use of a comparable wastewater facility. This method has previously been used in MEPA filings (e.g. the Harwich CWMP, EEA# 15022).

In place of the ESPM, the Single EIR should include a more project-specific GHG evaluation of emissions from the WWTF and pump stations. It should establish a Base Case and an as-proposed Preferred Alternative Case along with providing the other information required by the Policy. Both the projected energy consumption and related GHG emission should be quantified for both cases. Design assumptions for the base case should be based on a typical WWTF and pump station design that meets the requirements of TR-16, *Guides for the Design of Wastewater Treatment Works*, 2016 Edition, which is commonly used as a guide for wastewater facility design in Massachusetts. The as-proposed Preferred Alternative design should include features and measures that would result in a significant reduction from the Base Case in both the consumption of grid electricity and the related GHG emissions. Measures that should be evaluated include: increasing piping sizes to reduce friction loss; use of premium efficiency pumps and motors; and use of variable frequency pump drives (VFD).

The Town should consult MassDEP's "Energy Efficiency and Renewable Energy Opportunities at Water and Wastewater Facilities" webpage[1], the Water Environment Research Foundation's *Utilities of the Future Energy Findings*[2] report published in 2014, the EPA's *Evaluation of Energy Conservation Measures for Wastewater Facilities*[3] (2010), the *Water and Wastewater Energy Management Best Practices Handbook*[4] (2010) prepared by the New York State Energy Research and Development Authority, and other resources to identify energy efficiency practices at WWTFs. For key components and systems of the WWTF, the Single EIR should review energy-efficient alternatives identified in the reports cited above and indicate whether the Town will adopt the measure or not, and provide a rationale for the decision. recommend that the Town consult with MEPA staff before completing this analysis.

[1] http://www.mass.gov/eea/agencies/massdep/climate-energy/energy/water-utilities/energy-efficiency-at-water-and-wastewater-facilities.html

[2] Available online at https://www.werf.org/a/ka/Search/ResearchProfile.aspx?ReportId=ENER6C13

[3] Available online at https://nepis.epa.gov/Exe/ZyPDF.cgi/P1008SBM.PDF?Dockey=P1008SBM.PDF

[4] Available online at https://www.nyserda.ny.gov/-/media/Files/Programs/Clean-Energy-Communities/NYSERDA-Water-Wastewater-Energy-Management-Best-Practices-Handbook.pdf

The Single EIR should review opportunities for on-site energy generation, including biogas and solar photovoltaic (PV) systems. The Greater Lawrence Sanitary District has set a net zero energy goal that includes the use of biogas produced at the facility as fuel for a combined heat and power (CHP) plant. The Single EIR should review the feasibility of using similar technology to generate energy. The site of the proposed WWTF is adjacent to the Town's 6 Megawatt (MW) solar PV facility. The EENF indicated that the WWTF is not likely to be powered by the PV facility but may be funded in part by proceeds from the sale of solar power. The Single EIR should include an evaluation of adding capacity to the existing PV facility and/or adding rooftop or ground-mounted solar PV to provide power for the WWTF.

Cultural Resources

MHC will review the project under its federal and state review authorities. According to MHC, the Town must conduct an archaeological reconnaissance survey to develop an archaeological sensitivity assessment for the project. Additional archaeological testing may be required to locate and identify archaeological resources that could be impacted by the project prior to construction of each phase and to identify measures to minimize and mitigate impacts to cultural resources. MHC also recommends that the Town consult with the Dennis Historical Commission and/or Dennis Historic District Commission with respect to construction of new above-ground structures in historic districts.

Construction Impacts

The EENF indicated that the project will require Construction Access Permits from MassDOT and/or DCR to address work within State-controlled roadways and properties. The Town should consult with MassDOT and DCR to confirm what elements of the project will require approval. The DEIR should identify areas subject to MassDOT and/or DCR review, describe potential project impacts in those areas, and identify mitigation measures.

Construction period impacts and mitigation measures should be described in the Single EIR, including impacts from noise and dust, impacts on trees and other vegetation, and traffic impacts. Measures that will be taken to minimize and mitigate construction period impacts (in particular impacts on sensitive receptors or exceptional resources) should be detailed.

While much of the project will occur within existing roadways, it will increase impervious area by approximately six acres due to construction of the WWTF and other system components. The Single EIR should describe impervious areas to be created by the project and review alternatives for minimizing new impervious surfaces. The Single EIR should identify sedimentation and erosion control measures to be used during construction. A Stormwater Pollution Prevention Plan will be developed for the project in accordance with MassDEP's Stormwater Management Standards. The Single EIR should describe any stormwater BMPs to be constructed to offset new impervious area.

The Town must comply with MassDEP's Solid Waste and Air Quality Control regulations, pursuant to M.G.L. Chapter 40, Section 54, during construction. Erosion and sedimentation controls should be implemented and maintained in accordance with the

Stormwater Pollution Prevention Plan prepared in accordance with the NPDES Construction General Permit requirements. Response actions on the project site should continue to be conducted pursuant to the MCP (310 CMR 40.0000). The Town must require contractors to participate in the MassDEP Diesel Retrofit Program in conjunction with receiving SRF funding. Construction equipment must also use Ultra Low Sulfur Diesel (ULSD) fuels.

Mitigation Measures/Section 61 Findings

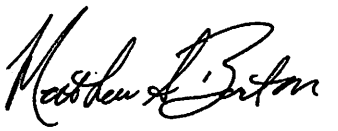
The Single EIR should include a summary of all mitigation measures to which the Town has committed that includes a schedule, estimated costs, and persons/agencies responsible for implementing the mitigation. It should also include draft Section 61 Findings for use by state permitting agencies.

Response to Comments

In order to ensure that the issues raised by commenters are addressed, the Single EIR should include a response to comments. This directive is not intended to and shall not be construed to enlarge the scope of the Single EIR beyond what has been expressly identified in the Certificate. The Single EIR should include a copy of this Certificate and of each comment received.

Circulation

The Single EIR should be circulated in compliance with Section 11.16 of the MEPA regulations and copies should also be sent to the list of "comments received" below and to Norton. A copy of the Single EIR should be made available for public review at the Dennis Public Library.



July 14, 2017
Date

Matthew A. Beaton

Comments received:

06/30/2017	Massachusetts Department of Transportation (MassDOT)
07/06/2017	Massachusetts Office of Coastal Zone Management (CZM)
07/06/2017	Massachusetts Historical Commission (MHC)
07/06/2017	Division of Marine Fisheries (DMF)
07/07/2017	Natural Heritage and Endangered Species Program (NHESP)
07/07/2017	Massachusetts Department of Environmental Protection – Southeast Regional Office (MassDEP– SERO)
07/07/2017	Cape Cod Commission (CCC)
07/07/2017	Department of Conservation and Recreation (DCR)

MAB/AJS/ajs

Charles D. Baker, Governor
Karyn E. Polito, Lieutenant Governor
Stephanie Pollack, MassDOT Secretary & CEO

massDOT
Massachusetts Department of Transportation

June 30, 2017

Matthew Beaton, Secretary
Executive Office of Energy and Environmental Affairs
100 Cambridge Street, Suite 900
Boston, MA 02114-2150

RE: Dennis: Draft Comprehensive Wastewater Management Plan – EENF
(EEA #15707)

ATTN: MEPA Unit
Alex Strysky

Dear Secretary Beaton:

On behalf of the Massachusetts Department of Transportation, I am submitting comments regarding the Draft Comprehensive Wastewater Management Plan in Dennis, as prepared by the Office of Transportation Planning. If you have any questions regarding these comments, please contact J. Lionel Lucien, P.E., Manager of the Public/Private Development Unit, at (857) 368-8862.

Sincerely,

David J. Mohler
Executive Director
Office of Transportation Planning

DJM/jll

Ten Park Plaza, Suite 4150, Boston, MA 02116
Tel: 857-368-4636, TTY: 857-368-0655
www.mass.gov/massdot

cc: Jonathan Gulliver, Acting Administrator, Highway Division
Patricia Leavenworth, P.E., Chief Engineer, Highway Division
Mary-Joe Perry, District 5 Highway Director
Neil Boudreau, State Traffic Engineer
Town of Dennis, Planning Department
Cape Cod Regional Transit Authority (CCRTA)
PPDU Files

Charles D. Baker, Governor
Karyn E. Polito, Lieutenant Governor
Stephanie Pollack, MassDOT Secretary & CEO

massDOT
Massachusetts Department of Transportation

MEMORANDUM

TO: David J. Mohler, Executive Director
Office of Transportation Planning

FROM: J. Lionel Lucien, P.E., Manager
Public/Private Development Unit

DATE: June 30, 2017

RE: Dennis: Draft Comprehensive Wastewater Management Plan – EENF
(EEA #15707)

The Public/Private Development Unit (PPDU) has reviewed the Expanded Environmental Notification Form (EENF) for the Draft Comprehensive Wastewater Management Plan in Dennis. The plan involves work around the community to install 92 miles of sewer pipes, 21 pumping stations, and one centralized treatment facility. Each of these components will be phased over 40 years.

The collection system (sewer main) will include Route 28, a state-owned highway, and therefore will require an Access Permit from MassDOT. Appendix C of the draft plan contains a letter to MassDOT requesting the widening of the Route 6 eastbound and westbound bridges, and the rail bridge over the Bass River, in order to remove flow restrictions and restore the water quality of the river. This effort will also require a MassDOT Access Permit. The widening of the rail bridge is currently incorporated in the Dennis-Yarmouth Cape Cod Rail Trail extension project advertised in 2014.

MassDOT recommends that no further environmental review be required based on transportation issues. The details of the above and any other access-related issues can be addressed during the permitting process for the project. If you have any questions regarding these comments, please contact me at (857) 368-8862 or Michael Clark at (857) 368-8867.

Ten Park Plaza, Suite 4150, Boston, MA 02116
Tel: 857-368-4636, TTY: 857-368-0655
www.mass.gov/massdot

THE COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF ENERGY AND ENVIRONMENTAL AFFAIRS
OFFICE OF COASTAL ZONE MANAGEMENT
251 Causeway Street, Suite 800, Boston, MA 02114-2136
(617) 626-1200 FAX: (617) 626-1240

MEMORANDUM

TO: Matthew Beaton, Secretary, EEA
ATTN: Alex Strysky, MEPA Unit
FROM: Bruce Carlisle, Director, CZM
DATE: July 6, 2017
RE: EEA 15707, EENF, Draft CWMP, Dennis

The Massachusetts Office of Coastal Zone Management (CZM) has completed its review of the above-referenced Expanded Environmental Notification Form (EENF) noticed in the *Environmental Monitor* dated June 7, 2017, and offers the following comments for the development of the final Comprehensive Wastewater Management Plan (CWMP).

Project Description

The EENF presents the preferred alternatives for the draft Comprehensive Wastewater Management Plan (CWMP) for the Town of Dennis. The Town's recommended course of action is to sewer priority areas in eight phases over 40 years (five years per phase), build a wastewater treatment facility, and investigate the utility of three alternative strategies to manage nitrogen in groundwater. The preferred alternative is a mix of pressure, vacuum, and gravity sewer lines with several pump stations, six of which are proposed along Old Wharf Road, in the coastal flood plain. The Town of Dennis is in discussions with the Towns of Yarmouth and Harwich to potentially form a regional wastewater facility in Dennis.

The Town has a grant from the U.S. Environmental Protection Agency to investigate the utility of a permeable reactive barrier (PRB) to denitrify groundwater nitrogen near Mayfair Road in the Bass River watershed. The Town is also proposing to install a PRB around the future site of the treated wastewater infiltration basins as a "final polishing step." As another alternative nitrogen remediation strategy, the Town is also proposing to install a half acre of floating oyster cages into the 150- acre Swan Pond to help remediate nitrogen pollution. Another alternative nitrogen remediation strategy that is currently underway is the widening of the Bass River at the site of the rail bed where the Cape Cod Rail Trail is being extended. In addition, the Town has written a letter to the Massachusetts Department of Transportation requesting the widening of the Route 6 bridges over the Bass River, just upstream of the Rail Trail location.

Project Comments

Alternative Nitrogen Attenuation Strategies & Nitrogen Loading

CZM supports the Town's investigations into alternative nitrogen attenuation strategies in the implementation of its Comprehensive Wastewater Management Plan. Studies and plans to reduce flow restrictions along the Bass River at the old railroad bridge and at Route 6 should include theinvestigation of both the local near field effects of improved flushing, as well as potential far field effects, looking at the fate of the nitrogen that would move downstream into the Bass River estuary and Nantucket Sound. CZM supports the PRB studies and evaluations and looks forward to seeing

the results of the pilot testing. Regarding the installation of oysters in Swan Pond, CZM suggests that the Town work closely with the Division of Marine Fisheries on how best to evaluate the feasibility of oyster-based nitrogen remediation, assess public health concerns, and examine long-term costs and benefits. For all of these alternatives, CZM recommends that baseline monitoring for evaluating the efficacy of alternatives should be targeted for at least three years, and across several seasons and depths, in order to account for temporal and spatial variability.

The draft CWMP references a 1 mg/l assumed nitrogen concentration, which is well below the current level of technology. We request that in the EIR, the Town clarify its near term and long term goals for nitrogen remediation and loading. We also note that the mathematical calculations on p. 14-7 that describe future nitrogen load to the Swan Pond watershed are incorrect: (1.045 mgd x 1 mg/l x 8.34 = 8.72 lbs/day, not 26.11 lbs/day). Likewise, the calculations on p. 14-8 that describe future nitrogen load to the Bass River watershed are incorrect: (0.54 mgd x 1 mg/l x 8.34 = 4.50 lbs/day, not 13.5 lbs/day).

Coastal Hazards

CZM suggests that the Town evaluate alternative locations for the proposed sewer collection system components outside of the flood plain, especially outside of Coastal A Zones and Velocity Zones. The EIR should document that the proposed sewer system is designed to be protected from inundation by significant storm events and that utility connections will be capable of withstanding storm forces without damage or contamination of nearby resources. The current Federal Emergency Management Agency (FEMA) flood zone maps only show the 1% annual chance event, not the less frequent, but more severe hurricanes that have the most effect on the south shore of Dennis. In addition to the FEMA flood zones identified in the initial analysis presented in the EENF, CZM recommends that the analysis of potential inundation include effects of sea level rise and hurricanes. There are resources available on CZM's StormSmart Coasts website regarding tools available to help assess vulnerability, sea level rise, and the hurricane inundation zones. CZM notes that the Coastal A Zone is considered a high hazard area by FEMA. It is differentiated from the rest of the A Zones in coastal areas by the Limit of Moderate Wave Action (LiMWA) on the FEMA flood maps. The updated complete LiMWA is only available through National Flood Hazard Layer (NFHL) on the FEMA Map Service Center website (note that the NFHL available on MassGIS does not currently have this data layer).

It is also important to consider the potential inundation risk for the life of the proposed infrastructure. As described in the EENF, the sewering is proposed to be constructed in phases, over 40 years. The proposed lifespan of the infrastructure should be taken into account as part of the analysis, and the EIR should include a plan for re-evaluation of the proposed plans as new information becomes available, particularly regarding new projections for flood and erosion hazards. For example, there is a coast-wide modeling effort being conducted for the state that will produce new projections for coastal storm flood levels in future tropical and extra-tropical storms, including projected sea level rise. This effort is scheduled to be completed within a year. This information would be important for this project to consider as part of the planning process. Designing for the potential inundation from storms and sea level rise is critical to avoiding damage in future coastal storms as well as future requests for public money to mitigate the flood hazards to this infrastructure.

Federal Consistency

The proposed project may be subject to CZM federal consistency review. For further information on this process, please contact, Robert Boeri, Project Review Coordinator, at 617-626-1050 or visit the CZM web site at www.state.ma.us/czm/fcr.htm.

BKC/tc/sm/rh

cc: Stephen McKenna, CZM Cape & Islands Regional Coordinator
Brian Dudley, MassDEP, Southeast Regional Office
David Johansen, Director of Public Works, Town of Dennis, MA 02660

RECEIVED
JUL 13 2017
MEPA

The Commonwealth of Massachusetts

William Francis Galvin, Secretary of the Commonwealth
Massachusetts Historical Commission

July 6, 2017

Secretary Matthew A. Beaton
Executive Office of Energy & Environmental Affairs
Attn: Alex Strysky, MEPA Unit
100 Cambridge Street, Suite 900
Boston, MA 02114

RE: Dennis Comprehensive Wastewater Management Plan, Dennis, MA. MHC # RC.62034. EEA # 15707.

Dear Secretary Beaton:

Staff of the Massachusetts Historical Commission have reviewed the Massachusetts Environmental Policy Act (MEPA) Expanded Environmental Notification Forms (EENF) for the project referenced above. The proposed project consists of the 8 phase comprehensive wastewater management plan for Dennis.

The EENF indicates that the proposed project will utilize federal funding through the State Revolving Fund administered by the Massachusetts DEP. MHC will review the project under Section 106 of the National Historic Preservation Act of 1966, as amended (36 CFR 800), in consultation with the DEP. The MHC proposes to coordinate the MHC's state historic preservation review for the state agency permitting and funding, and for the MEPA review (950 CMR 71.04 (2) & (3)).

The EENF incorporates the MHC's comments on the Project Notification Form. Project planners should submit scaled existing and proposed conditions project plans for the preferred project alternative to the MHC and other consulting parties, when they become available.

The MHC looks forward to reviewing the State Archaeologists permit application (950 CMR 70) from a qualified archaeological consultant with previous experience in this region of Massachusetts to conduct the archaeological reconnaissance survey (950 CMR 70) for the project. The goal of the investigation is to provide a detailed archaeological sensitivity assessment for the project, and to provide recommendations for further archaeological testing, if any, that may be required to locate and identify any significant archaeological resources that could be affected by the project, in advance of project construction for each phase. The scope should include limited subsurface testing to assist in the sensitivity assessment and implementation of a contingency for archaeological monitoring during construction as necessary. The results of survey(s) will be used in consultation in order to avoid, minimize or mitigate adverse effects to identified significant archaeological resources.

The MHC recommends that project planners provide project information to the Dennis Historical Commission and/or Dennis Historic District Commission as appropriate for any above-ground project elements in historic districts for concurrent review and comment. Copies of any written comments received from potential interested and consulting parties regarding historic and archaeological resources should be provided to the MHC.

220 Morrissey Boulevard, Boston, Massachusetts 02125
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www.sec.state.ma.us/mhc

These comments are offered to assist in compliance with Section 106 of the National Historic Preservation Act of 1966, as amended (36 CFR 800), M.G.L Chapter 9, Sections 26-27C (950 CMR 70-71) and MEPA (301 CMR 11). If you have any questions or require additional information, please contact Jonathan K. Patton at this office.

Sincerely,

Brona Simon

Brona Simon
State Historic Preservation Officer
Executive Director
State Archaeologist
Massachusetts Historical Commission

xc: Jane Peirce, DEP-BRP
Bettina Washington, Wampanoag Tribe of Gay Head (Aquinnah)
Ramona Peters, Mashpee Wampanoag Tribe
DEP-SERO, Div. Water Pollution Control
Dennis Historical Commission
David F. Young, CDM Smith Inc.

Strysky, Alexander (EEA)

From: Logan, John (FWE)
Sent: Thursday, July 06, 2017 11:03 AM
To: Strysky, Alexander (EEA)
Cc: Potti, Pooja (FWE)
Subject: Dennis Draft Comprehensive Wastewater Management Plan, EEA#15707

Secretary Matthew A. Beaton
Executive Office of Energy and Environmental Affairs (EEA)
Attn: MEPA Office
Alex Strysky, EEA No. 15707
100 Cambridge Street, Suite 900
Boston, MA 02114

Dear Secretary Beaton:

The Division of Marine Fisheries (MarineFisheries) has reviewed the Expanded Environmental Notification Form (EENF) and Draft Comprehensive Wastewater Management Plan (CWMP) by the Town of Dennis. The project was reviewed with respect to potential impacts to marine fisheries resources and habitat. The plan affects several estuaries and embayments along Nantucket Sound. The identified preferred alternative (Scenario 6A) relies primarily on expanded sewering with tie-in to a centralized wastewater treatment plant. Additional measures towards nitrogen remediation included in Scenario 6A consist of the installation of permeable reactive barriers at the proposed recharge sites, fertilizer education, stormwater best management practices, and an oyster aquaculture pilot study in Swan Pond.

The proposed oyster aquaculture component of the preferred alternative should follow the MarineFisheries Shellfish Planting Guidelines (Hickey et al. 2015). Based on the information provided, MarineFisheries has no further recommendation for sequencing, timing, or methods that would avoid or minimize impact at this time.

Questions regarding this review may be directed to John Logan in our New Bedford office at (508) 990-2860 ext. 141.

References

Hickey JM, Shields T, Kennedy J, Ford K (2015) Shellfish planting guidelines. Massachusetts Division of Marine Fisheries. 3rd Edition. March 2015. http://www.mass.gov/eea/docs/dfg/dmf/programsandprojects/shellfish-planting-guidelines.pdf.

John Logan, Ph.D.
MA Division of Marine Fisheries
1213 Purchase Street
New Bedford, MA 02740
(508) 990-2860 x141
http://www.mass.gov/eea/agencies/dfg/dmf/
https://www.researchgate.net/profile/John_Logan

MASSWILDLIFE

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FISHERIES & WILDLIFE

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MASS.GOV/MASSWILDLIFE

Jack Buckley, *Director*

July 5, 2017

Matthew A. Beaton, Secretary
Executive Office of Energy and Environmental Affairs
Attention: MEPA Office
Erin Flaherty, EEA No. 15701
100 Cambridge St.
Boston, Massachusetts 02114

Project Name: *Draft Comprehensive Wastewater Management Plan (CWMP)*
Proponent: *Town of Dennis, Elizabeth Sullivan, Town Administrator*
Location: *Throughout Dennis*
Project Description: *Comprehensive Wastewater Management Plan*
Document Reviewed: *Expanded Environmental Notification Form*
EEA File Number: *15707*
NHESP Tracking No.: *17-35943*

Dear Secretary Beaton:

The Natural Heritage & Endangered Species Program of the Massachusetts Division of Fisheries & Wildlife (the Division) has reviewed the *Expanded Environmental Notification Form* (EENF) for the proposed Town of Dennis Draft Comprehensive Wastewater Management plan (CWMP), Dennis, MA and would like to offer the following comments.

Portions of the Town of Dennis are mapped as *Priority and Estimated Habitat* for state-listed species, which are protected pursuant to the Massachusetts Endangered Species Act (M.G.L c. 131A) and its implementing regulations (MESA, 321 CMR 10.00) as well as the Massachusetts Wetlands Protection Act and its implementing regulations (WPA, 310 CMR 10.37, 10.58(4)(b) and 10.59). The estuarine waters, bays, ponds, streams and lakes of Dennis provide critical habitat for a suite of state-listed species. Improvements in water quality within these habitats will likely benefit residents and wildlife alike. The Division recognizes the Proponent's efforts to develop this plan and improve water quality.

Those projects that will occur within *Priority and Estimated Habitat* for state-listed species, which are not otherwise exempt from MESA review pursuant to 321 CMR 10.14, require a direct filing with the Division for compliance with the Massachusetts Endangered Species Act (MESA 321 CMR 10.00). According to Section 12 of the EENF, many of the scenarios recommended for further study may require review with the Division pursuant to the MESA and therefore the Proponent should consult with the Division as plans are developed. The Division notes that sewer systems within ten (10) feet of the edge of existing paved roads may be exempt from MESA review, please see 321 CMR 10.14(10).

The Division will not render a final decision until the MEPA review process and associated public and agency comment period is completed, and until all required MESA filing materials are submitted by the proponent to the Division. As our MESA review is not complete, no alteration to the soil, surface, or

vegetation and no work associated with the proposed project shall occur on the property until the Division has made a final determination.

If you have any questions about this letter, please contact Amy Hoenig, Endangered Species Review Biologist, at (508) 389-6364 or Amy.Hoenig@state.ma.us. We appreciate the opportunity to comment on this project.

Sincerely,

Thomas W. French

Thomas W. French, Ph.D.
Assistant Director

cc: Magdelena Lofstedt, CDM Smith, Inc
Dennis Board of Selectmen
Dennis Conservation Commission
Dennis Planning Department
DEP Southeast Regional Office, MEPA

Commonwealth of Massachusetts
Executive Office of Energy & Environmental Affairs

Department of Environmental Protection

Southeast Regional Office • 20 Riverside Drive, Lakeville MA 02347 • 508-946-2700

Charles D. Baker
Governor

Karyn E. Polito
Lieutenant Governor

Matthew A. Beaton
Secretary

Martin Suuberg
Commissioner

July 7, 2017

Mathew A. Beaton,
Secretary of Environment and Energy
ATTN: MEPA Office
Executive Office of Environmental Affairs
100 Cambridge Street, Suite 900
Boston, MA 02114

RE: ENF Review EOEEA #15707
15707.DENNIS. Draft Comprehensive Wastewater Plan at various streets throughout Dennis

Dear Secretary Beaton,

The Southeast Regional Office of the Department of Environmental Protection (MassDEP) has reviewed the Environmental Notification Form (ENF) for the proposed Draft Comprehensive Wastewater Plan, located at various streets throughout Dennis, Dennis, Massachusetts for the proposed (EOEEA # 15514). The Project Proponent provides the following information for the Project:

The Town is recommending a traditional wastewater program that includes: approximately 92 miles of sewer pipes, 21 pumping stations and one centralized treatment facility. Each of these components will be phased over 40 years. For this program, the treatment will occur at a new facility in Dennis. Implementing this program will allow Dennis to meet its water resource management needs as defined throughout the CWMP, including consistency with the Massachusetts Estuaries Project (MEP) nitrogen reduction goals as well as protecting freshwater resources, including ponds and drinking water resources. Section 14 of the CWMP describes the recommended program components. It also presents the wastewater phasing plan and identifies the potential cost recovery strategy being developed by the Town. Section 14 also describes the recommended non-infrastructure program components which include fertilizer and stormwater management programs, potential land use changes, and community based conservation and pollution reduction programs.

