# Oyster Pond
# Comprehensive Wastewater Management Plan
# Single Environmental Impact Report

September 2019
DRAFT

Prepared for the
Town of Falmouth, Massachusetts
by

WRIGHT-PIERCE
Engineering a Better Environment

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# Oyster Pond
# Comprehensive Wastewater Management Plan
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# TOWN OF FALMOUTH

# COMPREHENSIVE WASTEWATER MANAGEMENT PLAN

# OYSTER POND

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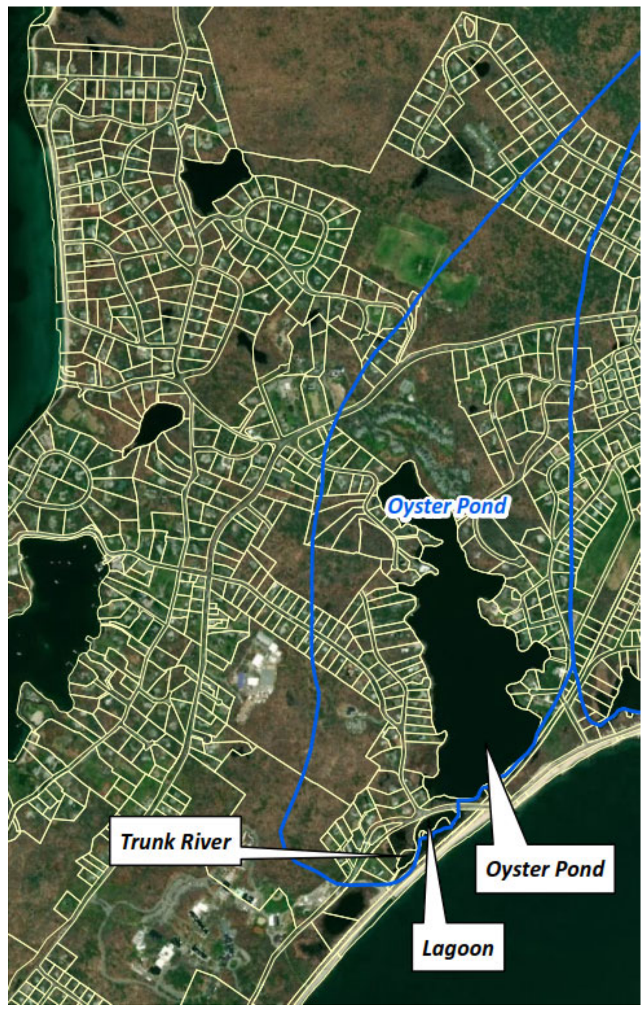
# TOWN OF FALMOUTH – OYSTER POND WATERSHED
# COMPREHENSIVE WASTEWATER MANAGEMENT PLAN
# EXECUTIVE SUMMARY

## OVERVIEW

The Town of Falmouth has developed a Comprehensive Wastewater Management Plan (CWMP) for the Oyster Pond watershed to guide the improvement in water quality of Oyster Pond and to meet the 2008 Nitrogen Total Maximum Daily Load (TMDL) requirements. The plan is highly adaptable to accommodate measured water quality improvements, changes in technology and changes in the environment. This CWMP has been developed consistent with the requirements of the Cape Cod Commission (CCC) 208 Water Quality Plan Update (2015, 2017) and consistent with the expected requirements of the Massachusetts Department of Environmental Protection (DEP) Watershed Permit program and the Massachusetts Environmental Policy Act (MEPA).




## INTRODUCTION

Oyster Pond is a small brackish pond located on Falmouth's south coast. Its watershed has 164 developed parcels on approximately 630 acres. The Town of Falmouth initiated the Oyster Pond CWMP in 2013, which consists of three principal segments of work: The Needs Assessment; the Alternatives Analysis; and the Implementation Plan. This process was informed by significant effort and input from Town's Wastewater Department, the Water Quality Management Committee (WQMC) and the WQMC Oyster Pond Working Group.

## NEEDS ASSESSMENT

The purpose of the Needs Assessment phase is to determine the nature and extent of the wastewater-related problems that need to be solved. Private on-lot wastewater disposal, in conformance with the State Sanitary Code (Title 5) and local amendments, adequately protects citizens from the potential public health problems associated with improperly designed or located wastewater disposal systems.

All the structures in the watershed are served by private septic systems. Virtually all the structures in the watershed are served by the municipal public water system. There are no public water supplies in the watershed and only 6 private water supply wells. There is very little development projected in the watershed.

There is a need to protect surface water from nutrient enrichment. Based on the Nitrogen TMDL, approximately 70% of the existing septic nitrogen load needs to be removed. There is no Phosphorus TMDL, so there are no specific targets to be achieved; however, wastewater, fertilizer and stormwater sources should be managed and monitored. The Needs Assessment is presented in Sections 2 and 3 of this report.

## ALTERNATIVES ANALYSIS

The first task of the Alternatives Analysis was to identify a host of traditional and non-traditional methods to address the needs identified in the Needs Assessment phase. These methods were then screened for applicability and compiled into "composite plans" for the watershed. Six composite alternatives were analyzed, ranging from traditional sewering options (Plans 1, 2, and 3), to non-traditional options (Plans 4 and 5) to a "no action plan" (Plan 6). Based on feedback from the Oyster Pond Working Group, WQMC and the public, two alternatives were shortlisted for final consideration:

- Plan 1 – Low-pressure sewer system connected to the Town's existing sewer system with treatment and disposal via the existing Blacksmith Shop Road Wastewater Treatment Facility (WWTF).
- Plan 5 – Advanced innovative/alternative (I/A) on-site treatment systems which produce effluent total nitrogen of less than 10-mg/l.

In short, Plan 1 (sewer) has a higher capital cost and a lower annual operating cost; whereas, Plan 5 (advanced I/A) has a lower capital cost and higher annual operating cost. Plan 1 removes more nitrogen per dwelling served and has a higher factor of safety relative to the TMDL. Both Plan 1 and Plan 5 can meet the quantitative criteria in TMDL. The Alternatives Analysis is presented in Sections 4 and 5 of this report.

## IMPLEMENTATION PLAN

The CWMP outlines a multi-faceted and multi-phased plan to improve water quality in Oyster Pond. The plan utilizes an adaptive management framework, as espoused in the 208 Water Quality Management Plan Update and includes "traditional" and "non-traditional" elements. The Implementation Plan is presented in Section 6 of this report and is outlined below.

- Planning for the use of **Advanced I/A treatment systems which can achieve <10-mg/l effluent total nitrogen concentration** to reduce nitrogen loads to the levels required by the TMDL;
- Continuing **fertilizer control** through the Town's 2012 Fertilizer Control Regulation;
- Continuing use and expansion of **stormwater best management practices (BMPs)** to reduce sediment and nutrient (nitrogen and phosphorus) loadings;
- Periodic **dredging of the Trunk River** to maintain the proper salinity regime and pond flows.
- Continuing promotion of the **water conservation program**;
- Obtaining a **DEP Watershed Permit**, as required by DEP for plans that include significant non-traditional elements;
- Establishing a **Responsible Management Entity (RME)** within the Town to manage the non-traditional elements of the plan in accordance with a DEP Watershed Permit.
- Maintaining a **Traditional Backup Plan** in the event that the Advanced I/A Plan is not desired (prior to Phase 1). The Traditional Backup Plan would consist of a municipal, low-pressure sewer system that would be constructed to serve a portion of the watershed. This system would convey the sewage approximately 6,000 feet to the Shiverick's Pond Lift Station. This sewage would be then be transported by the Town's existing sewer system and treated and disposed of at the Town's Blacksmith Shop Road Wastewater Treatment Facility (advanced wastewater treatment).

## Phasing and Adaptive Management

The CWMP includes phasing and adaptive management components as summarized below:

- **Continued planning activities**, including: confirming proof-of-concept for the Advanced I/A systems and the RME; securing effluent disposal capacity for the traditional backup plan; etc. ("Phase 0"). The purpose of continued planning is to fine-tune the costs and probabilities of each option as the Town approaches a decision point.
- A **two-phase implementation plan occurring over 30 years**.
- An **environmental monitoring program** to assess changes in the quality of the groundwater, surface water, benthic habitat, and atmospheric air quality.
- A **technology and progress monitoring program** which will be documented in an **Annual Progress Report** and an **Adaptive Management Update Report** (at 5-year increments). The Adaptive Management Update Report will also consider any positive and negatives implications of storm surge and/or sea level rise trends.

The Town will have completed several Adaptive Management Update Reports prior to making decisions on implementation of Phase 2. These Adaptive Management Update Reports should be used to "steer the plan" over time based on development, water use, system effectiveness, water quality and benthic habitat monitoring. The Phasing and Adaptive Management elements of the plan are described in Section 6.

## Implementation Schedule

Based on input from the WQMC, the CWMP outlines the following implementation schedule:

| | |
|---|---|
| Complete CWMP | 2019 |
| Complete MEPA review and CCC Consistency Review | 2020 |
| Continue Phase 0 Planning Activities | 2020 to 2024 |
| Neighborhood Update Meetings | 2020, 2021, 2022, 2023 |
| Town Meeting Appropriation for Phase 1 | 2024 |
| Design/ Bidding of Phase 1 | 2024 to 2025 |
| Construction of Phase 1 | 2026 to 2029 |
| Adaptive Management Report (5-year) | 2034, 2039 |

## Project Costs

Refer to Section 6 for additional information on costs and cost allocation. The Town will continue to work on methods to reduce these costs and develop a project financing scenario during Phase 0.

## Evaluation of Environmental Impacts

An evaluation of the environmental impacts of the project is described in Section 7 of this report. The CWMP will be submitted to the Massachusetts Executive Office of Energy and Environmental Affairs (EOEEA) for review under the Massachusetts Environmental Policy Act (MEPA). A concurrent submittal will need to be made to the Cape Cod Commission for review under its 208 Water Quality Plan Update Consistency Determination Guidance.

# SECTION 1

# INTRODUCTION

## 1.1 PURPOSE

A community generally undertakes a Comprehensive Wastewater Management Plan (CWMP) to address some, or all, of the following issues:

- Protect public health
- Protect groundwater
- Protect drinking water resources
- Protect surface waters by reducing nutrient loadings
- Support sustainable economic development
- Address aesthetic and convenience concerns attributable to wastewater issues

The current focus on Cape Cod has been on nutrient removal which has been causing eutrophication of its coastal embayments and freshwater ponds. This issue has been driven by the widespread reliance on on-site septic systems, coupled with significant population growth throughout Cape Cod. Eutrophication of coastal embayments can be reversed, and efforts are underway across Cape Cod to do so. All the 15 communities on Cape Cod are at some point in the wastewater planning and implementation process, each with a focus on nitrogen removal. This CWMP will identify wastewater management needs for Falmouth's Oyster Pond and Salt Pond watersheds and will outline the alternatives analysis and implementation plan for Falmouth’s Oyster Pond watershed.

## 1.2 CWMP SCOPE AND TIMELINE

This CWMP was developed in three phases, as follows:

- Phase 1: Needs Assessment (for both Oyster Pond and Salt Pond watersheds).
- Phase 2: Development and Screening of Alternatives (Oyster Pond).
- Phase 3: Detailed Evaluation of Screened Alternatives & Implementation Plan (Oyster Pond).

Phase 1 began in Spring 2013 and the Needs Assessment report was issued in October 2013. Phase 2 began in Fall 2013 and the Alternatives Analysis report was issued in February 2014. The project was put on hold for several years. Phase 2 restarted in July 2017 and a revised Alternatives Analysis report was issued in October 2017. Phase 3 began in Summer 2018 and was completed in 2019. The study area shown on **Figure 1-1**.

During the development of this CWMP, numerous relevant items occurred in Falmouth and on Cape Cod, including:

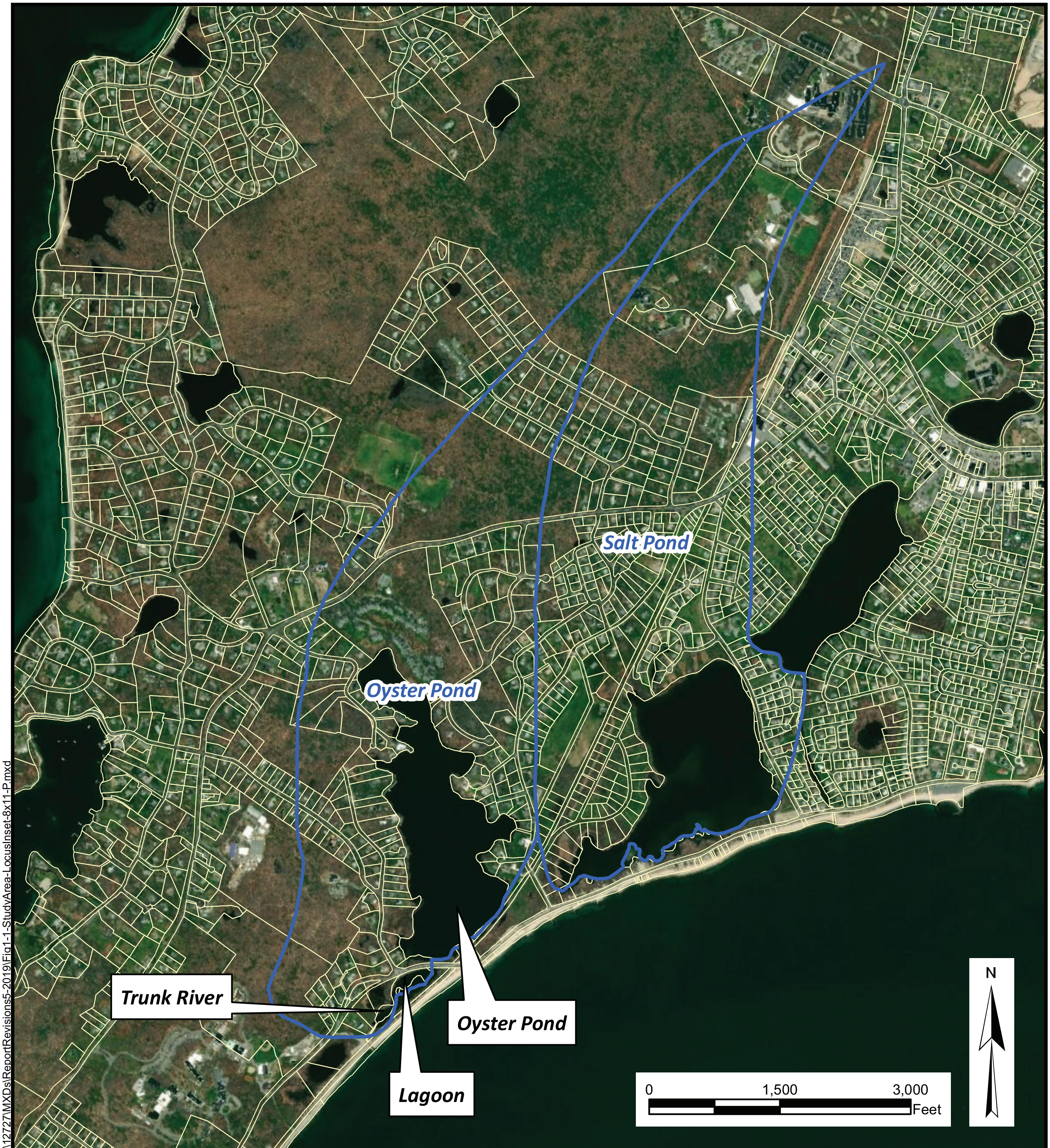
- Falmouth implemented upgrades to the Blacksmith Shop Road Wastewater Treatment Facility (WWTF) and expanded the sewer system to include the Little Pond service area.
- Falmouth received a revised Groundwater Discharge Permit from DEP for the Blacksmith Shop Road WWTF.
- The Cape Cod Commission issued its *Cape Cod Area Wide Water Quality Management Plan Update* (hereinafter referred to as the "208 Plan Update"). This process began in January 2013 and the final 208 Plan was issued in June 2015, certified by MADEP in June 2015 and approved by EPA in September 2015.
- Development occurred in the watersheds.

## 1.3 REPORT FORMAT

This report consists of the following sections and several supporting appendices:

| | |
|---|---|
| Section 2: | Summary of existing conditions |
| Section 3: | Description of current and future water resource protection needs |
| Section 4: | Identification and screening of wastewater management alternatives |
| Section 5: | Identification and screening of composite plans |
| Section 6: | Summary of the implementation plan |
| Section 7: | Evaluation of the environmental impacts of the project |

This report uses a variety of technical terms, abbreviations, and acronyms. **Table 1-1** identifies the most commonly used abbreviations and acronyms.




Watershed Boundary

Base data obtained from
Town of Falmouth (2013),
MassGIS (2009), ESRI (2019)


Falmouth
Oyster Pond CWMP

**Study Area**

| PROJ NO: 12727 | DATE: May 2019 | FIGURE: 1-1 |
| --- | --- | --- |

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## TABLE 1-1
## LIST OF COMMONLY USED ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| **ACEC** | Area of Critical Environmental Concern |
| **BOH** | Board of Health |
| **CCC** | Cape Cod Commission |
| **CWMP** | Comprehensive Wastewater Management Plan |
| **DEP** | Department of Environmental Protection (Massachusetts) |
| **DRI** | Developments of Regional Impact |
| **EIR** | Environmental Impact Report |
| **ENF** | Environmental Notification Form |
| **EENF** | Expanded Environmental Notification Form |
| **EOEEA** | Executive Office of Energy and Environmental Affairs |
| **ESA** | Environmentally Sensitive Area |
| **Future** | Referring to population, wastewater flows or nitrogen loads, expected at Planning Horizon (2040) |
| **GIS** | Geographic Information System |
| **gpd** | Gallons Per Day |
| **gpd/sf** | Gallons Per Day Per Square Foot |
| **I/A** | Innovative and Alternative |
| **I/I** | Infiltration and Inflow |
| **JBCC** | Joint Base Cape Cod (fka Massachusetts Military Reservation, Otis Air Force Base) |
| **kg/day** | Kilograms Per Day |
| **lb/yr** | Pounds Per Year |
| **MEP** | Massachusetts Estuaries Project |
| **MEPA** | Massachusetts Environmental Policy Act |
| **mgd** | Million Gallons Per Day |
| **mg/l** | Milligrams Per Liter |
| **NHESP** | Natural Heritage and Endangered Species Program |
| **NRCS** | Natural Resources Conservation Service |
| **ORW** | Outstanding Resource Water |
| **PALS** | Pond and Lake Stewards |
| **ppm** | Parts Per Million |
| **RMME, RME** | Responsible Municipal Management Entity |
| **SEIR** | Single Environmental Impact Report |
| **SMAST** | School of Marine Science and Technology, University of Massachusetts at Dartmouth |
| **SRF** | State Revolving Fund (administered by Massachusetts Department of Environmental Protection) |
| **TMDL** | Total Maximum Daily Load |
| **USEPA** | U.S. Environmental Protection Agency |
| **USGS** | United States Geologic Survey |
| **WMA** | Waste Management Agency |
| **WQMC** | Water Quality Management Committee |

# SECTION 2

# EXISTING CONDITIONS (OCTOBER 2013)

## 2.1 BACKGROUND

Several previous and on-going planning efforts have been reviewed and utilized herein. The efforts utilized most frequently, or which are most important are summarized below. ***Note: The technical work summarized in this section of the report was completed in October 2013. This section has not been updated to reflect developments in the watershed since that time.***

### 2.1.1 Other Wastewater Planning Efforts

There are no previous wastewater planning studies conducted for the Oyster Pond and Salt Pond watersheds. The Town has developed a *Draft Comprehensive Wastewater Management Plan* (GHD, July 2012) for the Little Pond, Great Pond, Green Pond, Bournes Pond, Eel Pond and Waquoit Bay watersheds, including recommendations for the West Falmouth Harbor watershed. Some information from that effort has been utilized in the development of this report.

### 2.1.2 Local Comprehensive Plan

The Town's Local Comprehensive Plan Update was last revised in 2005. The Local Comprehensive Plan provides a strategic vision for the community and includes the following subject matter which is relevant to this CWMP effort:

- Land Use and Growth Management;
- Water Resources and Coastal Resources;
- Wetland, Wildlife and Plant Habitat
- Economic Development;
- Capital Facilities and Infrastructure; and
- Open Space and Recreation.

The Local Comprehensive Plan has been referenced in the development of this report.

### 2.1.3 Stormwater Management Plan

The Town of Falmouth owns and operates stormwater infrastructure that collects, and discharges treated and untreated stormwater to groundwater and surface waters at various locations around the Town. In order to regulate discharges such as these, the Environmental Protection Agency (EPA) issues so-called NPDES Phase II permits to communities that are identified as Municipal Separate Storm Sewer System (MS4) communities. Falmouth will soon be required to secure coverage under the NPDES Phase II program. A major element of this coverage is the requirement to develop and maintain a Stormwater Management Plan. A Stormwater Management Plan will provide an assessment of Falmouth's water bodies, identify areas of concern, and develop Best Management Practices (BMPs) to address those concerns and improve water quality in the community.

### 2.1.4 Massachusetts Estuaries Project

The Massachusetts Estuaries Project (MEP) is being conducted jointly by the Massachusetts Department of Environmental Protection (DEP) and the School of Marine Science and Technology (SMAST) at the University of Massachusetts, Dartmouth. The MEP was initiated to identify resolutions to the problems caused by the anthropogenic nutrient loads delivered to the coastal environment. The MEP has developed and implemented a modeling approach to determine critical nutrient thresholds in embayments. This modeling approach includes simulating nutrient inputs, nutrient outputs, natural attenuation, and hydrodynamic conditions and calibrating these factors to measured water quality, hydrologic and hydrogeologic conditions. The output of this effort is called a MEP "technical report" for each watershed under study.

Following completion of a MEP technical report, DEP develops a Total Maximum Daily Load Report (TMDL) and submits it for review and approval by EPA. A TMDL establishes the threshold pollutant loads below which water quality impairment are not predicted to occur. These TMDLs (which can be written for any combination of pollutants including nutrients, bacteria, atmospheric pollutants, etc.) are the technical documents on which a management or implementation plan (such as this CWMP) is based. The TMDL also forms the regulatory basis for potential enforcement actions for lack of progress toward achieving the specified requirements.

Since this modeling approach is intended to serve as the basis for billions of dollars of infrastructure expenditures across Cape Cod, the Cape Cod Water Protection Collaborative (an agency of Barnstable County) sponsored an independent scientific peer review of the MEP work in order to address questions and concerns from the public. The scientific peer review was conducted in November 2011 by a panel of experts in the fields of estuarine water quality modeling, estuarine hydrodynamic modeling, estuarine biology, groundwater modeling, nitrogen transport in the environment, and TMDL policy and implementation. The Peer Review Panel issued a report of its findings in December 2011 which concluded that the MEP modeling approach is scientifically credible, functionally adequate, and appropriate for use as the basis for management planning.

The Oyster Pond MEP Report indicates a groundwater flow volume of approximately 91,300 cubic feet/day (pg. 23) and a pond operating volume of approximately 24,300,000 cubic feet (pg. 78); therefore, the residence time in Oyster Pond is approximately 266 days, or 9 months.

### 2.1.5 Summary of Previous Scientific Studies

Oyster Pond has been studied extensively since the 1960s. Much of the historic study is documented in a book entitled *A Coastal Pond Studied by Oceanographic Methods with Epilogue: Oyster Pond – Three Decades of Change* (Emery, et.al, 1997). More recent studies are documented in the Massachusetts Estuaries Project report entitled *Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Thresholds for Oyster Pond System, Falmouth, Massachusetts* (Howes, et.al., 2006) as well as on the Oyster Pond Environmental Trust website (www.opet.org).

Oyster Pond is approximately 3,200 feet long and is approximately 1,200 feet wide at its widest point, with a total surface area of approximately 63 acres. It is comprised of three flooded kettle ponds. The ecosystem in Oyster Pond has changed over its history as its outlets have changed and moved. Prior to 3,000 years ago, the kettle holes were freshwater basins. As sea level rose, the kettle holes were filled with saline water. Oyster Pond provided a source of oysters and fish to natives and settlers in the area. In the mid-1700s, longshore drifts and a hurricane (Falmouth

Historical Society) formed a baymouth bar which began restricting tidal exchange. The pond outlet location and number varied over time based on natural processes until the railroad and Surf Drive were constructed in the late 1800s (when the outlet was fixed at its present location). Between 1860 and 1960, salinity dropped to the point where oysters and eelgrass could not survive. The earliest recorded salinity measurements (from the 1940s) indicate a salinity of 3 ppt to 5 ppt, as compared to Vineyard Sound salinity of 29 to 32 ppt.

Oyster Pond drains to the Lagoon via a culvert under Surf Drive and ultimately to Vineyard Sound via the Trunk River. Under normal conditions, flow is strictly out of Oyster Pond to Vineyard Sound. During extreme weather and/or tide events, such as Hurricane Sandy (2012), flow from Vineyard Sound pushes up the Trunk River and into the Pond. In the mid-1980s, the Town replaced the Surf Drive culvert with a larger culvert. That allowed more ocean water flow into the pond which increased the salinity from its traditional 2 to 4 ppt up to 13 to 16 ppt. This resulted in a collapse of the Oyster Pond ecosystem. There was a discussion at that time on whether the pond should be allowed to become a saline environment, or whether to try to return it to its historic 2 to 4 ppt. The decision was made to do the latter, and a weir was installed near the culvert in March 1998 in order to control the salt water input to the pond.

In general, water quality in Oyster Pond is homogeneous in the horizontal plane but it can become highly stratified in the vertical plane due to both salinity (density) and water temperature differentials. Once stratified, the bottom waters are isolated from oxygen sources and dissolved oxygen is depleted to very low levels. Anthropogenic nutrient sources in the watershed amplify the dissolved oxygen depletion.

Thermal and density stratifications are naturally occurring phenomena in Oyster Pond. Based on data collected by the Falmouth Pond Watchers and the Oyster Pond Environmental Trust (OPET) since 1994, the depth of the naturally occurring stratification is <u>highly variable</u> (i.e., varies between 3 meters and 6 meters depth). The strength and depth of the stratification is strongly influenced by natural weather conditions including: ocean overwash or backflow from intense storms (which increase stratification by increasing salinity of bottom layers when the dense water sinks); rain events (which increase stratification by lowering temperature/ salinity/ transmittance of surface layers); and wind events (which reduce stratification due to increased wind shear mixing).

The following is a summary of additional relevant findings which are documented in the aforementioned studies (reference and page number noted, findings are paraphrased):

- Hydrogen sulfide and methane gases are present in the water column as well as in sediment samples. Hydrogen sulfide odor is noticeable in the water column. Disturbance of sediment releases gas bubbles. Some bubbles reach surface under calm conditions. Bubble rate peaks in June as temp rises to 15degC then trails off over the following months. Hydrogen sulfide gas is believed to be caused by sulfate-reducing bacteria in bottom sediment and water (Emery, pg. 23).

- Pond level is highly dependent on elevation of Trunk River "sill" (i.e., gravel and sand) (Emery, pg. 54).

- In the studies in the 1960s, benthic animals were found to live only in oxygenated waters of approximately 2-meter depth and shallower (Emery, pg. 63).

- A "pool of ammonium" was found in deep waters with high salinity. The ammonium levels result from the accumulation of remineralized nitrogen from the decay of phytoplankton which settle to the basin sediments. Almost all the nitrogen is in the form of ammonium, which is readily available for uptake by plants and therefore capable of stimulating algal blooms. The nitrogen levels in these layers [are/were] exceedingly high, >2000 uM or 28 mg/l. Injection of this pool into the surface water layer in a single mixing events would increase the surface water total nitrogen levels from ca. 50 uM to over 400 uM (Emery, pg. 100). *[Based on a review of current OPET data, typical ammonium values range from 0 to 0.5 mg/l; however, peak values in the bottom waters at sample location "OP 1" and "OP 3" range from 1 to 18 mg/l.]*

- An estimated 42 homes were present within 100m of shore prior to 1969. (Emery, pg. 61). Of the approximately 200 dwelling units present prior to 1997 within the watershed, almost two-thirds have been constructed between 1977 and 1997 (Emery, pg. 101). *[As of October 2013, there are 225 dwelling units.]*

- According to MEP modeling, human activities have increased the total nitrogen load to the watershed by a factor of 5.1 over the past few centuries (i.e., from 0.675 kg/day to 3.493 kg/day). The MEP modeling indicates that this has increased the water column nitrogen concentration from 0.385 mg/l to 0.694 mg/l. MEP reports the "threshold load" and "threshold water column nitrogen concentration" as 1.439 kg/day and 0.548 mg/l, respectively. MEP modeling indicates that the total nitrogen load to the watershed needs to be reduced by 59% in order to achieve the threshold values (Howes, pg. 89-91, 101-107). If this nitrogen load reduction is accomplished solely by elimination of septic system discharges, then 77% of the systems must be eliminated.

## 2.2 LAND USE AND DEMOGRAPHICS

Key land use and demographic data are summarized in **Table 2-1** based on information supplied by the Town's GIS Department. **Figure 2-1** shows the zoning districts and **Figure 2-2** shows current land uses.

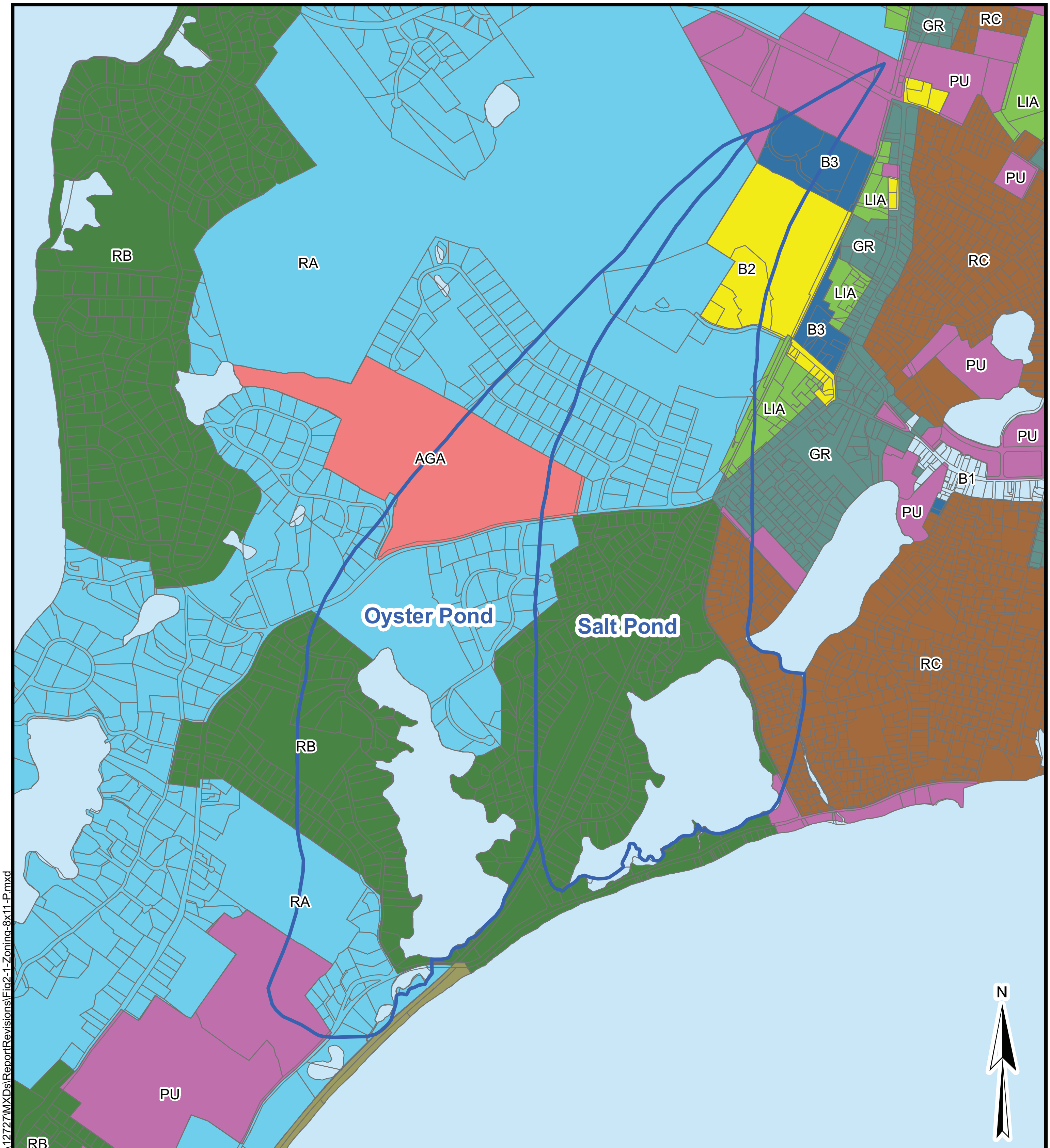
The Oyster Pond watershed is predominantly residential, with a small percentage of parcels dedicated to public service zoning. Approximately 24% of the land in this watershed is dedicated to conservation. There is a total of 211 parcels in this watershed. Of these, approximately: 163 parcels are developed residentially, and 3 parcels are developed as public service/exempt. The land in this watershed is substantially developed, with just 8% of the vacant parcels considered developable.

The Salt Pond watershed is predominantly residential, with a small percentage of parcels dedicated to commercial and public service zoning. Approximately 21% of the land in this watershed is dedicated to conservation. There is a total of 381 parcels in this watershed. Of these, approximately: 268 parcels are developed residentially; 9 parcels are developed commercially; 7 parcels are developed as public service/exempt. The land in this watershed is also substantially developed, with less than 3% of the vacant parcels considered developable.

**TABLE 2-1**
**SUMMARY OF LAND USE AND DEMOGRAPHIC DATA (OCT 2013)**

| | Oyster Pond | Salt Pond |
|---|---|---|
| **Residential (including multi-family and condo)** | | |
| Parcels - Number Developed | 161 | 268 |
| Parcels - Total Number | 208 | 360 |
| Lot Area - Developed, acres | 173.1 | 155.9 |
| Lot Area - Total, acres | 628.8 | 222.1 |
| Number of Dwelling Units | 225 | 303 |
| Number of Bedrooms | 603 | 956 |
| Avg Size of Developed Lot, acres | 0.74 | 0.58 |
| | | |
| **Commercial** | | |
| Parcels - Number Developed | 0 | 9 |
| Parcels - Total Number | 0 | 12 |
| Lot Area - Developed, acres | 0 | 19.7 |
| Lot Area - Total, acres | 0 | 26.2 |
| | | |
| **Municipal/Exempt** | | |
| Parcels - Number Developed | 3 | 7 |
| Parcels - Total Number | 3 | 9 |
| Lot Area - Developed, acres | 98.5 | 83.5 |
| Lot Area - Total, acres | 98.5 | 87.6 |
| | | |
| **Total** | | |
| Parcels - Number Developed | 164 | 285 |
| Parcels - Total Number | 210 | 381 |
| Lot Area - Developed, acres | 271.6 | 259.0 |
| Lot Area - Total, acres | 727.3 | 335.9 |
| | | |

Source: Falmouth GIS data, 2013 WP watershed delineation for Oyster Pond and Salt Pond.




Watershed Boundary

**Zoning Districts**

- Agricultural A
- Business 2
- Business 3
- General Residence
- Light Industrial A
- Public Use
- Single Residence A
- Single Residence AA
- Single Residence B
- Single Residence C

Base data obtained from Town of Falmouth (2013), MassGIS (2009)

0 0.3 0.6 Mile

Falmouth
Oyster Pond CWMP

**Zoning**

PROJ NO: 12727 DATE: Aug 2013

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**FIGURE: 2-1**

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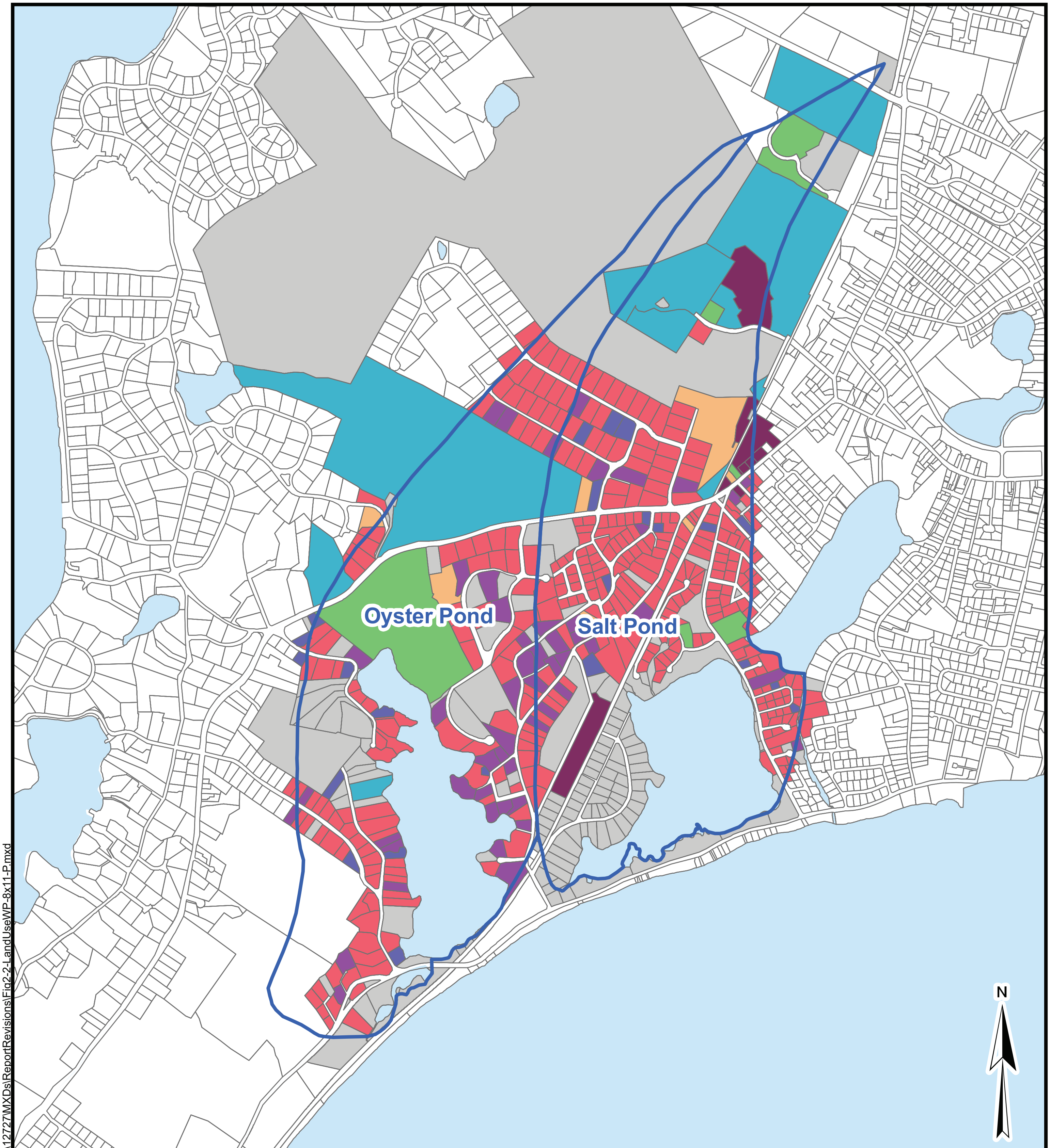


| | |
|---|---|
| Watershed Boundary | Single Family 1-2 Bedroom |
| Commercial | Single Family 3-4 Bedroom |
| Condo | Single Family 5+ Bedroom |
| Multi-Family | Vacant |
| Municipal/Exempt | |

Base data obtained from Town of Falmouth (2013), MassGIS (2009)

0 0.3 0.6 Mile

Falmouth
Oyster Pond CWMP

**Land Use**

PROJ NO: 12727 DATE: Aug 2013 FIGURE: 2-2

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## 2.3 POPULATION

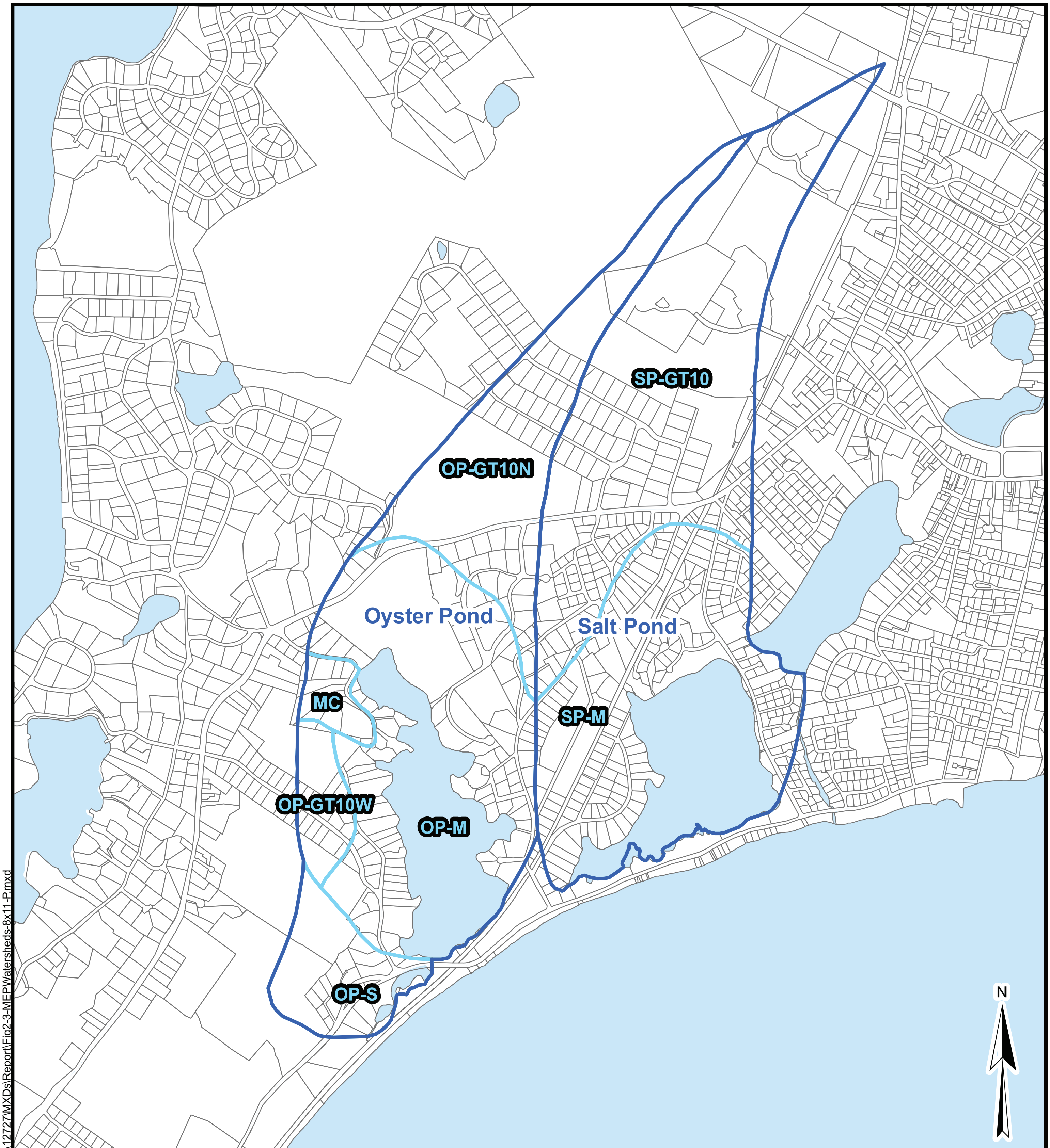
The Local Comprehensive Plan estimates the town-wide population at approximately 32,700 individuals in 2002. For the purposes of wastewater planning, we are interested in "equivalent annual population" as this considers seasonal population variation as well as the influence of commercial flows. The Local Comprehensive Plan estimates the “annualized” town-wide population at approximately 49,200 individuals in 2002. The Local Comprehensive Plan estimates that Falmouth's residential parcels are occupied 69% on a year-round basis, 30% on a seasonal basis, while 1% are vacant. The 2010 Census indicated a town-wide population of 31,531 with 2.22 people per household.

## 2.4 WATERSHEDS

All groundwater recharge in the Oyster Pond and Salt Ponds watershed ultimately flows to Vineyard Sound. Each of these primary watersheds can be further broken down into "subwatersheds", which drain to ponds, stream, wetlands, and coastal waters. The groundwater recharge watershed and subwatershed delineation work is done by the Massachusetts Estuary Project (MEP) as a part of the preparation of their technical reports. The watershed and subwatershed delineations for the watersheds that have completed MEP technical reports are indicated in blue on **Figure 2-3**. The surface watershed has not been delineated; however, OPET has provided preliminary information to the Town for review and analysis.

## 2.5 ENVIRONMENTALLY SENSITIVE AREAS

Environmentally sensitive areas (ESAs) represent significant natural resources in the town. The resources must be recognized when considering existing or potential alternative wastewater management options across town. The following section presents a summary of the ESAs identified for Falmouth based on a review of available Massachusetts Geographic Information System (MassGIS) and Town files, maps, and relevant documents. Information is provided in this section for: 1) freshwater ponds; 2) coastal ponds and embayments; and 3) protected areas.




MEP Watershed Boundary

MEP Subwatershed Boundary

Base data obtained from
Town of Falmouth (2013),
ESRI (2013)

0 0.3 0.6 Mile

Falmouth
Oyster Pond CWMP

**MEP Watersheds**

PROJ NO: 12727 DATE: Jul 2013

WRIGHT-PIERCE
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FIGURE: 2-3

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### 2.5.1 Freshwater Ponds

There are no freshwater ponds within the study area; however, Oyster Pond is brackish with low salinity and appears to be sensitive to phosphorus loadings. Oyster Pond serves as habitat for freshwater and brackish water fish species including herring, white perch, and yellow perch.

### 2.5.2 Coastal Ponds & Embayments

Oyster Pond and Salt Pond are designated coastal ponds. They support a diverse group of species as well as recreational activities like swimming, boating, fishing, and birding. Both ponds are included in the Massachusetts Estuaries Project. The MEP has completed a Technical Report (2006) and a Total Maximum Daily Load (TMDL) Study (2008) for Oyster Pond. The MEP has completed a Technical Report for Salt Pond (2014). According to published MEP technical reports, residential and commercial development on Cape Cod has negatively impacted estuarine water quality. The contaminant of principal concern for coastal embayments is nitrogen which primarily comes from on-site wastewater disposal, lawn fertilization, stormwater disposal, atmospheric deposition, and recycling from bottom sediments. On-site wastewater disposal is by far the largest controllable source of nitrogen to impaired estuaries; therefore, the TMDLs will constitute a significant driving force for wastewater management.

### 2.5.3 Protected Areas

Environmentally sensitive areas include "protected areas", which receive additional scrutiny by regulatory agencies. These areas include Areas of Critical Environmental Concern (ACECs), Districts of Critical Planning Concern (DCPCs), wetland resource areas, open space, and conservation areas, shellfishing areas, outstanding resource waters (ORWs), and protected lands. These areas were identified through mapping available from the Town, MassGIS and the Cape Cod Commission and are described below.

#### *2.5.3.1 Areas of Critical Environmental Concern/ Districts of Critical Planning Concern*

There are no designated Areas of Critical Environmental Concern (ACEC) or Districts of Critical Planning Concern (DCPC) in the study area.

#### *2.5.3.2 Wetland Resource Areas*

Wetlands, including marshes, shrub or wooded swamps, wet meadows, and bogs, serve a number of vital roles in the natural environment including providing areas of valuable habitat for many species and serving as natural filters and flood management locations. Wetland resource areas also include salt marshes. Vernal pools are temporary pools of water which provide significant seasonal habitat for amphibians during breeding season. Wetlands and vernal pools provide valuable habitat for many species and support recreational activities like bird watching. There are several areas of wetlands and vernal pools in the study area, as shown on **Figure 2-4**.