Bureau of Water Resources Comments

Wetlands and Waterways Comments: A local Order of Conditions is required from the Dennis Conservation Commission for each construction phase that proposes work within Areas Subject to Protection under M.G.L. c. 131 § 40 and buffer zones. The Project is being proposed as a limited Project under 310 CMR 10.24(7) and 310 CMR 10.53(3)(d). The EENF indicates that there are proposed alterations to Land Subject to Coastal Storm Flowage, Bordering Land Subject to Flooding and Riverfront Area. Pursuant to 310 CMR 10.58(6)(h) this Project is exempted from requirements for the Riverfront Area. Per 310 CMR 10.24(7) and 310 CMR 10.53(3)(d) in determining whether to exercise discretion to approve the limited Project, the following factors should be considered: the magnitude of the alteration and the significance of the Project site to the interests identified in M.G.L. c. 131 § 40, the availability of reasonable alternatives to the proposed activity, the extent to which adverse impacts are

minimized, and the extent to which mitigation measures, including replication or restoration, are provided to contribute to the protection of the interests identified in M.G.L. c. 131 § 40.

Wastewater Management Comments: The CWMP presents a 40 year phased plan with a primary focus on mitigating nitrogen enrichment to the Bass River, Swan Pond River, and Herring River along with Chase Garden Creek, Quivett Creek, and Sesuit Harbor watersheds.

The document represents a thorough evaluation of Dennis's needs for wastewater and nutrient management. Much of the recommended plan is driven by the findings of the Massachusetts Estuaries Project (MEP) which documented resource impairment from excess nitrogen loads in the Swan Pond, Bass River, and Herring River embayments MEP Technical Reports. MassDEP TMDL reports are available for the Swan Pond, Bass River and Herring River Embayments. The Chase Garden Creek study has recently been completed (too late for inclusion in this draft CWMP) and the Sesuit Harbor study is in progress.

MassDEP fully supports the Town of Dennis in its efforts to develop a Comprehensive Wastewater Management Plan (CWMP) that serves as a water resources management strategy to meet Total Maximum Daily Load (TMDL) requirements. Development of a CWMP is an important step toward meeting TMDL's and restoring impaired waters. Plans to meet TMDL requirements for nutrient loading must always consider source reduction as the primary means of long term nutrient control. Source reduction usually focuses on controlling watershed land use loads generated from human activity and can include but are not limited to constructing new sewer systems, eliminating fertilizers, constructing on-site systems with enhanced nutrient removal capability, reducing runoff from impervious surfaces, reducing impervious surfaces, and tightening standards for new and upgraded septic systems. In addition to source controls, successful nutrient management plans may include alternative nutrient control strategies to achieve the desired nitrogen concentrations specified in the TMDL and Massachusetts Estuary Project (MEP) reports. MassDEP is encouraged by the source controls proposed in the CWMP, and recommends that Dennis continue to evaluate and adopt additional source controls in the future to the maximum extent possible to reduce the need for alternative nutrient control strategies.

The Town developed 14 water quality management scenarios to evaluate MEP nitrogen removal requirements along with protection of freshwater ponds, and drinking water resources. The Dennis Comprehensive Wastewater Management Task Force recommended 4 scenarios for further evaluation. These scenarios include a mix of aquaculture, sewers, innovative/alternative septic system technology and permeable reactive barriers.

The recommended wastewater program for the town of Dennis includes a collection system utilizing one centralized treatment facility and two effluent recharge areas. Components would be phased in over 40 years in 8 phases. The recommended plan include a collection system, wastewater treatment, effluent recharge with a permeable reactive barrier (PRB) for about 1.7 MGD of wastewater along with aquaculture, fertilizer and stormwater management, land use changes, open space acquisition, and community conservation and pollution reduction programs. The plan includes sewering as many existing developed parcels as necessary in the Bass River and Swan River watersheds in order to meet the nitrogen removal requirements.

Wastewater flows were calculated using the MEP buildout estimates for the nitrogen loading model. The recommended treatment technology is SBR process. In the future, the SBR system may need additional denitrification to meet the TMDL for Bass River and Swan Pond embayments. Currently, the plan

recommends supplemental carbon addition and denitrification filters. Additional analysis needs to be completed to further evaluate effluent recharge. The recommended discharge sites will be fully evaluated during the permitting process.

Regional approaches
MassDEP is encouraged that the Town of Dennis has been in discussions with the neighboring towns of Harwich and Yarmouth with the potential to form a multi-town wastewater utility. MassDEP encourages this community partnership among the three towns and finds it preferable to individual arrangements between Dennis and Harwich or Dennis and Yarmouth. A tri-town partnership would be able to incorporate shared interests in Bass River (Dennis and Yarmouth) and both Swan Pond River and Herring River (Dennis and Harwich). As is evident from the CWMP, and discussed further in these comments, Dennis faces challenges by addressing wastewater issues on its own while an inter-municipal approach affords both cost savings and additional environmental benefits.

TMDL Compliance
The CWMP's recommended approach (Scenario 6A) includes a traditional single wastewater treatment facility the (with an associated collection system) located near the Dennis DPW facility with subsurface infiltration at two sites, one in the Swan Pond River watershed and one in the Bass River watershed. The recommended approach also includes non-traditional elements comprised of fertilizer reduction, stormwater BMPs, aquaculture (in Swan Pond River) and PRBs to polish effluent recharge at the infiltration beds. Preliminary loading calculations based on expected removal rates of both traditional and non-traditional strategies indicate that Dennis will meet its TMDL obligations throughout town. However, initial modeling by the Massachusetts Estuaries Project (MEP) indicated that in the Swan Pond River watershed, 100% removal of septic load was required while a 74% reduction of the total nitrogen load would meet target thresholds. Scenario 6A does not entirely eliminate septic load since there is residual nitrogen in the effluent discharge from the infiltration beds. The plan relies on with non-traditional approaches to achieve the additional removal required to meet the target nitrogen threshold. The CWMP should explicitly identify a contingency alternative to address the additional removal requirements should the performance of the non-traditional approaches fall short of expectations. This most likely would require identifying an infiltration site outside the Swan Pond River watershed.

Wastewater Infiltration
As previously mentioned, the two infiltration sites identified are in the Bass River and Swan Pond River watersheds, respectively. While final evaluation and approval will take place during the permitting process, a few issues should be mentioned for future consideration. While transient models were used in the initial evaluations, MassDEP will want to confirm that the flows used adequately reflect the maximum and minimum conditions likely to arise from operation of the treatment facility. Also, loading rates assumed in the model runs exceed those normally assigned to infiltration beds. If these higher loading rates are considered for design, then additional field loading tests will be required at the permitting stage to determine if the increased loading rates are supportable if they are desired to be part of the design.

The particle tracking for Site 1 indicates a split in flow between the Swan Pond River and Herring River watersheds. If higher loading rates are desired and can be confirmed, it may be possible to reconfigure and relocate a smaller infiltration bed to direct more flow away from the Swan Pond River watershed.

The particle tracking for Site 2 in the Bass River watershed shows an encroachment in the Zone II. During the permitting process MassDEP will determine whether this may trigger water reclamation

requirements for indirect recharge to a public water supply; however, given that the particles do not appear to encroach in a Zone of Contribution, MassDEP has the option to exercise discretion in requiring additional treatment.

Drip irrigation is an option for flows exceeding 10,000 gpd. Given that the proposed treatment works will produce high quality effluent, this option may warrant additional consideration. It has the potential to provide some additional flexibility especially if alternate sites outside of the Swan Pond River watershed need to be considered. Further discussion with MassDEP regarding this alternative is encouraged.

Buildout Analysis
The report has provided a thorough evaluation of existing and buildout conditions. However, the CWMP should acknowledge that additional evaluation may be needed for buildout assumptions depending upon how proposed zoning changes are enacted.

Alternative Treatment
The CWMP proposes the use of fertilizer reduction, stormwater BMPs, aquaculture and PRBs as non-traditional approaches. There should be further discussion of a monitoring program to evaluate the effectiveness of these strategies in meeting Project projected loading reductions for stormwater, aquaculture and PRBs. Additionally, the CWMP should develop a compliance and enforcement strategy to insure that fertilizer reduction targets are met. Finally, as mentioned previously, a contingency plan utilizing traditional approaches should be developed in the event that the non-traditional approaches not meet Projected reductions.

Phasing.
The CWMP is based on a 40 year design horizon divided in x phases. Traditionally, CWMPs have been based on 20 year horizons; however, the scope and cost of the recommended alternative requires an extended timeframe for affordability and capital planning. MassDEP believes that further discussion on the timetable is required to arrive at a mutually acceptable schedule for completion.

SRF Funding
The Town of Dennis is encouraged to work with MassDEP's State Revolving Fund (SRF) section to develop funding alternatives as Project development proceeds. The Draft CWMP clearly documents areas where nutrient enrichment needs control to improve water quality. As Projects approach the funding stage, the Town will need to show the percentage of each Project intended primarily to manage nutrients with reference to the final CWMP. Sewer regulations to be developed may need to comply with certain MassDEP and Department of Housing and Community Development requirements, depending on the funding program utilized. In particular, there is little discussion of growth neutrality in the CWMP. This item needs to be addressed if the town wishes to pursue 0% financing from the SRF.

The Massachusetts Natural Heritage and Endangered Species Program (NHESP) identified state-listed rare species in the vicinity of several Project components. During implementation of the CWMP, the Project Proponent must comply with 310 CMR 10.59, 310 CMR 10.32(6) and related performance standards for other resource areas, and 310 CMR 10.37 to ensure that there is no short or long term adverse effect on estimated habitats of rare wildlife.

Miscellaneous
On pages 14-7 and 14-8 there are some apparent miscalculations of nitrogen load. These should be reviewed and, if in error, checked to see if they have been carried through to other calculations in the report.

Conclusion. This CWMP is well crafted and presents a reasonable approach to the town's wastewater and nitrogen management challenges. The comments presented are not meant as criticisms, but rather additional avenues of exploration to further enhance the recommended plan. The town of Dennis has made an important step forward in addressing nutrient enrichment in the major embayments. MassDEP is of the opinion, however, that additional regional partnering with Yarmouth for the Bass River and Harwich for the Herring River and Swan River embayments, should be more fully explored and addressed in the EIR. MassDEP also recognizes that given the phasing, regardless of what timetable upon which the parties eventually agree, modifications to the existing plan can accommodate anticipated studies on regional alternatives.

Through the MA Water Pollution Abatement Trust, the Cape Cod Commission has completed a Section 208 Wastewater Management Plan Update pursuant to the Federal Clean Water Act. The 208 Plan Update represents a watershed-based approach to restore embayment water quality on Cape Cod that recommends strategies, regulatory reforms and a process for communities to reduce or eliminate excess nitrogen. From MassDEP's perspective, the CWMP reflects the overall goals of the 208 Plan Update. The Cape Cod Commission will make a determination of 208 consistency in conjunction with its Development of Regional Impact (DRI) review which will commence after issuance of the Secretary's Certificate.

Construction Stormwater Permit. The Project construction activities are scheduled to disturb 8.06 acres of land and therefore, may require a NPDES Stormwater Permit for Construction Activities. The Proponent can access information regarding the NPDES Stormwater requirements and an application for the Construction General Permit at the EPA website: https://www3.epa.gov/npdes/pubs/cgp2012_qanda.pdf. You are considered covered under this permit 14 calendar days after EPA has acknowledged receipt of your Notice of Intent (NOI) on the Agency's website (www.epa.gov/npdes/stormwater/cgpnoisearch), unless EPA notifies you that your authorization has been delayed or denied.

Bureau of Waste Site Cleanup Comments
Based upon the information provided, the Bureau of Waste Site Cleanup (BWSC) searched its databases for disposal sites and release notifications that have occurred at or might impact the proposed Project area. A disposal site is a location where there has been a release to the environment of oil and/or hazardous material that is regulated under M.G.L. c. 21E, and the Massachusetts Contingency Plan [MCP – 310 CMR 40.0000].

The proposed Project involves a town-wide initiative to address wastewater management needs, protect drinking water supplies, protect ponds, and restore estuaries. Please be advised that there are many listed BWSC disposal sites located in the vicinity of the proposed Project areas. Many of the sites have closed under the MCP, but many other disposal sites are open and require continued response actions under the MCP. A listing and discussion of each MCP site will not be presented here.

Interested parties may view a map showing the location of BWSC disposal sites using the MassGIS data viewer (Oliver) at: http://maps.massgis.state.ma.us/map_ol/oliver.php Under "Available Data Layers" select "Regulated Areas", and then "DEP Tier Classified 21E Sites". The compliance status and report

submittals for specific MCP disposal sites may be viewed using the BWSC Waste Sites/Reportable Release Lookup at: http://public.dep.state.ma.us/SearchableSites2/Search.aspx

The Project Proponent is advised that if oil and/or hazardous materials are identified during the implementation of this Project, notification pursuant to the Massachusetts Contingency Plan (310 CMR 40.0000) may be necessary. A Licensed Site Professional (LSP) should be retained to determine if notification is required, and render appropriate opinions as necessary. The LSP may evaluate whether risk reduction measures are necessary if contamination is present. Please contact BWSC for guidance if questions arise regarding assessment and cleanup under the MCP.

Bureau of Air and Waste Comments

Air Quality. Construction and operation activities shall not cause or contribute to a condition of air pollution due to dust, odor or noise. To determine the appropriate requirements please refer to:

310 CMR 7.09 Dust, Odor, Construction, and Demolition
310 CMR 7.10 Noise

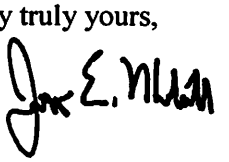
Massachusetts Idling Regulations. MassDEP requests that the Proponent state specifically in the subsequent environmental filing how it plans to prohibit the excessive idling during the construction period. Typical methods of reducing idling include driver training, periodic inspections by site supervisors, and posting signage. In addition, to ensure compliance with this regulation once the Project is occupied, MassDEP requests that the Proponent establish permanent signage limiting idling to five minutes or less at the completed Project.

Proposed s.61 Findings

The "Certificate of the Secretary of Energy and Environmental Affairs on the Draft Environmental Impact Report (DEIR) may indicate that this Project requires further MEPA review and the preparation of a Final Environmental Impact Report (FEIR). Pursuant to MEPA Regulations 301 4
CMR 11.12(5)(d), the Proponent will prepare Proposed Section 61 Findings to be included in the EIR in a separate chapter updating and summarizing proposed mitigation measures. In accordance with 301 CMR 11.07(6)(k), this chapter should also include separate updated draft Section 61 Findings for each State agency that will issue permits for the Project. The draft Section 61 Findings should contain clear commitments to implement mitigation measures, estimate the individual costs of each proposed measure, identify the parties responsible for implementation, and contain a schedule for implementation.

The MassDEP Southeast Regional Office appreciates the opportunity to comment on this proposed Project. If you have any questions regarding these comments, please contact George Zoto at (508) 946-2820.

Very truly yours,



Jonathan E. Hobill,
Regional Engineer,
Bureau of Water Resources

JH/GZ

Cc: DEP/SERO

ATTN: Millie Garcia-Serrano, Regional Director
David Johnston, Deputy Regional Director, BWR
Maria Pinaud, Deputy Regional Director, BAW
Gerard Martin, Deputy Regional Director, BWSC
Jennifer Viveiros, Deputy Regional Director, ADMIN
Allen Hemberger, Site Management/BWSC
Brian Dudley, Chief, Wastewater/BWR
Kermit Studley, Drinking Water/BWR

dcr
Massachusetts

July 7, 2017

Secretary Matthew A. Beaton
Executive Office of Energy and Environmental Affairs
Attn: Alex Strysky, MEPA Office
100 Cambridge Street, Suite 900
Boston, Massachusetts 02114

Re: EOEEA #15707 Draft Comprehensive Wastewater Management Plan EENF

Dear Secretary Beaton:

The Department of Conservation and Recreation ("DCR" or "Department") is pleased to submit the following comments in response to the Expanded Environmental Notification Form ("EENF") submitted by the Town of Dennis (the "Proponent") for its Draft Comprehensive Wastewater Management Plan (the "Project").

As described in the EENF, the Project consists of the implementation of a long-term wastewater management plan to provide public sewer service to a number of areas within the town currently served by private septic systems and affected by high nitrate concentrations. The Project aims to reduce nutrient loading to coastal waters, and meet anticipated Total Maximum Daily Loads ("TMDLs") for estuary/embayments along Nantucket Sound. The Project requires a mandatory Environmental Impact Report ("EIR"), due to construction of one or more new sewer mains ten or more miles in length, which the Proponent is seeking to fulfill through the submission of a Single EIR. The EENF states that the Project may require a Construction and Access Permit from DCR.

DCR has care, custody, and control over the Cape Cod Rail Trail, a 22-mile multi-use pathway that stretches from Dennis to Wellfleet. A portion of the proposed work for the Project appears to be near DCR's ownership of the rail trail. The EENF states that a DCR Construction and Access permit could be necessary for the Project.

DCR submits the following comments on the EENF:

As part of the site screening process for selecting locations to construct treatment plants or other infrastructure, the Proponent evaluated the presence of certain criteria that are perceived as favorable for project infrastructure. On maps included in the EENF, the Proponent shows the Cape Cod Rail Trail as being town-owned, including a section of the rail trail west of Route 134 recently opened. DCR notes that the CCRT is owned by the Commonwealth and managed by the Department, and requests that a correction is made in the EIR. Additionally, DCR notes that the CCRT is protected by Article 97 of the Amendments to the Massachusetts Constitution, and any disposition of a land interest, whether the

Department of Conservation and Recreation
251 Causeway Street, Suite 600
Boston MA 02114-2119
617-626-1250 617-626-1351 Fax
www.mass.gov/dcr

Charles D. Baker
Governor

Karyn E. Polito
Lt. Governor

Matthew A. Beaton, Secretary, Executive
Office of Energy & Environmental Affairs

Leo Roy, Commissioner
Department of Conservation & Recreation

conveyance of a fee interest or the granting of an easement, would require legislative approval by a 2/3 roll call vote.

DCR notes that Figure 14-2 ("Recommended Phasing Plan") appears to include a pump station and gravity force mains near the Cape Cod Rail Trail, adjacent to Great Western Road. In the EIR, DCR requests that the Proponent provide additional information on the location of this infrastructure in relation to the Cape Cod Rail Trail, and clarify whether a permanent disposition of land or an interest in land would be required from DCR. DCR also requests that the Proponent definitively identify whether a DCR Construction and Access Permit would be required for the Project, and, if so, clarify the proposed activity on DCR land which would trigger the need for such a permit.

DCR notes that transfers of interests in state conservation property must meet the requirements set forth in the Executive Office of Energy and Environmental Affairs ("EEA") Article 97 Land Disposition Policy, which has the stated goal of ensuring no net loss of Article 97 lands under the ownership and control of the Commonwealth. The policy states, as a general premise, that EEA and its agencies shall not sell, transfer or otherwise dispose of any right or interest in Article 97 lands. Transfer of ownership or interests therein may only occur under exceptional circumstances, as defined in the policy, including the determination that no feasible alternative is available, and a minimum amount of land is being disposed for the proposed use.

Thank you for the opportunity to comment on the EENF. If you have questions regarding our comments, please contact Nat Tipton, MEPA Review Coordinator at (617) 626-1341 or nathaniel.tipton@state.ma.us. Questions regarding Article 97 can be directed to Shaun Provencher at (617) 626-1376 or shaun.provencher@state.ma.us.

Sincerely,

Leo Roy
Commissioner

cc: Patrice Kish, Tom LaRosa (DCR)

3225 MAIN STREET • P.O. BOX 226
BARNSTABLE, MASSACHUSETTS 02630

(508) 362-3828 • Fax (508) 362-3136 • www.capecodcommission.org

CAPE COD
COMMISSION

Via Email

July 7, 2017

Matthew A. Beaton, Secretary
Secretary of Energy and Environmental Affairs
Executive Office of Energy and Environmental Affairs (EEA)
Attn: MEPA Office, Alex Strysky, Project Analyst
100 Cambridge Street, Suite 900
Boston MA 02114

Re: Town of Dennis Comprehensive Wastewater Management Plan (CWMP)
Expanded Environmental Notification Form- EEA No. 15707
(Cape Cod Commission File No. 17011)

Dear Secretary Beaton:

Thank you for the opportunity to provide comments on the above-referenced matter.

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The total estimated cost of the CWMP is $213 million over 40 years. The CWMP is divided into 8 phases, and includes a cost recovery plan with various funding options to that will be considered as the Plan progresses.

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The EENF references the Town's initial Needs Assessment, which identified particular Areas of Concern for wastewater planning such as those with Title 5 constraints and those in proximity to surface waters. The EENF augments the initial Needs Assessment with more specific land use information, such as updated Flood Maps, locations of I/A Septic systems, wetland areas, areas mapped as priority habitat for rare or endangered species under MESA, soil types, areas proposed for targeted economic development, and areas with established TMDL's or critical nitrogen loading thresholds; these areas have been compiled in and depicted on a management needs map included as Figure 7-10 in the EENF.

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The EENF includes an evaluation of suitable parcels to locate key wastewater infrastructure for treatment and groundwater discharge, utilizing specific siting criteria to initially identify 183 potential sites. Of these, 10 sites were selected for further evaluation. For these 10 sites, additional siting criteria was considered. Selecting sites outside of water supply Zones of Contribution was a primary consideration. Other criteria included siting outside mapped Flood Plains and wetlands, and within areas having a favorable depth to groundwater, and permeable soils. Potential siting within Zone II's was not categorically dismissed, consistent with the state GWDP regulations. The selection process resulted in 3 sites for which detailed hydrogeologic evaluations were conducted, including groundwater modeling to evaluate water table mounding and particle flow paths.

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- Dennis present a sewer-only scenario, with its associated costs, that doesn't use ocean outfall and which discharges treated effluent outside of nitrogen-sensitive watersheds;
- identify potential suitable discharge sites outside of nitrogen sensitive watersheds other than Site 3, which has limited capacity;
- more specifically document the phased loading reductions, discharge increases and mitigation in the Swan Pond watershed.

Consistency with the Area Wide Water Quality Plan Criteria ("208 Plan)

1. **WMA assumes responsibility for controllable nitrogen within its jurisdiction**
   It will be important for towns that contribute nitrogen to shared watersheds to agree on the bases for determining each town's responsibility to reduce nitrogen loads to affected coastal waters. The Town of Dennis has chosen to proceed using MEP wastewater flow rates, which would allow the CWMP to adapt to changing conditions over its 40 year planning period, e.g. future development and future implementation of strategies toward meeting TMDLs. If the town intends to proceed in reliance on MEP target numbers instead of the numbers presented in Appendix 8C of the 208 Plan Update (as those numbers may be updated in the 208 database), then the EIR should provide a roadmap for intermunicipal agreement for the allocation of nitrogen responsibility, and the town should pursue an IMA in each of its shared watersheds.

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   Yes, the EENF describes eight 5-year phases.

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Cape Cod Commission staff is available to answer any questions about the comments.

Sincerely,

Patty Daley

Patty Daley
Deputy Director

cc: Project File
Town of Dennis c/o CDM Smith
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Via Email

July 7, 2017

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Sincerely,

Patty Daley

Patty Daley
Deputy Director

cc: Project File
Town of Dennis c/o CDM Smith
Dennis Cape Cod Commission Representative via email

Mashpee Wampanoag Tribe
Section 106 Review
Consultation Response Form

Project ID Number:	Town of Dennis, CWMP Development
Consultant/Environmental Firm:	Mass. DEP/MEPA/Town of Dennis
Address or Location Description:	Various areas of
City, State:	Dennis, MA
Point of Contact	Elizabeth Sullivan

Response:

☐ We have no concerns related to the proposed project. MWT anticipates no adverse effects to our sites of cultural significance, by you or your client.

☐ The MWT considers this project in compliance with the MWTôs section 106 review process with agreed upon mitigations measures.

☐ This site will require the on-site presence of a Tribal Cultural Resource Monitor during ground disturbing activities. Contact the Compliance Review Supervisor with construction schedule.

☒ This project has the potential to have ñadverse effectsò to historic or cultural resources important to our tribe. We recommend the following actions:

Our office concurs with statements made in the MHCôs comment letter dated April 6th, 2017. Since the project is being supplemented with Federal Funds through the State Revolving fund the said project is subject to Section 106.

Thereôs significant documentation that available which validates Wampanoag habitation and occupation of the Dennis, MA area. Generally speaking we do consider this an area of interest for significant cultural resources. We expect to be consulted throughout the projects development as part of the Section 106 process.

We request that the town of Dennis, contract a reputable Archaeological firm for phase 1A (initial background review) of the proposed areas of potential effect (APE). The area has the potential for Archaeological evidence of pre-contact period Native American activity which could include subsistence-related features such as hearths, food storage/disposal pits, living areas including post molds, lithic workshops, diagnostic chipped and ground stone tool assemblages. The Mashpee Wampanoag Tribeôs primary concern is to ensure that burials and or habitation/occupation sites are not adversely impacted.

Our office will need digital copies of preliminary design plans being considered, archaeological assessment information and geotechnical information as it develops. This

information will assist in our determination of potential effects to culturally significant assemblages.

We will require a Tribal CRM to access/monitor ground disturbing activities involved with Archaeology and or preliminary field testing. We request contact information for the general contractor/project manager in charge of scheduling. The proponent will be responsible for cost associated with our monitoring at a rate of $75.00/hr. which is expected to be paid within 30 days of invoicing.

This consultation process is in compliance to the National Historic Preservation Act of 1966 and all relevant amendments including but not limited to section 106 and 36 CFR 800.

Condition: In the case that unanticipated discoveries of archeological resources or human remains are found during construction, **you must immediately stop construction and notify our office.**

David Weeden, Deputy THPO - Compliance Review
Tribal Historic Preservation Office

7/25/17
Date

THE COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF ENERGY AND ENVIRONMENTAL AFFAIRS
OFFICE OF COASTAL ZONE MANAGEMENT
251 Causeway Street, Suite 800, Boston, MA 02114-2136
(617) 626-1200 FAX: (617) 626-1240

MEMORANDUM

TO: Matthew Beaton, Secretary, EEA
ATTN: Alex Strysky, MEPA Unit
FROM: Bruce Carlisle, Director, CZM
DATE: July 6, 2017
RE: EEA 15707, EENF, Draft CWMP, Dennis

The Massachusetts Office of Coastal Zone Management (CZM) has completed its review of the above-referenced Expanded Environmental Notification Form (EENF) noticed in the *Environmental Monitor* dated June 7, 2017, and offers the following comments for the development of the final Comprehensive Wastewater Management Plan (CWMP).