#### *2.5.3.3 Conservation Lands*

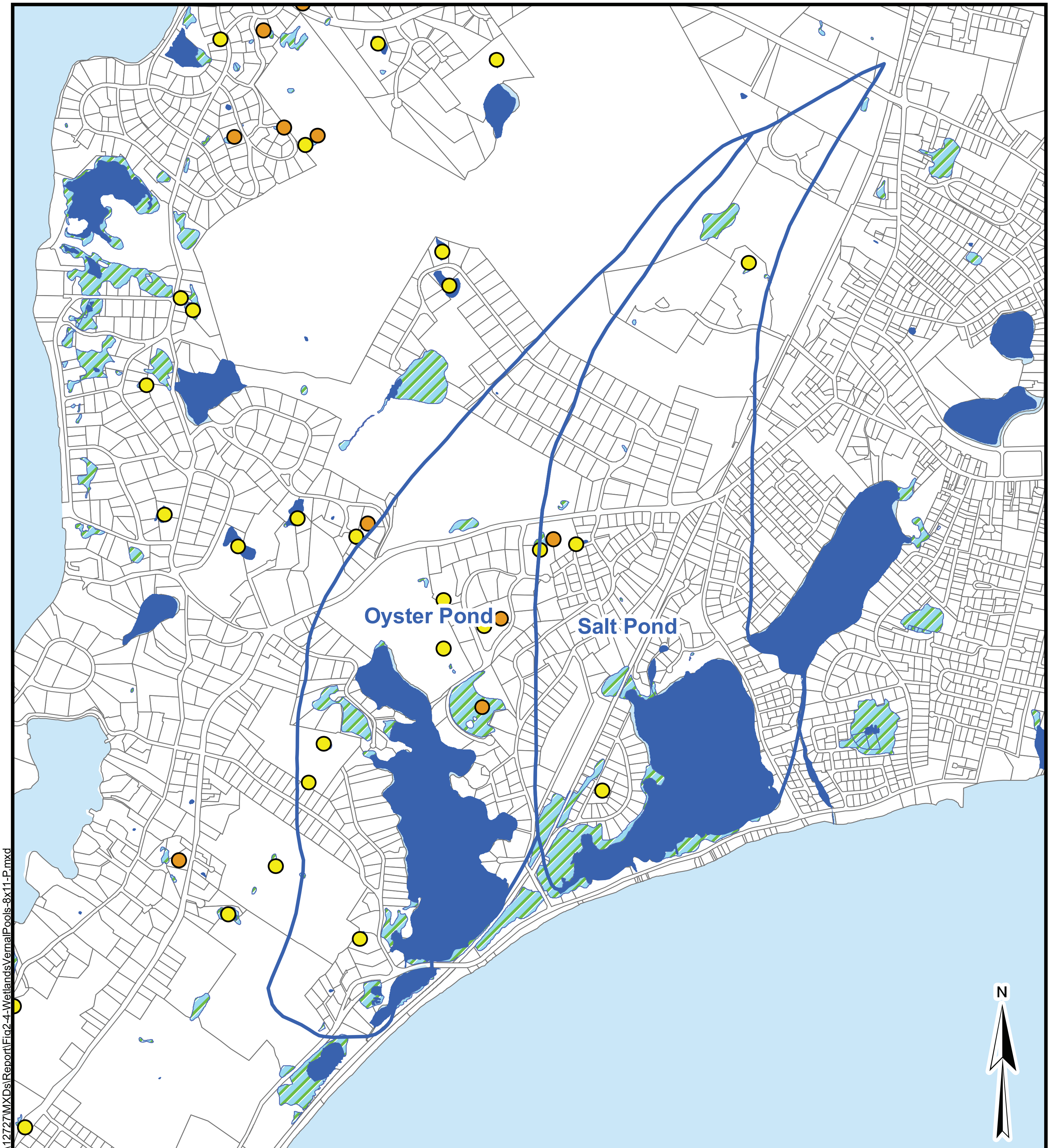
Conservation lands account for approximately 24% of the land area in the Oyster Pond and Salt Pond watersheds. Some of this land is held as privately-owned open space land, including the parcels owned by the Oyster Pond Environmental Trust and the Salt Pond Bird Sanctuaries Inc. Open space and conservation lands are shown on **Figure 2-5**.

#### *2.5.3.4 Shellfishing Areas*

MassGIS has a data layer of designated shellfish growing areas (2009) and shellfish suitability areas (2011). This data layer depicts areas of potential shellfish habitat and their respective harvest classification. According to this information, both Oyster Pond and Salt Pond are classified as "prohibited"; however, a small portion of Salt Pond is identified as potential habitat for the soft-shelled clam. The State stopped sampling Oyster Pond for bacteria in 1999 after the weir was installed and pond salinity was managed to 2-4 ppt. This information is presented on **Figure 2-6**.

#### *2.5.3.5 Outstanding Resource Waters*

Outstanding resource waters (ORWs) constitute water bodies, or the watersheds of waterbodies, that are designated for protection under Massachusetts surface water quality standards due to high ecological, recreational, or aesthetic values. There are no ORWs in the project area.




MEP Watershed Boundary
Certified Vernal Pool
Potential Vernal Pool
Open Water
Wetland

Base data obtained from
Town of Falmouth (2013),
MassGIS (2000, 2009, 2013),
ESRI (2013)

0 0.3 0.6 Mile

Falmouth
Oyster Pond CWMP

**Wetlands and Vernal Pools**

PROJ NO: 12727 DATE: Jul 2013 FIGURE: 2-4

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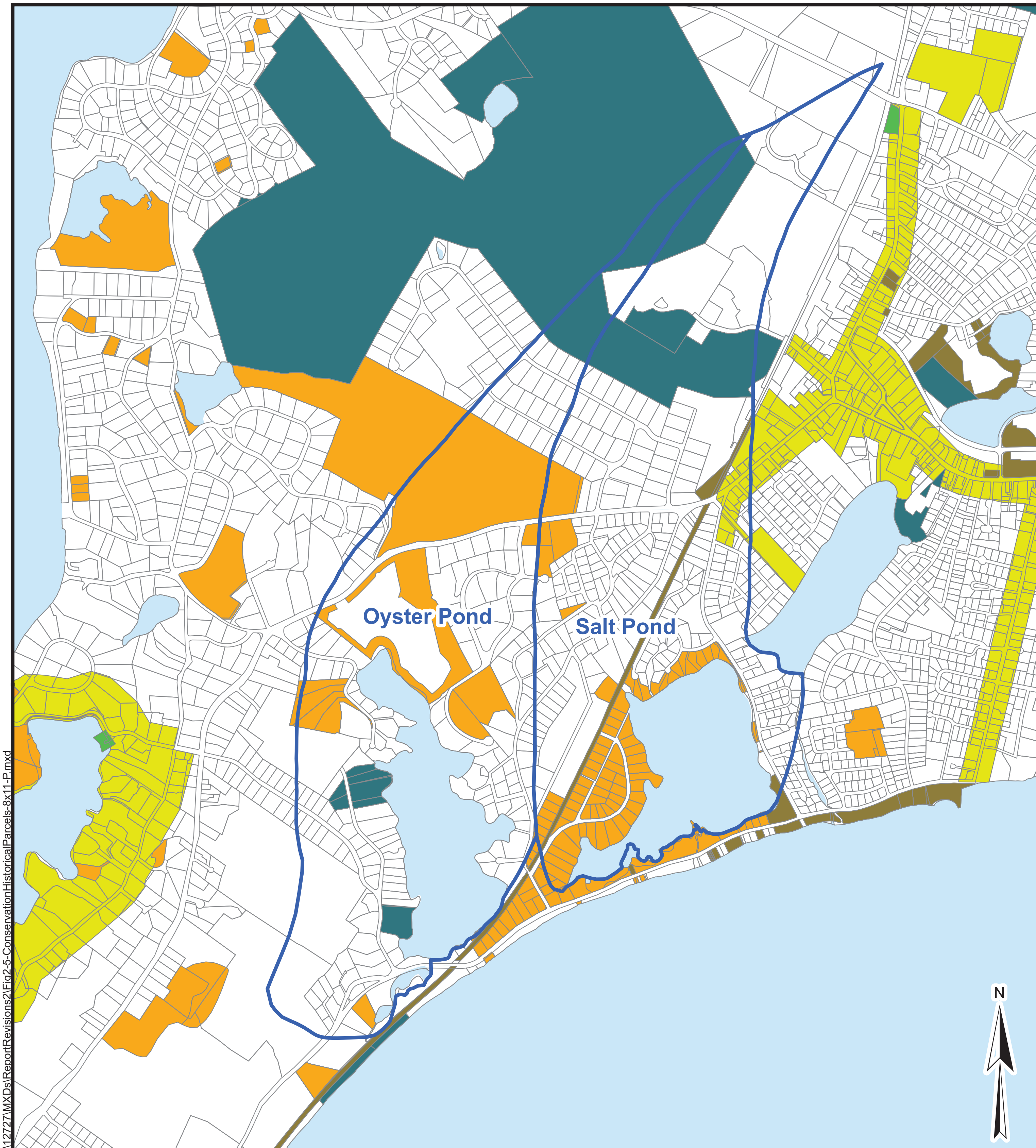
W:\GIS_Development\Projects\MA\Falmouth\12727\MXDs\Report\Fig2-4-WetlandsVernalPools-8x11-P.mxd




Watershed Boundary
Conservation
Historical/Cultural
Other
Recreation
Recreation and Conservation
Open Water

Base data obtained from
Town of Falmouth (2013),
MassGIS (2009, 2013)

0 0.3 0.6 Mile

Falmouth
Oyster Pond CWMP

**Conservation Land**
**Historical Parcels**

| PROJ NO: 12727 | DATE: Sep 2013 | FIGURE: 2-5 |
|---|---|---|

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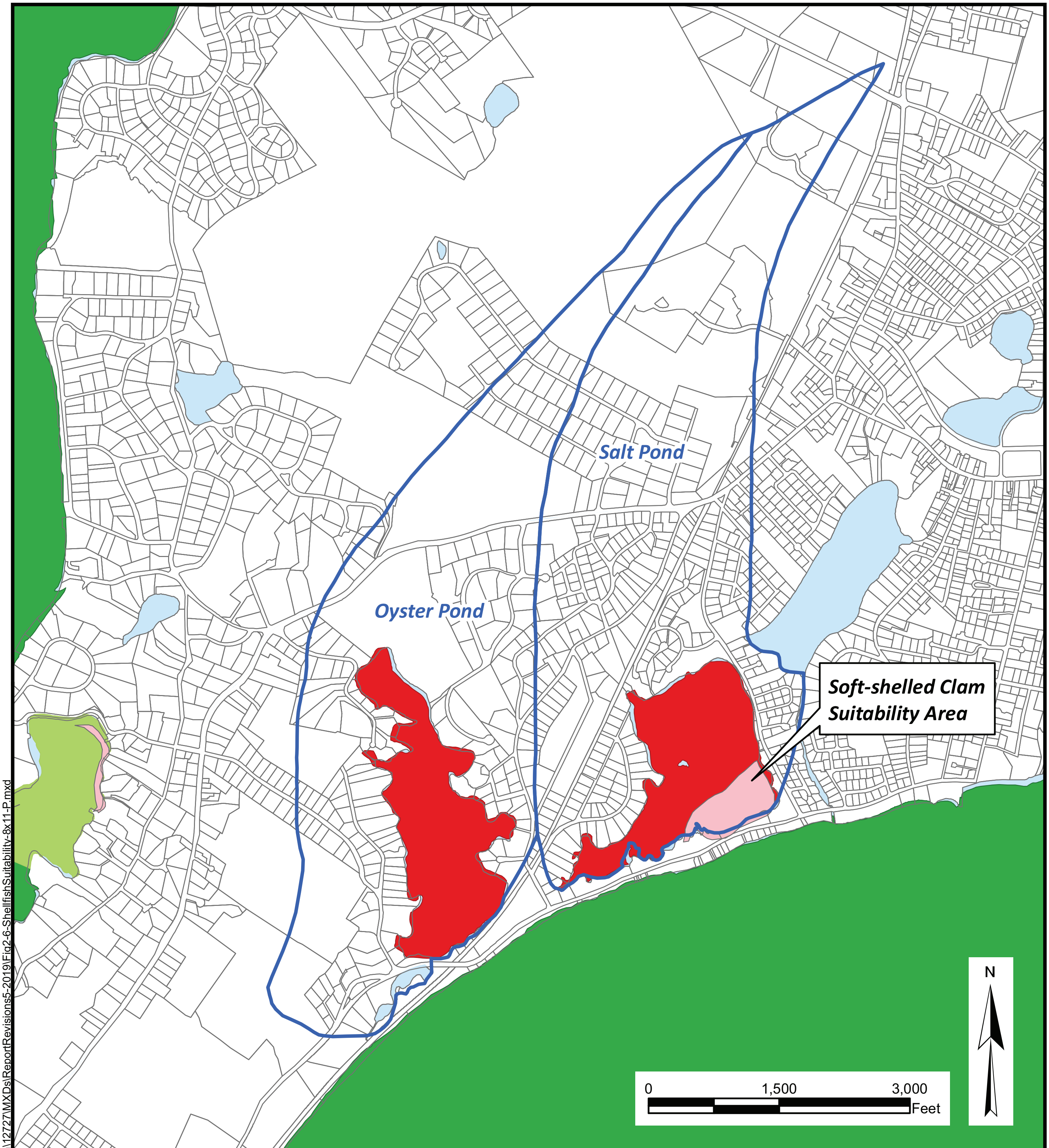
W:\GIS_Development\Projects\MA\Falmouth\12727\MXDs\ReportRevisions2\Fig2-5-ConservationHistoricalParcels-8x11-P.mxd




- Watershed Boundary
- Ocean Quahog
- Quahog
- Soft-shelled Clam
- Sea Scallop
- Surf Clam
- Approved
- Conditionally Approved
- Restricted
- Conditionally Restricted
- Prohibited
- Outstanding Resource Waters

Base data obtained from Town of Falmouth (2013), MassGIS (2009, 2011, 2017)

Falmouth
Oyster Pond CWMP

**Shellfish Suitability**
**Outstanding Resource Waters**

| PROJ NO: | DATE: | FIGURE: |
|---|---|---|
| 12727 | May 2019 | 2-6 |

WRIGHT-PIERCE
Engineering a Better Environment

W:\GIS_Development\Projects\MA\Falmouth\12727\MXDs\ReportRevisions5-2019\Fig2-6-ShellfishSuitability-8x11-P.mxd

#### *2.5.3.6 Floodplains*

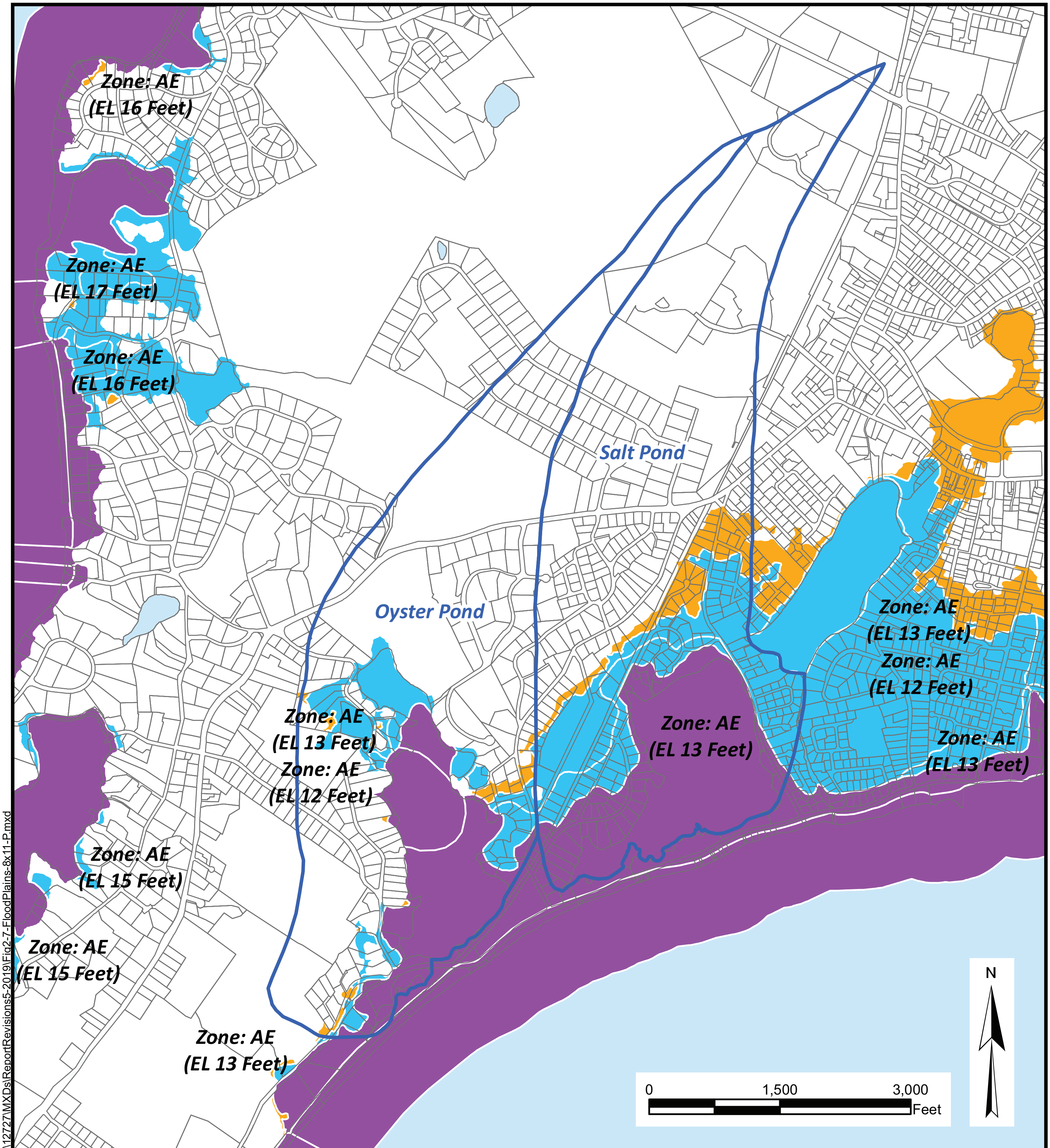
The Federal Emergency Management Agency (FEMA) provides mapping which indicates flood hazard areas based on a statistical 100-year and 500-year flood recurrence intervals. This flood hazard mapping is based on FEMA Flood Insurance Rate Mapping (effective July 2014) and is depicted on **Figure 2-7**. The extent of floodplains must be taken into consideration in the siting of wastewater infrastructure. The 100-year and 500-year flood plains intersect a portion of 48% of the parcels in the Oyster Pond watershed.

#### *2.5.3.7 Habitat of Rare and Endangered Species*

The Natural Heritage and Endangered Species Program (NHESP) at the Massachusetts Division Fisheries & Wildlife maintains mapping for priority habitat of rare and endangered species. Numerous species of special concern and endangered species have been identified in the Oyster Pond and Salt Pond watersheds (i.e., Eastern Box Turtle, Common Tern, Least Term and Roseate Tern). NHESP mapping for the study area is presented on **Figure 2-8** (MassGIS, October 2008).

## 2.6 SOILS

Soil conditions are important in selecting sites for disposal of stormwater or wastewater effluent as well as for assessing sanitary needs screening for Title 5 compliance. The rate at which effluent can percolate through soil directly impacts the size, design, viability, and longevity of effluent disposal systems. It also impacts how much "natural treatment" occurs prior to reaching a waterbody. From the standpoint of stormwater and wastewater disposal systems, most of the Cape benefits from sandy soils (i.e., well drained soils). However, the United States Department of Agriculture's Soil Conservation Service characterizes all soils present on Cape Cod as "severe" for the category of septic tank absorption/leaching fields (Soil Survey of Barnstable County MA, March 1993, Table 11) due either to poor percolation or rapid drainage. In the project area, the majority of soil is considered to be “excessively drained” to “well drained.” There are some areas of “poorly drained” soils that are in lowland areas near wetlands or shore areas. **Figure 2-9** highlights the location of soil type by these three major categories.






Watershed Boundary
1% Annual Chance Flood Hazard
1% Annual Chance Flood Hazard (Wave Action)
Regulatory Floodway
0.2% Annual Chance Flood Hazard
Area with Reduced Risk Due to Levee

Base data obtained from Town of Falmouth (2013), FEMA (NFHL_25_20190321.gdb) Database.

Falmouth
Oyster Pond CWMP

**Flood Plains**

PROJ NO: 12727 | DATE: May 2019 | FIGURE: 2-7

WRIGHT-PIERCE
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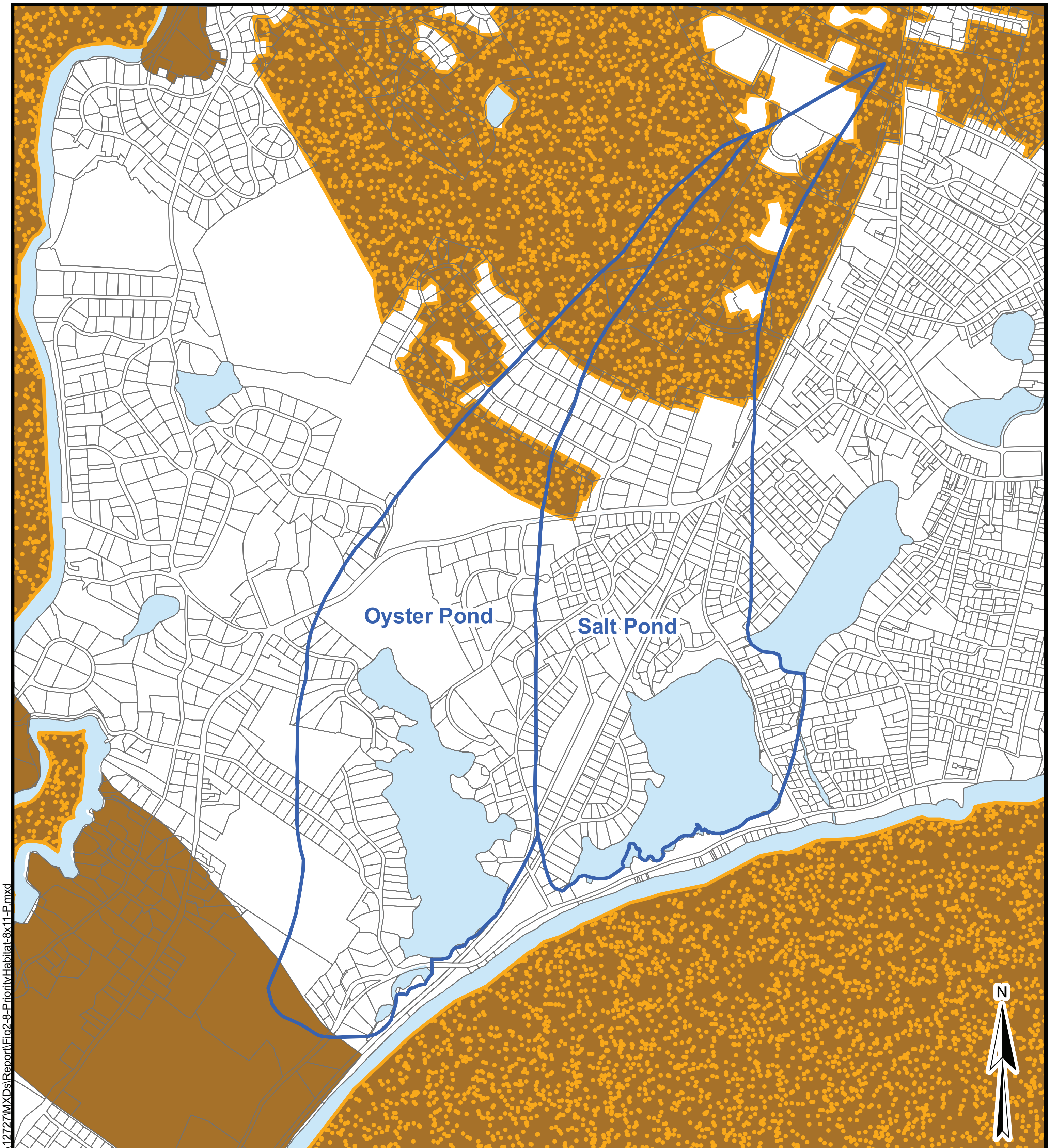


W:\GIS_Development\Projects\MA\Falmouth\12727\MXDs\Report\Fig2-8-PriorityHabitat-8x11-P.mxd

Falmouth
Oyster Pond CWMP

**Priority Habitat of Rare Species**

| PROJ NO: 12727 | DATE: Jul 2013 | FIGURE: 2-8 |
|---|---|---|

WRIGHT-PIERCE
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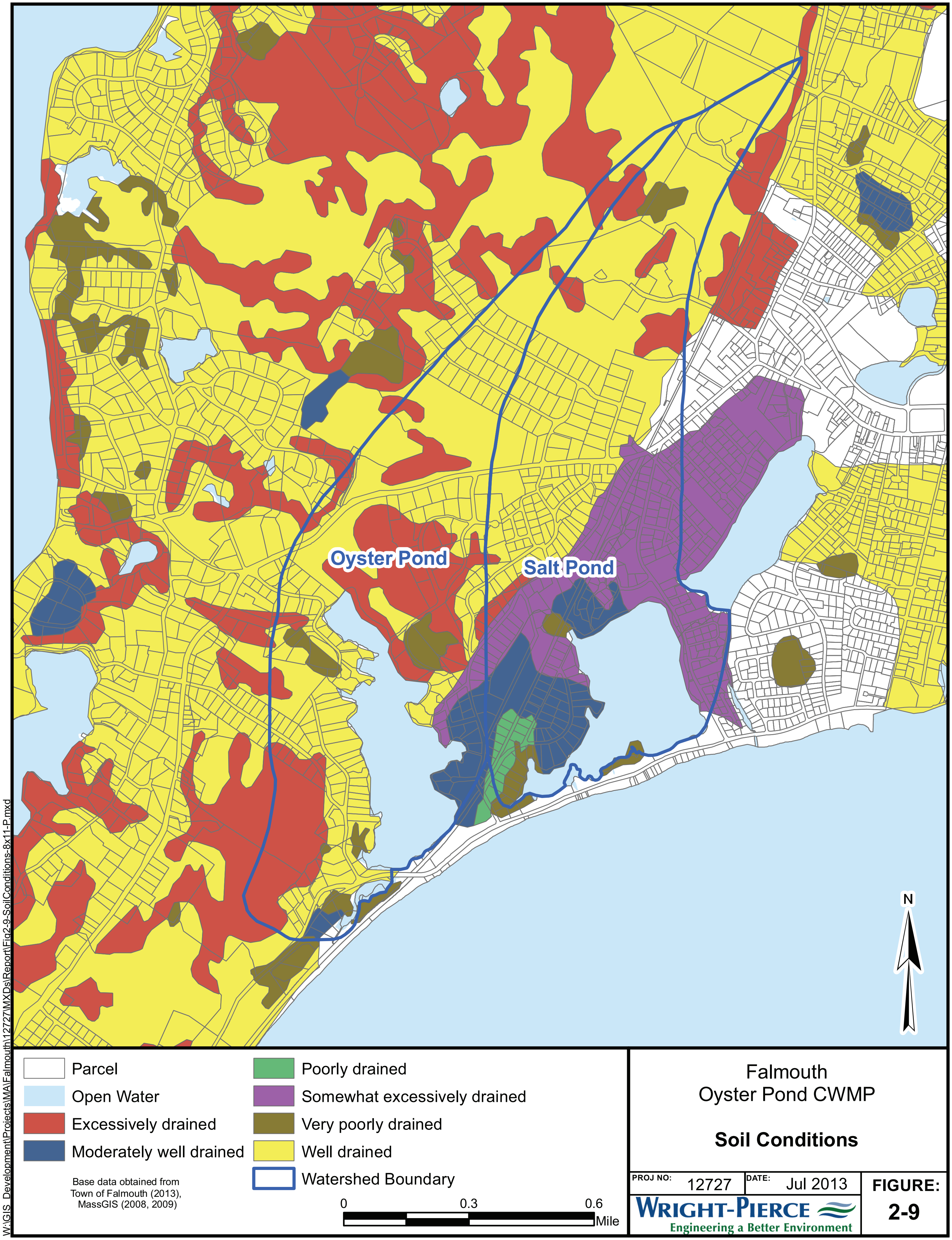


Falmouth
Oyster Pond CWMP

**Soil Conditions**

PROJ NO: 12727 | DATE: Jul 2013 | FIGURE: 2-9

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## 2.7 GROUNDWATER

Groundwater serves as the primary source of drinking water for the Town. Threats to groundwater include septic systems, fuel storage tanks, and hazardous materials use/ storage. There are no public water supply sources in the Oyster Pond or Salt Pond watersheds.

### 2.7.1 Water Supply Infrastructure

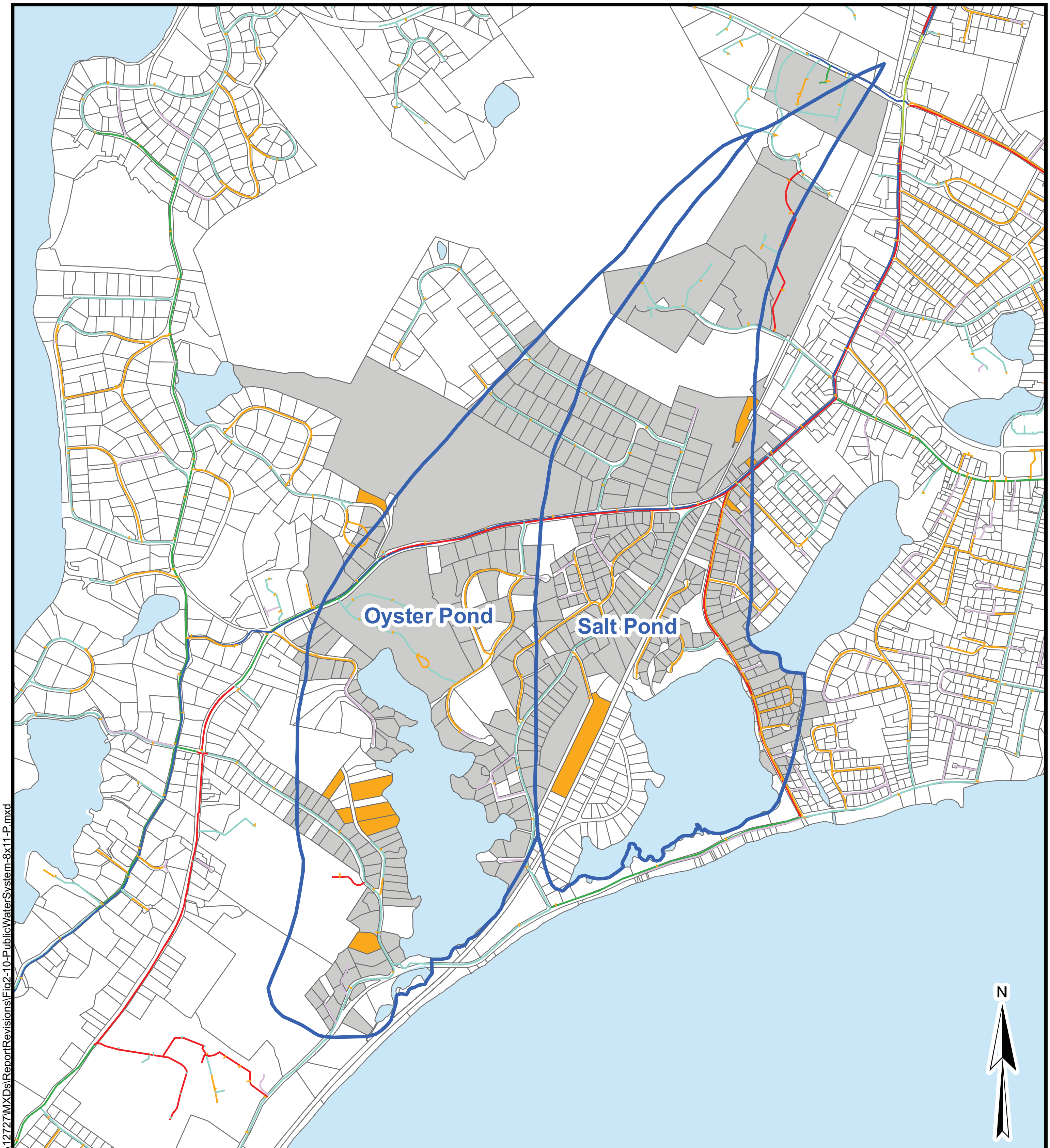
The Town has a public water supply system consisting of groundwater well sources, surface water sources, one water treatment plant, and a water distribution system. Properties which are not served by public water generally have their own private well on site. The properties in the study area which are served by public water as well as by private well are shown on **Figure 2-10**.

### 2.7.2 Wastewater Infrastructure

The Town owns and operates a public wastewater collection treatment system, including sewers, forcemains, pumping stations, and two wastewater treatment facilities (Blacksmith Shop Road and New Silver Beach). These treatment facilities are operated to comply with groundwater discharge permits issued by the Massachusetts Department of Environmental Protection.

No properties in the Oyster Pond watershed are connected to the public sewer system. Thirty-eight properties in the northern portion and the southeastern portion of the Salt Pond watershed are connected to the public sewer system. Wastewater flow from these parcels is conveyed to the wastewater treatment facility on Blacksmith Shop Road. Public wastewater infrastructure is shown on **Figure 2-11**.

There are no other public or private wastewater treatment systems serving more than one property in these watersheds. The wastewater flow from all remaining properties is treated and disposed of via on-site systems. As of October 2013, approximately one-third of the existing on-site systems are Title 5 systems, one-third are cesspools and one-third are septic tanks with leaching pits. There are five denitrifying systems (“I/A" or innovative/alternative systems). There are no known “tight tanks” in these watersheds. Treetops Condominiums has 2 four-unit septic systems, 27 two-unit septic systems and 1 one-unit septic system for the clubhouse.




**Water Main Diameter**

- 4" and smaller
- 6"
- 8"
- 10"
- 12"
- 16"
- 18"
- 20"
- 24"
- Zone II's
- Watershed Boundary
- Watershed Parcels Developed w/ Private Well
- Watershed Parcels Developed w/ Public Water

Base data obtained from Town of Falmouth (2013), MassGIS (2009)

0 0.3 0.6 Mile

Falmouth
Oyster Pond CWMP

**Public Water System**

PROJ NO: 12727 | DATE: Aug 2013 | FIGURE: 2-10

WRIGHT-PIERCE
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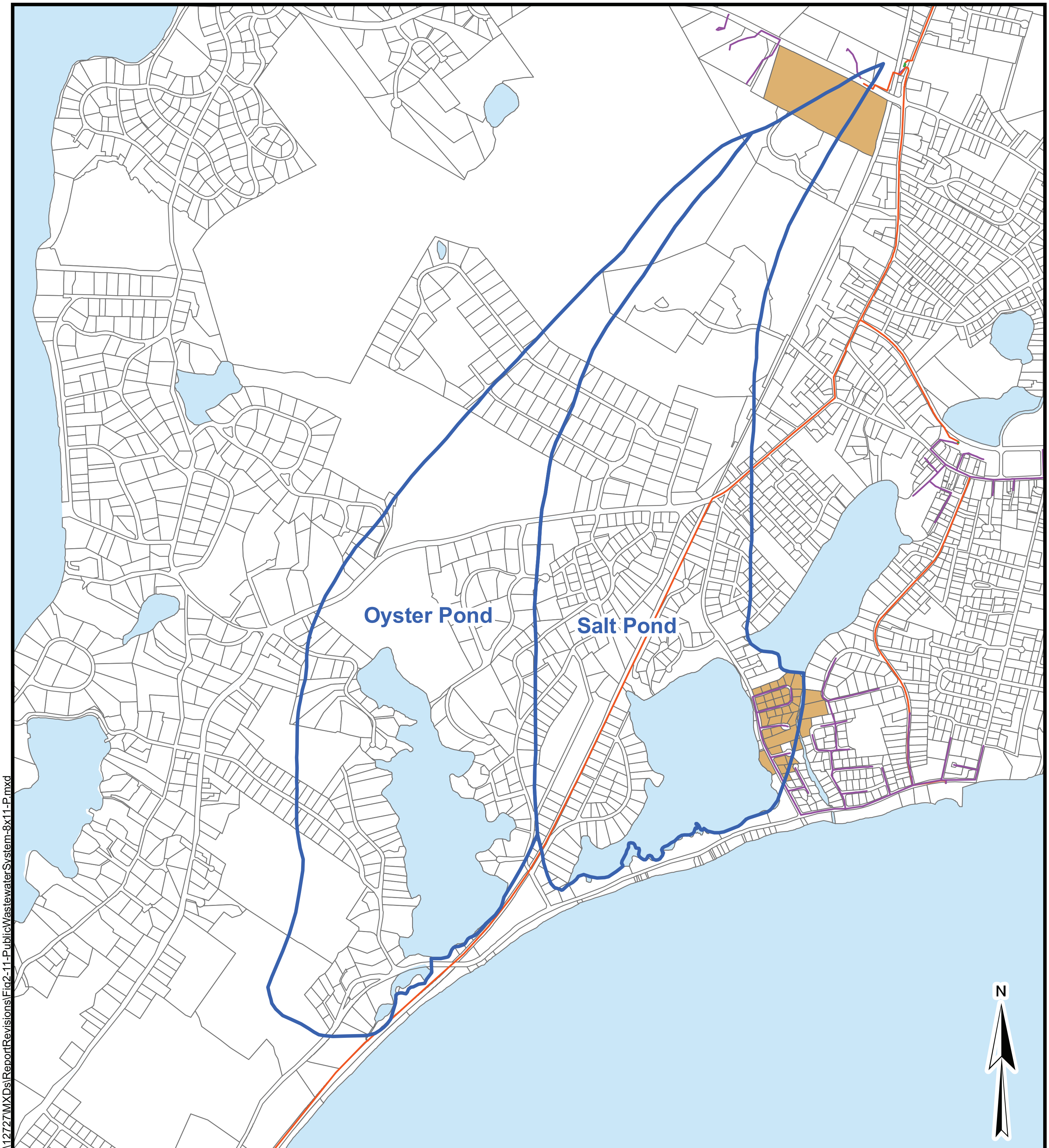
W:\GIS_Development\Projects\MA\Falmouth\12727\MXDs\ReportRevisions\Fig2-10-PublicWaterSystem-8x11-P.mxd




Watershed Boundary
Sewer Force Main
Sewer Gravity Main
Other Sewer Main
Watershed Parcels Served by Public Sewer

Base data obtained from Town of Falmouth (2013), MassGIS (2009)

0 0.3 0.6 Mile

Falmouth
Oyster Pond CWMP

**Public Wastewater System**

PROJ NO: 12727 DATE: Aug 2013

WRIGHT-PIERCE
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FIGURE: 2-11

W:\GIS_Development\Projects\MA\Falmouth\12727\MXDs\ReportRevisions\Fig2-11-PublicWastewaterSystem-8x11-P.mxd

## 2.8 SURFACE WATER

The health of surface waters (including estuaries, coastal ponds, streams, rivers, lakes, ponds, wetlands, and vernal pools) are affected by numerous factors such as atmospheric deposition, groundwater recharge and storm water runoff. Nutrients and chemicals from industrial processes can be carried in the atmosphere and deposited with rain. Nutrients and chemicals can be conveyed to surface water by way of groundwater recharge of wastewater effluent from septic systems. Nutrients and chemicals can also be present on land and carried to these resources in potentially harmful concentrations from stormwater runoff.

### 2.8.1 Stormwater Infrastructure

The Town owns and operates a public stormwater system consisting of storm drain piping, including catch basins and drain manholes. These stormwater management systems were generally developed as part of the facilities that they serve (e.g., roads, buildings, subdivisions, etc.). A stormwater drainage system site review was conducted on 1 May 2013 by Wright-Pierce and the Falmouth Engineering Department. The purpose of the site review was to locate stormwater drainage system structures in the Oyster Pond watershed and to identify the presence of illicit connections, if any. No evidence of illicit connections was observed during the site review. Wright-Pierce was prepared to collect and analyze samples for: ammonia, nitrate, nitrite, chlorine, e.coli and detergents. No flowing water was observed, and no samples were collected.

Based on our site review, we identified numerous drainage system features (e.g., catch basins, drain manholes, pipes, area drains, and curb cuts both in public roads, rights-of-way as well as within private development) which were not previously identified on Town GIS mapping. These drainage system components were located by GPS and were compiled into a GIS shape file (provided to the Town electronically). Of the drainage system features identified, only five features discharge directly to either Oyster Pond or to its adjacent wetlands, as follows:

- P-001: Pipe to the wetland adjacent to Oyster Pond (Oyster Pond Road)
- P-022: Curb cut to Oyster Pond (Ransom Road)
- P-033: Drywell Overflow Pipe to Oyster Pond (TreeTops Landfall Road)
- P-101 and P-102: CB and pipe to Oyster Pond (Quonset Road)

The extent of the public and private stormwater management systems is shown on **Figure 2-12**.


Watershed Boundary
Selected Surveyed Structures (W-P)
Surveyed Structures (W-P)
Outfalls
No Diameter

4"; 6"
8"; 10"
12"; 14"
15"; 16"
18" and > 18"

0 0.3 0.6 Mile

Base data obtained from Town of Falmouth (2013), MassGIS (2009)

Falmouth
Oyster Pond CWMP

**Public Stormwater System**

| PROJ NO: 12727 | DATE: Jul 2013 | FIGURE: 2-12 |
|---|---|---|

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Engineering a Better Environment

W:\GIS_Development\Projects\MA\Falmouth\12727\MXDs\Report\Fig2-12-PublicPrivateStormwater-8x11-P.mxd

## 2.9 WATER USE AND WASTEWATER FLOWS

### 2.9.1 Town-Wide Water Use

Parcel-specific water use information provided by the Town is one of the key building blocks for estimating wastewater flows for the study area. There can be variability from year to year in water use that is influenced by weather or economic conditions. One way to reduce that variability is to compute the average over multiple years of data. For the purposes of this CWMP, data have been obtained for the period of 2007 through 2011. The Town's GIS database serves as the basis for linking water use data to site location and land use.

A summary of town-wide water use data is provided in **Table 2-2**. The town-wide average water use for residential parcels has been documented in previous reports as 153 gpd (2006 Oyster Pond MEP Report, p. 32) and as 154 gpd (2007 Needs Assessment Report, GHD, p. 5-19). For the period 2007 to 2011, the town-wide average water use for residential parcels was 150 gpd (based on residential water billing data provided by the Town).

**TABLE 2-2: SUMMARY OF TOWN-WIDE WATER USE (OCT 2013)**

| Year | Average Residential Water Use per Account (gpd) | Annual Average (mgd) | Peak Week (mgd) | Peak Day (mgd) |
|---|---|---|---|---|
| 2007 | 159 | 4.54 | 8.96 | 10.70 |
| 2008 | 162 | 4.16 | 8.65 | 9.86 |
| 2009 | 148 | 3.66 | 5.82 | 7.85 |
| 2010 | 126 | 4.19 | 9.98 | 11.46 |
| 2011 | 153 | 4.32 | 7.94 | 9.52 |
| Average | 150 | 4.17 | 8.27 | 9.88 |

Source: Town of Falmouth Water Department Reports

### 2.9.2 Residential Water Use in Oyster Pond and Salt Pond Watersheds

A summary of the single-family residential water use data for each watershed is presented in **Table 2-3** (Oyster Pond) and **Table 2-4** (Salt Pond). An estimate of "seasonal use" was developed using the Town Assessor's data for the parcels identified as having "taxable personal property." This was considered the best available indicator of seasonal use. Based on this indicator, approximately 54% of the single-family properties in the Oyster Pond watershed (counting Treetops as an individual unit) are seasonal use and represent 50% of the single-family water use. For the Salt Pond watershed, approximately 40% of the single-family properties are seasonal use and represent 32% of the single-family water use in the watershed. The greater the amount of seasonal use, the higher the peaking factors are for water use. Also, when determining build-out potential, seasonal properties could be converted to year-round properties which would result in greater water use in the future. While the Oyster Pond watershed has a larger percentage of seasonal properties and seasonal water use, the Salt Pond watershed has a larger differential between year-round use and seasonal use.

### 2.9.3 Water Use in Oyster Pond Watershed

The significant majority of the water demand in the Oyster Pond watershed (96%) is met by the Town's public water system, with the remaining coming from 6 private wells. Since water use from private wells is not measured or documented by the Town, it must be estimated. For the purposes of this analysis, the water use on the residential parcels served by private wells was assumed to be equal to the average value of the residential parcels served by the public water system. For the period 2007 to 2011, water use in the Oyster Pond watershed averaged 32,000 gallons per day (gpd). Water use in the Oyster Pond watershed represents approximately 0.8% of the town-wide water use.

**TABLE 2-3**
**SUMMARY OF SINGLE-FAMILY RESIDENTIAL WATER USE - OYSTER POND**

| | **Town Water (Year Round)** | | | **Town Water (Seasonal)** | | | **Private Well** | | | **Total Developed Properties** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No. of | Water Use | | No. of | Water Use | | No. of | Water Use | | No. of | Water Use | |
| | Properties | gpd/parcel | gpd | Properties | gpd/parcel | gpd | Properties | gpd/parcel | gpd | Properties | gpd/parcel | gpd |
| 1-2 Bedroom | 4 | 88 | 350 | 5 | 69 | 346 | 1 | 168 | 168 | 10 | 86 | 864 |
| 3-4 Bedroom | 62 | 169 | 10,497 | 51 | 135 | 6,860 | 5 | 168 | 840 | 118 | 154 | 18,197 |
| 5+ Bedroom | 12 | 244 | 2,928 | 20 | 242 | 4,834 | - | 168 | - | 32 | 243 | 7,762 |
| TOTAL | 78 | 177 | 13,775 | 76 | 158 | 12,040 | 6 | 168 | 1,008 | 160 | 168 | 26,823 |
| | | | | *48%* | | *45%* | | | | | | |

**TABLE 2-4**
**SUMMARY OF SINGLE-FAMILY RESIDENTIAL WATER USE - SALT POND**

| | **Town Water (Year Round)** | | | **Town Water (Seasonal)** | | | **Private Well** | | | **Total Developed Properties** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No. of | Water Use | | No. of | Water Use | | No. of | Water Use | | No. of | Water Use | |
| | Properties | gpd/parcel | gpd | Properties | gpd/parcel | gpd | Properties | gpd/parcel | gpd | Properties | gpd/parcel | gpd |
| 1-2 Bedroom | 6 | 106 | 635 | 7 | 59 | 415 | - | 142 | - | 13 | 81 | 1,049 |
| 3-4 Bedroom | 137 | 154 | 21,146 | 86 | 113 | 9,699 | 1 | 142 | 142 | 224 | 138 | 30,987 |
| 5+ Bedroom | 11 | 259 | 2,844 | 9 | 192 | 1,724 | - | 142 | - | 20 | 228 | 4,568 |
| TOTAL | 154 | 160 | 24,625 | 102 | 116 | 11,838 | 1 | 142 | 142 | 257 | 142 | 36,604 |
| | | | | *40%* | | *32%* | | | | | | |

A summary of current water use for developed parcels in the Oyster Pond watershed is presented in **Table 2-5**. The average and median single-family residential water use values were 168 gpd and 124 gpd. For the purposes of the CWMP, the parcel-specific average values will be utilized (as opposed to median values).

**TABLE 2-5**
**CURRENT WATER USE – OYSTER POND WATERSHED**

| Type of Use | Total Developed Properties | | |
|---|---|---|---|
| | Number of Properties | Est. Water Use, gpd | |
| | | Annual Avg per Property | Annual Total per Category |
| **Residential** | | | |
| Single-Family (Note 1, 2) | 160 | 168 | 26,824 |
| Multi-Family | 2 | 208 | 415 |
| Condo (***Note 3***) | 1 | 4,739 | 4,739 |
| **Commercial** | 2 | 0 | 0 |
| **Municipal/Exempt** | 3 | 42 | 125 |
| **TOTAL** | **168** | **191** | **32,103** |

Notes:
1) Source: Falmouth GIS database, 2007 to 2011 water use data.
2) Water use from private wells is assumed to be consistent with water use from public water accounts in the same category (i.e., single-family residential and municipal).
3) This single property is the TreeTops Condominiums which includes 62 residential condo units. The average water use per condo unit is 76 gpd.
4) CWMP parcel selection; varies slightly from MEP parcel selection.

It is important to note that there is a large discrepancy between the values reported in the 2006 Oyster Pond MEP Technical Report and those utilized herein. A comparison of the MEP water use analysis versus the CWMP water use analysis is presented in **Table 2-6** and is summarized below. **Figure 2-13** depicts the selections by MEP, the parcel selections by WP and the parcels that were developed since the MEP Technical Report was completed.

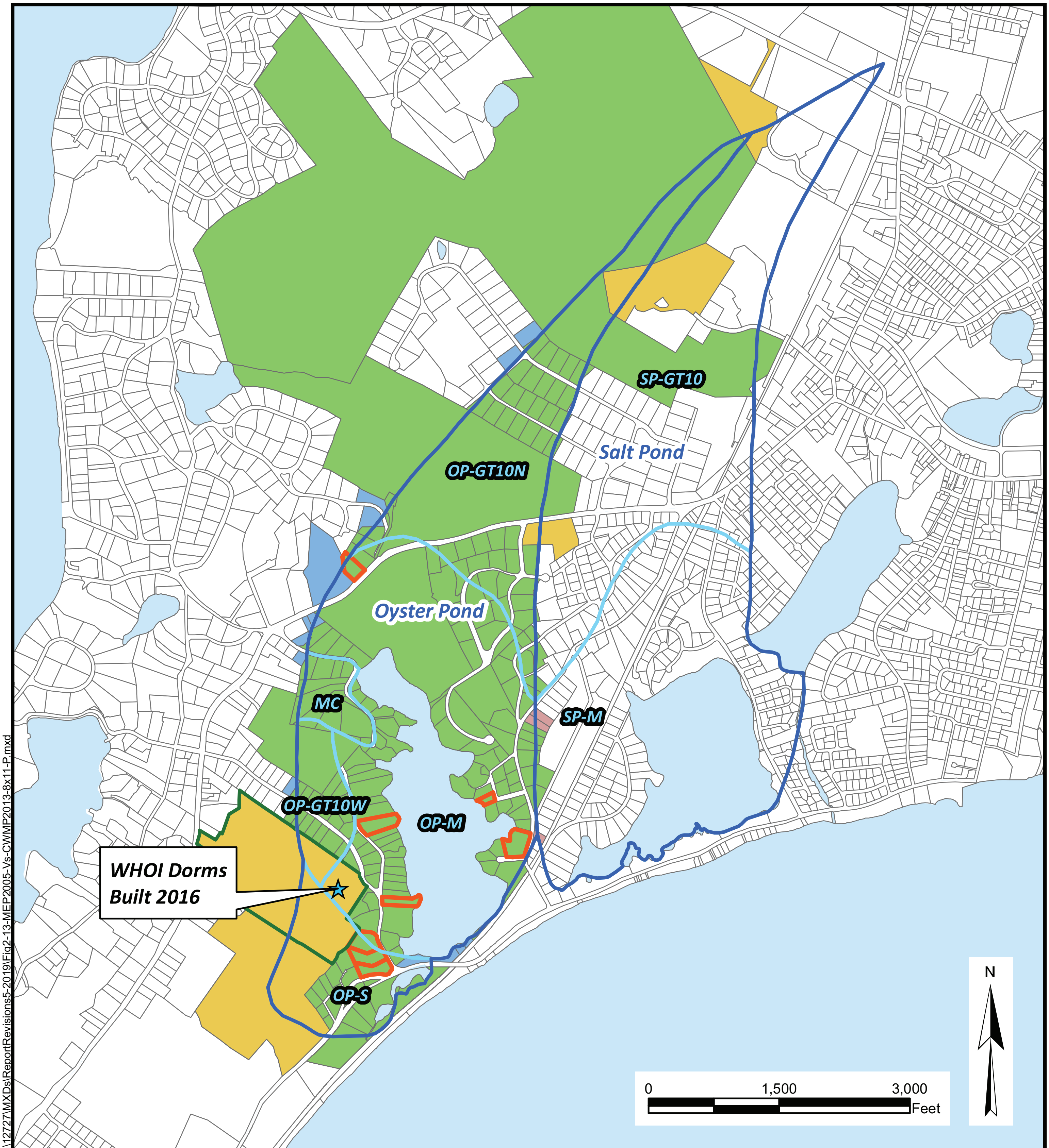
1) The MEP analysis was developed using 2002 to 2003 water use data (two years) and determined that there was 41,785 gpd water use, 10% consumptive use and 37,607 gpd wastewater generation and 26.25 mg/l leachfield effluent TN concentration to arrive at 1,367 kg/y shown on Table IV-4 of the Technical Report (the 'rainbow table').