Project Description

The EENF presents the preferred alternatives for the draft Comprehensive Wastewater Management Plan (CWMP) for the Town of Dennis. The Town's recommended course of action is to sewer priority areas in eight phases over 40 years (five years per phase), build a wastewater treatment facility, and investigate the utility of three alternative strategies to manage nitrogen in groundwater. The preferred alternative is a mix of pressure, vacuum, and gravity sewer lines with several pump stations, six of which are proposed along Old Wharf Road, in the coastal flood plain. The Town of Dennis is in discussions with the Towns of Yarmouth and Harwich to potentially form a regional wastewater facility in Dennis.

The Town has a grant from the U.S. Environmental Protection Agency to investigate the utility of a permeable reactive barrier (PRB) to denitrify groundwater nitrogen near Mayfair Road in the Bass River watershed. The Town is also proposing to install a PRB around the future site of the treated wastewater infiltration basins as a "final polishing step." As another alternative nitrogen remediation strategy, the Town is also proposing to install a half acre of floating oyster cages into the 150- acre Swan Pond to help remediate nitrogen pollution. Another alternative nitrogen remediation strategy that is currently underway is the widening of the Bass River at the site of the rail bed where the Cape Cod Rail Trail is being extended. In addition, the Town has written a letter to the Massachusetts Department of Transportation requesting the widening of the Route 6 bridges over the Bass River, just upstream of the Rail Trail location.

Project Comments

Alternative Nitrogen Attenuation Strategies & Nitrogen Loading

CZM supports the Town's investigations into alternative nitrogen attenuation strategies in the implementation of its Comprehensive Wastewater Management Plan. Studies and plans to reduce flow restrictions along the Bass River at the old railroad bridge and at Route 6 should include theinvestigation of both the local near field effects of improved flushing, as well as potential far field effects, looking at the fate of the nitrogen that would move downstream into the Bass River estuary and Nantucket Sound. CZM supports the PRB studies and evaluations and looks forward to seeing

the results of the pilot testing. Regarding the installation of oysters in Swan Pond, CZM suggests that the Town work closely with the Division of Marine Fisheries on how best to evaluate the feasibility of oyster-based nitrogen remediation, assess public health concerns, and examine long-term costs and benefits. For all of these alternatives, CZM recommends that baseline monitoring for evaluating the efficacy of alternatives should be targeted for at least three years, and across several seasons and depths, in order to account for temporal and spatial variability.

The draft CWMP references a 1 mg/l assumed nitrogen concentration, which is well below the current level of technology. We request that in the EIR, the Town clarify its near term and long term goals for nitrogen remediation and loading. We also note that the mathematical calculations on p. 14-7 that describe future nitrogen load to the Swan Pond watershed are incorrect: (1.045 mgd x 1 mg/l x 8.34 = 8.72 lbs/day, not 26.11 lbs/day). Likewise, the calculations on p. 14-8 that describe future nitrogen load to the Bass River watershed are incorrect: (0.54 mgd x 1 mg/l x 8.34 = 4.50 lbs/day, not 13.5 lbs/day).

Coastal Hazards

CZM suggests that the Town evaluate alternative locations for the proposed sewer collection system components outside of the flood plain, especially outside of Coastal A Zones and Velocity Zones. The EIR should document that the proposed sewer system is designed to be protected from inundation by significant storm events and that utility connections will be capable of withstanding storm forces without damage or contamination of nearby resources. The current Federal Emergency Management Agency (FEMA) flood zone maps only show the 1% annual chance event, not the less frequent, but more severe hurricanes that have the most effect on the south shore of Dennis. In addition to the FEMA flood zones identified in the initial analysis presented in the EENF, CZM recommends that the analysis of potential inundation include effects of sea level rise and hurricanes. There are resources available on CZM's StormSmart Coasts website regarding tools available to help assess vulnerability, sea level rise, and the hurricane inundation zones. CZM notes that the Coastal A Zone is considered a high hazard area by FEMA. It is differentiated from the rest of the A Zones in coastal areas by the Limit of Moderate Wave Action (LiMWA) on the FEMA flood maps. The updated complete LiMWA is only available through National Flood Hazard Layer (NFHL) on the FEMA Map Service Center website (note that the NFHL available on MassGIS does not currently have this data layer).

It is also important to consider the potential inundation risk for the life of the proposed infrastructure. As described in the EENF, the sewering is proposed to be constructed in phases, over 40 years. The proposed lifespan of the infrastructure should be taken into account as part of the analysis, and the EIR should include a plan for re-evaluation of the proposed plans as new information becomes available, particularly regarding new projections for flood and erosion hazards. For example, there is a coast-wide modeling effort being conducted for the state that will produce new projections for coastal storm flood levels in future tropical and extra-tropical storms, including projected sea level rise. This effort is scheduled to be completed within a year. This information would be important for this project to consider as part of the planning process. Designing for the potential inundation from storms and sea level rise is critical to avoiding damage in future coastal storms as well as future requests for public money to mitigate the flood hazards to this infrastructure.

Federal Consistency

The proposed project may be subject to CZM federal consistency review. For further information on this process, please contact, Robert Boeri, Project Review Coordinator, at 617-626-1050 or visit the CZM web site at www.state.ma.us/czm/fcr.htm.

BKC/tc/sm/rh

cc: Stephen McKenna, CZM Cape & Islands Regional Coordinator
Brian Dudley, MassDEP, Southeast Regional Office
David Johansen, Director of Public Works, Town of Dennis, MA 02660

dcr
Massachusetts

July 7, 2017

Secretary Matthew A. Beaton
Executive Office of Energy and Environmental Affairs
Attn: Alex Strysky, MEPA Office
100 Cambridge Street, Suite 900
Boston, Massachusetts 02114

Re: EOEEA #15707 Draft Comprehensive Wastewater Management Plan EENF

Dear Secretary Beaton:

The Department of Conservation and Recreation ("DCR" or "Department") is pleased to submit the following comments in response to the Expanded Environmental Notification Form ("EENF") submitted by the Town of Dennis (the "Proponent") for its Draft Comprehensive Wastewater Management Plan (the "Project").

As described in the EENF, the Project consists of the implementation of a long-term wastewater management plan to provide public sewer service to a number of areas within the town currently served by private septic systems and affected by high nitrate concentrations. The Project aims to reduce nutrient loading to coastal waters, and meet anticipated Total Maximum Daily Loads ("TMDLs") for estuary/embayments along Nantucket Sound. The Project requires a mandatory Environmental Impact Report ("EIR"), due to construction of one or more new sewer mains ten or more miles in length, which the Proponent is seeking to fulfill through the submission of a Single EIR. The EENF states that the Project may require a Construction and Access Permit from DCR.

DCR has care, custody, and control over the Cape Cod Rail Trail, a 22-mile multi-use pathway that stretches from Dennis to Wellfleet. A portion of the proposed work for the Project appears to be near DCR's ownership of the rail trail. The EENF states that a DCR Construction and Access permit could be necessary for the Project.

DCR submits the following comments on the EENF:

As part of the site screening process for selecting locations to construct treatment plants or other infrastructure, the Proponent evaluated the presence of certain criteria that are perceived as favorable for project infrastructure. On maps included in the EENF, the Proponent shows the Cape Cod Rail Trail as being town-owned, including a section of the rail trail west of Route 134 recently opened. DCR notes that the CCRT is owned by the Commonwealth and managed by the Department, and requests that a correction is made in the EIR. Additionally, DCR notes that the CCRT is protected by Article 97 of the Amendments to the Massachusetts Constitution, and any disposition of a land interest, whether the

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Charles D. Baker
Governor

Karyn E. Polito
Lt. Governor

Matthew A. Beaton, Secretary, Executive
Office of Energy & Environmental Affairs

Leo Roy, Commissioner
Department of Conservation & Recreation

conveyance of a fee interest or the granting of an easement, would require legislative approval by a 2/3 roll call vote.

DCR notes that Figure 14-2 ("Recommended Phasing Plan") appears to include a pump station and gravity force mains near the Cape Cod Rail Trail, adjacent to Great Western Road. In the EIR, DCR requests that the Proponent provide additional information on the location of this infrastructure in relation to the Cape Cod Rail Trail, and clarify whether a permanent disposition of land or an interest in land would be required from DCR. DCR also requests that the Proponent definitively identify whether a DCR Construction and Access Permit would be required for the Project, and, if so, clarify the proposed activity on DCR land which would trigger the need for such a permit.

DCR notes that transfers of interests in state conservation property must meet the requirements set forth in the Executive Office of Energy and Environmental Affairs ("EEA") Article 97 Land Disposition Policy, which has the stated goal of ensuring no net loss of Article 97 lands under the ownership and control of the Commonwealth. The policy states, as a general premise, that EEA and its agencies shall not sell, transfer or otherwise dispose of any right or interest in Article 97 lands. Transfer of ownership or interests therein may only occur under exceptional circumstances, as defined in the policy, including the determination that no feasible alternative is available, and a minimum amount of land is being disposed for the proposed use.

Thank you for the opportunity to comment on the EENF. If you have questions regarding our comments, please contact Nat Tipton, MEPA Review Coordinator at (617) 626-1341 or nathaniel.tipton@state.ma.us. Questions regarding Article 97 can be directed to Shaun Provencher at (617) 626-1376 or shaun.provencher@state.ma.us.

Sincerely,

Leo Roy
Commissioner

cc: Patrice Kish, Tom LaRosa (DCR)

Commonwealth of Massachusetts
Executive Office of Energy & Environmental Affairs

Department of Environmental Protection
Southeast Regional Office • 20 Riverside Drive, Lakeville MA 02347 • 508-946-2700

Charles D. Baker
Governor

Karyn E. Polito
Lieutenant Governor

Matthew A. Beaton
Secretary

Martin Suuberg
Commissioner

July 7, 2017

Mathew A. Beaton,
Secretary of Environment and Energy
ATTN: MEPA Office
Executive Office of Environmental Affairs
100 Cambridge Street, Suite 900
Boston, MA 02114

RE: ENF Review EOEEA #15707
15707.DENNIS. Draft Comprehensive Wastewater Plan at various streets throughout Dennis

Dear Secretary Beaton,

The Southeast Regional Office of the Department of Environmental Protection (MassDEP) has reviewed the Environmental Notification Form (ENF) for the proposed Draft Comprehensive Wastewater Plan, located at various streets throughout Dennis, Dennis, Massachusetts for the proposed (EOEEA # 15514). The Project Proponent provides the following information for the Project:

The Town is recommending a traditional wastewater program that includes: approximately 92 miles of sewer pipes, 21 pumping stations and one centralized treatment facility. Each of these components will be phased over 40 years. For this program, the treatment will occur at a new facility in Dennis. Implementing this program will allow Dennis to meet its water resource management needs as defined throughout the CWMP, including consistency with the Massachusetts Estuaries Project (MEP) nitrogen reduction goals as well as protecting freshwater resources, including ponds and drinking water resources. Section 14 of the CWMP describes the recommended program components. It also presents the wastewater phasing plan and identifies the potential cost recovery strategy being developed by the Town. Section 14 also describes the recommended non-infrastructure program components which include fertilizer and stormwater management programs, potential land use changes, and community based conservation and pollution reduction programs.

Bureau of Water Resources Comments

Wetlands and Waterways Comments: A local Order of Conditions is required from the Dennis Conservation Commission for each construction phase that proposes work within Areas Subject to Protection under M.G.L. c. 131 § 40 and buffer zones. The Project is being proposed as a limited Project under 310 CMR 10.24(7) and 310 CMR 10.53(3)(d). The EENF indicates that there are proposed alterations to Land Subject to Coastal Storm Flowage, Bordering Land Subject to Flooding and Riverfront Area. Pursuant to 310 CMR 10.58(6)(h) this Project is exempted from requirements for the Riverfront Area. Per 310 CMR 10.24(7) and 310 CMR 10.53(3)(d) in determining whether to exercise discretion to approve the limited Project, the following factors should be considered: the magnitude of the alteration and the significance of the Project site to the interests identified in M.G.L. c. 131 § 40, the availability of reasonable alternatives to the proposed activity, the extent to which adverse impacts are

minimized, and the extent to which mitigation measures, including replication or restoration, are provided to contribute to the protection of the interests identified in M.G.L. c. 131 § 40.

Wastewater Management Comments: The CWMP presents a 40 year phased plan with a primary focus on mitigating nitrogen enrichment to the Bass River, Swan Pond River, and Herring River along with Chase Garden Creek, Quivett Creek, and Sesuit Harbor watersheds.

The document represents a thorough evaluation of Dennis's needs for wastewater and nutrient management. Much of the recommended plan is driven by the findings of the Massachusetts Estuaries Project (MEP) which documented resource impairment from excess nitrogen loads in the Swan Pond, Bass River, and Herring River embayments MEP Technical Reports. MassDEP TMDL reports are available for the Swan Pond, Bass River and Herring River Embayments. The Chase Garden Creek study has recently been completed (too late for inclusion in this draft CWMP) and the Sesuit Harbor study is in progress.

MassDEP fully supports the Town of Dennis in its efforts to develop a Comprehensive Wastewater Management Plan (CWMP) that serves as a water resources management strategy to meet Total Maximum Daily Load (TMDL) requirements. Development of a CWMP is an important step toward meeting TMDL's and restoring impaired waters. Plans to meet TMDL requirements for nutrient loading must always consider source reduction as the primary means of long term nutrient control. Source reduction usually focuses on controlling watershed land use loads generated from human activity and can include but are not limited to constructing new sewer systems, eliminating fertilizers, constructing on-site systems with enhanced nutrient removal capability, reducing runoff from impervious surfaces, reducing impervious surfaces, and tightening standards for new and upgraded septic systems. In addition to source controls, successful nutrient management plans may include alternative nutrient control strategies to achieve the desired nitrogen concentrations specified in the TMDL and Massachusetts Estuary Project (MEP) reports. MassDEP is encouraged by the source controls proposed in the CWMP, and recommends that Dennis continue to evaluate and adopt additional source controls in the future to the maximum extent possible to reduce the need for alternative nutrient control strategies.

The Town developed 14 water quality management scenarios to evaluate MEP nitrogen removal requirements along with protection of freshwater ponds, and drinking water resources. The Dennis Comprehensive Wastewater Management Task Force recommended 4 scenarios for further evaluation. These scenarios include a mix of aquaculture, sewers, innovative/alternative septic system technology and permeable reactive barriers.

The recommended wastewater program for the town of Dennis includes a collection system utilizing one centralized treatment facility and two effluent recharge areas. Components would be phased in over 40 years in 8 phases. The recommended plan include a collection system, wastewater treatment, effluent recharge with a permeable reactive barrier (PRB) for about 1.7 MGD of wastewater along with aquaculture, fertilizer and stormwater management, land use changes, open space acquisition, and community conservation and pollution reduction programs. The plan includes sewering as many existing developed parcels as necessary in the Bass River and Swan River watersheds in order to meet the nitrogen removal requirements.

Wastewater flows were calculated using the MEP buildout estimates for the nitrogen loading model. The recommended treatment technology is SBR process. In the future, the SBR system may need additional denitrification to meet the TMDL for Bass River and Swan Pond embayments. Currently, the plan

recommends supplemental carbon addition and denitrification filters. Additional analysis needs to be completed to further evaluate effluent recharge. The recommended discharge sites will be fully evaluated during the permitting process.

Regional approaches
MassDEP is encouraged that the Town of Dennis has been in discussions with the neighboring towns of Harwich and Yarmouth with the potential to form a multi-town wastewater utility. MassDEP encourages this community partnership among the three towns and finds it preferable to individual arrangements between Dennis and Harwich or Dennis and Yarmouth. A tri-town partnership would be able to incorporate shared interests in Bass River (Dennis and Yarmouth) and both Swan Pond River and Herring River (Dennis and Harwich). As is evident from the CWMP, and discussed further in these comments, Dennis faces challenges by addressing wastewater issues on its own while an inter-municipal approach affords both cost savings and additional environmental benefits.

TMDL Compliance
The CWMP's recommended approach (Scenario 6A) includes a traditional single wastewater treatment facility the (with an associated collection system) located near the Dennis DPW facility with subsurface infiltration at two sites, one in the Swan Pond River watershed and one in the Bass River watershed. The recommended approach also includes non-traditional elements comprised of fertilizer reduction, stormwater BMPs, aquaculture (in Swan Pond River) and PRBs to polish effluent recharge at the infiltration beds. Preliminary loading calculations based on expected removal rates of both traditional and non-traditional strategies indicate that Dennis will meet its TMDL obligations throughout town. However, initial modeling by the Massachusetts Estuaries Project (MEP) indicated that in the Swan Pond River watershed, 100% removal of septic load was required while a 74% reduction of the total nitrogen load would meet target thresholds. Scenario 6A does not entirely eliminate septic load since there is residual nitrogen in the effluent discharge from the infiltration beds. The plan relies on with non-traditional approaches to achieve the additional removal required to meet the target nitrogen threshold. The CWMP should explicitly identify a contingency alternative to address the additional removal requirements should the performance of the non-traditional approaches fall short of expectations. This most likely would require identifying an infiltration site outside the Swan Pond River watershed.

Wastewater Infiltration
As previously mentioned, the two infiltration sites identified are in the Bass River and Swan Pond River watersheds, respectively. While final evaluation and approval will take place during the permitting process, a few issues should be mentioned for future consideration. While transient models were used in the initial evaluations, MassDEP will want to confirm that the flows used adequately reflect the maximum and minimum conditions likely to arise from operation of the treatment facility. Also, loading rates assumed in the model runs exceed those normally assigned to infiltration beds. If these higher loading rates are considered for design, then additional field loading tests will be required at the permitting stage to determine if the increased loading rates are supportable if they are desired to be part of the design.

The particle tracking for Site 1 indicates a split in flow between the Swan Pond River and Herring River watersheds. If higher loading rates are desired and can be confirmed, it may be possible to reconfigure and relocate a smaller infiltration bed to direct more flow away from the Swan Pond River watershed.

The particle tracking for Site 2 in the Bass River watershed shows an encroachment in the Zone II. During the permitting process MassDEP will determine whether this may trigger water reclamation

requirements for indirect recharge to a public water supply; however, given that the particles do not appear to encroach in a Zone of Contribution, MassDEP has the option to exercise discretion in requiring additional treatment.

Drip irrigation is an option for flows exceeding 10,000 gpd. Given that the proposed treatment works will produce high quality effluent, this option may warrant additional consideration. It has the potential to provide some additional flexibility especially if alternate sites outside of the Swan Pond River watershed need to be considered. Further discussion with MassDEP regarding this alternative is encouraged.

Buildout Analysis
The report has provided a thorough evaluation of existing and buildout conditions. However, the CWMP should acknowledge that additional evaluation may be needed for buildout assumptions depending upon how proposed zoning changes are enacted.

Alternative Treatment
The CWMP proposes the use of fertilizer reduction, stormwater BMPs, aquaculture and PRBs as non-traditional approaches. There should be further discussion of a monitoring program to evaluate the effectiveness of these strategies in meeting Project projected loading reductions for stormwater, aquaculture and PRBs. Additionally, the CWMP should develop a compliance and enforcement strategy to insure that fertilizer reduction targets are met. Finally, as mentioned previously, a contingency plan utilizing traditional approaches should be developed in the event that the non-traditional approaches not meet Projected reductions.

Phasing.
The CWMP is based on a 40 year design horizon divided in x phases. Traditionally, CWMPs have been based on 20 year horizons; however, the scope and cost of the recommended alternative requires an extended timeframe for affordability and capital planning. MassDEP believes that further discussion on the timetable is required to arrive at a mutually acceptable schedule for completion.

SRF Funding
The Town of Dennis is encouraged to work with MassDEP's State Revolving Fund (SRF) section to develop funding alternatives as Project development proceeds. The Draft CWMP clearly documents areas where nutrient enrichment needs control to improve water quality. As Projects approach the funding stage, the Town will need to show the percentage of each Project intended primarily to manage nutrients with reference to the final CWMP. Sewer regulations to be developed may need to comply with certain MassDEP and Department of Housing and Community Development requirements, depending on the funding program utilized. In particular, there is little discussion of growth neutrality in the CWMP. This item needs to be addressed if the town wishes to pursue 0% financing from the SRF.

The Massachusetts Natural Heritage and Endangered Species Program (NHESP) identified state-listed rare species in the vicinity of several Project components. During implementation of the CWMP, the Project Proponent must comply with 310 CMR 10.59, 310 CMR 10.32(6) and related performance standards for other resource areas, and 310 CMR 10.37 to ensure that there is no short or long term adverse effect on estimated habitats of rare wildlife.

Miscellaneous
On pages 14-7 and 14-8 there are some apparent miscalculations of nitrogen load. These should be reviewed and, if in error, checked to see if they have been carried through to other calculations in the report.

Conclusion. This CWMP is well crafted and presents a reasonable approach to the town's wastewater and nitrogen management challenges. The comments presented are not meant as criticisms, but rather additional avenues of exploration to further enhance the recommended plan. The town of Dennis has made an important step forward in addressing nutrient enrichment in the major embayments. MassDEP is of the opinion, however, that additional regional partnering with Yarmouth for the Bass River and Harwich for the Herring River and Swan River embayments, should be more fully explored and addressed in the EIR. MassDEP also recognizes that given the phasing, regardless of what timetable upon which the parties eventually agree, modifications to the existing plan can accommodate anticipated studies on regional alternatives.

Through the MA Water Pollution Abatement Trust, the Cape Cod Commission has completed a Section 208 Wastewater Management Plan Update pursuant to the Federal Clean Water Act. The 208 Plan Update represents a watershed-based approach to restore embayment water quality on Cape Cod that recommends strategies, regulatory reforms and a process for communities to reduce or eliminate excess nitrogen. From MassDEP's perspective, the CWMP reflects the overall goals of the 208 Plan Update. The Cape Cod Commission will make a determination of 208 consistency in conjunction with its Development of Regional Impact (DRI) review which will commence after issuance of the Secretary's Certificate.

*C*onstruction Stormwater Permit. The Project construction activities are scheduled to disturb 8.06 acres of land and therefore, may require a NPDES Stormwater Permit for Construction Activities. The Proponent can access information regarding the NPDES Stormwater requirements and an application for the Construction General Permit at the EPA website: https://www3.epa.gov/npdes/pubs/cgp2012_qanda.pdf . You are considered covered under this permit 14 calendar days after EPA has acknowledged receipt of your Notice of Intent (NOI) on the Agency's website (www.epa.gov/npdes/stormwater/cgpnoisearch), unless EPA notifies you that your authorization has been delayed or denied.

Bureau of Waste Site Cleanup Comments
Based upon the information provided, the Bureau of Waste Site Cleanup (BWSC) searched its databases for disposal sites and release notifications that have occurred at or might impact the proposed Project area. A disposal site is a location where there has been a release to the environment of oil and/or hazardous material that is regulated under M.G.L. c. 21E, and the Massachusetts Contingency Plan [MCP – 310 CMR 40.0000].

The proposed Project involves a town-wide initiative to address wastewater management needs, protect drinking water supplies, protect ponds, and restore estuaries. Please be advised that there are many listed BWSC disposal sites located in the vicinity of the proposed Project areas. Many of the sites have closed under the MCP, but many other disposal sites are open and require continued response actions under the MCP. A listing and discussion of each MCP site will not be presented here.

Interested parties may view a map showing the location of BWSC disposal sites using the MassGIS data viewer (Oliver) at: http://maps.massgis.state.ma.us/map_ol/oliver.php Under "Available Data Layers" select "Regulated Areas", and then "DEP Tier Classified 21E Sites". The compliance status and report

submittals for specific MCP disposal sites may be viewed using the BWSC Waste Sites/Reportable Release Lookup at: http://public.dep.state.ma.us/SearchableSites2/Search.aspx

The Project Proponent is advised that if oil and/or hazardous materials are identified during the implementation of this Project, notification pursuant to the Massachusetts Contingency Plan (310 CMR 40.0000) may be necessary. A Licensed Site Professional (LSP) should be retained to determine if notification is required, and render appropriate opinions as necessary. The LSP may evaluate whether risk reduction measures are necessary if contamination is present. Please contact BWSC for guidance if questions arise regarding assessment and cleanup under the MCP.

Bureau of Air and Waste Comments

Air Quality. Construction and operation activities shall not cause or contribute to a condition of air pollution due to dust, odor or noise. To determine the appropriate requirements please refer to:

310 CMR 7.09 Dust, Odor, Construction, and Demolition
310 CMR 7.10 Noise

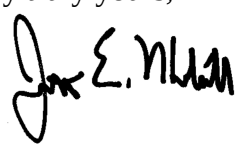
Massachusetts Idling Regulations. MassDEP requests that the Proponent state specifically in the subsequent environmental filing how it plans to prohibit the excessive idling during the construction period. Typical methods of reducing idling include driver training, periodic inspections by site supervisors, and posting signage. In addition, to ensure compliance with this regulation once the Project is occupied, MassDEP requests that the Proponent establish permanent signage limiting idling to five minutes or less at the completed Project.

Proposed s.61 Findings

The "Certificate of the Secretary of Energy and Environmental Affairs on the Draft Environmental Impact Report (DEIR) may indicate that this Project requires further MEPA review and the preparation of a Final Environmental Impact Report (FEIR). Pursuant to MEPA Regulations 301 4
CMR 11.12(5)(d), the Proponent will prepare Proposed Section 61 Findings to be included in the EIR in a separate chapter updating and summarizing proposed mitigation measures. In accordance with 301 CMR 11.07(6)(k), this chapter should also include separate updated draft Section 61 Findings for each State agency that will issue permits for the Project. The draft Section 61 Findings should contain clear commitments to implement mitigation measures, estimate the individual costs of each proposed measure, identify the parties responsible for implementation, and contain a schedule for implementation.