**TABLE 2-6 COMPARISON OF WATER USE DATA BETWEEN MEP AND CWMP ANALYSES**

| Description | MEP Report and Data Disk | | WP Needs Assessment, Modified Parcel Selection | | Current Conditions as of 2011 | | Development between 2004 (MEP) and 2011 (Current) | | Updated Water Use Comparable to MEP Report and Data Disk |
|---|---|---|---|---|---|---|---|---|---|
| Parcel Selection | MEP Parcels | | WP Parcels | | MEP Parcels | | MEP Parcels | | MEP Parcels |
| Water Use Data Set | MEP (2002-2003) | | WP (2007-2011) | | WP (2007-2011) | | WP (2007-2011) | | WP (2007-2011) |
| Comments | WP Table 2-6 | | WP Table 2-6 | | | | | | |
| | | | | | | | | | |
| **Water** | | | | | | | | | |
| Single Family | 153 | 31,924 | 160 | 26,824 | 153 | 26,822 | 7 | 1,062 | 25,760 |
| Multi-Family | 2 | 3,968 | 2 | 415 | 2 | 416 | 0 | 0 | 416 |
| Condo | 1 | 5,410 | 1 | 4,739 | 1 | 4,739 | 0 | 0 | 4,739 |
| Commercial | 2 | 0 | 2 | 0 | 2 | 0 | 0 | 0 | 0 |
| Municipal/Exempt | 3 | 483 | 3 | 125 | 3 | 86 | 0 | 0 | 86 |
| ***Water Total (gpd)*** | | **41,785** | | 32,103 | | 32,063 | | 1,062 | **31,001** |
| | | | | | | | | | |
| **Consumptive Use** | | 10% | | 10% | | 10% | | 10% | 10% |
| | | | | | | | | | |
| **Wastewater (gpd)** | | 37,607 | | 28,893 | | 28,857 | | 956 | 27,901 |
| | | | | | | | | | |
| **Wastewater TN (mg/l)** | | 26.25 | | | | **Raise concentration >>** | | | 35.4 |
| | | | | | | | | | |
| **Wastewater TN (kg/yr)** | | 1,364 | << MEP Table IV-4 | | | **Hold mass constant >>** | | | 1,366 |

Notes:

1) Source of MEP data is MEP Technical Report (Jan 2006) and data disk. Water use data from 2002 to 2003 (2 years).
2) Source of CWMP data is Falmouth GIS (2013) and Falmouth water use records from 2007 to 2011 (5 years).
3) Refer to Figure 2-13 for parcel selections for MEP and CWMP.




- Watershed Boundary
- MEP Subwatershed Boundary
- MEP Oyster Pond Parcel Built 2004-2016
- WP Oyster Pond Parcel Built 2004-2016
- Key MEP Split Parcel from Data Disk with 0 GPD Wastewater to Oyster Pond
- MEP 2005 Data Disk Parcel
- MEP 2005 Data Disk Parcel and WP Oyster Pond Parcel
- WP Oyster Pond Parcel

Base data obtained from Town of Falmouth (2013), MassGIS (2009)

Falmouth
Oyster Pond CWMP

**Comparison of MEP and CWMP Parcel Analysis**

| PROJ NO: 12727 | DATE: Mar 2019 | FIGURE: |
|---|---|---|
| WRIGHT-PIERCE Engineering a Better Environment | | 2-13 |

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2) The CWMP analysis was developed using 2007 to 2011 water use data (five years) for a slightly different parcel selection. Note: the alternative parcel selection was in part because the Town wanted the Needs Assessment to include the adjacent Salt Pond watershed and in part because several additional parcels on the west watershed boundary were included. The analysis determined that there was 32,103 gpd water use for the CWMP parcel selection, 10% consumptive use and 28,893 gpd wastewater generation. Included in these numbers are 7 single family homes that were constructed between 2004 and 2011.

3) The CWMP analysis was revised to identify watershed water use using the MEP parcel selections and the CWMP water use data. This analysis determined that there was 32,063 gpd water use for the MEP parcel selection, 10% consumptive use and 28,857 gpd wastewater generation. Included in these numbers are 7 single family homes that were constructed between 2004 and 2011.

4) After removing the 1,062 gpd of water use from the single-family homes that did not exist at the time of the MEP analysis, it was determined that there was 31,001 gpd water use for the MEP parcel selection, 10% consumptive use and 27,901 gpd wastewater generation.

5) The difference between the MEP flow estimates and CWMP flow estimates is attributed to:

   a. Utilizing a longer-term data set (five years vs two years) with more water meter readings. The Oyster Pond MEP Report estimated that the single-family residential average water use in the Oyster Pond watershed was 209 gpd; whereas, the CWMP analysis estimated it at 168 gpd. The 15 highest single-family residential water users in the Oyster Pond MEP Report averaged 690 gpd. The 15 highest single-family residential water users in the CWMP averaged 490 gpd.
   b. Eliminating a significant outlier value in the MEP data set (Parcel 48-12-002-049, LUC 109, Subwatershed 4) which indicated 3590 gpd for the single-family property. The same property averaged 228 gpd during the 2007 to 2011 data set. The owner of this property reported to the Town that the higher water use was related to a leaking pipe which was repaired. This outlier value also raised the residential average water use.
   c. Increasing prevalence of low-volume and water-efficient fixtures.

While the water use estimates do vary between the Oyster Pond MEP Report and this CWMP, each analysis is considered complete and separate. For the reasons stated above, the CWMP is based on the "CWMP analysis." The implications of the different values could be assessed via a sensitivity analysis conducted through the MEP process later.

Given that this is a small watershed with relatively limited growth and given that a TMDL is already issued, the wastewater load to the watershed was held constant (1,364 kg/yr) and the leachfield effluent nitrogen concentration was increased (from 26.25 mg/l to 35.4 mg/l) for the Needs Assessment and Alternatives Analysis. These values (1,364 kg/yr and 35.4 mg/l) will be utilized in the remainder of this CWMP.

### 2.9.4 Water Use in Salt Pond Watershed

The significant majority (98%) of the water demand in the Salt Pond watershed is met by the Town's public water system, with the remaining coming from 1 private well. Since water use from private wells is not measured or documented by the Town, it must be estimated. For the purposes of this analysis, the water use on the residential parcels served by private wells was assumed to be equal to the average value of the residential parcels served by the public water system. For the period 2007 to 2011, water use in the Salt Pond watershed averaged 96,900 gpd. Water use in the Salt Pond watershed represents approximately 2.3% of the town-wide water use.

A summary of current water use for developed parcels in the Salt Pond watershed is presented in **Table 2-7**. For the Salt Pond watershed, the average and median single-family residential water use values were 142 gpd and 120 gpd, respectively. For the purposes of the CWMP, the parcel-specific average values will be utilized (as opposed to median values). This CWMP value compares well to the MEP single-family residential average water use value of 140 gpd.

**TABLE 2-7**
**CURRENT WATER USE – SALT POND WATERSHED**

| Type of Use | Total Developed Properties | | |
|---|---|---|---|
| | Number of Properties | Est. Water Use, gpd | |
| | | Annual Avg per Property | Annual Total per Category |
| **Residential** | | | |
| Single-Family (Note 1, 2) | 257 | 142 | 36,604 |
| Multi-Family | 5 | 780 | 3,902 |
| Condo | 6 | 144 | 868 |
| **Commercial** | 9 | 542 | 4,877 |
| **Municipal/Exempt** | 7 | 6,243 | 43,698 |
| **TOTAL** | **285** | **316** | **89,949** |

Notes:
1) Source: Falmouth GIS database, 2007 to 2011 water use data.
2) Water use from private wells is assumed to be consistent with water use from public water accounts in the same category (i.e., single-family residential and municipal).
3) CWMP parcel selection; varies slightly from MEP parcel selection.

### 2.9.5 Wastewater Flows - General

Since wastewater flows are not measured, they need to be estimated from water use data. The difference between water use and wastewater flows is termed "consumptive use" and represents the water use that does not reach the on-site disposal facility (e.g., lawn irrigation, outdoor showers, etc.). Consumptive uses are generally quite low in the winter and reach their peak in the summer months. For this CWMP, consumptive use has been estimated at 10% for all sources on an annual average basis.

### 2.9.6 Wastewater Flows in Oyster Pond Watershed

This analysis leads to the estimate of current wastewater flow of approximately 28,900 gallons per day for the Oyster Pond watershed, expressed as an annual average value. A summary of wastewater flows is presented in **Table 2-8** (by use).

### 2.9.7 Wastewater Flows in Salt Pond Watershed

This analysis leads to the estimate of current wastewater flow of approximately 81,000 gallons per day for the Salt Pond watershed, expressed as an annual average value. A summary of wastewater flows is presented in **Table 2-9** (by use).

## TABLE 2-8
## CURRENT WASTEWATER FLOWS – OYSTER POND WATERSHED

| Type of Use | Total Developed Properties | | |
|---|---|---|---|
| | Number of Properties | Est. Wastewater Flow, gpd | |
| | | Annual Average per Property | Annual Total per Category |
| **Residential** | | | |
| Single-Family (Note 1, 2) | 160 | 151 | 24,141 |
| Multi-Family | 2 | 187 | 374 |
| Condo (Note 3) | 1 | 4,265 | 4,265 |
| **Commercial** | 0 | 0 | 0 |
| **Municipal/Exempt** | 3 | 38 | 113 |
| **TOTAL** | **166** | **174** | **28,893** |

Notes:
1) Source: Falmouth GIS database, 2007 to 2011 water use data.
2) Wastewater flows are estimated from water use.
3) This single property is the TreeTops Condominiums which includes 62 residential units. The average wastewater flow per condo unit is 68 gpd.
4) CWMP parcel selection; varies slightly from MEP parcel selection.

## TABLE 2-9
## CURRENT WASTEWATER FLOWS – SALT POND WATERSHED

| Type of Use | Total Developed Properties | | |
|---|---|---|---|
| | Number of Properties | Est. Wastewater Flow, gpd | |
| | | Annual Average per Property | Annual Total per Category |
| **Residential** | | | |
| Single-Family (Note 1, 2) | 257 | 128 | 32,944 |
| Multi-Family | 5 | 702 | 3,511 |
| Condo | 6 | 130 | 781 |
| **Commercial** | 9 | 488 | 4,389 |
| **Municipal/Exempt** | 7 | 5,617 | 39,329 |
| **TOTAL** | **285** | **284** | **80,954** |

Notes:
1) Source: Falmouth GIS database, 2007 to 2011 water use data.
2) Wastewater flows estimated from water use.
3) CWMP parcel selection; varies slightly from MEP parcel selection.
4) Of this total, approximately 40,100 gallons per day is currently sewered.

### 2.9.8 Wastewater Peaking Factors

All wastewater treatment and disposal systems, whether on-site or off-site, must be sized adequately to handle short-term peak flows (e.g., seasonal maximum month, maximum 2-day flow). According to the Local Comprehensive Plan, approximately 30% of the town-wide residential housing stock is considered seasonal use. According to the 2007 Needs Assessment Report (GHD, Table 5-7), the town-wide water supply seasonal peaking factor is 1.8 (i.e., the ratio of maximum month flow to annual average flow). As noted previously, the Oyster Pond and Salt Pond watersheds are "more seasonal" than the town as a whole. Based on our review of Falmouth's water use data as well as our experience with other seasonal populations on Cape Cod, we recommend using utilizing a higher seasonal peaking factor for these two watersheds. For the purposes of this CWMP, we will utilize the following peaking factors:

| | |
|---|---|
| Maximum month: | 2.1 times annual average |
| Maximum week: | 2.3 times annual average |
| Maximum 2-day: | 2.5 times annual average |

The wastewater flow estimates presented herein are based on water use records from the period of 2007 to 2011. These flows are characterized as "current", even though they will represent a time frame prior to the final publication of a completed CWMP.

It is important to note that several residential parcels were constructed after the data collection period for Oyster Pond MEP Report. Specifically, eight residential parcels were constructed between 2004 and 2011. The wastewater flows and loadings from these parcels are included in the CWMP current conditions but should be considered "future growth" in terms of the Oyster Pond MEP Report.

## 2.10 REGULATORY FRAMEWORK

Major elements of the local, regional, and state regulatory framework related to wastewater management and water resource protection are summarized below.

### 2.10.1 Town

**Falmouth Health Regulations** includes numerous supplements to the State Title 5 Environmental Code (FHR-15.0). These regulations specify local requirements for permitting, design and construction of new systems as well as system repairs. These regulations prohibit systems within 100 feet of surface water or wetlands for new construction and outline a procedure for repair or replacement of existing systems within 100 feet of surface water or wetlands.

**Falmouth Sewer Regulations** specify the requirements for connection to and use of the public sewerage infrastructure.

**Falmouth Coastal Pond Overlay District** identifies the procedure for applicants wishing to develop properties within the watersheds of listed coastal ponds. Applicable development for this overlay district is: subdivisions greater than five lots or five acres; commercial development requiring site plan review; and special permit uses. The intent of the District is to limit the nitrogen loading to coastal ponds. Applicable projects in the District shall utilize DEP-approved nitrogen reducing individual or cluster systems, as approved by the Reviewing Board. Applicable coastal ponds (and established critical eutrophic levels) are identified as follows: High Quality Areas (threshold value of 0.32 mg/l annual average total nitrogen); Stabilization Areas (threshold value of 0.52 mg/l annual average total nitrogen); or Intensive Water Activity Areas (threshold value of 0.75 mg/l annual average total nitrogen). Oyster Pond and Salt Pond are both identified in the Stabilization Area list.

**Falmouth Zoning** does not allow off-site private wastewater treatment facilities in any zone. A publicly-owned wastewater treatment facility is allowed as a matter of right in public use districts and in business districts.

### 2.10.2 Department of Environmental Protection

DEP has established a policy that prohibits the issuance of a groundwater discharge permit in a nitrogen-sensitive watershed unless the applicant has already put into effect a project that removes an existing nitrogen load equal to or greater than the load the that proposed project will add to the groundwater. Based on discussions with DEP staff, the nitrogen offset must be in place prior to the start-up of the proposed groundwater discharges; the applicant cannot merely fund a related study or set money aside for Town use on a future project. A nitrogen-sensitive watershed is one where a draft or final MEP Technical Report indicates that nitrogen-reduction is needed to restore or maintain water quality or one where a TMDL has been issued.

### 2.10.3 Cape Cod Commission

The Cape Cod Commission's Regional Policy Plan (RPP) has numerous elements related to water resource protection, including:

- Parcel nitrate loading must be below 5 parts per million (ppm) for projects in general and below 1 ppm in potential water supply areas, based on the Commission's Technical Bulletin 91-001. The nitrate loading limit reverts to 5 ppm in a potential water supply area if the Town (including Water Department) signs off. (**MPS WR2.1 and WR2.6**).
- **MPS WR6.1** prohibits a private WWTF if a feasible public option is expected to be constructed within 3 years.
- All WWTFs must meet a 5-ppm total nitrogen limit, either in the effluent or in the groundwater at the downgradient property line. (**MPS 6.2**).
- No WWTFs are allowed in ACECs or critical wildlife habitat. (**MPS WR6.6**)
- WWTFs larger than 2,000 gpd must participate in an Operation, Maintenance and Compliance Agreement (OMC Agreement) with the Commission and the local BOH. (**MPS WR6.9**), if the effluent limit is lower than would be included in the typical groundwater discharge permit (10 mg/l).

The Cape Cod Commission’s *Cape Cod Area Wide Water Quality Management Plan Update* (the “208 Plan Update”) was completed in 2015 and provides an updated framework for water resource protection on Cape Cod, with emphasis on coastal estuaries. The 208 Plan Update also identifies that the Commission will update in RPP and Development of Regional Impact (DRI) regulations to streamline the review and approval of municipal projects aimed at water resource protection. Regulatory amendments are on-going.

# SECTION 3

# WATER RESOURCE PROTECTION NEEDS (OCTOBER 2013)

## 3.1 APPROACH

***Note: The technical work summarized in this section of the report was completed in October 2013. This section has not been updated to reflect developments in the watershed since that time.*** Many communities rely exclusively on private on-site systems for wastewater treatment and disposal. The Commonwealth of Massachusetts sanitary code ("Title 5") provides a thorough regulatory framework for such systems. Under ideal circumstances, on-site systems can provide cost-effective and environmentally-sound wastewater management. Those circumstances include favorable soils, adequate depth to groundwater, reliable and protected water supplies, absence of sensitive downgradient receiving waters, and absence of high-intensity water users.

The fundamental question is: *"On which properties is the on-site wastewater system an adequate means of providing for sanitation and environmental protection, and on which properties is an off-site solution required?"* One way to answer this question is to identify areas where the above-noted ideal circumstances do not exist. For the purposes of this report, wastewater management needs have been evaluated in the following five categories:

- **Ensuring Sanitary Conditions**--correction or avoidance of unsanitary conditions (that is, public health problems) such as effluent surfacing over a leaching field, inadequate set-back from a private well, or direct discharge of sanitary wastewater to a watercourse.

- **Protecting Private and Public Water Supplies**--preventing contaminants (such as bacteria, viruses, nitrates, pharmaceuticals, and personal care products) from reaching private or public drinking water sources.

- **Protecting Surface Waters from Nutrient Enrichment**--reducing nutrients that can cause accelerated degradation of freshwater ponds (typically phosphorus) or estuarine waters (typically nitrogen).

- **Addressing Convenience and Aesthetic Issues**--avoiding unsightly mounded septic systems or individual treatment systems that may be the only way to achieve compliance with Title 5 if off-site options do not exist or avoiding frequent septage pumping that creates odor and disruption.

- **Enabling Sustainable Economic Development**--providing wastewater solutions, where necessary, so that wastewater restrictions (such as impermeable soils, shallow groundwater, locations within a Zone II water supply protection area, etc.) are not the limiting factors to economic development.

The overall approach for this need's assessment is to categorize the lots in the Oyster Pond and Salt Pond watersheds according to these five general categories. The specific approach is different for each category and is presented in the paragraphs that follow. Each category has been evaluated separately, and then the results compiled to address the fact that some lots fall into more than one category of need. Where improved on-site or off-site disposal is necessary, the reasons must be well documented and defensible.

## 3.2 SANITARY NEEDS

Title 5, the state sanitary code, provides regulation to ensure that on-site systems are properly designed to handle sanitary disposal of wastewater. With a few exceptions, a Title 5 wastewater system is both cost-effective and environmentally sound. Systems that are not compliant with Title 5 or were built prior to Title 5, may not adequately protect public health. A failure to protect public health occurs when one of the following happens: 1) sewage backs up into the home; 2) breakout occurs at the surface of the leaching field; or 3) breakout occurs along the sloping edge of the leaching field. Wastewater or septic tank effluent can also cause harm if a septic system was poorly sited and is proximate to wetlands, surface water or to a public or private drinking water supply (these topics will be addressed separately).

In considering which parcels may be best served by an upgraded on-site system or an off-site system, the following should be considered as direct or indirect indicators of sanitary need:

- Properties that have required significant variances from Title 5 to install or repair an on-site system and/or property requiring frequent repairs to an on-site system;

- Properties that use a large amount of potable water; and

- Properties near receiving waters where high bacterial counts have been recorded with no other apparent cause.

### 3.2.1 Title 5 Variances

Title 5 is a thorough sanitary code with respect to sanitary issues. If significant variances from Title 5 have been required to allow an on-site system to be constructed or repaired, then there may be benefits to providing that property with other wastewater solutions. Variances fall in two categories: “procedural” and “environmentally significant.” A procedural variance could be granted for a reduction in the setback between a structure and the leach field. An environmentally significant variance could be granted for a reduction in the distance between a leach field and a private drinking water well or a wetland. The latter could have a negative impact on public health and may not have been granted if an off-site solution had been available. Lots requiring variances may be spread across town, or perhaps may be clustered. Clustered variances could be, for example, the result of small lots, or shallow depth to groundwater. A cluster of variances for these reasons would make a strong case for an off-site solution as the best long-term solution for wastewater management.

The Health Department provided copies of all Title 5 variances granted for the two watersheds through Spring 2013. For each variance that was granted, key information was tabulated, such as the name and address of the applicant, and the nature of the variance that was granted. Each variance was reviewed to determine the specific problem that triggered the variance. Points were then assigned to each variance based on the environmental significance of that type of variance. **Table 3-1** summarizes an additive points system for assigning a score to each lot based on the type and severity of the variance granted. Variances that are minor or procedural in nature (e.g., setback from a property line or structure) received a zero-point score. Variances that could significantly impair public or environmental health (e.g., setback to a private water supply) would add 3 to 5 points to a lot's rating. In the case where multiple minor variances have been granted on a single lot, the cumulative impact can be considered, even if each individual variance would be insignificant on its own.

**TABLE 3-1**
**ENVIRONMENTAL SIGNIFICANCE RATING SYSTEM**
**FOR TITLE 5 VARIANCES**

| | Nature of Variance | Points |
|---|---|---|
| 1 | **Setback from Wetlands (100-foot local requirement)** | |
| | Setback greater than 50 feet | **1** |
| | Setback less than 50 feet | **2** |
| 2 | **Setback from Well (100 feet required)** | |
| | **Potable Well** Setback greater than 75 feet | **1** |
| | Setback of 50 to 75 feet | **3** |
| | Setback less than 50 feet | **5** |
| 3 | **Setback from Property Lines** | **0** |
| 4 | **Setback from Structures** | **0** |
| 5 | **Depth to Groundwater (4 feet required)** | |
| | Depth of 3 to 4 feet | **1** |
| | Depth less than 3 feet | **2** |
| 6 | **Thickness of Underlying Pervious Soil** | |
| | Thickness of 3 to 4 feet | **1** |
| | Thickness less than 3 feet | **2** |
| 7 | **Depth of Cover Over Disposal System** | |
| | Depth greater than 3 feet | **0** |
| | Depth less than 3 feet | **1** |
| 8 | **Inadequate Reserve Area** | |
| | Reserve area less than 50% | **1** |
| | No reserve area | **2** |

To convert this scoring process into a rating system for needs assessment, properties were grouped into one of three categories: little or no environmental significance (0 or 1 point); moderate environmental significance (2 points); and major environmental significance (3 points or more). This additive system provides a consistent and graduated method for identifying individual needs and is central to this assessment of sanitary needs town-wide.

A total of 18 variances were granted for the two watersheds based on records dated back to the late 1980s, as shown on **Figure 3-1**. Variances were granted for 13 parcels in the Oyster Pond watershed (8% of developed parcels) and for 5 parcels in the Salt Pond watershed (2% of developed parcels).

Based on our review of these 18 variances, we find that:

- 40% of the variances are procedural
- 40% of the variances represent "low" environmental significance
- 20% of the variances represent "moderate" environmental significance
- None of the variances represent "major" environmental significance. Properties with variances of major environmental significance are not well suited for on-site disposal. Based on the Board of Health records, there are no parcels that fall in this category.

### 3.2.2 Health Department Inspection Reports

Health Department inspections are typically triggered by property sale. While the inspection reports represent a snapshot in time, they do provide good information about the property. Inspection reports were reviewed for the period of 2006 through 2009. A total of 49 records were found for the two watersheds for period in question (approximately 8% of the developed parcels). Based on this limited data set, we find the following:

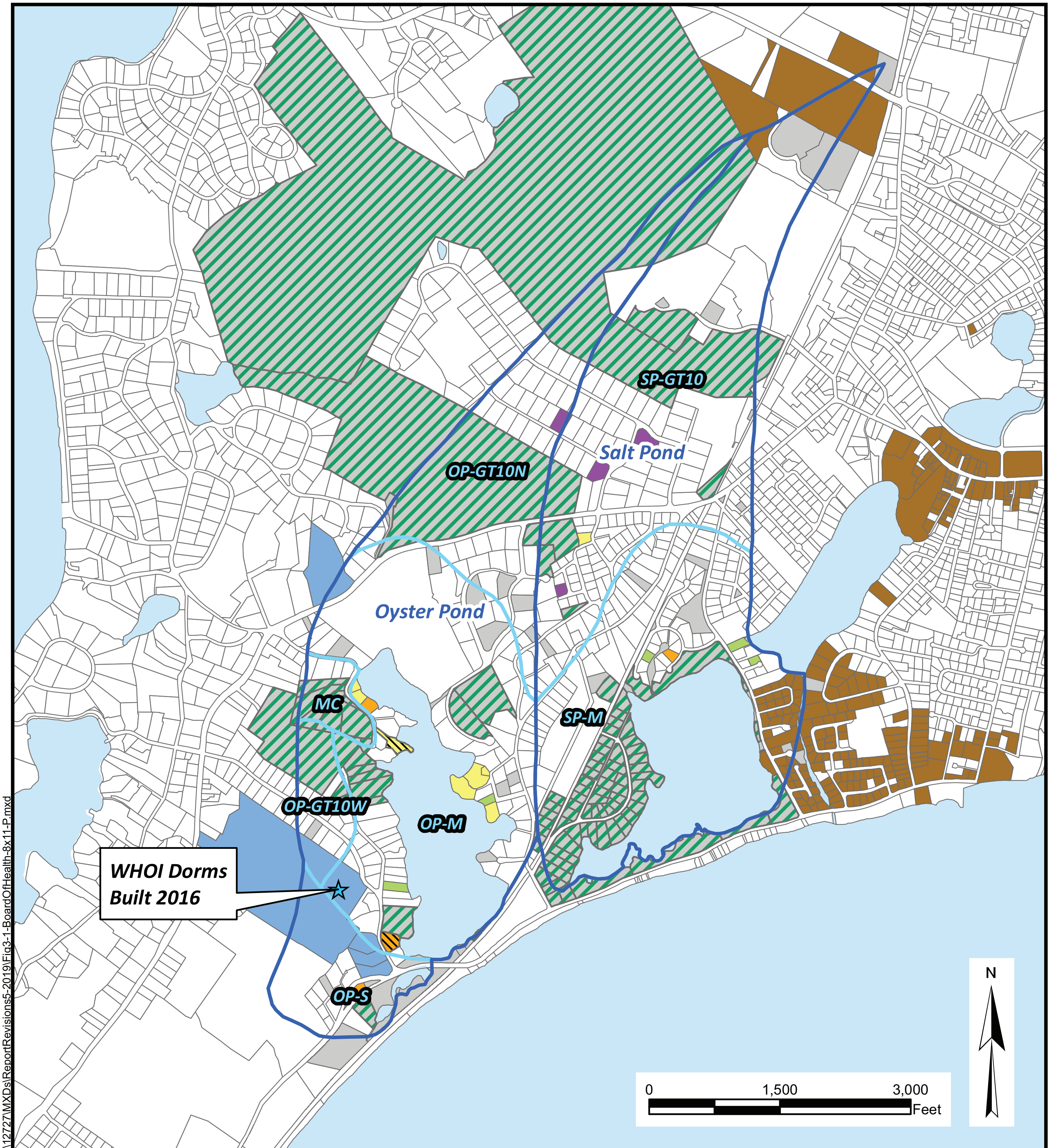
***Oyster Pond***

- 23 records reviewed
- 39% of the systems are cesspools (some single, some multiple units in series)
- 30% of the systems are septic tank with leaching pit (or former cesspool as leaching pit)
- 30% of the systems are septic tanks with leaching fields
- 22% of the systems were noted as "failed" based the Health Agent's inspection and judgment (all of these were cesspools or septic tanks with leaching pits) (required repair/replacement)
- 57% of the systems were installed in the rear yard.

***Salt Pond***

- 26 records reviewed
- 13% of the systems are cesspools (some single, some multiple units in series)
- 25% of the systems are septic tank with leaching pit (or former cesspool as leaching pit)
- 9% of the systems are septic tanks with leaching fields
- 4% of the systems were noted as "failed" based the Health Agent's inspection and judgment (all of these were cesspools or septic tanks with leaching pits) (required repair/replacement)
- 29% of the systems were installed in the rear yard.

Since the Town allows for the continued use of non-failing cesspools and septic tanks with leaching pits, the Health Department inspection records will not be utilized as indicators of sanitary need. However, these data are informative and are presented herein for future reference.




- Watershed Boundary
- MEP Subwatershed Boundary
- Cesspool (based on Town GIS records)
- I/A System
- Title 5 Variance - Procedural
- Title 5 Variance w/ Low Environmental Significance
- Title 5 Variance w/ Low Environmental Significance, I/A System
- Title 5 Variance w/ Moderate Environmental Significance
- Title 5 Variance w/ Moderate Environmental Significance, with I/A System
- Sewered
- Conservation/Recreation
- Vacant

Base data obtained from Town of Falmouth (2013), MassGIS (2009)

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Oyster Pond CWMP

**Board of Health Records and I/A Systems**

| PROJ NO: 12727 | DATE: Mar 2019 | FIGURE: 3-1 |
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### 3.2.3 Intensive Water Use

Intensive water use is an indirect indicator of parcels which could have potential wastewater disposal problems. The greater the water use intensity, the greater the potential difficulty with on-site wastewater disposal. Title 5 uses a similar approach to determine if a project warrants nitrogen control in the recharge areas of public water supply wells. Parcel size was calculated based on overall property boundaries. Annual average water use values were utilized as described in Section 2.9. For example, a parcel with an annual average water use of 200 gpd and a total lot area of 50,000 sq. ft. has a water use intensity of 40 gpd/10,000 sq. ft. **Figure 3-2** shows the water use intensity for the developed parcels in the watersheds. Whereas this category is an indirect measure of sanitary need, we will utilize this measure to prioritize parcels that may require an off-site solution for other categories of need (e.g., surface water protection).

### 3.2.4 Receiving Water Impacts

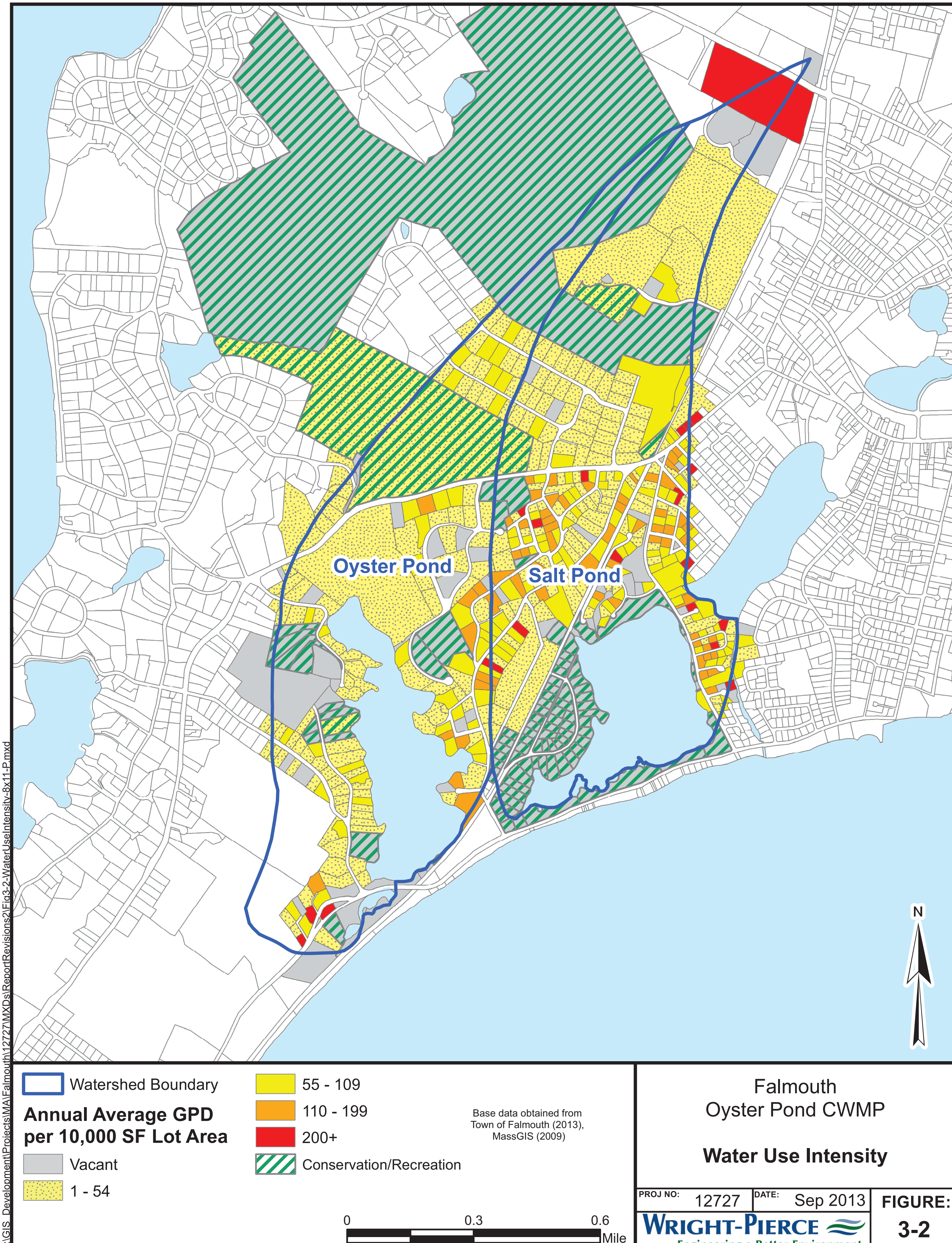
The presence of bacteria in surface waters can have a negative impact on humans or aquatic animals in contact with these waters. Bacterial sources can include road runoff, animal feces (pets, livestock, waterfowl, etc.), or in rare cases, septic tank effluent. In almost all cases, Title 5 systems can be sited such that bacteria in the septic tank effluent are not a threat when the effluent-impacted groundwater reaches nearby surface waters.

While there were documented incidences of human bacteria sources in Oyster Pond in the 1960s, these sources were remedied (Emery, et.al., 1997). Barnstable County Health Department is not aware of any bacteria testing or beach closures at either Oyster Pond or Salt Pond. The Town Health Department is also not aware of any bacteria testing results or beach closures at either pond. Accordingly, no sanitary needs will be attributed to bacteria in surface water. OPET indicates that no bacteria testing has been completed since 1999 after the new weir was installed.

## 3.3 WATER SUPPLY PROTECTION

### 3.3.1 Public Water Supply

The Oyster Pond and Salt Pond watersheds do not include any recharge area for the Town's public water supplies (i.e., groundwater or surface).




Falmouth
Oyster Pond CWMP

**Water Use Intensity**

PROJ NO: 12727 DATE: Sep 2013

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FIGURE: 3-2

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### 3.3.2 Private Wells

According to Town records, 6 residential parcels are on private wells in the Oyster Pond watershed and 1 residential parcel is on a private well in the Salt Pond watershed. The Town does not require homeowners to test their wells and is not aware of any water quality issues with these private wells. These homeowners should be encouraged to monitor the water quality in their wells periodically. If nitrate levels are high or are increasing, it would be appropriate to extend public water to these parcels at that time. Each of the residential parcels on private wells could be served with relatively short water main extensions (e.g., Fells Road) or by connection to the public water system at the property line (e.g., Oyster Pond Road, Nonquit Road).

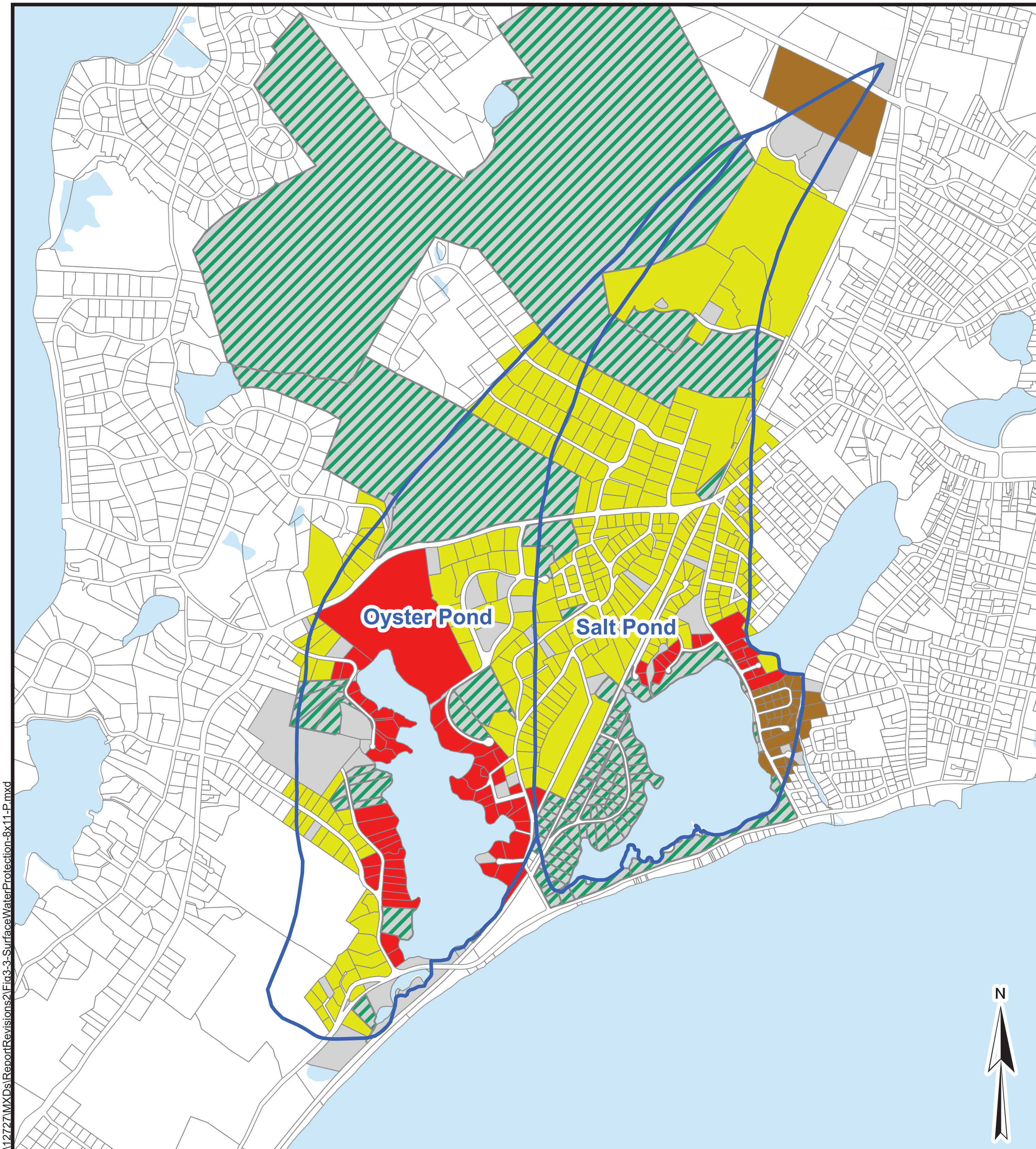
## 3.4 SURFACE WATER PROTECTION

### 3.4.1 Freshwater Ponds

One of the principal causes of water quality degradation in freshwater ponds is phosphorus loading. Phosphorus sources include subsurface wastewater disposal, lawn fertilization, stormwater runoff, and release from bottom sediments. While Oyster Pond (and Salt Pond) are not freshwater ponds, there is some concern that phosphorus sources may contribute to water quality problems in Oyster Pond. Cape Cod Commission guidance suggests that parcels within 300 feet of surface water should be considered for pond protection due to both stormwater runoff (in general and especially from near-shore fertilized lawns) and septic systems (longer-term). We have identified the parcels that are within 300 feet of Oyster Pond and Salt Pond, which are shown on **Figure 3-3**.

For the Oyster Pond watershed, this analysis identified 53 developed parcels within 300 feet of the pond with a current wastewater flow of 10,720 gallons per day (approximately 37% of watershed wastewater flow).

For the Salt Pond watershed, this analysis identified 41 developed parcels within 300 feet of the pond with a current wastewater flow of 4,935 gpd. Of the 41 developed parcels, 22 parcels are currently sewered (2,410 gpd) so wastewater is conveyed out of the watershed to the Town’s WWTF. Therefore, only 18 developed parcels with a current wastewater flow of 2,330 gpd fall within the category (approximately 3% of watershed wastewater flow).




- Watershed Boundary
- Parcels ≤ 300 ft
- Parcels > 300 ft
- Sewered
- Conservation/Recreation
- Other Vacant

Base data obtained from Town of Falmouth (2013), MassGIS (2009)

0 0.3 0.6 Mile

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**Surface Water Protection Based on Proximity**

| PROJ NO: 12727 | DATE: Sep 2013 | FIGURE: 3-3 |
|---|---|---|

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### 3.4.2 Coastal Embayments

Coastal embayments have been the focus of much attention in Falmouth and neighboring towns due to their status as nitrogen-sensitive waters and their functional role in the environment. The Massachusetts Estuaries Project (MEP) includes the study of both the Oyster Pond and Salt Pond watersheds. The Oyster Pond MEP Report was completed in 2006. The Oyster Pond Total Maximum Daily Load (TMDL) Report was completed by DEP in February 2008. The Salt Pond MEP Report was completed in 2014. The Oyster Pond TMDL as well as the executive summaries from the Oyster Pond and Salt Pond MEP Reports are included in **Appendix A**.

### 3.4.3 TMDL Requirements for Oyster Pond

The MEP Report identifies a variety of nitrogen sources to the Oyster Pond watershed, each with different management approaches. The TMDL specifies the maximum watershed nitrogen load which can reach the embayment in order to restore the ecological balance of the watershed system (the "threshold value"). In this case, the threshold value was set to achieve the Class SA criteria, with a minimum dissolved oxygen value of 6.0 mg/l, in accordance with the State Surface Water Quality Standards set forth in 314 CMR 4.00.

The EPA-approved TMDL identifies the "present watershed load" at 4.474 kg/day and identifies the threshold value for the Oyster Pond watershed at 1.439 kg/day. The TMDL defines present watershed load as the combination of natural background, fertilizer, stormwater runoff and septic system loadings to the watershed at the time of study.

The TMDL does not dictate how the threshold value is to be achieved, so the Town could consider several approaches to achieve the TMDL. For example, the Town could elect to focus more intensively on septic and fertilizer nitrogen sources and ignore stormwater and atmospheric sources. Alternatively, the Town could elect to document reductions in land use/stormwater loads as well as atmospheric sources and focus somewhat less intensively on septic and fertilizer nitrogen sources. The former approach is more in line with the expectations identified in the TMDL; whereas the latter approach may require some negotiation and discussion with the regulators.

The primary difference between these two examples in how much *non-septic load reduction* is pursued. To this end, we have identified the following range of non-septic nitrogen reduction scenarios to illustrate the importance of these factors:

- Scenario 1 assumes that all nitrogen reductions to achieve TMDL-compliance will be accomplished by mitigating septic system loads.
- Scenario 2 assumes that TMDL-compliance credit will be obtained for "small" modifications to nitrogen-loading assumptions for atmospheric deposition to allow for less septic load reduction.
- Scenario 3 assumes that TMDL-compliance credits will be obtained for "medium" modifications to nitrogen-loading assumptions for atmospheric deposition as well as past and future modifications to lawn fertilizer use and stormwater BMPs.
- Scenario 4 assumes that TMDL-compliance credit will be obtained for "large" modifications to nitrogen-loading assumptions for atmospheric deposition as well as past and future modifications to lawn fertilizer use and stormwater BMPs.

A summary of the various nitrogen sources (from the MEP Report) and the threshold value (from the TDML) is presented in **Table 3-2**. A summary of the nitrogen reduction scenarios is presented in **Table 3-3**.

The MEP program has historically treated atmospheric nitrogen deposition as a static value; however, there is a growing body of data which indicates that atmospheric nitrogen deposition is decreasing, especially since the late 1990s when the Clean Air Act and Clean Air Act Amendments were promulgated. Notably, the atmospheric nitrogen deposition concentration used to calibrate the Oyster Pond MEP model is from the late 1990s.

- The Long Island Sound TMDL Report (CTDEP, 2000) included an 18% reduction in atmospheric nitrogen deposition as a part of the required reductions. The CTDEP Long Island Sound Study Work Group is currently re-evaluating the TMDL and expects that atmospheric nitrogen deposition has been reduced more than the 18% value.

**TABLE 3-2: NITROGEN LOADING TO OYSTER POND WATERSHED BASED ON MEP REPORT**

| Oyster Pond Embayment | Present Wastewater (kg/yr) | Present Lawn Fertilizers (kg/yr) | Present Impervious Surfaces (kg/yr) | Present Natural Surfaces (kg/yr) | Present Watershed Load (kg/yr) | Mosquito Creek Correction (kg/yr) (see notes) | Present Watershed Load (kg/day) | Present Atmos. Dep. Load (kg/day) | Benthic Flux (kg/day) | Nitrogen Load-All Sources (kg/day) |
|---|---|---|---|---|---|---|---|---|---|---|
| Full Watershed | 1364 | 78 | 107 | 60 | 1609 | 24 | 4.474 | 0.800 | -1.781 | 3.493 |
| EPA-Approved TMDL (SA, Dissolved Oxygen - 6.0 mg/l at 4-m depth) >> | | | | | | | | | | **1.439** |
| Excluding Oyster Pond South | 1280 | 72 | 97 | 52 | 1501 | 24 | 4.181 | 0.773 | -1.733 | 3.221 |
| EPA-Approved TMDL (SA, Dissolved Oxygen - 6.0 mg/l at 4-m depth) >> | | | | | | | | | | **1.143** |

**TABLE 3-3: NITROGEN REDUCTION SCENARIOS FOR OYSTER POND TMDL COMPLIANCE (excluding OP South, 1.143 kg/day Total Nitrog**

| Load Reduction Scenarios | Present Wastewater (kg/yr) | Present Lawn Fertilizers (kg/yr) | Present Impervious Surfaces (kg/yr) | Present Natural Surfaces (kg/yr) | Present Watershed Load (kg/yr) | Mosquito Creek Correction (kg/yr) (see notes) | Present Watershed Load - Corrected (kg/day) | Atmos. Dep. Load (kg/day) | Benthic Flux (kg/day) | Nitrogen Load-All Sources (kg/day) |
|---|---|---|---|---|---|---|---|---|---|---|
| Scenario 1 - "None" | **84.0%** | **0%** | **0%** | **0%** | - | **0%** | - | **0%** | - | - |
| *- Load Remaining* | *205* | *72* | *97* | *52* | *426* | *24* | *1.232* | *0.773* | *-0.863* | ***1.14*** |
| Scenario 2 - "Small" | **79.7%** | **0%** | **0%** | **0%** | - | **0%** | - | **20%** | - | - |
| *- Load Remaining* | *260* | *72* | *97* | *52* | *481* | *24* | *1.383* | *0.618* | *-0.863* | ***1.14*** |
| Scenario 3 - "Medium" | **70.4%** | **25%** | **25%** | **25%** | - | **25%** | - | **40%** | - | - |
| *- Load Remaining* | *379* | *54* | *73* | *39* | *545* | *18* | *1.541* | *0.464* | *-0.863* | ***1.14*** |
| Scenario 4 - "Large" | **64.7%** | **50%** | **25%** | **25%** | - | **25%** | - | **60%** | - | - |
| *- Load Remaining* | *452* | *36* | *73* | *39* | *600* | *18* | *1.692* | *0.309* | *-0.863* | ***1.14*** |

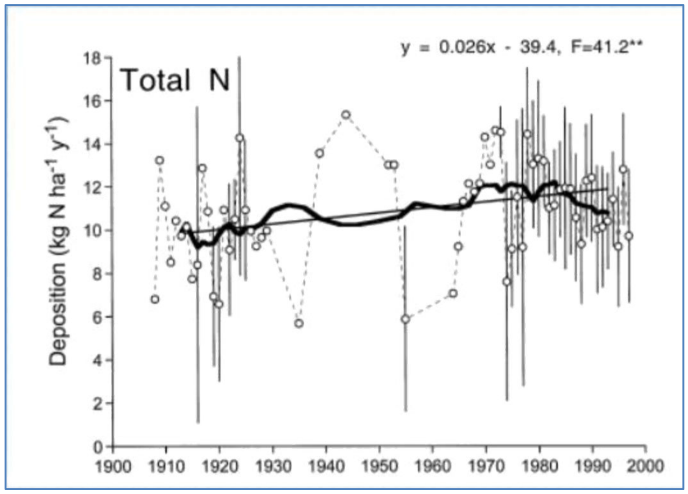
**Notes:**

Data from Table IV-4 of MEP Technical Repor Data from Table ES-1 of MEP Technical Report Data from Table ES-2 of MEP Technical Report

Oyster Pond South is excluded from Table 3-3 because the MEP TMDL concludes that the Lagoon is at or below the TN threshold.