The MassDEP Southeast Regional Office appreciates the opportunity to comment on this proposed Project. If you have any questions regarding these comments, please contact George Zoto at (508) 946-2820.

Very truly yours,



Jonathan E. Hobill,
Regional Engineer,
Bureau of Water Resources

JH/GZ

Cc: DEP/SERO

ATTN: Millie Garcia-Serrano, Regional Director
David Johnston, Deputy Regional Director, BWR
Maria Pinaud, Deputy Regional Director, BAW
Gerard Martin, Deputy Regional Director, BWSC
Jennifer Viveiros, Deputy Regional Director, ADMIN
Allen Hemberger, Site Management/BWSC
Brian Dudley, Chief, Wastewater/BWR
Kermit Studley, Drinking Water/BWR

Strysky, Alexander (EEA)

From: Logan, John (FWE)
Sent: Thursday, July 06, 2017 11:03 AM
To: Strysky, Alexander (EEA)
Cc: Potti, Pooja (FWE)
Subject: Dennis Draft Comprehensive Wastewater Management Plan, EEA#15707

Secretary Matthew A. Beaton
Executive Office of Energy and Environmental Affairs (EEA)
Attn: MEPA Office
Alex Strysky, EEA No. 15707
100 Cambridge Street, Suite 900
Boston, MA 02114

Dear Secretary Beaton:

The Division of Marine Fisheries (MarineFisheries) has reviewed the Expanded Environmental Notification Form (EENF) and Draft Comprehensive Wastewater Management Plan (CWMP) by the Town of Dennis. The project was reviewed with respect to potential impacts to marine fisheries resources and habitat. The plan affects several estuaries and embayments along Nantucket Sound. The identified preferred alternative (Scenario 6A) relies primarily on expanded sewering with tie-in to a centralized wastewater treatment plant. Additional measures towards nitrogen remediation included in Scenario 6A consist of the installation of permeable reactive barriers at the proposed recharge sites, fertilizer education, stormwater best management practices, and an oyster aquaculture pilot study in Swan Pond.

The proposed oyster aquaculture component of the preferred alternative should follow the MarineFisheries Shellfish Planting Guidelines (Hickey et al. 2015). Based on the information provided, MarineFisheries has no further recommendation for sequencing, timing, or methods that would avoid or minimize impact at this time.

Questions regarding this review may be directed to John Logan in our New Bedford office at (508) 990-2860 ext. 141.

References

Hickey JM, Shields T, Kennedy J, Ford K (2015) Shellfish planting guidelines. Massachusetts Division of Marine Fisheries. 3rd Edition. March 2015. http://www.mass.gov/eea/docs/dfg/dmf/programsandprojects/shellfish-planting-guidelines.pdf.

John Logan, Ph.D.
MA Division of Marine Fisheries
1213 Purchase Street
New Bedford, MA 02740
(508) 990-2860 x141
http://www.mass.gov/eea/agencies/dfg/dmf/
https://www.researchgate.net/profile/John_Logan

Charles D. Baker, Governor
Karyn E. Polito, Lieutenant Governor
Stephanie Pollack, MassDOT Secretary & CEO

massDOT
Massachusetts Department of Transportation

June 30, 2017

Matthew Beaton, Secretary
Executive Office of Energy and Environmental Affairs
100 Cambridge Street, Suite 900
Boston, MA 02114-2150

RE: Dennis: Draft Comprehensive Wastewater Management Plan – EENF
(EEA #15707)

ATTN: MEPA Unit
Alex Strysky

Dear Secretary Beaton:

On behalf of the Massachusetts Department of Transportation, I am submitting comments regarding the Draft Comprehensive Wastewater Management Plan in Dennis, as prepared by the Office of Transportation Planning. If you have any questions regarding these comments, please contact J. Lionel Lucien, P.E., Manager of the Public/Private Development Unit, at (857) 368-8862.

Sincerely,

David J. Mohler
Executive Director
Office of Transportation Planning

DJM/jll

Ten Park Plaza, Suite 4150, Boston, MA 02116
Tel: 857-368-4636, TTY: 857-368-0655
www.mass.gov/massdot

cc: Jonathan Gulliver, Acting Administrator, Highway Division
Patricia Leavenworth, P.E., Chief Engineer, Highway Division
Mary-Joe Perry, District 5 Highway Director
Neil Boudreau, State Traffic Engineer
Town of Dennis, Planning Department
Cape Cod Regional Transit Authority (CCRTA)
PPDU Files

Charles D. Baker, Governor
Karyn E. Polito, Lieutenant Governor
Stephanie Pollack, MassDOT Secretary & CEO

massDOT
Massachusetts Department of Transportation

MEMORANDUM

TO: David J. Mohler, Executive Director
Office of Transportation Planning

FROM: J. Lionel Lucien, P.E., Manager
Public/Private Development Unit

DATE: June 30, 2017

RE: Dennis: Draft Comprehensive Wastewater Management Plan – EENF
(EEA #15707)

The Public/Private Development Unit (PPDU) has reviewed the Expanded Environmental Notification Form (EENF) for the Draft Comprehensive Wastewater Management Plan in Dennis. The plan involves work around the community to install 92 miles of sewer pipes, 21 pumping stations, and one centralized treatment facility. Each of these components will be phased over 40 years.

The collection system (sewer main) will include Route 28, a state-owned highway, and therefore will require an Access Permit from MassDOT. Appendix C of the draft plan contains a letter to MassDOT requesting the widening of the Route 6 eastbound and westbound bridges, and the rail bridge over the Bass River, in order to remove flow restrictions and restore the water quality of the river. This effort will also require a MassDOT Access Permit. The widening of the rail bridge is currently incorporated in the Dennis-Yarmouth Cape Cod Rail Trail extension project advertised in 2014.

MassDOT recommends that no further environmental review be required based on transportation issues. The details of the above and any other access-related issues can be addressed during the permitting process for the project. If you have any questions regarding these comments, please contact me at (857) 368-8862 or Michael Clark at (857) 368-8867.

Ten Park Plaza, Suite 4150, Boston, MA 02116
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Jack Buckley, *Director*

July 5, 2017

Matthew A. Beaton, Secretary
Executive Office of Energy and Environmental Affairs
Attention: MEPA Office
Erin Flaherty, EEA No. 15701
100 Cambridge St.
Boston, Massachusetts 02114

Project Name: *Draft Comprehensive Wastewater Management Plan (CWMP)*
Proponent: *Town of Dennis, Elizabeth Sullivan, Town Administrator*
Location: *Throughout Dennis*
Project Description: *Comprehensive Wastewater Management Plan*
Document Reviewed: *Expanded Environmental Notification Form*
EEA File Number: *15707*
NHESP Tracking No.: *17-35943*

Dear Secretary Beaton:

The Natural Heritage & Endangered Species Program of the Massachusetts Division of Fisheries & Wildlife (the Division) has reviewed the *Expanded Environmental Notification Form* (EENF) for the proposed Town of Dennis Draft Comprehensive Wastewater Management plan (CWMP), Dennis, MA and would like to offer the following comments.

Portions of the Town of Dennis are mapped as *Priority and Estimated Habitat* for state-listed species, which are protected pursuant to the Massachusetts Endangered Species Act (M.G.L c. 131A) and its implementing regulations (MESA, 321 CMR 10.00) as well as the Massachusetts Wetlands Protection Act and its implementing regulations (WPA, 310 CMR 10.37, 10.58(4)(b) and 10.59). The estuarine waters, bays, ponds, streams and lakes of Dennis provide critical habitat for a suite of state-listed species. Improvements in water quality within these habitats will likely benefit residents and wildlife alike. The Division recognizes the Proponent's efforts to develop this plan and improve water quality.

Those projects that will occur within *Priority and Estimated Habitat* for state-listed species, which are not otherwise exempt from MESA review pursuant to 321 CMR 10.14, require a direct filing with the Division for compliance with the Massachusetts Endangered Species Act (MESA 321 CMR 10.00). According to Section 12 of the EENF, many of the scenarios recommended for further study may require review with the Division pursuant to the MESA and therefore the Proponent should consult with the Division as plans are developed. The Division notes that sewer systems within ten (10) feet of the edge of existing paved roads may be exempt from MESA review, please see 321 CMR 10.14(10).

The Division will not render a final decision until the MEPA review process and associated public and agency comment period is completed, and until all required MESA filing materials are submitted by the proponent to the Division. As our MESA review is not complete, no alteration to the soil, surface, or

vegetation and no work associated with the proposed project shall occur on the property until the Division has made a final determination.

If you have any questions about this letter, please contact Amy Hoenig, Endangered Species Review Biologist, at (508) 389-6364 or Amy.Hoenig@state.ma.us. We appreciate the opportunity to comment on this project.

Sincerely,

Thomas W. French

Thomas W. French, Ph.D.
Assistant Director

cc: Magdelena Lofstedt, CDM Smith, Inc
Dennis Board of Selectmen
Dennis Conservation Commission
Dennis Planning Department
DEP Southeast Regional Office, MEPA

Appendix I

Nitrogen Balance MEP Data Disk Spreadsheets

(Spreadsheets to be provided upon request, contact Michaela Bogosh at bogoshml@cdmsmith.com)

Appendix J

Public Archaeology Laboratory, Technical Memorandum: Dennis CWMP Wastewater Treatment Site 1 Dennis, Massachusetts Cultural Resource Due Diligence Review and Archaeological Sensitivity Assessment, November 9, 2017

Public Archaeology Laboratory, Public Archaeology Laboratory, Technical Memorandum: Dennis CWMP Project Phase 1 Pump Stations Dennis, Massachusetts Cultural Resource Due Diligence Review and Archaeological Sensitivity Assessment, July 2019

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Public Archaeology Laboratory

Technical Memorandum
Dennis CWMP
Wastewater Treatment Site 1
Dennis, Massachusetts

Cultural Resources Due Diligence Review
and
Archaeological Sensitivity Assessment

November 9, 2017
PAL No. 3418

Submitted to:

CDM Smith
73 State Street, Suite 701
Boston, Massachusetts 02109

PAL has completed a cultural resources due diligence review and archaeological sensitivity assessment as part of a phased Comprehensive Wastewater Management Plan (CWMP; the Project) under contract with CDM Smith on behalf of the Town of Dennis (the Town). The proposed Project involves the phased construction of sewer mains, treatment sites, pump stations, vacuum stations, and other infrastructure throughout the Town. The final design and the locations for the new infrastructure have not been determined, however the general locations of proposed impacts are known (Figure 1). The wastewater treatment site that is currently being considered (Site 1) is a 72-acre parcel owned by the Town, and it contains two facilities proposed for construction (Figure 2: the 5.9-acre Treatment Plant and the 7.2-acre Effluent Recharge Site). Final placement of the two facilities and associated access routes are still to be determined.

The Massachusetts Historical Commission (MHC) reviewed a Project Notification Form (PNF) for the Project and requested that proposed Project impacts are planned for areas that may have minimal previous ground disturbance and be archaeologically sensitive (MHC letter to the Town dated April 6, 2017). CDM Smith, on behalf of the Town, expects to file future PNFs as specific Project elements are identified.

The goal of the cultural resources due diligence review and archaeological sensitivity assessment was to collect information about previously identified historic architectural and archaeological resources; to document existing conditions within Site 1; and to identify areas within the Site 1 parcel that have the potential to contain archaeological sites. The assessment also includes the recommendations for and the scope of additional archaeological investigations at the intensive (locational) survey level. The survey will be designed to address MHC review and comment on the phased Project, and to provide information necessary to facilitate Project review under Section 106 of the National Historic Preservation Act of 1966, as amended (36 CFR 800) and M.G.L. Chapter 9, Sections 26-27c (950 CMR 70–71).

Methods and Results of the Cultural Resources Due Diligence Review

Previously identified historic architecture and archaeological resources were located through a search of the MHC's Inventory of the Historic and Archaeological Assets of the Commonwealth through the Massachusetts Cultural Resource Information System (MACRIS). The study area established for the purposes of the due diligence review were broadly defined to provide information about the types of resources known and expected to be located within the vicinity of the Project.

No previously identified cultural resources have been identified within the Site 1 parcel. The South Dennis Historic District (MHC# DEN.E) is approximately 0.7 mile west and southwest of the Site 1 parcel. Depot Street, a historic architectural inventory area in North Harwich (MHC# HRW.H), is 0.4 mile east and southeast of the eastern edge of the Site 1 parcel, and dozens of pre-contact and post-contact archaeological sites have been identified along Bass River approximately 1 mile to the southwest and along a transmission line and among the many ponds to the south, east, and north, within 1.5 miles of Site 1. The location of the historic district, each recorded site, and the surveys are depicted on Figure 3 with the corresponding MHC inventory number.

The South Dennis Historic District (MHC# DEN.E) was historically known as "The Sea Captain's Village" since the homes in the area were built by prosperous nineteenth-century sea captains. The historic district is significant at the local level for being "evocative of a quintessential new England Village"; it contains historic structures such as Liberty Hall and the adjoining village green; the "gingerbread" South Dennis Free Public Library; the Toll House at Bass River Upper Bridge; the Ancient Burial Ground behind Dennis Town Offices; the Indian Lands Conservation Area; the Fresh Pond Conservation Area; and the Meeting House of The Congregational Church of South Dennis, also known as "The Sea Captain's Church," with the adjoining historic South Dennis Cemetery (South Dennis Historic District Commission 2010). The historic district extends from Route 6 south to Old Main Street and Route 28 and from the Bass River east to Fresh Pond and Route 134 (see Figure 3).

The North Harwich historic architectural inventory area on Depot Street (MHC# HRW.H) is a nineteenth- and early twentieth-century village that contains several agricultural, commercial, residential, and recreational buildings. The village extends from the Brewster town line in the north to the wetlands south of Great Western Road and from the Dennis town line in the west to Pleasant Lake Avenue (MHC 1993; see Figure 3).

The previously identified pre-contact archaeological sites (e.g., 19-BN-32) are villages, burials, shell middens, habitation sites, flake scatters, and workshops that date to the Paleoindian, Archaic, Woodland, and/or Contact Periods. The village sites (19-BN-562 and 19-BN-563) were recorded on either side of the Bass River based on information provided by avocational collectors, and 19-BN-562, the only site within 1.5 miles of Site 1 to contain burials had been destroyed at the time its site form was recorded with the MHC (1984). Post-contact archaeological sites (e.g., HRW.12 and HRW.19) include eighteenth- through twentieth-century residences or agricultural buildings (MACRIS 2017; see Figure 3).

One professional archaeological survey (Raber and Loparto 1983) has been conducted within 0.5 mile of the Dennis CWMP Project; the archaeological intensive survey did not identify any cultural resources (see Figure 3: RPTNO:481).

Methods and Results of the Archaeological Sensitivity Assessment of Site 1

Site 1 of the Dennis CWMP Project was ranked according to the potential for the presence of archaeological resources based on information collected during the archival research and walkover survey. Table 1 is a summary of the factors used to develop the archaeological sensitivity rankings. Historic maps (Deyo 1890; Walker 1880) and PAL's 2005 archaeological reconnaissance survey report (Herbster 2005) was also consulted as part of the file review to identify general areas of predicted archaeological sensitivity, environmental settings, and historic/cultural patterns of land use in the Site 1 parcel (see Figure 3: RPTNO:2621).

Table 1. Archaeological Sensitivity Ranking.

Presence of Sites		Proximity to Favorable Cultural/ Environmental Characteristics			Degree of Disturbance			Sensitivity Ranking
Known	Unknown	< 150 m	≥ 150 ≤ 500 m	> 500 m	None/ Minimal	Moderate	Extensive	
•		•			•			High
•		•				•		High
•		•					•	Low
•			•		•			High
•			•			•		High
•			•				•	Low
•				•	•			High
•				•		•		High
•				•			•	Low
	•	•			•			High
	•	•				•		Moderate
	•	•					•	Low
	•		•		•			Moderate
	•		•			•		Moderate
	•		•				•	Low
	•			•	•			Moderate
	•			•		•		Low
	•			•			•	Low

A walkover/driveover survey of the entire Site 1 parcel was conducted by PAL principal investigator Jenifer Elam to examine and document the existing physical conditions of Site 1, to assess the integrity of the ground surface, to collect data about the current environmental setting, and to look for any surface indications of archaeological sites. A combination of variables affecting archaeological sensitivity, such as evidence of prior ground disturbance or the presence of favorable environmental attributes, was noted throughout the Site 1 parcel (see Table 1). The information collected during the walkover/driveover survey was used to refine the sensitivity assessment of Site 1 and to stratify the Project impact areas into zones of high, moderate, or low archaeological

sensitivity (Figure 4). No surface indications of pre-contact or post-contact sites were observed within the Site 1 parcel.

Site 1 is in the south-central portion of the Town of Dennis, 0.3 mile south of Route 6. The northeast edge of the Site 1 parcel follows the Dennis/Harwich town line. The Site 1 parcel is approximately 1 mile northeast of Bass River, 100 m south of Eagle Pond, and approximately 0.5 mile north of Swan Pond (see Figure 1). The southern edge of the Site 1 parcel is 0.2 mile north of Great Western Road and the center of the southern Site 1 boundary passes through a gravel pit (see Figure 2). The western boundary of Site 1 is 130 m east of South Gates Way and passes through the Town's Department of Public Works' (DPW) solid waste and recycling transfer station (see Figure 2).

The majority of the western half of Site 1 has been previously disturbed by construction and leveling conducted to create the DPW headquarters east of Duck Pond Road and the DPW solid waste yard. The DPW headquarters covers the southwest quadrant of the Site 1 parcel and the yard area comprises the remainder of the western half of the parcel. The yard area has been leveled and compacted from the passage of large vehicles and trucks over the many gravel roads that criss-cross the yard and enable the dumping and/or stock-piling of compost, large granite boulders, gravel, and woody detritus, etc. (Photos 1 and 2). The south center of the parcel appears to have been formerly disturbed from either DPW or gravel pit activities (see Figures 2 and 4)

Within the northwest quadrant of the parcel is a prominent landform in what is essentially the middle of the DPW yard. It is a round raised and forested landform with a kettle pond in the middle (Photos 3 and 4). The forested ring surrounding the pond is of a similar elevation and contains similar vegetation as the undeveloped forest to the north of the Site 1 parcel suggesting the surrounding yard area has been excavated and leveled leaving this narrow ring of intact forest surrounding the pond. The outer edge of the ring is sloping, contains different vegetation than the interior of the ring, and is likely the result of shoring-up a buffer to hold the pond and its surrounding landform in place.

The majority of the eastern half of the parcel is comprised of forested rolling hills and terraces interspersed with low-ling areas and hiking trails (Photos 5 and 6); one small kettle pond is in the southeast quadrant of the parcel. The sourtheastern-most edges of parcel appear to have been disturbed from gravel pit activities, an unimproved two-track road parallels the eastern edge of the parcel, and a modern household dump was observed in the disturbed portion of the southeast corner of the parcel, but otherwise the forest appears to be undisturbed. Soils within the undisturbed portions of the forest are excessively drained Carver coarse sand with 0–15% slopes (United States Department of Agriculture-Natural Resources Conservation Service [USDA-NRCS] 2017).

Conclusions and Recommendations

The results of the cultural resources due diligence review indicate that no cultural resources have been previously recorded within the Site 1 parcel; however, pre-contact Native American and post-contact Euro-American archaeological resources have been recorded in proximity to Site 1 along Bass River to the west and scattered to the south, east, and north of Site 1. Site 1 is also between South Dennis Historic District (MHC# DEN.E) to the west and North Harwich village on Depot Street (MHC# HRW.H) to the east.

Photograph 1. Stock-piles of compost in the north-center of Site 1 in the proposed location for the Treatment Plant, Dennis CWMP, view northeast (PAL 2017).

Photograph 2. Forest within the northeastern edge of the proposed location for the Treatment Plant, Site 1, Dennis CWMP, view northwest (PAL 2017).

Photograph 3. Northwest quadrant of Site 1 with the kettle pond landform in the center background, Dennis CWMP, view northwest (PAL 2017).

Photograph 4. Interior of the kettle pond landform in the DPW solid waste and recycling yard, Site 1, Dennis CWMP, view west (PAL 2017).

Photograph 5. Forest within the proposed location for the Effluent Recharge Site, Site 1, Dennis CWMP, view north (PAL 2017).

Photograph 6. Hiking trail within the forested eastern half of Site 1, Dennis CWMP, view east (PAL 2017).

The majority of the western half of the Site 1 parcel has been previously disturbed and was assigned low sensitivity; this area has little to no potential to contain significant cultural resources. The one area of exception is the elevated, narrow ring of land with the small kettle pond in the middle of the DPW yard. The narrow ring (2.82 acres) surrounding the kettle pond was assessed as having high/moderate sensitivity for significant cultural resources. Kettle ponds are found throughout the Cape and are popular locations for pre-contact (fresh water sources) and post-contact (swimming holes) activities. Kettle ponds formed when remnant blocks of ice, left behind when the glaciers retreated, melted after having been completely or partially buried by outwash deposits. Once melted, the outwash deposits slumped in, creating depressions deep enough for water-table-formed, fresh water ponds (Herbster 2005).

PAL assessed the forested eastern half of the parcel (29.96 acres) as having a high/moderate sensitivity for cultural resources. Expected resources include pre-contact Native American camps or workshops, which may yield stone tool manufacture or maintenance debitage, stone tools, and/or cultural features such as fire pits, and post-contact sheet refuse, which may include ceramics, bottle glass, and/or architectural debris such as nails or window glass.

PAL recommends that no additional archaeological investigations are necessary for areas of low archaeological sensitivity (unshaded areas) as depicted on Figure 4. PAL recommends that an intensive (locational) archaeological survey (identification survey) be conducted for areas of high/moderate archaeological sensitivity (shaded areas totaling 32.78 acres) as depicted on Figure 4 to identify any potentially significant archaeological resources.

The results of this sensitivity assessment can be used by the Town and its consultants to facilitate ongoing consultation with the MHC as Project plans are finalized and construction plans are implemented. The intensive survey will address MHC's comments in their letter of April 6, 2017, specifically for this Site 1 parcel.

References Cited

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Walker, George H., & Co.
1880 Town of Dennis, Massachusetts. *Atlas of Barnstable County, Massachusetts*. Boston, MA.

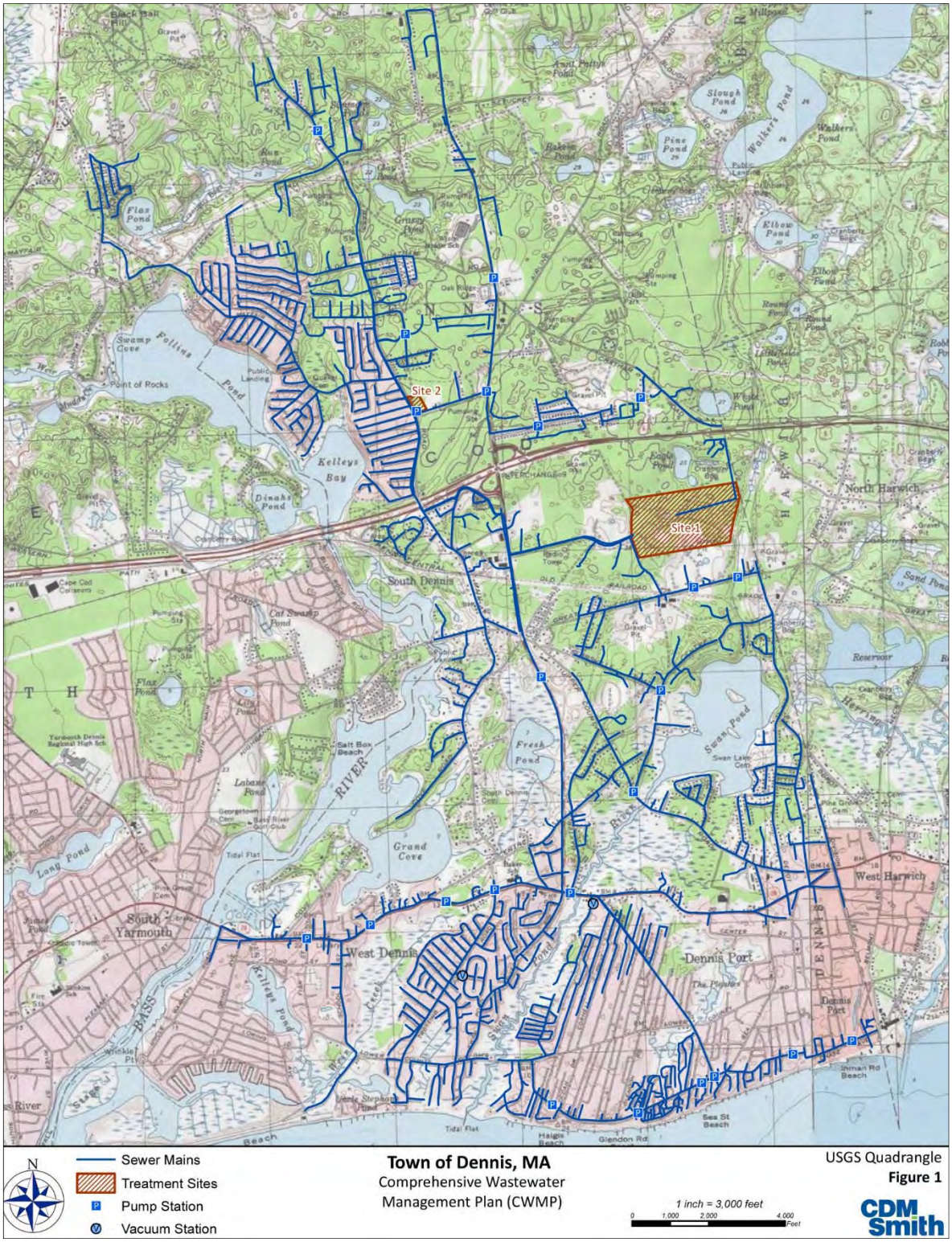

Figure 1. Proposed project plans for the Dennis CWMP on the Dennis, Massachusetts USGS topographic quadrangle (source: USGS 1974).