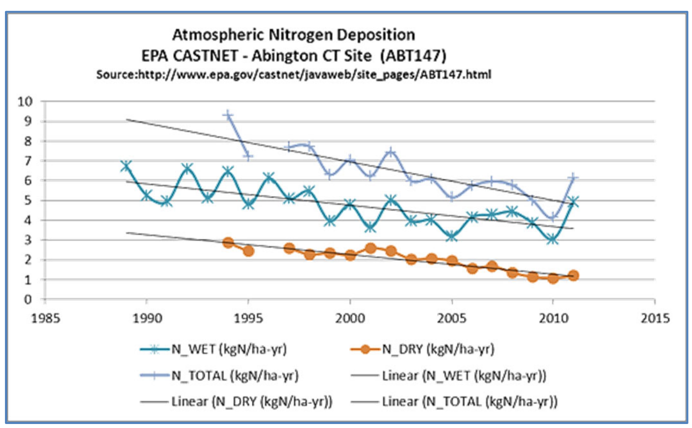
Table IV-4 of the MEP Technical Report indicates a slightly lower present watershed load (1609 kg/yr = 4.408 kg/d) than Table ES-1 of the MEP Technical Report. According to MEP, this is due to a differential between the calculated and measured subwatershed load to Mosquito Creek. The measured subwatershed load to Mosquito Creek is 0.115 kg/d (42 kg/yr), as noted in Table IV-5 of the MEP Technical Report, which was used in the modeling and in Table ES-1 of the MEP Technical Report

- A paper entitled "Historical Changes in Atmospheric Deposition to Cape Cod", (Bowen, Valiela, 2001) analyzes atmospheric nitrogen deposition trends for the twentieth century in Figure 5 (inset). The conclusions presented in the paper indicate that there was an upward trend through the 20th century; that the data was very variable; and that the upward trend through the 20th century does seem to slow down or even reverse in the last decade. The linear trend in Figure 5 suggests an extrapolated total nitrogen deposition value of approximately 11 to 12 kg N/ha-yr for the year 2000. This is consistent with the value used by MEP for the Oyster Pond Technical Report (11.1 kgN/ha-yr based on 1.09 mg/1 TN, 40 inches/yr precipitation and 63 acres for Oyster Pond).




- The New Hampshire Department of Environmental Services "Great Bay Non-Point Source Study" (draft report, May 2013) summarizes the basis for the NHDES nitrogen loading model for the Great Bay Estuary (http:Udes.nh.govIorganization/divisions/water/wmb/coasta1/great-bay-estuarv.htm). Appendix A of the Draft Report summarizes data regarding wet deposition rates, dry deposition rates, NOx emissions estimates and NOx emissions projections through 2020. Referencing EPA estimates, NHDES cites that NOx emissions are expected to decrease by 65% from 2001 to 2020.

- The EPA CASTNET (Clean Air Status and Trends Network) program is a long-term environmental monitoring program. Data collected from selected sites around the country are posted on its website (www.epa.gov/castnet). Data for wet deposition, dry deposition, and



total deposition for their site in Abington, CT (which is the closest site to Cape Cod) indicate clear trends towards reduced Atmospheric Nitrogen Deposition (see inset figure). Reductions in total deposition from the late 1990s to 2012 at this site are approximately 20%.

The above data provide a reasonable justification for the use of a 40% reduction in atmospheric nitrogen reduction for the planning period (2000 to 2040), as shown in Scenario 3.

The Town selected Scenario 3, which assumes the following watershed load reductions:

- 70% reduction in wastewater loads that existed at the time of the MEP work;
- 100% reduction in the wastewater loads that were added after the MEP, including future loads;
- 25% reduction in nitrogen loads from fertilizer use based on Falmouth fertilizer regulations as well as historic reductions in fertilizer use from Treetops, WHOI, and WHRC;
- 25% reduction is stormwater runoff from impervious and natural surfaces based on stormwater best management practices (BMPs) based on the Town's MS4 permit and specific stormwater point source items identified on page 2-24;
- 40% reduction in nitrogen load from 1999 atmospheric deposition levels; and
- Changes in benthic flux as predicted by MEP.

**Tables 3-4** summarizes the wastewater load removal requirements by subwatershed based on Scenario 3. The table breaks down the removals required for the wastewater load that existed at the time MEP completed its work (i.e., excludes new wastewater load that was added between 2004 to 2011 and 'future' wastewater load). It is important to recognize that the TMDL does not require nitrogen removal in the Oyster Pond South subwatershed because the TMDL indicates that the Lagoon is below threshold.

**TABLE 3-4: SEPTIC NITROGEN REMOVAL BY SUBWATERSHED FOR TMDL COMPLIANCE (SCENARIO 3)**

| Oyster Pond Embayment | Existing MEP WW Load, Unattenuated (kg/yr) | Removal of Existing MEP WW Load | Remaining Load, Unattenuated (kg/yr) | Natural Attenuation | Remaining Load, Attenuated (kg/yr) |
|---|---|---|---|---|---|
| 1-Oyster Pond GT10N | 366.46 | 70.4% | 108.47 | 0% | 108.47 |
| 2-Oyster Pond GT10W | 43.06 | 70.4% | 12.74 | 0% | 12.74 |
| 3-Mosquito Creek_Oyster Pond | 10.10 | 70.4% | 2.99 | 30% | 2.09 |
| 4-Oyster Pond_Main | 860.53 | 70.4% | 254.72 | 0% | 254.72 |
| 5-Oyster Pond_South | 83.85 | n/a | n/a | n/a | n/a |
| **Total** | **1,364.00** | | | | |
| **Total, excluding OP South** | **1,280.14** | | 378.92 | | **378.02** |
| **Allowable Septic Nitrogen Remaining per Table 3-3, Scenario 3 >>** | | | | | **379.00** |

The Oyster Pond MEP Report and TMDL identified three dissolved oxygen threshold values – 6.0-mg/l, 5.0-mg/l, and 3.8-mg/l. These documents selected the 6.0-mg/l dissolved oxygen criteria (i.e., the most conservative one) but left 5.0-mg/l and 3.8-mg/l in the report as "alternative criteria." There has been some discussion regarding the merits of pursuing these alternative criteria; however, the Town has decided not to do so at this time; however, it may re-evaluate this position in the future.

### 3.4.4 TMDL Requirements – Salt Pond

The Salt Pond MEP Report was completed in 2014; however, there is no TMDL Report for Salt Pond at this time. The MEP Report indicates that 100% septic nitrogen load and significantly improved tidal flushing are needed in Salt Pond. For the purposes of this need's assessment, 100% septic nitrogen removal will be utilized.

## 3.5 CONVENIENCE AND AESTHETICS

On-site wastewater disposal can be inconvenient and/or aesthetically displeasing to property owners or neighbors under certain circumstances (e.g., mounded systems, I/A system control panels, I/A system enclosures, etc.). These instances can be independent of public health issues or the protection or drinking water or surface waters. Typically, the factors listed below are considered in this category. These factors were discussed with the Town Health Agent, with the results of the discussions indicated in *italics*.

- A record of frequent septage pumping – *records not maintained by the Town;*
- A tight tank – *None identified in the Oyster Pond or Salt Pond watersheds;*
- A mounded septic system – *None identified in the Oyster Pond or Salt Pond watersheds;*
- Septic systems with a high replacement cost – *Kettle Hole Road/Two Ponds Road/Riddle Hill Road neighborhood (approximately 90 parcels in Oyster Pond, Salt Pond and the "direct discharge" watershed to the west of Oyster Pond watershed).*

The use of enhanced (I/A) treatment systems allows for improved nitrogen removal but, in some cases, the above-ground portions of I/A systems may be objectionable to the owner and/or to neighbors. I/A systems also cost more to operate on an annual basis than a typical septic system. A list of the locations of I/A systems within the watersheds was obtained from the Barnstable County Department of Health and Environment in Spring 2013. Five systems were identified in Oyster Pond watershed and none in the Salt Pond watershed. Of the five Oyster Pond systems, three are in the Oyster Pond South subwatershed and two are in the Oyster Pond Main subwatershed (see **Figure 3-1**).

The convenience and aesthetics category will be considered "not applicable" for the Oyster Pond and Salt Pond watersheds because it involves a relatively small number of properties and because the Town considers I/A systems to be an appropriate nutrient management strategy.

## 3.6 SUSTAINABLE ECONOMIC DEVELOPMENT

Wastewater management planning must address both current and future needs. Wastewater flows will increase as vacant lots are developed, as seasonal homes are converted to year-round use (or are occupied a greater percentage of the year), and as commercial development expands to serve the larger population. For "future conditions", the following terms will be used:

- *New Flow.* In wastewater terms, it is appropriate to characterize growth as the difference between "current" conditions and "future" conditions and call it "new" flow.

- *Theoretical Build-Out.* The residential and commercial/industrial/institutional activity associated with the ultimate development to the fullest extent possible under current zoning and other regulations (including Title 5).

- *Practical Build-Out.* The residential and commercial/industrial/institutional activity associated with more realistic assumptions on the extent of build-out, factoring in such concerns as economic realities, other limitations on growth (such as infrastructure capacity), land protection efforts, and retention of estate properties.

- *Planning Horizon.* The residential and commercial/industrial/institutional activity, and its associated wastewater flow, that will be the basis for analyzing wastewater management options and for the design of whatever infrastructure may be recommended. This value could be less than, or equal to, the level of development anticipated at Practical Build-Out. We recommend a planning horizon of 20 to 30 years into the future and suggest a planning horizon for this study is 2040.

Once the build-out conditions are determined, wastewater flow estimates are calculated. The projection of future wastewater quantities is in the form of annual average flow values. The following sections summarize the results of previous build-out assessments for the study area, as well as the build-out assessment which will form the basis for the CWMP.

### 3.6.1 Mass. Estuaries Project Build-Out Assessment

As a part of the 2006 Oyster Pond MEP Report and the 2014 Salt Pond MEP Report, SMAST estimated residential growth for the Oyster Pond watershed as summarized below. These parcels are identified on the attached **Figure 3-4A** (Figure IV-3 from the Oyster Pond MEP Report) and **Figure 3-4B** (Figure IV-4 from the Salt Pond MEP Report). Based on the MEP projections, build-out in the Oyster Pond and Salt Pond watersheds will results in an 11% and a 6%, respectively, increase in nitrogen loading over current conditions. Note that MEP does not typically include “redevelopment” flows in its build-out projections.

**FIGURE 3-4A – PARCELS IDENTIFIED FOR BUILD-OUT IN OYSTER POND MEP REPORT**

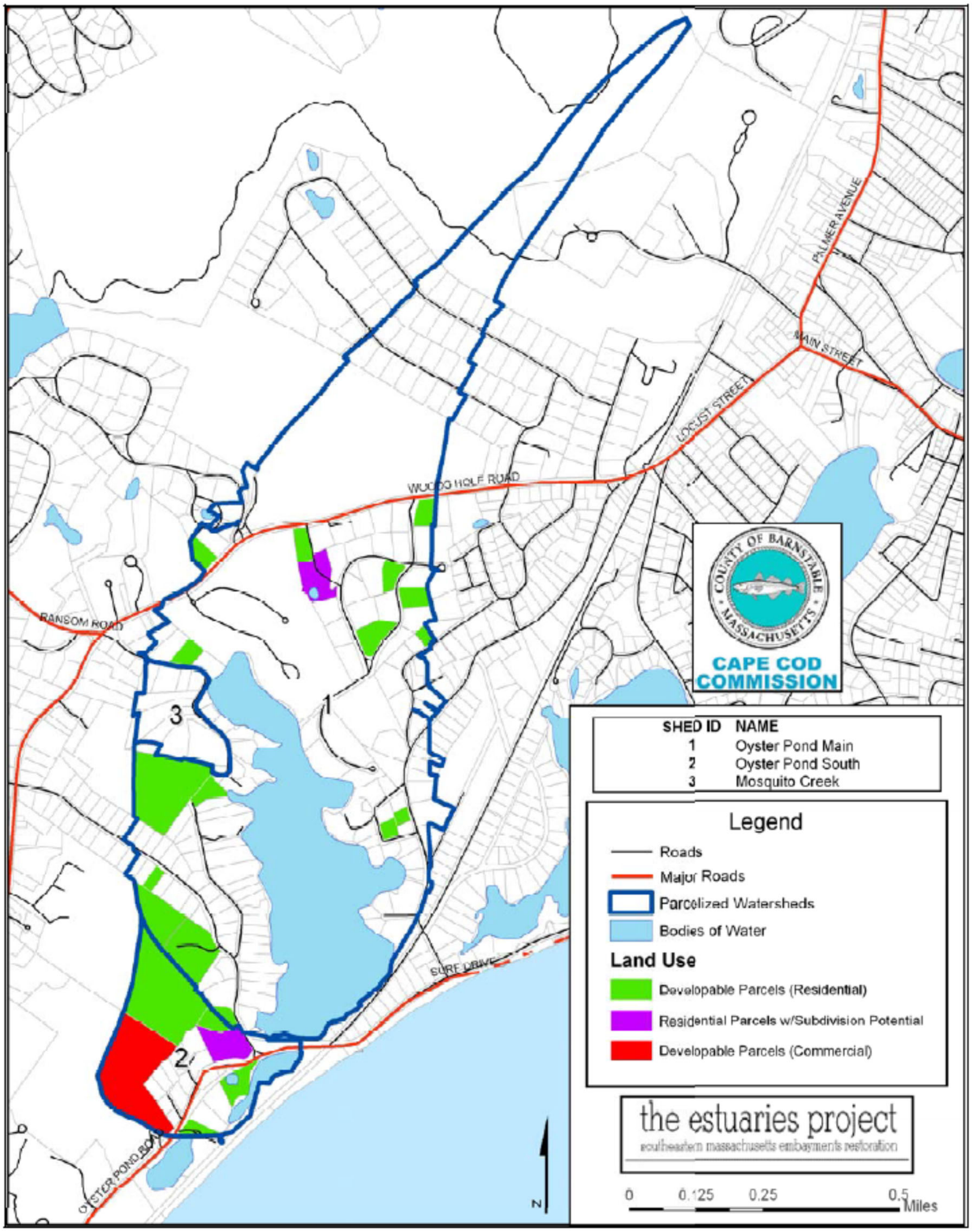



Figure IV-3. Parcels, Parcelized Watersheds, and Developable Parcels in the Oyster Pond watersheds. The Developable Commercial Parcel is owned by WHOI.

**FIGURE 3-4B – PARCELS IDENTIFIED FOR BUILD-OUT IN SALT POND MEP REPORT**

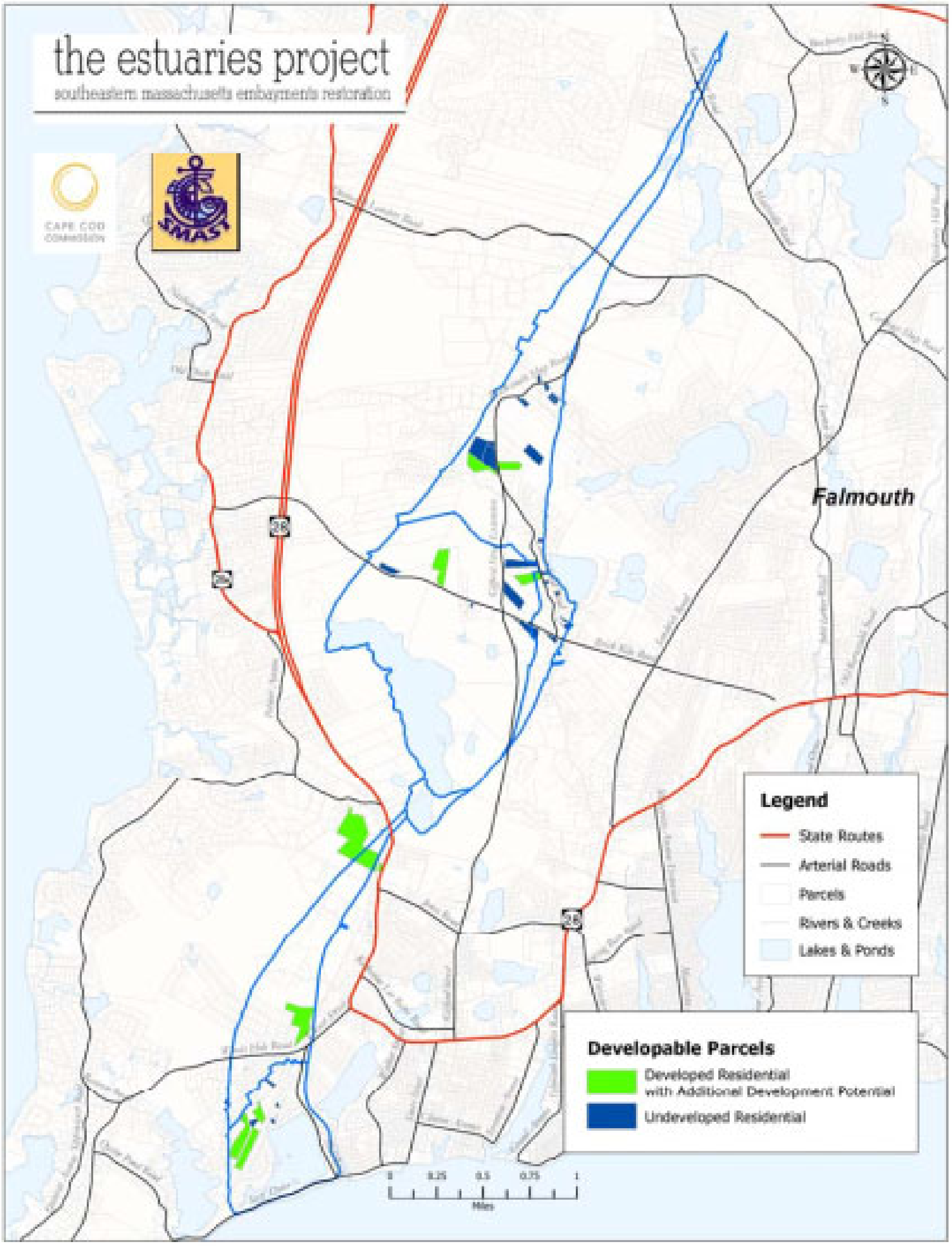



Figure IV-4. Parcels, Parcelized Watersheds, and Developable Parcels in the Salt Pond watersheds. Parcels colored green are developed residential parcels with additional development potential based on current zoning, while parcel colored blue are undeveloped residential parcels classified as developable by the town assessor. The parcelized watersheds are drawn to minimize the division of properties for management purposes while achieving a match of area with the modeled watersheds of 2% or less. Developable parcels are based on town assessor classifications and minimum lot sizes specified in town zoning; these parcels are assigned estimated nitrogen loads in MEP buildout calculations. All buildout results were reviewed with town staff and modified based on comments (personal communication, Brian Currie, Town of Falmouth, 4/13).

### 3.6.2 Cape Cod Commission Build-Out Assessment

As a part of its on-going regional wastewater management planning efforts, the Cape Cod Commission (CCC) estimated potential future residential and commercial development for all of Cape Cod (CCC, July 31, 2012). The CCC estimates of future development within the Oyster Pond and Salt Pond watersheds are summarized below. The build-out parcels identified by the CCC are identified on the attached **Figure 3-5** (residential) and **Figure 3-6** (commercial).

#### 3.6.2.1 Oyster Pond Watershed

- Miscellaneous development of single-family homes on vacant parcels (14 units).
- Significant subdivision development on the following existing parcels partially located in the Oyster Pond watershed as follows. Refer to Figure 3-5.

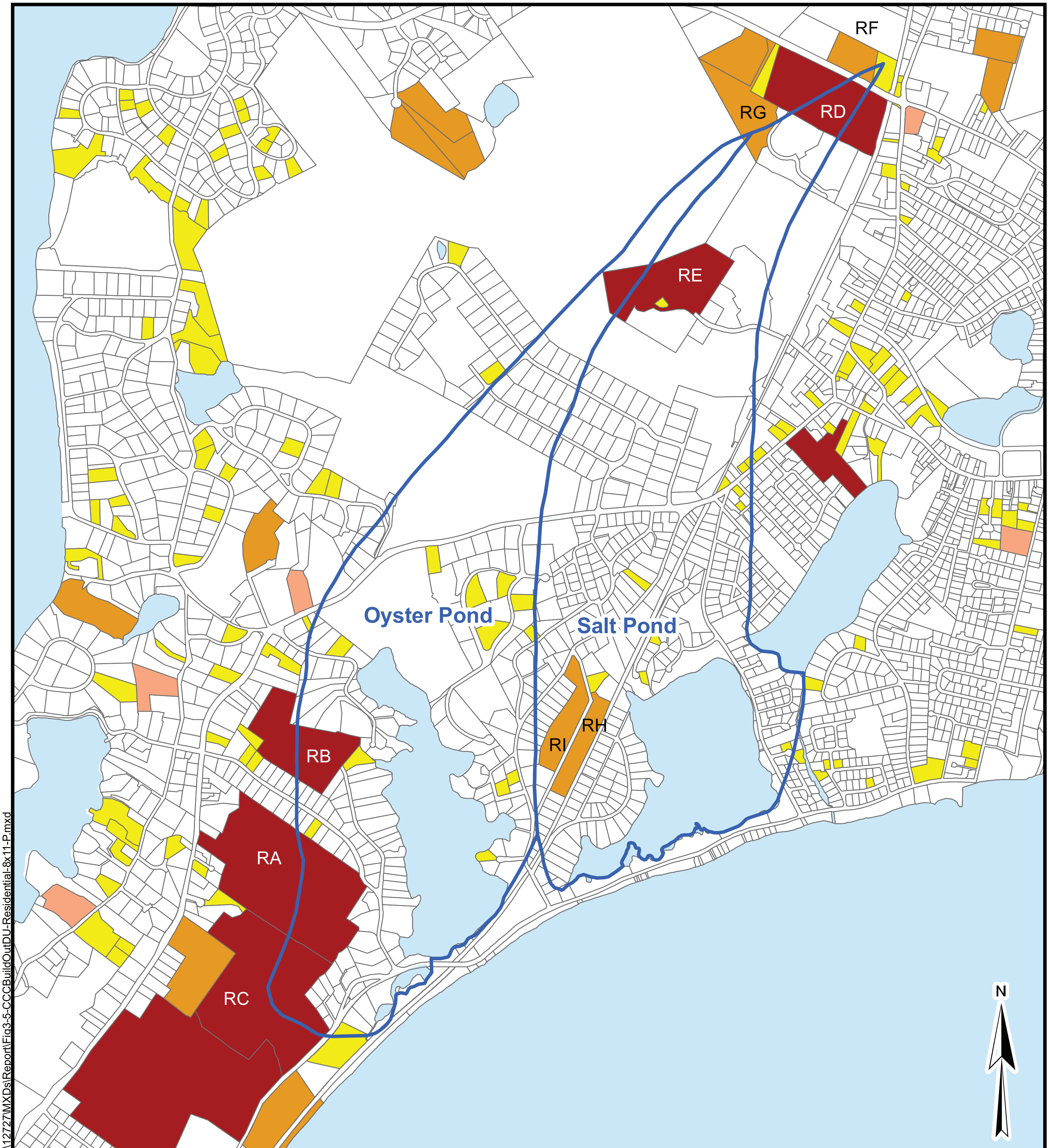
| Key | Map | Owner | Dwelling Units | Excluded from Analysis |
|---|---|---|---|---|
| RA | 48 09 002 003 | Woods Hole Oceanographic Institute | 39 | X |
| RB | 48 10 009 000C | ~~Woods Hole Oceanographic Institute~~<br>Oyster Pond Environmental Trust (2014) | ~~15~~<br>0 | <br>X |
| RC | 50 06 009 000A | Woods Hole Oceanographic Institute | 36 | X |

- No commercial development

The future development estimated by the CCC is significantly higher than that estimated by the MEP (i.e., 104 residential units vs 23 residential units) and includes development of some commercially zoned parcels as residential dwelling units. Based on the CCC projections, build-out in this watershed will result in a 47% increase in loadings (versus 11% increase projected by MEP).

#### 3.6.2.2 Salt Pond Watershed

- Miscellaneous development of single-family homes on vacant parcels (15 units).
- Significant subdivision development on the following existing parcels partially located in the Salt Pond watershed as follows. Where indicated, parcels were excluded by Wright-Pierce because the parcel centroid is outside the watershed and development is assumed to occur in the adjacent watershed.