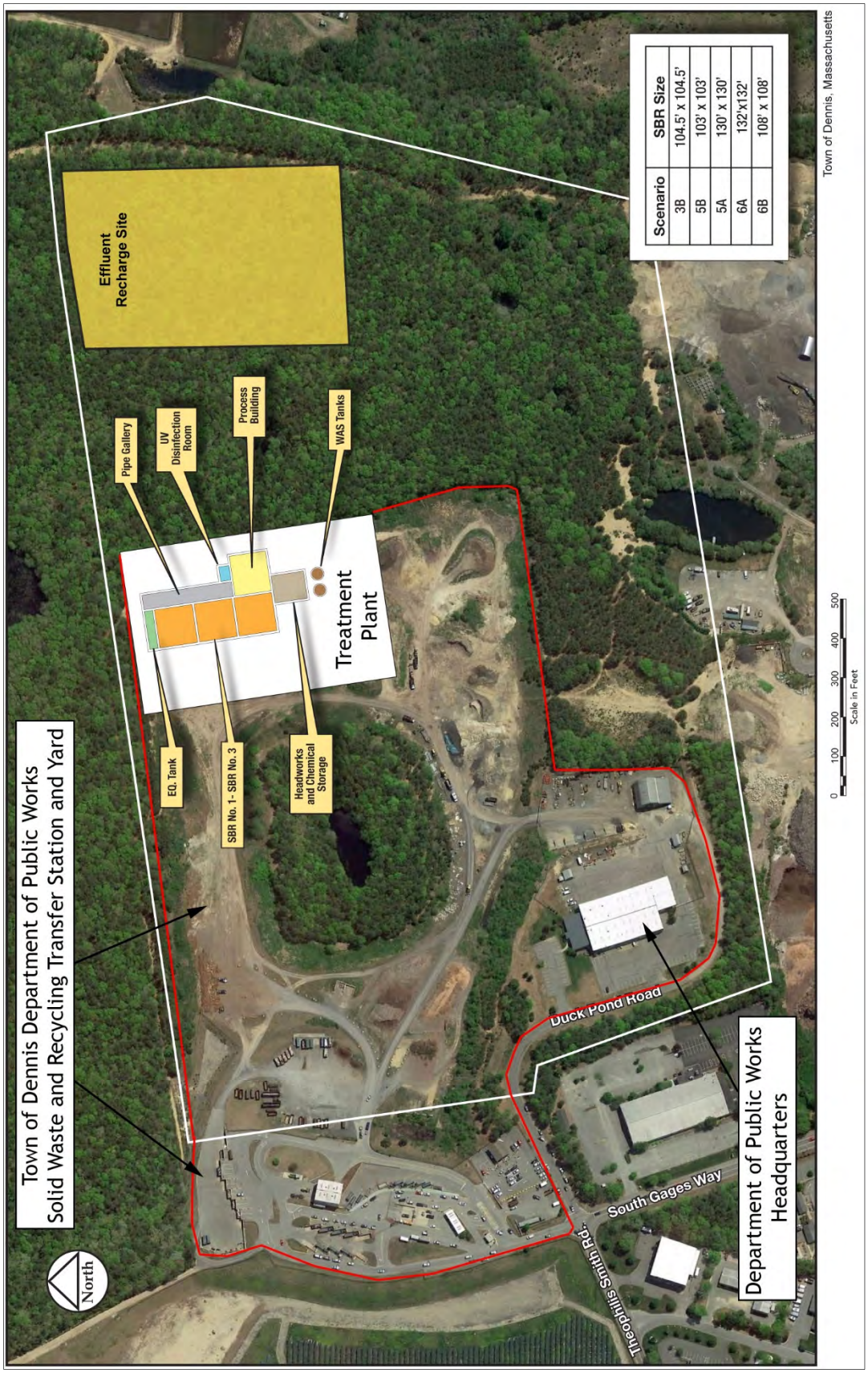

Figure 2. Aerial map of Site 1 showing the proposed locations for the Treatment Plant and the Effluent Recharge Site, Dennis CWMP.

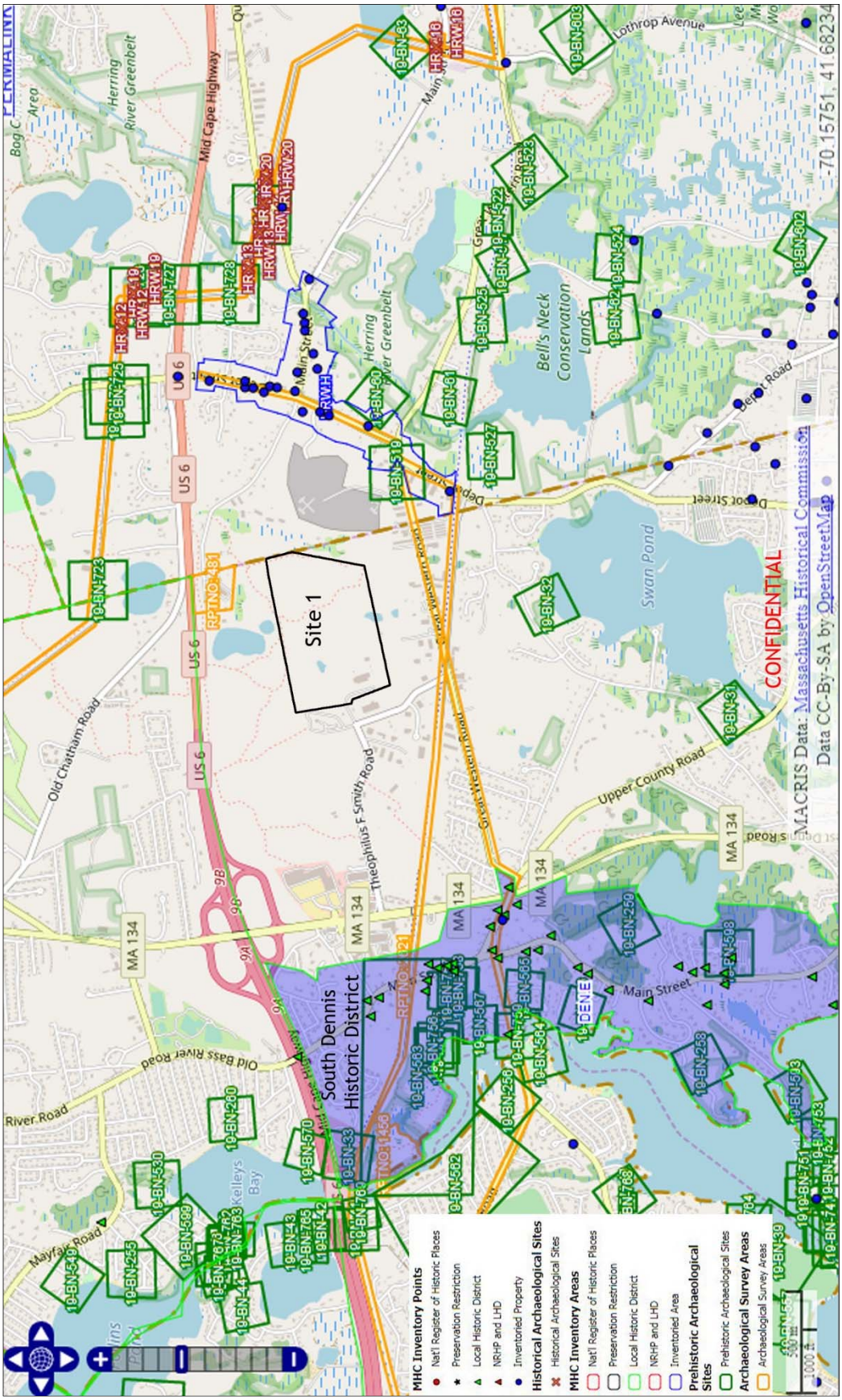

Figure 3. Previously identified and inventoried historic architectural and archaeological resources near the Site 1 parcel, Dennis CWMP.

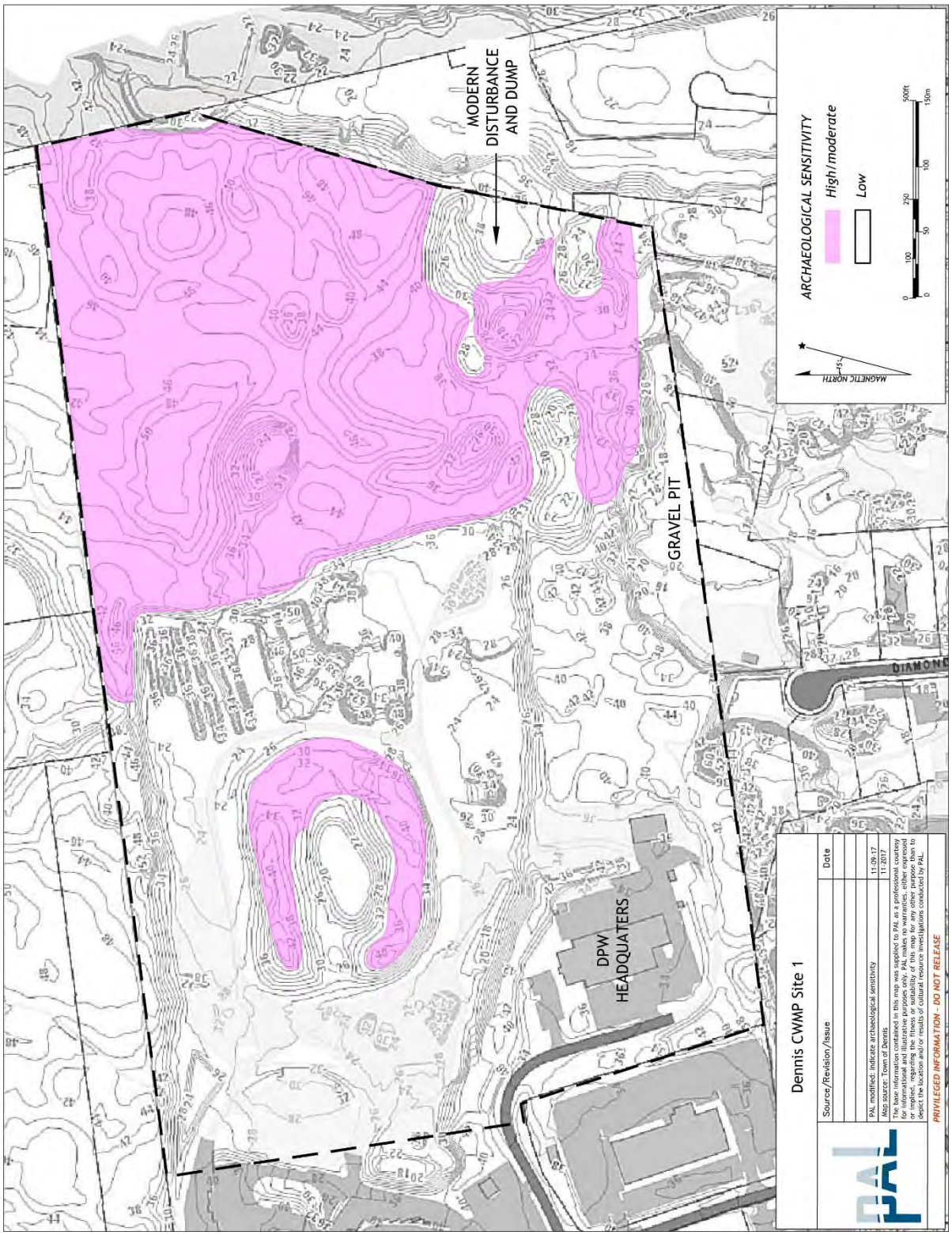

Figure 4. Archaeological sensitivity within Site 1 with high/moderate sensitivity areas proposed for archaeological intensive (locational) survey, Dennis CWMP.

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Public Archaeology Laboratory

Technical Memorandum
Dennis CWMP Project
Phase 1 Pump Stations
Dennis, Massachusetts

Due Diligence and
Archaeological Sensitivity Assessment

July 2019

Submitted to:

CDM Smith, Inc.
73 State Street, Suite 701
Boston, Massachusetts 02109

The Public Archaeology Laboratory, Inc. (PAL) has completed an archaeological sensitivity assessment as part of the proposed Comprehensive Wastewater Management Plan (CWMP) for the Town of Dennis, Massachusetts, under contract to CDM Smith, Inc. (CDM Smith). The proposed CWMP Project will involve the phased construction of sewer mains, a treatment facility, pump stations, vacuum stations, and other infrastructure throughout the Town. For Phase 1 for the Project, construction is being planned for 7 of the 21 proposed pump stations, each of which will conservatively have a 50-x-50-foot impact area (Figure 1).

The Massachusetts Historical Commission (MHC) reviewed information on the CWMP Project, including a Project Notification Form, and requested that an archaeological sensitivity assessment be conducted for all of the Project phases (MHC letter to the Town of Dennis dated April 6, 2017). The MHC noted that the proposed Project facilities, inclusive of the pump stations, are within and adjacent to multiple historic and archaeological resources contained in the *Inventory of Historic and Archaeological Assets of the Commonwealth* (MHC Inventory), and that undisturbed portions of the proposed Project impact areas may be sensitive for archaeological resources. The completion of an archaeological sensitivity assessment for the pump stations will serve to facilitate ongoing review of the Project and provide the MHC will all pertinent information regarding the pump station sites prior to the submittal of an application for a State Archaeologist's Permit for any subsequent archaeological survey and/or monitoring. This due diligence fulfills the request of MHC for advancing the Draft CWMP to final status. Should locations require additional investigation prior to final design those intensive surveys will be conducted at that time.

The goal of the archaeological sensitivity assessment was to collect updated information about previously-identified archaeological resources in the vicinity of the seven proposed pump station sites, document previous disturbance and existing conditions at the pump station sites, and assess archaeological sensitivity. CDM Smith is also considering alternate locations for three of the seven pump stations; PAL included these proposed alternate locations in the assessment (see Figure 1). In addition, the assessment includes recommendations on the need for and scope of additional archaeological investigations for the proposed pump stations. The survey was designed to address MHC review and comments on the phased CWMP Project, and to provide information necessary to facilitate Project review under Section 106 of the National Historic Preservation Act of 1966, as amended (54 USC 306108), and Massachusetts General Laws Chapter 9, Sections 26-27c (950 CMR 70-71).

Information on previously-identified archaeological sites and aboveground historic resources in the vicinity of the seven proposed pump station sites and the three proposed alternate locations was gathered through a search of the MHC Inventory and the *Massachusetts Cultural Resource Information System* (MACRIS). For the purposes of the identification effort, the study area for each proposed pump station site was broadly defined to provide information about the types of resources known and expected to be located within their vicinities. For archaeological resources, the study area extended one-half mile around each proposed location. For aboveground resources, the study area extended one-quarter mile around each proposed location.

Results of Inventory File and Background Research Review

The study area contains 43 aboveground resources and 27 archaeological sites (Figure 2; Appendices A and B). Of these, only the West Dennis Graded School (DEN.283) is currently listed in the National Register of Historic Places (National Register). None of the previously-identified resources in the study area fall within the impact areas at the proposed pump station locations.

Aboveground Resources

Inventoried aboveground resources in the study area consist of 40 buildings, 2 historic areas, and 1 burial ground (see Appendix A). The two historic areas are the South Dennis Historic District (DEN.E) and the West Dennis – Jericho historic area (DEN.C). The South Dennis Historic District is a Local Historic District that is also listed in the State Register of Historic Places. It encompasses the part of Dennis that was the town center in the eighteenth and nineteenth centuries and contains civic and residential buildings associated with those periods; 18 of the 40 historic buildings within the study area are contributing resources to the district. The West Dennis – Jericho area is within the South Dennis Historic District and represents the part of town formerly known as "Jericho;" it contains several surviving nineteenth-century homes that were in the historic town center.

The majority of the aboveground resources are historic residences that were constructed during the nineteenth century, with a few exceptions. The most notable exception is the Daniel Baker House (DEN.300), which was originally built by Daniel Baker in 1680 and expanded on by subsequent owners in the eighteenth and nineteenth centuries. The house was bought by the town in 1931 and moved to its present location prior to the construction of the Ezra H. Baker School (DEN.237). It is one of four inventoried aboveground resources in Dennis that date to the seventeenth century and is the only surviving historic building in town whose original construction predates 1700 (Derick 1969).

The National Register-listed West Dennis Graded School was constructed in 1867 to serve as the graded school for the village of West Dennis. The new graded school was part of an initiative to reorganize and modernize the schools within the town. Dennis had previously contained fourteen small district schoolhouses, and the new graded schools in each village were larger buildings that could not only accommodate all the children in the village but also allowed them to be divided in classes based on age and achievement. The building later became the Dennis Community Center in the mid-twentieth century, after the graded schools were replaced by the Ezra Baker Elementary School (Jenkins et al. 2000).

The only burial ground captured by the study area is the West Dennis Cemetery (DEN.802), also known as the Crowell Family Burying Ground. The cemetery was first established by the Crowell

family in 1833 at the intersection of Fisk and Pond streets and served as their family burial ground. It became a parish cemetery in 1857, and most of the interments within the cemetery occurred between that date and the end of the nineteenth century. It is currently still in use and contains more than 500 individuals (Goheen 2001). In 2001, the MHC determined that the cemetery was individually eligible for listing in the National Register under Criteria A and C due to its association with the early settlers of Dennis, many of whom are interred within, and the local stone cutting trade, which produced the cemetery's headstones and monuments in the nineteenth century.

Archaeological Sites

The identified archaeological sites in the study area are all pre-contact sites and include village sites, shell middens, lithic scatters, and isolated find spots (see Appendix B). Almost all of these sites were identified within the Town of Dennis, although the study area also captures the Bass River Golf Club Site (19-BN-39) in Yarmouth. Thirteen of the sites in the study area were identified through surface collection and, in some cases, limited excavation by avocational collectors and members of the Massachusetts Archaeological Society (MAS). Some of these sites are known only by their general locations, as the collectors who identified them could not recall their precise locations or what materials in their collections were associated with them. The ones that have more information available consist of three shell midden sites identified along the Bass River (19-BN-257, 19-BN-258, and 19-BN-259) and two village sites: the Nickerson/Bush Site (19-BN-563) and the Bass River Golf Club Site.

The Nickerson/Bush Site is a multi-component village site on the Bass River that was repeatedly inhabited by Native American groups from the Middle Archaic Period (8000 to 6000 B.P.) to the Contact Period (A.D. 1500 to 1620). Collection and excavation at the site has yielded diagnostic projectile points such as Neville, Brewerton, Small Stemmed, Orient Fishtail, Rossville, and Fox Creek points; bifaces; a pestle; an abrading stone; steatite bowl fragments; a bone bead; Native American pottery; and chipping debris (Mahlstedt 1985). The Bass River Golf Club Site is a similar village site situated on the west side of the Bass River, to the south of the Nickerson/Bush Site. It was identified at the eastern end of the Bass River Golf Course, on the opposite side of the river from the inlet to Grand Cove. Artifact collection at the site yielded Woodland Period artifacts.

The remaining 14 archaeological sites in the study area were all identified in 1995 by Mark Horvath and Steve Grelis, who conducted a walkover survey along the Bass River on behalf of the Dennis Historic Commission. The two men documented 11 shell middens that were visible eroding from the shoreface along the river, and surface collected a projectile point and chipping debris from three other locations. They filed the information on the sites they collected with the MHC but did not produce a technical report on their work.

To date, the only professional cultural resource management investigation conducted in proximity to the pump station locations was an intensive (locational) archaeological survey completed by PAL in 2005 for a road reconstruction project. PAL's survey involved the excavation of 35, 50-x-50-centimeter test pits in archaeologically sensitive areas along Swan River Road, near the proposed location of Pump Station 5. The test pits encountered fill deposits overlaying natural soils but did not yield any cultural materials (Herbster and Millard 2005).

Archaeological Sensitivity Assessment

Archaeological sensitivity is the potential for a given area to contain archaeological sites. The proposed pump station locations were ranked according to the potential for the presence of archaeological resources based on the information collected during the archival research and a walkover survey. The factors considered in the development of the sensitivity rankings are summarized in Table 1.

Table 1. Archaeological Sensitivity Rankings.

Presence of Sites		Proximity to Favorable Cultural/ Environmental Characteristics			Degree of Disturbance			Sensitivity Ranking
Known	Unknown	< 150 m	≥ 150 ≤ 500 m	> 500 m	None/Minimal	Moderate	Extensive	
•		•			•			High
•		•				•		High
•		•					•	Low
•			•		•			High
•			•			•		High
•			•				•	Low
•				•	•			High
•				•		•		High
•				•			•	Low
	•	•			•			High
	•	•				•		Moderate
	•	•					•	Low
	•		•		•			Moderate
	•		•			•		Moderate
	•		•				•	Low
	•			•	•			Moderate
	•			•		•		Low
	•			•			•	Low

PAL staff conducted the walkover survey for the proposed pump station locations on May 9, 2019. The walkover survey involved the documentation of the existing physical conditions, an assessment of the integrity of the ground surface, the collection of data about the current environmental setting, and an inspection for any surface indications of archaeological sites at each pump station location. Soil augers were also taken at each location (Figures 3a and 3b).

A combination of variables affecting archaeological sensitivity, such as evidence of prior ground disturbance or the presence of favorable environmental characteristics, was noted at each pump

station location. The information collected during the walkover was used to stratify each pump station location into zones of high, moderate, and low archaeological sensitivity. The results are presented by pump station location below.

Pump Station 1A

The first option for Pump Station 1, designated by PAL and CDM Smith as Pump Station 1A during the walkover, is located at the northwest corner of the town-owned property for the West Dennis Library at 260 Main Street in West Dennis (see Figure 1). The impact area for the pump station is located in a grassy area to the north of the library's parking lot (Photograph 1). An old concrete curb, ostensibly related to the parking area, is visible at the northern edge of the grassy area and suggests that the parking lot once extended further north. A soil auger placed within the impact area appeared to confirm this, revealing a very dark grayish brown (10YR 3/2) silty fine to medium sand developing topsoil over very compact, brown (10YR 4/3) medium to coarse gravelly sand (see Figure 3a). Since the impact area at Pump Station 1A had been previously disturbed by the construction of the library parking lot and does not contain natural soils, it is unlikely to contain significant archaeological deposits and is assessed as having low archaeological sensitivity.

Pump Station 1B

The alternate location that is being considered for Pump Station 1 was designated as Pump Station 1B during the walkover. Pump Station 1B is located at the northern end of the municipal parking lot at 296 Main Street in West Dennis (see Figure 1). The impact area occupies a disturbed area that lies between the municipal parking lot and the concrete foundation of a razed twentieth-century building (Photograph 2). A deteriorating wooden fence that formerly separated the two runs through the impact area roughly east-west. A soil auger documented a mottled brown (10YR 4/3) and yellowish brown (10YR 5/6) silty fine sand fill in the impact area (see Figure 3a). Based on the previous disturbance to the area, Pump Station 1B is unlikely to contain significant archaeological deposits and is assessed as having low archaeological sensitivity.

Pump Station 2A

The first option for Pump Station 2 was designated as Pump Station 2A during the walkover; this pump station is located at the northern end of a largely developed parcel at 394 Main Street in West Dennis (see Figure 1). The impact area for the pump station is located in a wooded area to the north of the parking lot for the shopping plaza (Photograph 3). A soil auger indicated that the impact area contained a very dark grayish brown (2.5Y 3/2) fine to medium sand fill layer over yellowish brown (10YR 5/6) fine to medium sand B_1 subsoil (see Figure 3a). While there are no recorded sites in the immediate vicinity of Pump Station 2A, it is less than 500 meters from the pre-contact sites that have been identified along the Bass River (see Figure 2). Despite the fact that the topsoil appears to have been removed and the area filled over, the presence of potentially intact natural subsoils indicates that this location may contain potentially significant archaeological deposits. Pump Station 2A is assessed with moderate archaeological sensitivity.

Pump Station 2B

The alternate location for Pump Station 2 was designated as Pump Station 2B during the walkover. It is located to the north of the driveway that encircles the Westies Shoe Outlet at 416 Main Street in

West Dennis (see Figure 1). The impact area is mostly grass-covered, although it is also sparsely populated by a few small deciduous trees (Photograph 4). A soil auger placed in the impact area indicated that it contains disturbed and mottled dark grayish brown (10YR 4/2) and yellowish brown (10YR 5/6) fine to medium sand topsoil overlaying redeposited yellowish brown (10YR 5/6) fine to medium sand B_1 subsoil and brown (10YR 4/3) fine sand fill (see Figure 3a). Since the impact area has been heavily disturbed and does not contain natural soils, Pump Station 2B is unlikely to contain potentially significant archaeological deposits and is assessed with low archaeological sensitivity.

Pump Station 3A

The first option for Pump Station 3 was designated as Pump Station 3A during the walkover. It is located at the western end of the property for the Grand Cove Place shopping plaza, at 581 Main Street in West Dennis (see Figure 1). The impact area is in a landscaped, grass-covered area on the west side of the parking lot for the shopping plaza (Photograph 5). The area appeared to have been graded during the construction of the plaza and the parking lot. A soil auger indicated that the impact area was indeed disturbed, as it encountered an olive brown (2.5Y 4/4) compact and gravelly fine sand fill layer below the very dark brown (10YR 2/2) silty fine sand landscaped topsoil (see Figure 3a). Based on the extent of the previous ground disturbance to the area, Pump Station 3A is assessed as having low archaeological sensitivity.

Pump Station 3B

The alternate location for Pump Station 3 was designated as Pump Station 3B during the walkover. It is located at the northwest corner of the property containing the now-defunct Steamer Trunk Beach Store, at 608 Main Street in West Dennis (see Figure 1). The impact area for Pump Station 3B is within the open lawn space behind the store, at the edge of the wooded area north of the property (Photograph 6). Based on a soil auger placed within the impact area, soils at this location are intact and consist of very dark grayish brown (10YR 3/2) silty fine sand A_1 topsoil overlaying dark yellowish brown (10YR 4/6) fine sand B_1 subsoil and yellowish brown (10YR 5/6) fine sand B_2 subsoil (see Figure 3b). While no recorded archaeological sites are present in the immediate vicinity of Pump Station 3B, it is less than 500 meters from the pre-contact sites that have been identified along the Bass River, and it is at the edge of the South Dennis Historic District, where much of the town's early settlement was concentrated (see Figure 2). Considering this and the intact soils that are present, Pump Station 3B is assessed with high archaeological sensitivity.

Pump Station 4

Pump Station 4 is located at the southwestern part of the town-owned property containing the Ezra H. Baker Elementary School, at 810 Main Street in West Dennis (see Figure 1). The impact area for the pump station is in an open lawn area that lies east of Trotting Park Road and north of one of the school's parking lots (Photograph 7). A soil auger placed in the impact area documented two compact fill layers: the first was a very dark grayish brown (2.5Y 3/2) silty fine to medium sand with gravel fill, and the second was an olive brown (2.5Y 4/3) medium sand with gravel fill (see Figure 3b). The fill soils indicated that the impact area had been heavily disturbed during the construction of the school and its parking lot. Although Pump Station 4 is within the South Dennis Historic District, the extensive disturbance to the property negates any potential that it may have to contain potentially significant archaeological deposits. Pump Station 4 is assessed with low archaeological sensitivity.

Pump Station 5

Pump Station 5 is located at the southeastern end of the town-owned property containing the Dennis Chamber of Commerce building, at 242 Swan River Road in West Dennis (see Figure 1). The impact area for the pump station contains a fill berm that surrounds the parking lot for the Chamber of Commerce and the adjacent convenience store (Photograph 8). Beyond the fill berm, there is a slope down to a wetland associated with the Swan Pond River. A soil auger was placed in the impact area to confirm the nature of the area as a fill berm; the recorded soil consisted of an olive yellow (2.5Y 6/6) very fine sand fill (see Figure 3b). Based on the presence of the fill berm and the wetland within the impact area, Pump Station 5 was assessed with low archaeological sensitivity.

Pump Station 6

Pump Station 6 is located east of the Dennis Housing for the Elderly at 167 Center Street in South Dennis (see Figure 1). The impact area for the pump station is within a wetland that lies downslope from the built-up area surrounding the Housing for the Elderly office (Photograph 9). A soil auger taken in the impact area confirmed that it contained wetland soils, with a very dark grayish brown (10YR 3/2) silty fine sand hydric A horizon overlaying a dark olive brown (2.5Y 3/3) silty fine sand hydric B horizon (see Figure 3b). Since it is situated within a wetland, Pump Station 6 is unlikely to contain potentially significant archaeological deposits and is assessed with low archaeological sensitivity.

Pump Station 7

Pump Station 7 is located behind the Windmill Village housing development at 109 Upper County Road in South Dennis (see Figure 1). The pump station's impact area is in a slightly undulating wooded area that lies between the housing development and Route 134 (Photograph 10). The ground surface in the area appeared to have been minimally disturbed by the deposition of modern trash, including tires, chairs, and metal fragments. A soil auger taken in the impact area demonstrated that soils are largely intact despite this and consisted of very dark brown (10YR 2/2) silty fine sand A_1 topsoil overlaying dark yellowish brown (10YR 4/4) silty fine sand B_1 subsoil and olive brown (2.5Y 4/4) fine sand B_2 subsoil (see Figure 3b). While the impact area does contain natural soils, Pump Station 7 is more than 500 meters from both the nearest known pre-contact site and the nearest known water source at Fresh Pond. As a result, it is assessed as having moderate archaeological sensitivity.

Recommendations

The results of the inventory file review indicate that pre-contact Native American archaeological sites and aboveground historic resources have been recorded in the vicinity of the pump station locations that are proposed for Phase 1 of the CWMP Project. While none of the known sites and aboveground resources overlap with the 50-x-50-foot impact areas for the proposed pump stations, the proposed locations of Pump Station 3B and Pump Station 4 are within or at the boundary of the South Dennis Historic District.

Table 2. Results of Sensitivity Assessment

Pump Station Number	Assessor's Lot Number	Recommendation
1A	260	No Further Survey
1B	300	No Further Survey
2A	394	Intensive Survey
2B	416	No Further Survey
3A	581	No Further Survey
3B	608	Intensive Survey
4	810	No Further Survey
5	238	No Further Survey
6	167	No Further Survey
7	311	Intensive Survey

Most of the proposed pump station locations are in areas where substantial ground disturbance has occurred or where soil conditions are not conducive to containing potentially significant archaeological sites. However, three of the proposed pump station locations are in wooded/unpaved areas that were assessed as having high or moderate archaeological sensitivity: Pump Station 2A, Pump Station 3B, and Pump Station 7. **PAL recommends that an intensive (locational) archaeological survey be conducted at the proposed location of Pump Station 7 in order to identify any potentially significant archaeological resources that may be affected by project construction. PAL also recommends intensive (locational) archaeological survey at the proposed locations of Pump Station 2A and Pump Station 3B, if CDM Smith selects these locations over the alternates for Pump Station 2 and Pump Station 3.**

The remaining proposed pump station locations are assessed as having low archaeological sensitivity, and no additional archaeological investigations are recommended for them.

The intensive survey for the pump station locations assessed with high and moderate archaeological sensitivity will need to be conducted under a State Archaeologist's Permit issued by the MHC. PAL can provide a scope of work and a cost proposal for the additional archaeological investigations at the request of the proponent. The results of this sensitivity assessment can be used by the Town of Dennis and its consultants to facilitate ongoing consultation with the MHC as Project plans are finalized and construction plans are implemented.

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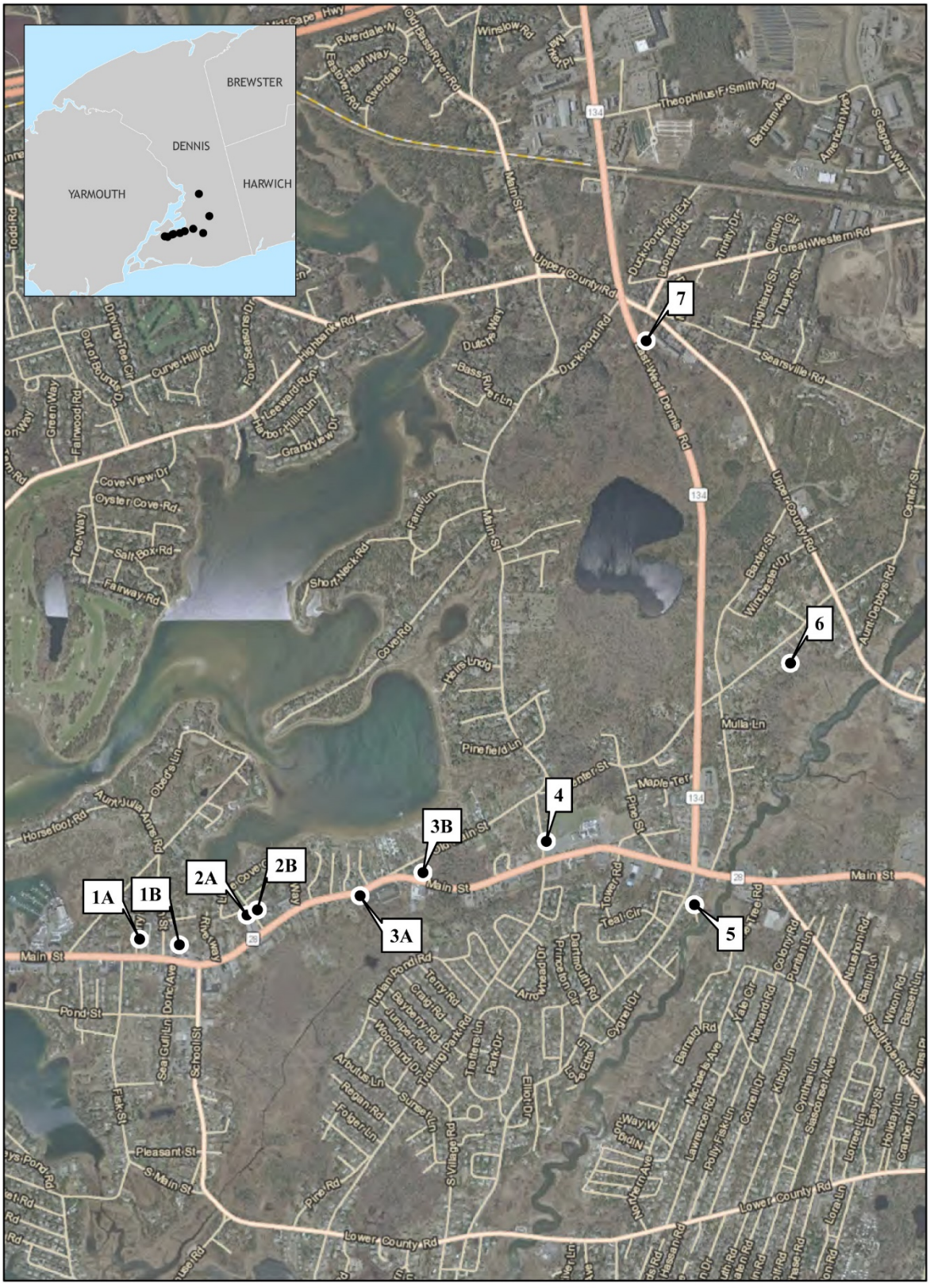
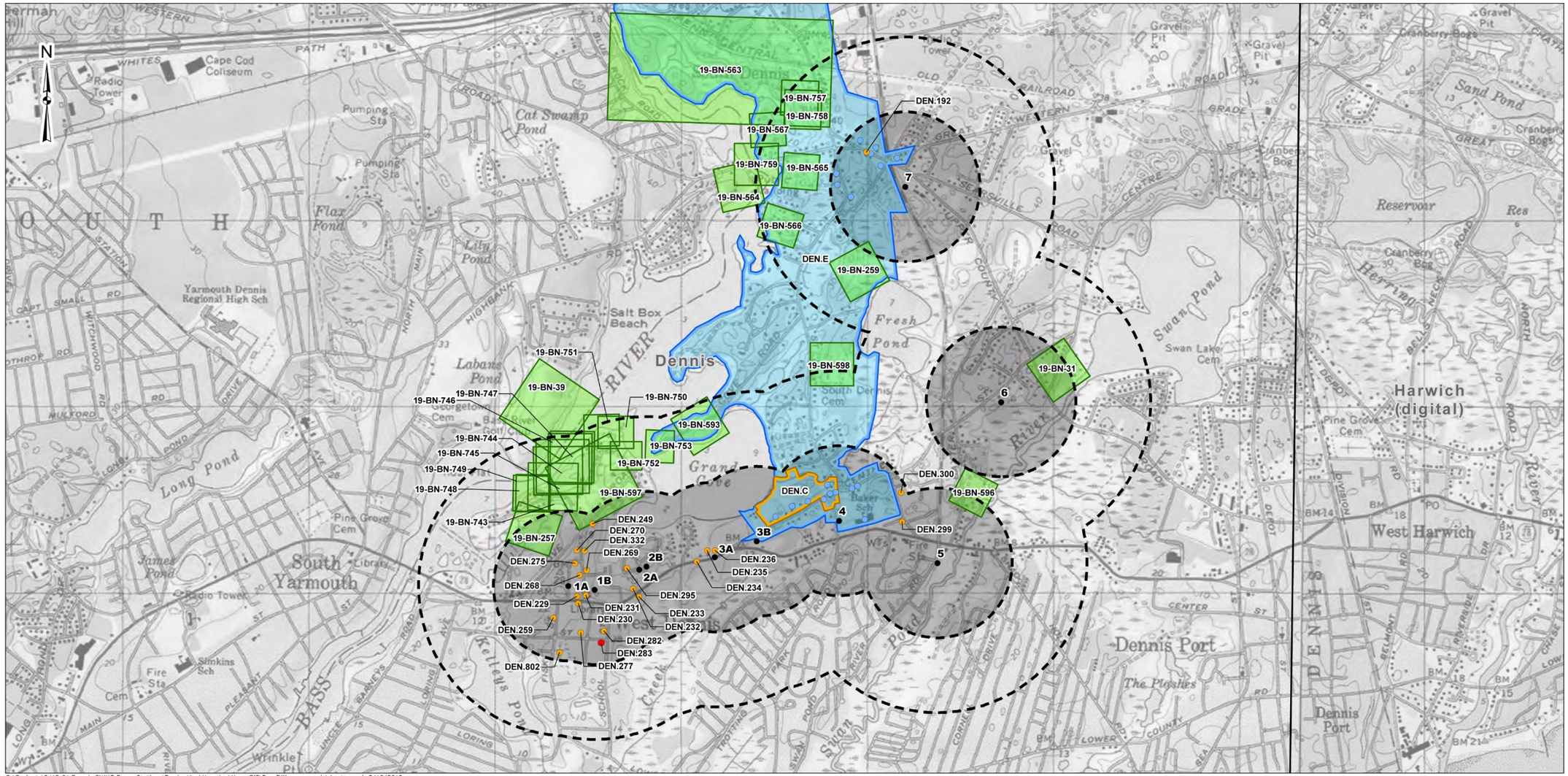


Figure 1. Orthophoto (2014) showing locations of the Dennis CWMP Pump Stations.



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CWMP Pump Stations
Dennis, Massachusetts
Barnstable County

MAP LAST SAVED	5-10-2019
Due diligence and project areas: PAL	5-10-2019
Base: USGS topo/ArcGIS Online	Various

PAL makes no warranties, either expressed or implied, regarding the fitness or suitability of this map for any other purpose than to depict the results of cultural resource investigations conducted by PAL.
THIS MAP IS INTENDED FOR PLANNING PURPOSES ONLY

KEY:

- ● Proposed Pump Station
- Archaeological Study Area, ½-Mile
- Recorded Pre-Contact Site
- *No post-contact sites recorded within study area*
- Aboveground Study Area, ¼-Mile
- Local Historic District (showing contributing properties)
- Inventoried Historic Area or Property
- Historic Property Listed in the National Register

MAP CONTAINS PRIVILEGED INFORMATION - NOT FOR PUBLIC RELEASE

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METERS

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Figure 2. Recorded archaeological sites within a half-mile and inventoried or listed historic aboveground properties within a quarter-mile of the CWMP Pump Station project areas on the Dennis USGS topographic quadrangle, 7.5 minutes series.

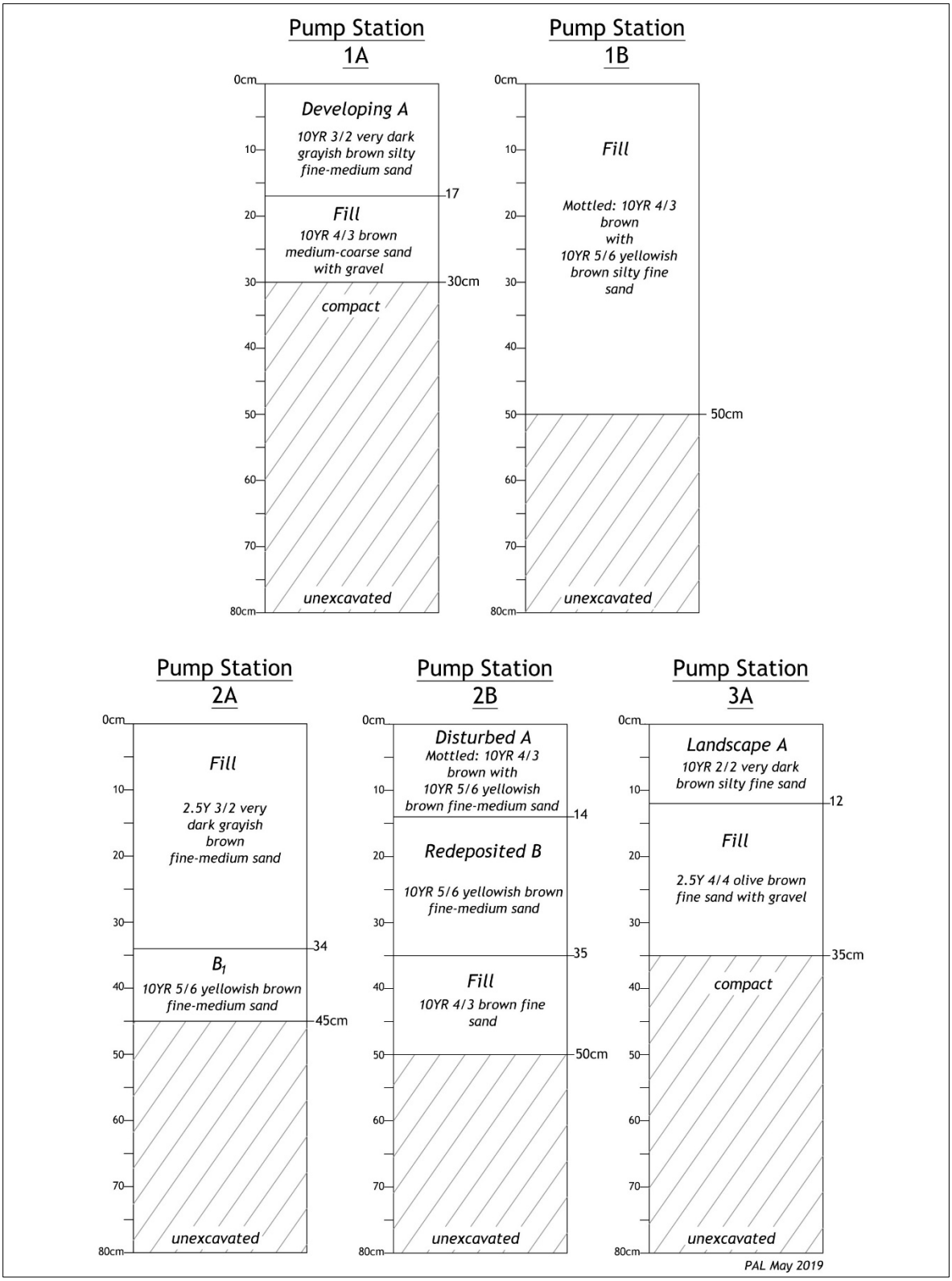

Figure 3a. Representative auger profiles, Dennis CWMP Pump Station project area.

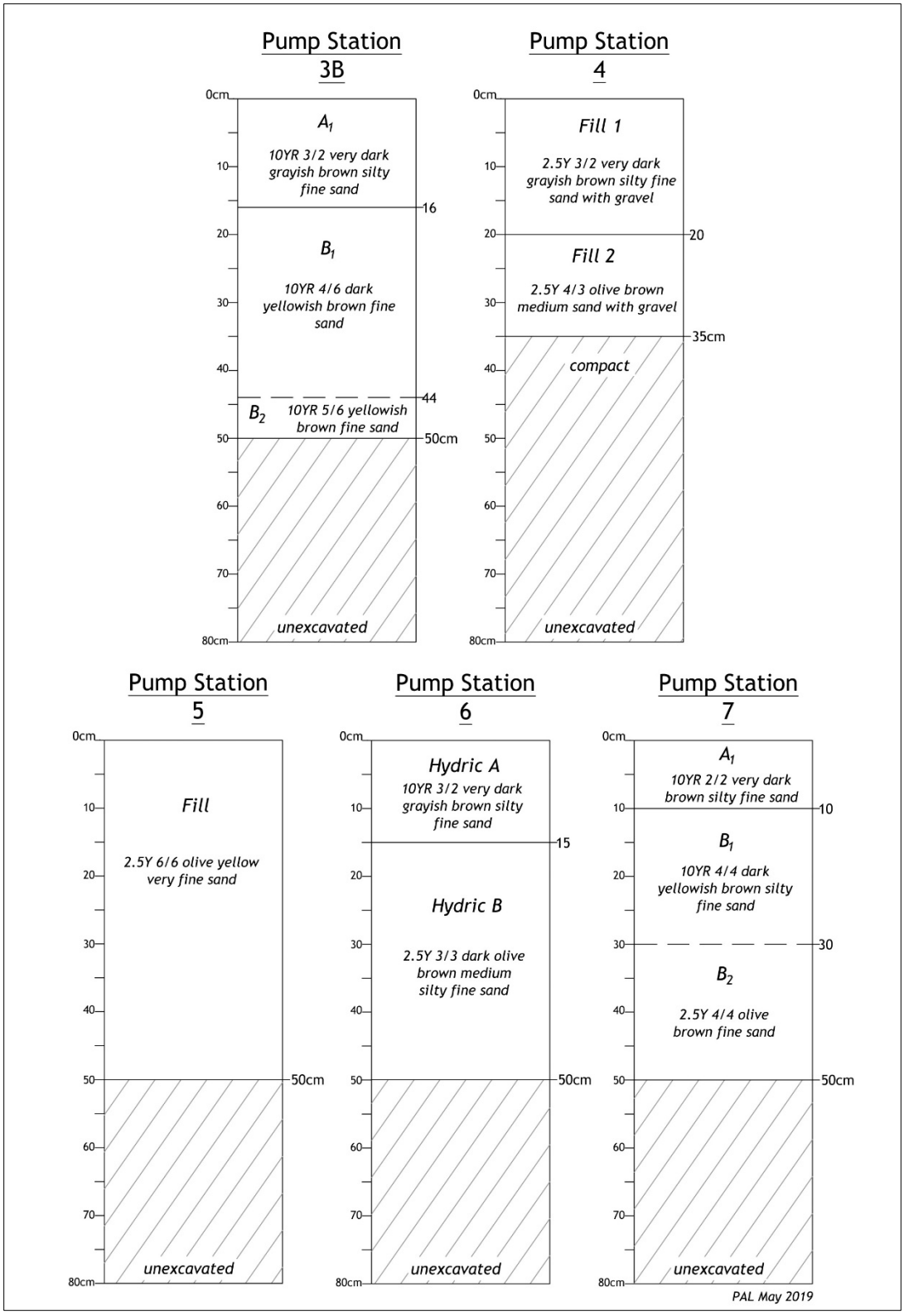

Figure 3b. Representative auger profiles, Dennis CWMP Pump Station project area.

Photograph 1. View northwest of the Pump Station 1A impact area, low sensitivity.

Photograph 2. View west of the Pump Station 1B impact area, low sensitivity.

Photograph 3. View north of the Pump Station 2A impact area, moderate sensitivity.

Photograph 4. View east of the Pump Station 2B impact area, low sensitivity.

Photograph 5. View south of the Pump Station 3A impact area, low sensitivity.

Photograph 6. View northwest of the Pump Station 3B impact area, high sensitivity.

Photograph 7. View north of the Pump Station 4 impact area, low sensitivity.

Photograph 8. View southeast of the Pump Station 5 impact area, low sensitivity.

Photograph 9. View east of the Pump Station 6 impact area, low sensitivity.

Photograph 10. View southwest of the Pump Station 7 impact area, moderate sensitivity.

APPENDIX A

ABOVEGROUND RESOURCES WITHIN ONE-QUARTER MILE OF THE PUMP STATION LOCATIONS

Appendix A. Aboveground Resources Within One-Quarter Mile of the Pump Station Locations.

Town	Resource Name	MHC Inventory #	Resource Type	Period of Significance
Dennis	West Dennis - Jericho Historic Area	DEN.C	Area	19th century
Dennis	South Dennis Historic District	DEN.E	Area	18th & 19th century
Dennis	Luther Child House	DEN.232	Building	19th century
Dennis	51 School Street	DEN.282	Building	19th century
Dennis	Crowell, Levi House	DEN.332	Building	19th century
Dennis	Ezra H. Baker School	DEN.237	Building	20th century
Dennis	24 Upper County Road	DEN.191	Building	19th century
Dennis	97 Old Main Street	DEN.178	Building	18th century
Dennis	Theophilus Baker House	DEN.179	Building	19th century
Dennis	41 Old Main Street	DEN.183	Building	19th century
Dennis	Edward Crowell II House	DEN.270	Building	19th century
Dennis	Capt. Elisha Crowell House	DEN.275	Building	18th century
Dennis	South Dennis Free Public Library	DEN.166	Building	19th century
Dennis	27 Church Street	DEN.268	Building	19th century
Dennis	98 Cove Road	DEN.249	Building	19th century
Dennis	David Baker House	DEN.195	Building	18th century
Dennis	John Baker House	DEN.214	Building	18th century
Dennis	West Dennis Cemetery	DEN.802	Burial Ground	19th century
Dennis	West Dennis Graded School	DEN.283	Building	19th century
Dennis	Hersey Crowell House	DEN.277	Building	19th century
Dennis	84 Old Main Street	DEN.180	Building	19th century
Dennis	Howes Baker House	DEN.222	Building	19th century
Dennis	35 Upper County Road	DEN.193	Building	19th century
Dennis	520 Main Street	DEN.235	Building	19th century
Dennis	71 Old Main Street	DEN.181	Building	19th century
Dennis	Elisha Crowell II House	DEN.269	Building	19th century
Dennis	Zenas Crowell House	DEN.295	Building	19th century
Dennis	530 Main Street	DEN.236	Building	18th century
Dennis	Benjamin Thacker House	DEN.223	Building	19th century
Dennis	Baker House	DEN.224	Building	19th century
Dennis	Daniel Baker House	DEN.300	Building	17th century
Dennis	25 Fisk Street	DEN.259	Building	19th century
Dennis	29 Upper County Road	DEN.192	Building	19th century
Dennis	Frederick Nickerson - James Allen House	DEN.165	Building	19th century
Dennis	275 Main Street	DEN.230	Building	19th century

Town	Resource Name	MHC Inventory #	Resource Type	Period of Significance
Dennis	57 Old Main Street	DEN.182	Building	19th century
Dennis	West Dennis Methodist Meeting House	DEN.231	Building	19th century
Dennis	25 Pine Street	DEN.299	Building	18th century
Dennis	West Dennis Free Public Library	DEN.229	Building	20th century
Dennis	Capt. Obed L. Baker House	DEN.233	Building	19th century
Dennis	Caleb Howes House	DEN.234	Building	19th century
Dennis	390 Main Street	DEN.167	Building	19th century
Dennis	36 Upper County Road	DEN.194	Building	19th century

APPENDIX B

ARCHAEOLOGICAL SITES WITHIN ONE-HALF MILE OF THE PUMP STATION LOCATIONS

Appendix B. Archaeological Sites Within One-Half Mile of the Pump Station Locations.

Town	Site Name	MHC Site #	Site Type	Temporal Period
Dennis	N/A	19-BN-31	Unknown	Unknown
Dennis	Shellheap	19-BN-257	Shell Midden	Unknown
Dennis	Shellheap	19-BN-258	Shell Midden	Unknown
Dennis	Shellheap	19-BN-259	Shell Midden	Unknown
Dennis	Nickerson/Bush Site	19-BN-563	Village Site	Middle Archaic to Contact
Dennis	Dutch's Way Site	19-BN-565	Unknown	Late Archaic
Dennis	Bass River Lane Site	19-BN-566	Unknown	Middle Archaic to Early Woodland
Dennis	High Bank Site	19-BN-567	Unknown	Late Archaic/Early Woodland/Late Woodland
Dennis	Cove Road North Site	19-BN-593	Unknown	Unknown
Dennis	Baxter Street Site	19-BN-596	Find Spot	Unknown
Dennis	Cove Road South Site	19-BN-597	Unknown	Unknown
Dennis	South Dennis Cemetery Site	19-BN-598	Unknown	Unknown
Dennis	Desert Site #1	19-BN-743	Unknown	Late Woodland to Contact
Dennis	Desert Site #2	19-BN-744	Shell Midden	Unknown
Dennis	Desert Site #3	19-BN-745	Shell Midden	Unknown
Dennis	Desert Site #4	19-BN-746	Shell Midden	Unknown
Dennis	Desert Site #5	19-BN-747	Flake Scatter	Unknown
Dennis	Aunt Julia Midden #1	19-BN-748	Shell Midden	Unknown
Dennis	Aunt Julia Midden #2	19-BN-749	Shell Midden	Unknown
Dennis	Point Midden #1	19-BN-750	Shell Midden	Unknown
Dennis	Point Midden #2	19-BN-751	Shell Midden	Unknown
Dennis	Cove Road Landing Site	19-BN-752	Shell Midden	Unknown
Dennis	Cove Road West Landing Site	19-BN-753	Shell Midden	Unknown
Dennis	Dirt Pit Site	19-BN-757	Shell Midden	Unknown
Dennis	Dirt Pit #2 Site	19-BN-758	Unknown	Unknown
Dennis	Highbank Midden Site	19-BN-759	Shell Midden	Unknown
Yarmouth	Bass River Golf Club Site	19-BN-39	Village Site/ Shell Midden	Woodland

Appendix K

UMass Donahue Institute, Town of Dennis Wastewater Development Study, April, 2018.

Town of Dennis Wastewater Development Study

April 2018

UMASS DONAHUE INSTITUTE
Economic & Public Policy Research

Town of Dennis Wastewater Development Study

Prepared by the UMass Donahue Institute's
Economic & Public Policy Research Group

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Economic & Public Policy Research

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Executive Summary

Due to environmental concerns, and associated lawsuits, related to elevated nitrogen levels in the waters of Cape Cod, there is an imperative for Dennis and other towns on Cape Cod to review their wastewater planning processes and the ramifications of building (or not building) wastewater infrastructure.

The purpose of this study is to: (1) examine the role of wastewater infrastructure as a driver of economic growth; and (2) demonstrate the types and extent of growth that may be unlocked in the Town of Dennis with the introduction of a municipal wastewater treatment system.

The underlying **Economic and Demographic Backdrop** of Dennis demonstrates concerns, both as a place to live and to conduct business.

- While Massachusetts showed relatively strong population growth between 2010 and 2016, Dennis and Barnstable County lost residents.
- Dennis has seen little change in the number of business establishments since 2010.
- Job numbers have recovered since the Great Recession in Dennis but growth lags the state's.
- Revenues from room occupancy taxes are relatively low in Dennis compared to Cape Cod towns with more developed wastewater infrastructure.
- Dennis's tax base is dependent on residential properties, demonstrating a potential opportunity to diversify further through the expansion of retail and commercial enterprises.

There are a range of **Economic Advantages** for introducing municipal wastewater services.

- Generally, businesses do not want to be in the wastewater treatment business and wastewater infrastructure provides the capacity for larger-scale businesses to operate.
- Wastewater infrastructure allows for more compact, higher density development and thus enables the building of more affordable housing options, notably for the types of workers Cape Cod finds in short supply.
- With municipal sewerage, homeowners can more easily expand or add bedrooms.

There are **Negative Potential Consequences** for not addressing the wastewater infrastructure situation in Dennis.

- Poor water quality resulting in beach closures and an onerous traffic situation can turn visitors off from future visits to Dennis. People can also choose to travel to competitor destinations – Maine, New Hampshire, and New Jersey.

- Restaurants, hotels, and conference facilities in Dennis are constrained from reaching their market potential due to the lack of municipal wastewater treatment.

- With uncertainty over wastewater, existing lodging owners may be unwilling to invest in their properties and allow them to deteriorate. Antiquated and obsolete lodging facilities join traffic congestion and water pollution as threats to Dennis's and the mid-Cape's image as a destination. In next-door Yarmouth, a major hotel investment is on hold due to concern that other commercial property owners are not similarly investing in their properties.

- Cost burdens for updating septic systems discourages home owners from investing in their properties and can lead some to move if they need additional space for a child or parents.

- Non-compliance with wastewater standards may force the closure of some of Dennis's cottage communities and their accompanied local purchases which help support the economy.

Wastewater infrastructure may introduce numerous **Benefits** to Dennis.

- The high price of housing on Cape Cod has led to a worker shortage, notably in occupations to an aging population. Water infrastructure could lead to more affordable, higher-density housing which would help retain or attract labor and defray Cape Cod's high costs.

- Tastes have changed - people increasingly are showing a preference for denser, more walkable areas that provide better access to a variety of amenities and activities. These types of areas need wastewater infrastructure.

- Hyannis, today, is able to build much higher density development than Dennis due to wastewater infrastructure. Bourne also is seeing the possibility of substantial investment, as well as higher property tax revenues, being unlocked by municipal wastewater treatment.

- With wastewater treatment, numerous investments may be unlocked in Dennis to support the tourism economy, including additional amenities at the Cape Playhouse and an expansion at the Lighthouse Inn. The availability of municipal wastewater treatment is an indicator to property owners and developers that it is safe to invest.

- Municipal wastewater treatment would encourage a large capital infusion (commercial, hotel, motel, and residential) in Dennis and this would help with cost recovery for the improved infrastructure. Today, commercial growth tends to be headed to Hyannis and business owners also indicate that they are concentrating more of their investments off-Cape to realize growth opportunities.

Introduction

In 2010, the Conservation Law Foundation filed a lawsuit suing the U.S. Environmental Protection Agency (EPA) for failing to address the issue of elevated nitrogen levels in the waters of Cape Cod. As a result of this, and other lawsuits, the Cape Cod Commission updated its Area-wide Water Quality Management Plan and developed a Regional Wastewater Management Plan. Even before this, individual towns on Cape Cod started their own wastewater planning processes, including the Town of Dennis. As Dennis has moved forward with its Comprehensive Wastewater Management Planning process, there was a desire to investigate the potential economic benefits of implementing a municipal wastewater treatment system. The University of Massachusetts Donahue Institute's Economic and Public Policy Research group was retained to provide an initial understanding of:

1) the types of benefits that other municipalities have experienced from implementing municipal wastewater treatment;

2) what benefits Dennis might experience; and

3) what might happen if Dennis chooses to do nothing on this front.

This study reviews the underlying demographic and economic trends that provide a socioeconomic context for introducing water and wastewater treatment in Dennis. It then reviews, generally, the types of benefits that accrue economically and for the environment that are linked to wastewater treatments. Finally, through interviews conducted by the research staff in Dennis, the study goes into more specifics about how water and wastewater treatment could introduce greater economic opportunities for the Town of Dennis. The findings also translate for much of the mid-Cape region.

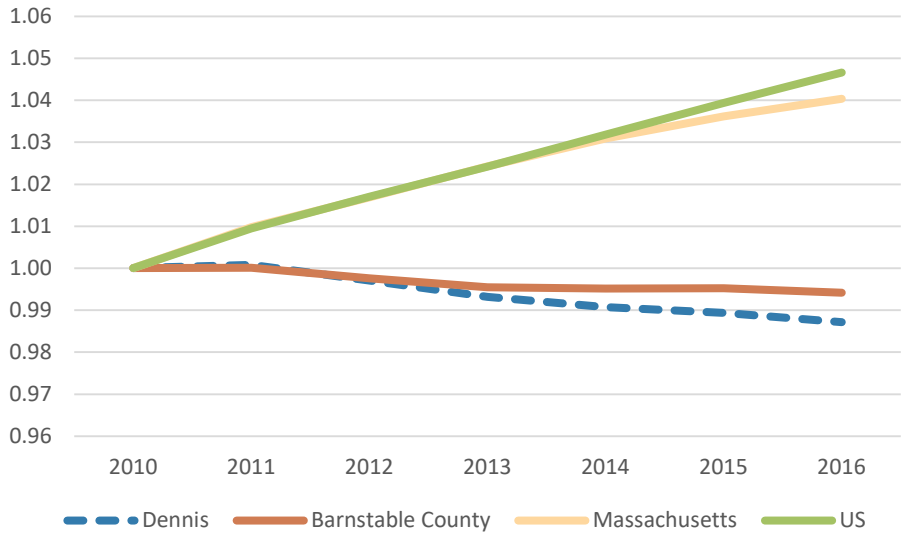
Socioeconomic Context for Introducing Wastewater Treatment to Dennis

Local Population and Economic Trends

While not a direct indicator of economic conditions, trends in population change can be indicative of the underlying fundamentals that make a place an attractive place to live. This is particularly true in seasonal tourist locations such as Cape Cod, where summertime population may be booming while witnessing an actual decrease in the number of full-time residents. In some instances this may be the result of the conversion of residences from full-time residents to seasonal second homes. In others, it can be indicative of an economy that is not strong enough to support a year-round population as large as previously was the case.

When comparing Dennis and Barnstable County to the state and nation, the change in population between 2010 and 2016 tells a tale of two diverging trends (**Figure 1**). While both Massachusetts and the U.S. grew in population by between four and five percent between 2010 and 2016, both Dennis and Barnstable County have seen population declines of between 1.3 percent and 0.6 percent, respectively. The lack of population growth in Dennis and Cape Cod is worrisome because it translates to a declining labor supply and that, in turn, can make the region less appealing for business expansions and investments. As will be shown later in this study, a lack of wastewater treatment can negatively affect population growth by making housing more expensive and by not providing necessary infrastructure for larger-scale business establishments.

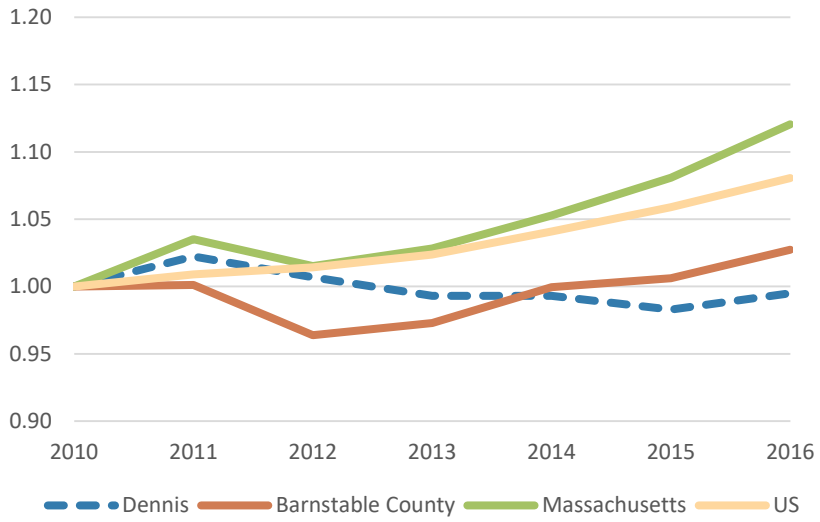
Figure 1: Population Change, Indexed to 2010



Source: U.S. Census Bureau, Population Division

Similar to the population trends, Dennis and Barnstable County have also diverged from the state and the nation in terms of business establishment growth (**Figure 2**). While Massachusetts and the United States have experience strong growth in the numbers of businesses since 2010, Cape Cod has seen relatively flat growth, overall, and the Town of Dennis has actually witnessed a decline in the number of business establishments. Again, as with population, the sluggish performance with business establishments points to a lack of dynamism, with water infrastructure likely being one of several possible contributing factors.

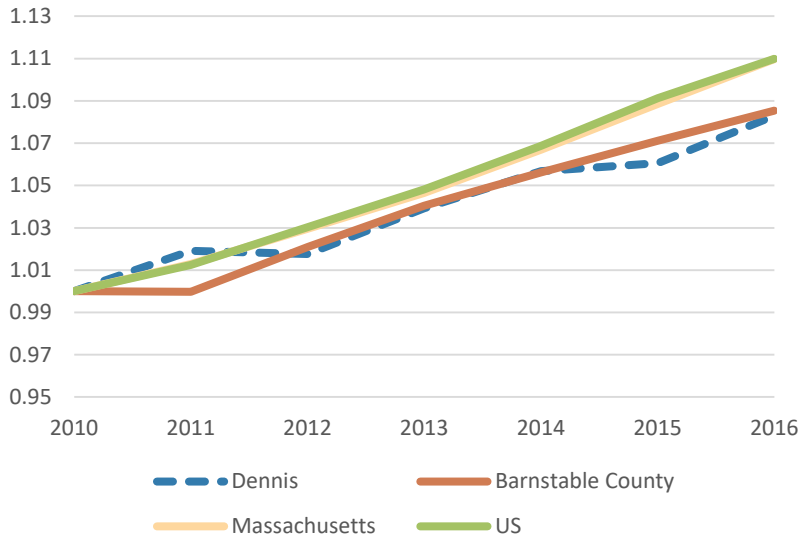
Figure 2: Change in Establishments, Indexed to 2010



Source: Mass. Executive Office of Labor and Workforce Development ES-202, Bureau of Labor Statistics Quarterly Census of Employment and Wages.

In terms of employment, all four geographies are showing growth, much of it cyclical due to an economic rebound following the Great Recession (**Figure 3**). Nevertheless, neither Dennis nor Barnstable County are seeing their job numbers increase as quickly as Massachusetts or the United States.

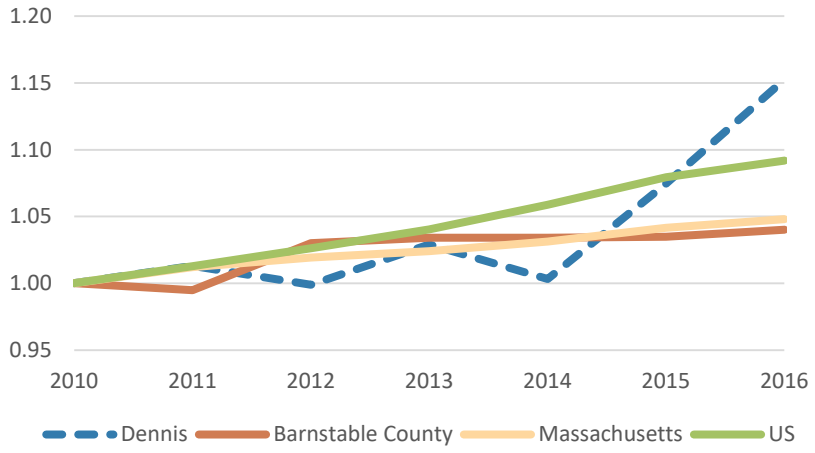
Figure 3: Change in Employment, Indexed to 2010



Source: Mass. Executive Office of Labor and Workforce Development ES-202, Bureau of Labor Statistics Quarterly Census of Employment and Wages.

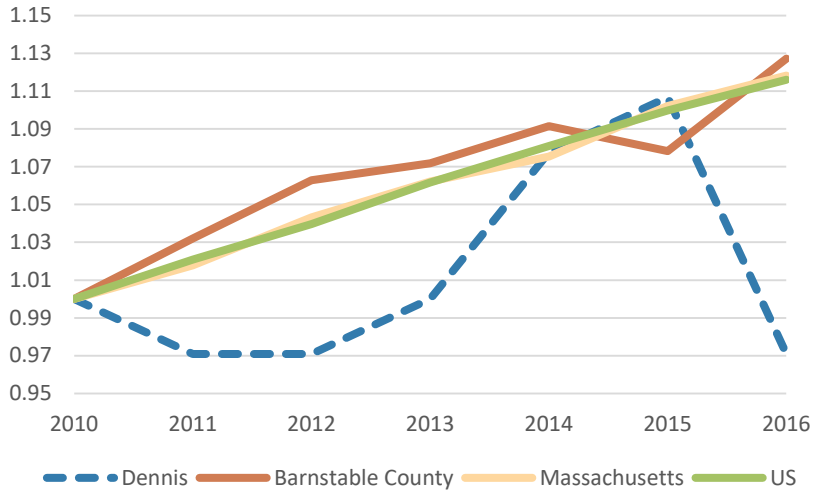
Drilling down into some of the industry sectors most relevant to Cape Cod's economy, we can see some diverging trends. For example, employment in the retail sector shows employment has grown faster in Dennis than in Barnstable County, the state, and the nation (**Figure 4**). Meanwhile, employment in the accommodation and lodging sector (**Figure 5**) has fallen precipitously in Dennis since 2010, while the other three geographies have shown steady rises in employment in this sector. Dennis's fall in accommodations employment is consistent with messages that came from interviews concerning antiquated and obsolete hotel and motel properties that are in need of major upgrades or replacement to bring them up to the standards expected by contemporary guests.

Figure 4: Change in Retail Sector Employment, Indexed to 2010



Source: Mass. Executive Office of Labor and Workforce Development ES-202, Bureau of Labor Statistics Quarterly Census of Employment and Wages.

Figure 5: Change in Employment in the Accommodation and Lodging Sector, Indexed to 2010

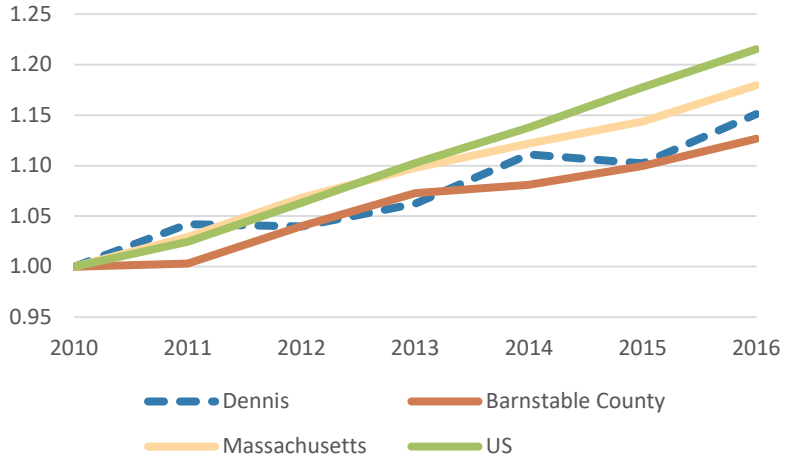


Source: Mass. Executive Office of Labor and Workforce Development ES-202, Bureau of Labor Statistics Quarterly Census of Employment and Wages.

Lastly, employment in eating and drinking places has trended higher for all four geographies (**Figure 6**) since 2010. Again, however, both Dennis and Barnstable County are not seeing their jobs growth keep up with either Massachusetts or the United States. This is particularly important as food and drinking jobs are particularly vital in an economy that is led by tourism, like Dennis' and Cape Cod's. Through interviews, it was evident that some food establishments (or places that serve food as part of their business) could not grow to scale or could not even clean dishes (forcing the use of paper and plastic

disposables) due to the lack of municipal wastewater treatment services. There are many other factors that may be contributing to the slower growth but the lack of infrastructure is a clear hindrance.

Figure 6: Change in Employment in the Food Services and Drinking Places Sector, Indexed to 2010



Source: Mass. Executive Office of Labor and Workforce Development ES-202, Bureau of Labor Statistics Quarterly Census of Employment and Wages.

Appendix 1, at the back of this study includes six tables comparing Dennis to Barnstable, Chatham, Falmouth, and Provincetown for each of these concepts. The comparison towns were selected because each offers the municipal wastewater treatment services that Dennis does not. Despite this disadvantage compared to the other towns, Dennis generally demonstrated similar performance. That said, there is a pervasive sense in Dennis that growth is stagnant and has been for the last five years (and this is during a period of Massachusetts and national economic expansion). Investments are going elsewhere and infrastructure is really needed to help turn this trend around.

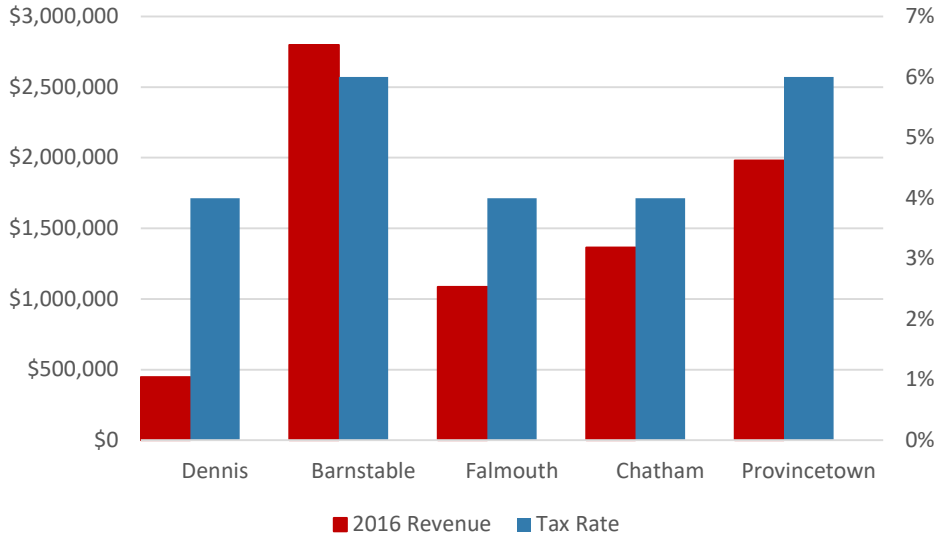
In terms of sectoral performance, a stand-out for Dennis was the notably subpar performance of the town's accommodations and lodging industry. The industry showed growth in the other towns but declined in Dennis between 2010 and 2016. Additionally, Dennis has much lower employment levels in this crucial tourism-related industry than its competitor towns. The precipitous drop in Dennis between 2015 and 2016, in particular, should be monitored to see if it continues or is a one-year aberration. Regardless, and as noted previously, the condition of Dennis's motel and hotel offerings has become a concern which may be contributing to the jobs decline. Needed updates and investments in these properties may not be forthcoming without the availability of municipal wastewater treatment infrastructure.

Tax Revenues

A measure of Dennis's overall competitiveness on Cape Cod and a reflection of progress in diversifying revenue sources, is its ability to generate tax revenues and reduce its dependence on residential property taxes to support municipal services. This section analyzes three types of tax revenues, meal, hotel room, and property, and compares Dennis, in each, with Barnstable, Chatham, Falmouth, and Provincetown. Beyond property taxes, towns and cities in Massachusetts, can levy meal and room occupancy taxes to help generate revenues to support city and town services.

The Massachusetts Department of Revenue allows municipalities to levy room occupancy taxes of up to six percent. In Dennis, the town has had a 4 percent room occupancy tax in place since 1987. Falmouth and Chatham also use a four percent rate while Barnstable and Provincetown both impose a six percent room occupancy tax. As **Figure 7** shows, Dennis generates significantly less revenue from the room occupancy tax than competitor destinations on Cape Cod. At less than $500,000 in 2016, hotel room tax revenues are only a fraction of Barnstable's ($2.75 million) and much lower than Chatham's, Falmouth's, or Provincetown's. Significantly, Falmouth and Chatham both raise more revenue with the same four percent room occupancy tax rate. The relatively low room occupancy tax revenues in Dennis point to an opportunity to expand the number of rooms in the town and/or to increase average room rates. However, as shown in a later section of this report, expansions, the building of larger hotels and motels, and the types of property investments that would bring in larger-scale room rates are currently constrained by the lack of wastewater treatment infrastructure.

Figure 7: Room Occupancy Tax Rate and Revenue

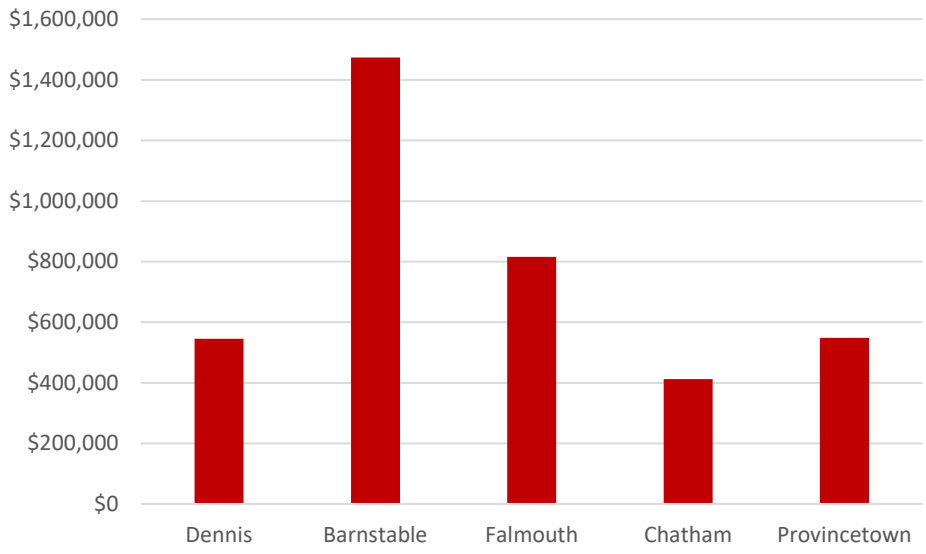


Source: Town Budget Documents.

There are two different meals tax rates in Massachusetts. One is the 6.25 percent that goes to the Commonwealth's coffers. The other is 7 percent, with the additional .75 percent going to the community in which the restaurant resides. Massachusetts law provides cities and towns with the "local option" to increase the meals tax in their communities to 7 percent as a way of bringing in additional revenue. With the exception of Eastham, all towns on Cape Cod have a meals tax. Dennis instituted a local sales tax on meals in 2010. In 2016, Dennis reaped nearly $550,000 from the meals tax, a significant increase over the $315,000 collected in 2011. In terms of meals tax revenue, Dennis is fairly similar to other Cape Cod towns, with the exception of much larger Barnstable as shown on **Figure 8**. Dennis benefits from the Exit 9 cloverleaf which provides excellent access for local and longer-distance travelers on Cape Cod. The exit area includes the operations of several major franchises like Burger King and Dunkin Donuts that tend to have high turn-over, generating significant revenues. As such, Dennis may benefit as a location due to the more restrictive bylaws put into place by other Cape Cod communities, like Wellfleet, that prevents or limits the development of chain stores and restaurants in those communities.

Meals taxes, like hotel room taxes, are an important source of revenue in Dennis and other Cape Cod communities. However, just as hotels are restrained in their growth and investment opportunities in Dennis by the lack of wastewater treatment, restaurants are also encumbered by the absence of sewerage services that limit their capacity to serve or force practices that create other problems (e.g., increased trash volumes from using disposable utensils in lieu of metal flatware to reduce water consumption from dishwashing). By opening options and providing the impetus for eating places to invest and expand, wastewater treatment in Dennis would be a means for increasing revenues via the local sales tax on meals.

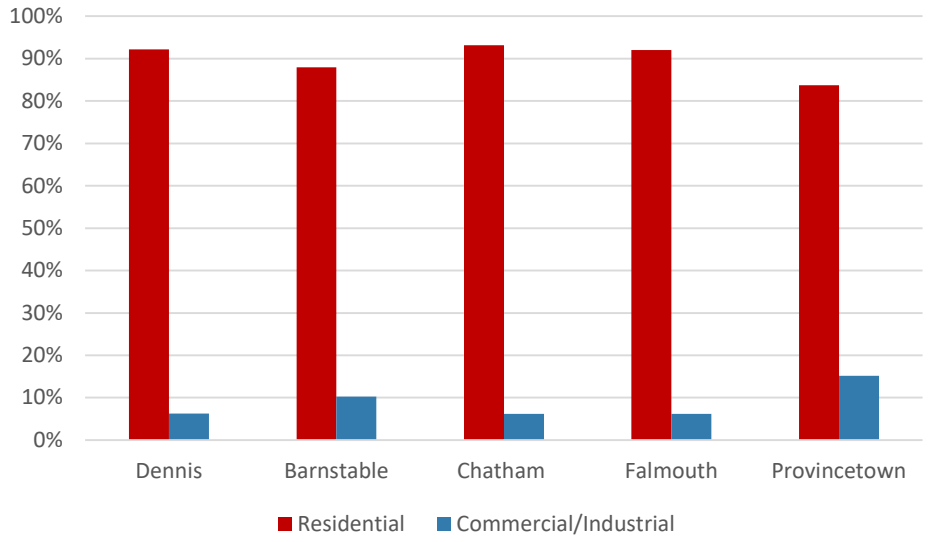
Figure 8: Meal Tax Revenue



Source: Town Budget Documents.

Like other towns on Cape Cod and reflective of visitor-oriented economy dependent on second homes and tourism, Dennis is dependent on residential property taxes as a primary source of tax revenues. In terms of assessed value, residential property types accounted for 92 percent of Dennis's total property valuation in 2016, with commercial/industrial property contributing only six percent (see **Figure 9**). By comparison, Barnstable's and Provincetown's commercial/industrial properties account for 10 percent and 15 percent, respectively, of total assessed property values. Cities with diversified economies with extremely strong business and office presence, like Waltham, can see commercial/industrial properties comprise upwards of 30 percent of total assessed property values. While few towns or cities have as diversified a property tax base as Waltham, an expansion of retail businesses, office buildings and other commercial entities in Dennis (and elsewhere on Cape Cod) would help shift the tax burden from homeowners to other sources and better allow the Town of Dennis to embark upon capital projects and expansions or improvements in services. However, as will be discussed in a later section of this report, the relative lack of wastewater treatment in Dennis can stymie interest from investors in expanding (or updating existing properties) and prevent the needed scale and densities to make projects economically justifiable. The suppression of these types of investments represents a missed opportunity in Dennis and will limit the possibilities for diversifying the town's tax base in the future.

Figure 9: Share of Total Assessed Property Value, by Property Type



Source: Town Budget Documents.

Cape Cod Wastewater Treatment – What Is Happening in Other Towns

Dennis, like all towns on Cape Cod, must reduce the amount of nitrogen flowing primarily from septic systems into estuaries, embayments, and ocean waters and degrading the marine environment. Too much nitrogen can result in algae blooms that choke out eelgrass and other pond organisms and can lead to fish kills. Eel grass is crucial to the Cape Cod ecosystem by providing a habitat for oysters and a wide range of other organisms. Cape Cod communities, per the Regional Wastewater Management Plan, need to address this issue which requires alternative technology nitrogen removal systems to be installed in areas declared nitrogen sensitive. With these clean water challenges, Dennis and many other towns are considering building or expanding existing municipal wastewater treatment systems. While it is relatively straightforward process to clean up water discharged by a water treatment plant, it is far harder to remove nitrogen when the source of the pollution is individual septic systems spread across a town.

Examples of wastewater treatment initiatives taking place in other communities on Cape Cod include the following:

- **Chatham.** Chatham has been moving towards expanding its municipal wastewater treatment system since the town approved its final comprehensive wastewater management plan in 2009. Chatham first installed its sewer system more than 40 years ago to serve the downtown area, but has recently undertaken construction to build an expanded treatment plant and to expand sewer service, with a goal of covering two-thirds of the town by 2030.

- **Orleans.** The town is moving forward with adding a sewer system and a water treatment facility that would initially cover its downtown area as well as a large residential district. Initial pipe-laying is planned for the spring of 2018.

- **Harwich.** In May 2017, Harwich voters approved $11 million to fund the next phase in the town's comprehensive wastewater management plan, which involves installing sewer mains to connect East Harwich to Chatham's wastewater treatment plant. A month later, both towns reached a 25-year intergovernmental agreement under which Harwich paid a portion of the costs for Chatham's newly expanded wastewater treatment facility in exchange for having wastewater treated at the plant.

- **Mid-Cape.** Barnstable, Dennis, Harwich, and Yarmouth were awarded a state grant in early 2018 to further study a regional solution to the towns' collective wastewater treatment needs.

- **Bourne.** In October 2017, Bourne voters approved funding the construction of a new wastewater treatment facility to provide the capacity needed to allow for a number of new developments to take place on Main Street.

- **Provincetown.** After declaring a state of limited sewer capacity in 2015, Provincetown is exploring options for expanding the town's tightly constrained sewer system. Restaurant and

marina owners are pleased to see the town looking into a wastewater treatment expansion as it will help accommodate future economic growth.

- **Falmouth.** The town has a wastewater treatment facility with more treatment capacity than it is allowed to discharge. The imbalance is due to the amounts of nitrogen the facility is permitted to discharge locally. To accommodate future growth, Falmouth is looking into either finding a remote discharge location (e.g., at Joint Base Cape Cod in Bourne) or introducing new nitrogen filtration technologies (e.g., a membrane treatment system) at the plant.

The imperative for the improvement and preservation of water resources on Cape Cod has pushed the region's towns into a very active period of planning to address water treatment issues. Towns reliant of septic systems are looking into introducing sewerage systems while other towns with existing wastewater infrastructure are exploring ways to expand capacity. By addressing wastewater issues, particularly with regards to nitrogen discharges, Cape Cod's towns, including Dennis, can help to ensure a more pristine environment as well as increase economic development opportunities in coming years. The economic and environmental arguments for introducing municipal wastewater treatment are reviewed in the next section of this report.

The Case for Municipal Wastewater Treatment

The lack of a municipal wastewater treatment and sewerage system in Dennis has two main effects; the first is economic and the second is on the environment. While this effects are focused on Dennis, they can also affect the larger mid-Cape region as well.

The Economic Case

The economic effects of wastewater treatment are wide-ranging, but can generally be summarized as:

1. Septic systems put wastewater treatment responsibility and compliance on the owner.
2. Septic systems are expensive to upgrade/repair/replace
3. Generally, businesses don't want to be in the "wastewater treatment business," but a lack of sewerage forces them to operate septic systems or more expensive package treatment plants. Commercial property owners can spend hundreds of thousands of dollars to install one of these systems, and pay annual operating costs of tens of thousands of dollars to operate and maintain such systems and provide testing to ensure compliance with environmental regulations.
4. Enables reuse of vacant/underutilized properties and more compact, dense downtown areas
5. Enables homeowners to expand/add bedrooms to their homes, allowing more families to stay invested in their local communities
6. Provide viable wastewater treatment options for residential properties on lots too small for modern system
7. Prevent the need for expensive and unsightly raised septic systems
8. Attract property and business owners who want to live/operate a business in the area but don't want to be in the wastewater treatment business.

More generally, the construction and operation of municipal wastewater treatment systems has its own direct and indirect economic benefits.

In a 2002 study,[1] the author studied the economic impact of 87 sewer and water projects financed by the Economic Development Association (EDA). The projects were completed in 1989 and 1990 and spread across 30 states, with 33 projects located in rural areas and 54 in urban areas. These projects were built for specific firms or businesses, with the express goal of promoting economic development in

[1] Bagi, Faqir. Economic Impact of Water-Sewer Facilities on Rural and Urban Communities. Rural America. 2002

the host communities. Clearly these firms and businesses were direct beneficiaries of the water project, but the study found a host of other businesses benefitted indirectly from the same project; from companies that supplied or serviced the direct beneficiary of the project, to new businesses that moved into the area to hook up to the new water system, to existing businesses that used the increased water or sewerage capacity to expand their own business. Together, these direct and indirect benefits results in more investment, jobs, and wages in the local economy. Specifically, the study found that every dollar (1990$) spent on construction of a sewer/water project:

- Resulted in nearly $15 of private investment
- Generated $2 in public investment
- Increased the property tax base by $14
- Every $10,000 in construction costs saved or created 5.75 jobs

In Massachusetts, Mansfield, Foxboro, and Norton are seeing clear economic development benefits from an ongoing project to introduce sewerage into new areas and expand its regional wastewater treatment plant. The expansion project, designed to accommodate growing commercial and residential neighborhoods in the three towns, likely has already had a major impact on encouraging development according to Lee Azinheira, the executive director of the MFN Regional Wastewater District.[2] Local officials indicate the wastewater treatment expansion is now resulting in:

- Growth at many businesses in Norton;
- Construction of residential and commercial buildings in downtown Mansfield;
- Retail, residential, and commercial/industrial activity as well as growth prospects are seen as improving in Foxboro. The expansion of wastewater treatment is also expected to jumpstart the town's downtown area.

The Environmental Case

On Cape Cod, perhaps the biggest problem stemming from a lack of municipal wastewater treatment is the presence of elevated levels of nitrogen in lakes, ponds, rivers, and streams. Excess nitrogen levels in surface water can lead to excessive growth of aquatic plants and algae and reduced oxygen levels. Because even properly maintained and functioning septic systems emit significant amounts of nitrogen, a municipal wastewater treatment and sewer system would prevent much of this nitrogen from entering the ecosystem in the first place, thus preventing these negative environmental effects.

[2] "Expansion of wastewater treatment plant serving Mansfield, Norton and Foxboro progressing," The Sun Chronicle, July 17, 2017.

Other environmental benefits to municipal wastewater treatment include[3]:

1. Fewer beach closures due to poor water quality, high bacteria levels, algal blooms, or other similar events. The economic impact of beach closures, which often coincide with the peak tourist season, can range into the millions of dollars. A study in Washington State estimated that the local economy lost $6.4 million in spending impact when four beaches were shut down for a period of two to five days. A study from Florida has estimated that almost $10.6 million was lost, per month, in the lodging and restaurant industries along a 10-mile stretch of beach during closures from red tide events (2017$)[4]. Further, the economic impacts to tourism can linger even after the beach closures are over, as tourists may be turned off or negatively associate the beach closures with the Cape as a destination overall and decide to vacation elsewhere in subsequent years.

2. Fewer closures of commercial fishing grounds and shellfish beds. In 2005, a red tide event shut down shellfish beds in Massachusetts (as well as New Hampshire and Maine). It is estimated that this closure alone cost the Massachusetts shellfish industry $22.4 million. Numerous other studies have been conducted that confirm the economic impact algal blooms on the commercial fishing industry.

3. Lower drinking water treatment costs. Because almost all drinking water on Cape is supplied from one single aquifer, any contaminants, including excess nitrogen, can end up in the water supply. Additional equipment, supplies, and processes are required to remove these excess nutrients, which in turn increases the cost of providing clean, safe, drinking water.

4. Reduced impacts on health. Whether through contact in surface water or consumed through drinking water or contaminated shellfish, algal blooms and elevated nitrogen levels can cause a number of negative health impacts for both humans and animals. Infants are particularly susceptible to nitrates in drinking water, which can oxygen levels in the blood. Horses, dogs, and other animals that consume surface water can be at risk as well.

5. Lower environmental impact from pollution from leaking/failing septic systems, cesspools, or other outdated or ineffective wastewater treatment systems.

6. During a flooding event, MWWT would reduce the risk floodwater being contaminated by untreated sewage leaking from raised septic systems or backed-up underground septic systems.

[3] All dollar values updated to 2017$ using CPI-U.

[4] U.S. EPA. A Compilation of Cost Data Associated with the Impacts and Control of Nutrient Pollution. 2015.

The Case for Introducing Wastewater Treatment in Dennis

The study team spent a day touring Dennis and meeting with town officials, members of the wastewater implementation committee, property owners, developers, and other stakeholders to hear first-hand about the challenges and opportunities presented by wastewater treatment.

The Cost of Doing Nothing

There is a sense that Cape Cod, and Dennis in particular, needs quality redevelopment and reinvestment in order to both maintain and strengthen its status as a first class vacation destination. Cape Cod already has an onerous traffic situation and people can choose to vacation in numerous other destinations, with locations in Maine, New Hampshire, and the New Jersey Shore being the primary competitors for tourism.

Without a municipal wastewater treatment system, owners of large commercial properties are forced to provide their own on-site treatment systems. In many cases a septic system cannot handle the volume of wastewater generated, and so owners must install a package treatment plant, which is essentially a miniature wastewater treatment plant. Depending on the size and design of such systems, installation of a new system can cost anywhere from $500,000 to $750,000 and beyond. Furthermore, operating and maintaining these systems is costly, with annual costs of up to $100,000. Much of these costs would be avoided with MWWT and replaced instead with a monthly sewer bill.

Limitations in septic system capacity also constrain small businesses in Dennis. Conference and meeting venues that could otherwise accommodate larger groups are prevented from reaching their maximum capacity due to septic systems and inadequate wastewater treatment capacity. In some instances, the lack of wastewater treatment creates the unintended consequence of increased trash volumes. Some restaurants and bars in Dennis must serve food on paper plates and with disposable utensils because they do not have adequate septic system capacity to handle the dirty water coming from dishwashing.

Businesses are not alone in feeling the side effects of not having municipal wastewater treatment. Because of the high cost of bringing older septic systems up to code, many homeowners have found that they cannot substantially renovate or expand their homes without incurring prohibitive costs. The cost burdens for updating residential septic systems discourages property owners from investing in their properties. Without the ability to add an extra bedroom or an in-law suite, many families find it hard to stay on Cape when they have another child or need to move their parents into the same home. Additionally, the lack of investment can also take a visual toll on Dennis as older properties are allowed to deteriorate. Dennis, like other Cape Cod communities, needs to maintain its appeal for both residents and visitors, and any property degradation can erode the town's ability to draw the people it needs to sustain its economy and provide opportunities for growth.

One recurring concern was about the cottage communities in Dennis and how these seasonal cottages were often built without even consideration of wastewater treatment. The result being that it would be very expensive to retrofit septic systems in these communities, if it were even technically feasible, which

may not be the case due to space limitations. Without a connection to a sewer system, it is possible that some of Dennis's cottage communities could ultimately face being closed over Title 5 non-compliance. The cottage communities form an important part of Dennis's historic legacy and closure would also translate into economic losses. A single cottage rental can generate $1,000 per week in local food and entertainment purchases. If this is multiplied by hundreds, representing the types of activity currently taking place during the summer months at Dennis's cottage communities, it is clear that the economic impacts resulting from any closures would be significant.

Furthermore, without municipal wastewater treatment, the environmental effects will continue to compound, leading to deteriorating conditions in the waterways that are so important in making Dennis an attractive place to live and visit. Already, a beachfront inn reports having to remove five to ten pickup-truck-loads of seaweed and algae growth daily during the summer season. In fact, at least one group decided against booking a three-day conference there because the smell from the seaweed was so intense. Clearly, a problem like this cannot continue indefinitely or be allowed to worsen if Dennis is to maintain its quality of life attributes that are integral to its vitality.

How Dennis Can Benefit from Wastewater Treatment

An investment in municipal wastewater treatment has the potential to generate outsize returns when it comes to land use and development patterns in Dennis. Perhaps one of the greatest challenges facing the Cape right now is the need for more workforce housing. Per a 2017 Cape Cod Commission study on the issue, Cape Cod is short 22,000 housing units that would be affordable to those households earning under $90,000 a year. Furthermore, as portions of the Cape's economy become more dependent on services and occupations like landscaping, housekeeping, and healthcare that cater to an aging population, this workforce housing crisis, if not addressed, could lead to a worker shortage in these critical services because there is not an adequate supply of affordable housing options. A worker shortage also leads to higher wages to attract labor which further perpetuates already high costs on Cape Cod. The only way to provide a very large number of affordable housing units is to enable higher density development to occur in areas that have the infrastructure to handle it, and currently wastewater treatment is often the missing piece in most areas that is needed to make such developments feasible.

As an example, Cape Built is currently working on a project in Hyannis called Sea Captain's Row. With the municipal sewer in place there, they are able to build 60 units on 2.5 acres with a mix of workforce and market rate housing. In contrast, at another Cape Built development in Dennis, Heritage Sands, was built at a density of 63 units on eight acres. The Sea Captain's Row development in Hyannis accommodates the same number of units on one-third the amount of land as the Dennis project. This housing density would not be feasible without the municipal wastewater infrastructure that is available in Hyannis.

There has also been a profound shift in the types of places people want to live and visit, with people increasingly showing a preference for denser, more walkable neighborhoods that provide better access to a variety of amenities and activities. This type of development, often called "New Urbanism", requires levels of density that can only be accommodated through infrastructure, including sewerage

systems. The lack of wastewater treatment, as in Dennis, is a limiting factor that prevents the building of developments that better meet changing tastes in living styles.

A New Urbanism, higher density development initiative is now in its early stages in Bourne. Three owners of vacant or underutilized properties on Main Street in downtown Buzzards Bay want to develop their properties, but need the town to provide wastewater treatment capacity to accommodate the higher density style of development. The potential value of the proposed development exceeds $100 million and is expected to provide several hundred jobs. The proposed treatment plant would include sufficient capacity to treat wastewater from these developments as well as other potential projects downtown. If these developments were assessed at 75 percent of their development costs, they would generate almost $800,000 in property taxes for the town of Bourne. Similar developments located in Dennis, with its lower property tax rates, would generate $475,000 in property tax revenue.

By using wastewater treatment to facilitate denser developments in downtown locations, another, perhaps counterintuitive benefit, can be realized. By concentrating development in a few, smaller areas, a larger share of remaining parts of Dennis can be preserved in its current state, which is a goal many residents and stakeholders would like to see realized.

Additionally, a number of specific developments were cited (and mentioned, below) that would become feasible and move forward through the planning stages if municipal wastewater treatment were to be built in Dennis as well as in neighboring Yarmouth.

The Cape Playhouse has in the past considered adding additional amenities on-site, including dormitories for staff housing as well as a small outdoor performance space. Similarly, the Lighthouse Inn would like to expand with an additional new building with 70 new rooms and some conference and meeting space to improve economies of scale and help extend its operating season further into the shoulder seasons. In both these cases, the lack of municipal wastewater treatment means that the costs of providing on-site wastewater treatment are significant enough to discourage this type of investment in new and/or expanded facilities. With much of the peak tourism activity in Dennis and on Cape Cod concentrated into a very short season and now becoming shorter due to earlier start times for schools, strategies to expand visitor activity beyond the summer months has become increasingly important. Again, the lack of wastewater treatment services is an obstacle for developing options to address this problem.

Red Jacket Resorts in Yarmouth (which is facing similar water treatment problems as Dennis) has reached a 20-year development agreement with the Cape Cod Commission to demolish and replace four resorts between the Parkers River and Bass River with two, new hotel resort properties. This development, representing $75 million or more in investment, is on hold as there is concern about making such a large investment while other commercial property owners are not investing similarly in their properties. The lack of reinvestment and redevelopment of existing properties in Dennis and the mid-Cape region is a clear problem and cannot improve without municipal wastewater treatment given the concerns for estuary, bay, river, and aquifer quality. Reinvestment is a key pillar for economic vitality in Dennis wastewater puts the town and the mid-Cape in a “chicken and egg” situation. Wastewater treatment is needed for reinvestment and reinvestment is needed to fund wastewater

treatment infrastructure. Wastewater treatment is an indicator to property owners and developers that it is safe to invest. This lack of investment sends a signal that the market in and around Dennis is not vibrant enough to generate the economic activity needed to make such a substantial investment pay off.

Municipal wastewater treatment would encourage a large capital infusion (commercial, hotel, motel, and residential) in Dennis and this would help with cost recovery for the improved infrastructure. Today, commercial growth tends to be headed to Hyannis and business owners also indicate that they are concentrating more of their investments off-Cape to realize growth opportunities.

Conclusion

In conclusion, this study helps to inform the Town of Dennis as it pursues the building of a municipal wastewater treatment system. Through the information and data collected over the course of the study, evidence shows that water infrastructure has the potential to unlock development and increase investment in the community, both commercially and residentially.

Towns on Cape Cod that have already built municipal wastewater systems, namely Barnstable, Provincetown, Falmouth, and Chatham, are showing larger relative levels of room occupancy tax revenues. Barnstable and Provincetown, overall, are also less dependent on residential property for their tax bases. In Bourne, the passage of funding for a wastewater facility is expected to stimulate significant investment on that town's Main Street. Numerous other Cape Cod communities are also pursuing initiatives to introduce municipal wastewater infrastructure. Outside of Boston, a shared wastewater treatment expansion in Foxboro, Mansfield, and Norton is now seen as underpinning retail, residential, and commercial activity and new downtown construction, notably in Mansfield.

In Dennis, the provision of a municipal wastewater treatment system, as shown in this study, could result in a number of enhancements that would better situate the town for future residential and commercial investments. Homeowners could more easily expand their properties for children and aging parents, restaurants and venue operators could accommodate larger numbers of people, and motel/hotel-owners would see a greater impetus to upgrade their facilities. In terms of preserving the Town of Dennis's character, wastewater treatment would allow cottage communities to comply with environmental standards and help secure their future. The combination of these types of improvements would be further complemented by higher density development that would be made possible in Dennis with wastewater infrastructure. Higher densities are crucial for stimulating the building of more affordable housing in Dennis and attracting the workers needed to make the economy run.

Without municipal wastewater treatment, Dennis will have more limited policy levers to help guide its own future and it will be less able to capitalize on economic opportunities as they arise. Needed residential and commercial investments would continue to be intermittent and the worker-housing mismatch would contribute to an erosion of business competitiveness in both Dennis and Cape Cod. Additionally, further deterioration of estuary, bay, river, and aquifer quality due to poorly maintained septic systems would undermine the natural attributes that make Dennis attractive to visitors and residents alike. Left "as is", this combination of factors would damage both the tourism economy in Dennis and also negate possibilities for developing a more diversified economy.

Appendix 1: Population and Economic Indicators

	Population				Total Employment		
	2010	2016	Change		2010	2016	Change
Chatham	6,125	6,146	0.3%		2,822	3,550	25.8%
Dennis	14,207	14,024	-1.3%		4,609	4,991	8.3%
Falmouth	31,531	31,547	0.1%		14,158	14,597	3.1%
Provincetown	2,942	2,979	1.3%		2,459	2,809	14.2%
Barnstable	45,193	44,362	-1.8%		26,103	27,870	6.8%
Barnstable County	215,888	214,621	-0.6%		88,699	96,271	8.5%
Massachusetts	6,547,629	6,811,779	4.0%		3,149,169	3,494,553	11.0%
US	308,745,538	323,127,513	4.7%		127,820,442	141,870,066	11.0%
	Establishments				Employment in Retail Trade		
	2010	2016	Change		2010	2016	Change
Chatham	402	406	1.0%		383	460	20.1%
Dennis	585	582	-0.5%		925	1,066	15.2%
Falmouth	1,183	1,168	-1.3%		1,920	1,805	-6.0%
Provincetown	446	436	-2.2%		604	619	2.5%
Barnstable	2,257	2,326	3.1%		5,112	5,103	-0.2%
Barnstable County	9,196	9,446	2.7%		14,921	15,520	4.0%
Massachusetts	220,134	246,651	12.0%		339,425	355,771	4.8%
US	8,993,109	9,716,618	8.0%		14,549,251	15,886,000	9.2%
	Employment in Accommodation and Lodging				Employment in Food and Drinking Places		
	2010	2016	Change		2010	2016	Change
Chatham	353	490 [1]	38.8%		403	438	8.7%
Dennis	103	100	-2.9%		901	1,037	15.1%
Falmouth	325	411	26.5%		1,566	1,736	10.9%
Provincetown	324	353	9.0%		647	826	27.7%
Barnstable	643	650	1.1%		2,631	2,764	5.1%
Barnstable County	3,245	3,658	12.7%		11,154	12,567	12.7%
Massachusetts	31,932	35,706	11.8%		226,566	267,279	18.0%
US	1,809,341	2,019,459	11.6%		9,373,409	11,391,578	21.5%

Notes: [1] 2016 value has been imputed to account for missing data.
Source: Mass. Executive Office of Labor and Workforce Development ES-202, Bureau of Labor Statistics Quarterly Census of Employment and Wages.