Watershed Boundary

**Build-Out Dwelling Units**

- 0
- 1
- 2
- 3 - 10
- > 10

Base data obtained from
Town of Falmouth (2013),
Cape Cod Commission (2013)
MassGIS (2009)

0 0.3 0.6 Mile

Falmouth
Oyster Pond CWMP

**Residential Build-Out**
**CCC Analysis**

| PROJ NO: 12727 | DATE: Jul 2013 | FIGURE: 3-5 |
|---|---|---|

WRIGHT-PIERCE
Engineering a Better Environment

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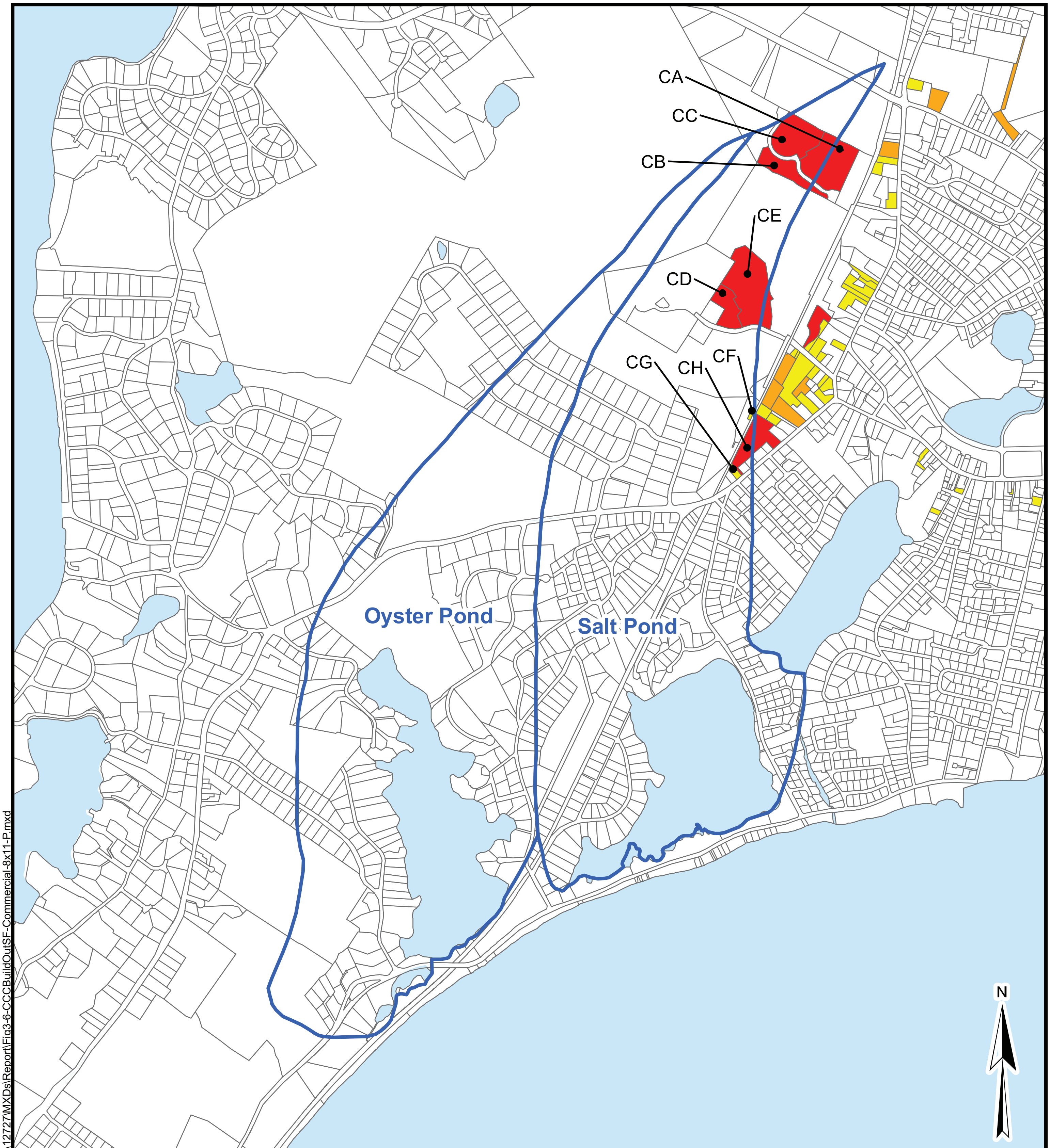


Base data obtained from
Town of Falmouth (2013),
Cape Cod Commission (2013)
MassGIS (2009)

Falmouth
Oyster Pond CWMP

**Commercial Build-Out**
**CCC Analysis**

| PROJ NO: 12727 | DATE: Jul 2013 | FIGURE: 3-6 |
|---|---|---|

WRIGHT-PIERCE
Engineering a Better Environment

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| Key | Map | Owner | Dwelling Units | Excluded from Analysis |
|---|---|---|---|---|
| RD | 38 01 009A 004 | Falmouth Hospital Assoc. | 19 | Connected to Sewer |
| RE | 38 01 015 000F | Cape Cod Conservatory | 16 | |
| RF | 38 01 008 002 | Visiting Nursing Assoc. | 4 | X |
| RG | 38 01 009 003 | Falmouth Assisted Living | 8 | X |
| RH | 47 01 024 229 | Falmouth Assoc. | 4 | |
| RI | 48 14 037 242 | Falmouth Assoc. | 6 | |

- Miscellaneous commercial development, as follows. All parcels were included in the analysis because the parcel centroid was inside the watershed.

| Key | Map | Owner | Developed Square Feet | Notes |
|---|---|---|---|---|
| CA | 38 01 010 002A | Falmouth Hospital Assoc. | 66,280 sf | Connected to Sewer |
| CB | 38 01 010 003 | Bramblebush Condo Owners | 23,140 sf | |
| CC | 38 01 010B 001A | Bramblebush Condo Owners | 27,470 sf | |
| CD | 38 01 011A 001 | Cape Cod Curling Club | 11,150 sf | |
| CE | 38 01 011B 003 | DMCP Corp. | 24,095 sf | |
| CF | 38 01 014 000 | Wood Lumber Co. | 1,110 sf | |
| CG | 47A 01 049 001A | Locust Street Condo Owners | 870 sf | |
| CH | 47A 01 051 000 | Wood Lumber Co. | 17,680 sf | |
| | | TOTAL | 171,795 sf | |

The future development estimated by the CCC is higher than that estimated by the MEP. Based on the CCC projections, build-out in this watershed will result in a 17% increase in loadings (versus 6% increase projected by MEP).

### 3.6.3 CWMP Build-Out Assessment

The MEP and CCC build-out analyses provided a baseline for the Town to complete its own estimate of future development in these two watersheds for the CWMP. The Town Planner, Town Wastewater Superintendent and Wright-Pierce reviewed the MEP and CCC build-out assessments. It was agreed that the MEP values appear to be a reasonable representation of "practical build-out" and that the values calculated by CCC appear to be a reasonable representation of the "theoretical build-out" condition.

In addition, the Town Planner, Town Wastewater Superintendent and Wright-Pierce reviewed the development potential associated with the following categories: conversion of seasonal homes to year-round homes; addition of accessory apartments in residential zones; addition of apartments over commercial establishments; conversion of commercial properties to residential units; changes to more intensive commercial uses; and conversion to affordable housing (Chapter 40B). The results of this analysis are presented in **Table 3-5**.

**TABLE 3-5: SUMMARY OF DEVELOPMENT CRITERIA FOR PRACTICAL BUILD-OUT**

| | Oyster Pond | Salt Pond |
|---|---|---|
| New Homes on Vacant Lots | 75% of Theoretical Build-Out | |
| New Homes on New Lots | 50% of Theoretical Build-Out | |
| Conversion of seasonal homes to year-round homes | Allowance - 10% of existing seasonal flow | |
| Addition of accessory apartments in residential zones | 0 units | 0 units |
| Addition of apartments over commercial establishments | 0 units | 0 units |
| Conversion of commercial properties to residential units | 0 units | 0 units |
| Conversion of commercial properties to more intensive commercial uses | 0 units | Allowance 30% of commercial growth at an increased flow of 50 gpd/thousand sf |
| Conversion to affordable housing (Chapter 40B) | 0 units | 0 units |

Lastly, the Town Planner, Town Wastewater Superintendent and Wright-Pierce reviewed the ratio of development at practical build-out versus that at theoretical build-out. Based on this review, the Town elected to set the planning horizon for this study at practical build-out. The build-out assessment to be utilized for the CWMP is summarized on **Table 3-6** (Oyster Pond) and **Table 3-7** (Salt Pond).

# TABLE 3-6: CWMP BUILD-OUT FOR OYSTER POND WATERSHED

| Wastewater Flows, gpd (Annual Average) | Oyster Pond Watershed | | | | | |
|---|---|---|---|---|---|---|
| | Planning Horizon | | Practical Build-out | | Theoretical Build-out | |
| | Flow, gpd | Notes | Flow, gpd | Notes | Flow, gpd | Notes |
| **Current Flows (thru 2011)** | | | | | | |
| Residential | 28,780 | | 28,780 | | 28,780 | |
| Commercial | 0 | | 0 | | 0 | |
| Municipal | 113 | | 113 | | 113 | |
| Total | **28,893** | | **28,893** | | **28,893** | |
| **Increases in Flows** | | | | | | |
| Seasonal conversion and home expansion | | | 1,200 | *10% of Ex.* | 3,010 | *25%* |
| Undeveloped but Developable Lots | | | | *8 lots* | | *12 lots* |
| New dwellings and apartments | | | | | | |
| New homes on existing vacant lots | | | 1,210 | *8 du* | 1,810 | *12 du* |
| New homes on new lots | | | 0 | *n/a* | 0 | *n/a* |
| Accessory apts in residential zones | | | 0 | *n/a* | 0 | *n/a* |
| Apts. over commercial | | | 0 | *n/a* | 0 | *n/a* |
| Comm. conversion to Residential | | | 0 | *n/a* | 0 | *n/a* |
| Subtotal | | | 1,210 | | 1,810 | |
| Commercial | | | | | | |
| New comm. space on vacant land | | | 0 | *n/a* | 0 | *n/a* |
| Expansion of existing uses (New Dorms, 2016) | | | 220 | *n/a* | 220 | *n/a* |
| Change to more intensive comm. use | | | 0 | *n/a* | 0 | *n/a* |
| Conversion to 40B housing | | | 0 | *n/a* | 0 | *n/a* |
| Comm. conversion to Residential | | | 0 | *n/a* | 0 | *n/a* |
| Subtotal | | | 220 | *n/a* | 220 | *n/a* |
| Total increase | **2,630** | *100%* | **2,630** | | **5,040** | |
| **Future Flows** | **31,523** | | **31,523** | | **33,933** | |
| *Percentage Increase over Current Conditions* | *9%* | | *9%* | | *17%* | |

## TABLE 3-7: CWMP BUILD-OUT FOR SALT POND WATERSHED

| Wastewater Flows, gpd (Annual Average) | Salt Pond Watershed | | | | | |
|---|---|---|---|---|---|---|
| | Planning Horizon | | Practical Build-out | | Theoretical Build-out | |
| | Flow, gpd | Notes | Flow, gpd | Notes | Flow, gpd | Notes |
| **Current Flows** | | | | | | |
| Residential | 37,236 | | 37,236 | | 37,236 | |
| Commercial | 4,389 | | 4,389 | | 4,389 | |
| Municipal | 39,329 | | 39,329 | | 39,329 | |
| Total | **80,954** | | **80,954** | | **80,954** | |
| **Increases in Flows** | | | | | | |
| Seasonal conversion and home expansion | | | 1,180 | *10% of Ex.* | 9,310 | *25%* |
| Undeveloped but Developable Lots | | | | *11 lots* | | *11 lots* |
| New dwellings and apartments | | | | | | |
| New homes on existing vacant lots | | | 1,430 | *75% of TBO* | 1,905 | *15 du* |
| New homes on new lots (sewered) | | | 1,210 | *50% of TBO* | 2,413 | *19 du* |
| New homes on new lots (unsewered) | | | 1,650 | *50% of TBO* | 3,302 | *26 du* |
| Accessory apts in residential zones | | | 0 | *n/a* | 0 | *0 apt* |
| Apts. over commercial | | | 0 | *n/a* | 0 | *0 apt* |
| Comm. conversion to Residential | | | 0 | *n/a* | 0 | *n/a* |
| Subtotal | | | 4,290 | | 7,620 | |
| Commercial | | | | | | |
| New comm. space on vacant land | | | 3,310 | *50%* | 6,628 | *66,280 sf* |
| Expansion of existing comm. uses | | | 5,290 | *50%* | 10,572 | *105,720 sf* |
| Change to more intensive comm. use | | | 1,250 | *50%* | 2,500 | *50,000 sf* |
| Conversion to 40B housing | | | 0 | *n/a* | 0 | *n/a* |
| Comm. conversion to Residential | | | 0 | *n/a* | 0 | *n/a* |
| Subtotal | | | 9,850 | | 19,700 | |
| Total increase | **15,320** | *100%* | **15,320** | | **36,630** | |
| **Future Flows** | **96,274** | | **96,274** | | **117,584** | |
| *Percentage Increase over Current Conditions* | *19%* | | *19%* | | *45%* | |

### 3.6.4 Summary of CWMP Build-Out Assessment

For Oyster Pond, based on the assumptions described herein, the annual average wastewater flows have been estimated to increase by 9% through the planning horizon/ practical build-out and 17% through theoretical build-out. Redevelopment (i.e., as opposed to new development on vacant land) represents approximately 46% of new wastewater flows at practical build-out. The CWMP build-out assessment does not allow for more wastewater flow than would be allowed under Title 5 and other Town zoning, land use, ordinances, and by-laws.

For Salt Pond, based on the assumptions described herein, the annual average wastewater flows have been estimated to increase by 19% through the planning horizon/ practical build-out and 45% through theoretical build-out. Redevelopment represents approximately 50% of new wastewater flows at practical build-out. The CWMP build-out assessment does not allow for more wastewater flow than would be allowed under Title 5 and other Town zoning, land use, ordinances, and by-laws.

## 3.7 AGGREGATED NEEDS

The single largest need for the Oyster Pond and Salt Pond watersheds is protection of surface waters from nutrient enrichment based on the findings of the 2006 Oyster Pond MEP Report, the 2008 Oyster Pond TMDL and the 2014 Salt Pond MEP Report.

While there are numerous on-site wastewater systems which will require upgrades during the planning period, it is expected that all systems could be upgraded on-site. That is, this need can be satisfied by owner-implemented replacement of the existing system with a Title 5 compliant system and, therefore, does not represent a municipal need. While it is important to characterize wastewater needs in these separate categories, it is also important to recognize that numerous properties could fall into more than one category of need. In the case of Oyster Pond and Salt Pond, the needs are categorized as surface water protection only.

It is possible (and necessary) to identify specific parcels for alternative wastewater management when sanitary conditions or water supply protection are involved. In case of coastal embayment surface water protection, the specific lot identity is less important. Lots should be prioritized (if possible) based on their proximity to the surface water (restoration will occur faster if near-shore septic systems are eliminated), water use (proportional to the wastewater volume), density of development, occupancy status (typically year-round homes produce more nitrogen than seasonal homes), history of Title 5 variances issued and current condition of the site septic system.

Wastewater management needs are first estimated based on assumed "out-of-watershed disposal" (i.e., 100% of the wastewater nitrogen load for a given parcel is removed from the watershed). The aggregated wastewater management needs for Oyster Pond are estimated at 22,600 gallons per day (i.e., 69% of 28,890 gallons per day existing flow and 100% of 2,630 gallons per day new flow from **Table 3-6**). The aggregated wastewater management needs for Salt Pond are estimated at 96,300 gallons per day (i.e., 100% of 80,950 gallons per day existing flow and 100% of 15,320 gallons per day new flow from **Table 3-7**). If in-watershed disposal is ultimately implemented, additional wastewater management is needed to offset the residual wastewater nitrogen load remaining in the watershed.

### 3.8 SUMMARY OF WOODS HOLE GROUP REVIEW

Woods Hole Group (WHG) was retained to perform a scientific review of: 1) the water quality data collected since the MEP Technical Report was published; and 2) the MEP methodology as it pertains to assessing compliance with the model inputs and outputs. The WHG report is included as **Appendix C**. A brief summary of the WHG findings is provided below:

- The water quality data indicates a highly variable system. This variability is a function of watershed inputs and of the natural phenomena described above. A rigid TMDL framework does not provide flexibility to address the natural variability in this system.

- Maintenance dredging of the Trunk River sill is an important aspect to allowing freshwater (and nutrient) outflow from Oyster Pond.

- The MEP report provides all data in terms of "total nitrogen" and does not provide a breakdown of the fractionation (or types) of nitrogen. The water quality data collected by OPET since 2004 does not include all the components necessary to determine total nitrogen (i.e., particulate organic nitrogen, or PON, is excluded from the OPET data set). *Unfortunately, this does not allow for direct comparison of the two data sets unless or until the MEP fractionation is made available*. That said, limited historic fractionation data from the Falmouth Pond Watchers allows for estimation of total nitrogen for the OPET data. Based on this estimation, it appears that the water column total nitrogen concentrations have decreased since the MEP report was published. This apparent reduction is consistent with efforts made by residents in the watershed to reduce the watershed nitrogen load (refer to Table 3 in Appendix C) as well as with reduction in atmospheric NOx concentrations resulting from EPA air pollution reduction regulations. Further data review should be performed if/when MEP data can be obtained.

- The MEP modeling approach uses a set of conservative assumptions and conditions to model a static condition aimed at meeting the State water quality classification criteria (*e.g., "what reduction in water column nitrogen concentration is required to increase the minimum dissolved oxygen concentration from 2.0 mg/l to 6.0 mg/l at a salinity of 2 ppt and a temperature of 25degC at a depth of 4 meters assuming a [inverse] linear relationship between dissolved oxygen concentration and water column nitrogen concentration"*). This approach is not flexible enough to address the natural factors which control the Oyster Pond system; however, additional modeling is not recommended. Rather, a probabilistic approach to assessing compliance with the TMDL criteria, which appropriately recognizes the unique characteristics and natural factors associated with Oyster Pond, needs to be incorporated into the monitoring program. Ideally, this approach would allow for temporal variation in dissolved oxygen concentration similar to the approach utilized by EPA for the Chesapeake Bay ("Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll *a* for the Chesapeake Bay and its Tidal Tributaries," 2003).

- Based on a review of the Oyster Pond data, phosphorus appears to be a limiting nutrient under certain conditions and certain times of year. This phenomenon has also been observed in the Gulf of Mexico at the eastern periphery of the Mississippi River/Gulf of Mexico confluence ("Evaluation of the Role of Nitrogen and Phosphorus in Causing or Contributing to Hypoxia in the Northern Gulf," EPA, 2004). This means that phosphorus management also needs to be included in the alternatives analysis.

- It is important to note that there is no phosphorus TMDL or phosphorus watershed load analysis and there are no data regarding watershed phosphorus sources, phosphorus fractionation in the environment, attenuation mechanisms, or benthic sources/sinks for the watershed. Accordingly, it is not possible to provide specific conclusions on the expected changes in the total phosphorus loadings and resulting N:P ratio(s) in Oyster Pond until such data becomes available.

- Until a phosphorus load analysis is completed, the goal should be to significantly reduce the phosphorus load from fertilizer and stormwater sources and to reduce the septic phosphorus load.

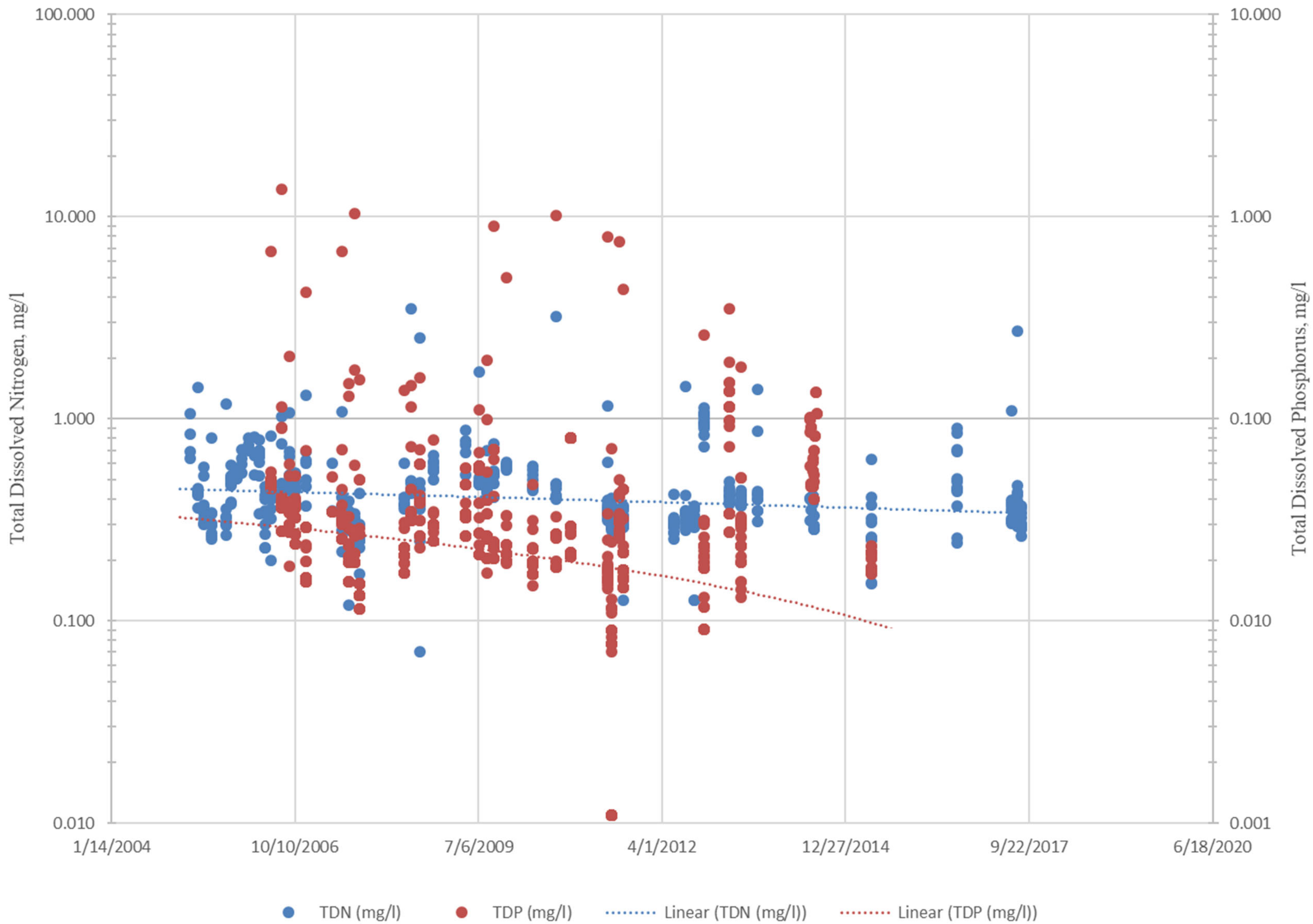
- Given its location and elevation, Oyster Pond will be sensitive to the impacts of sea level rise, climate change and storm intensity. The Trunk River sill elevation will likely require more intensive management based on increased storm intensity and/or frequency and changes in long shore drift. Pond water levels will likely rise as sea level rises. Density and thermal stratification patterns will be modified based on more intense storms and/or more frequent backflow or overwash. Benthic and finfish habitat could be impacted by changes in the frequency and duration of thermal stress events, including low dissolved oxygen concentrations related to temperature.

## 3.9 OYSTER POND MONITORING DATA

The Oyster Pond Environmental Trust (OPET) has been collecting water quality data routinely for many years from numerous locations in and around the pond, including the MEP OP1 location (surface, 1-m depth, 2-m depth, 3-m depth and bottom), the MEP OP2 location (surface, 1-m depth, 2-m depth, 3-m depth and bottom), the MEP OP3 location (surface, 1-m depth, 2-m depth, 3-m depth, 4-m depth, 5-m depth and bottom), Mosquito Creek, at the Treetops dock (surface and bottom), at the Ransom Road dock (surface and bottom), upstream and downstream of the Oyster Pond outlet weir, and the Lagoon. Water quality collected includes temperature, conductivity, salinity, dissolved oxygen, total suspended solids, volatile suspended solids, alkalinity, dissolved organic carbon, total dissolved nitrogen (TDN), nitrate, nitrite, dissolved organic nitrogen, ammonia, silicon dioxide, total phosphorus, total dissolved phosphorus (TDP), phosphate, and chloride. TDN and TDP has been collected consistently for a range of sampling locations and sampling depths over a relatively long period of time.

OPET publishes its data on its website. **Figure 3-7** presents TDN and TDP data collected between 2004 and 2017 (from all locations and depths, except for "OP3 bottom" and "Mosquito Creek"), at log scale. While there is significant scatter in the data set (due to the variable sampling locations, sampling depths and sampling times), this plot shows a generally decreasing trend in both TDN and TDP. Many of the highest TDN and TDP concentrations are episodic and are related to low dissolved oxygen in the lower water column samples (e.g., OP1 bottom, OP bottom, OP3 4-m).

## FIGURE 3-7: OYSTER POND TDN AND TDP (OPET SAMPLING)



## 3.10 IMPLICATIONS OF NO ACTION

It is standard practice in wastewater management planning to consider the implications of taking no action. For the Oyster Pond and Salt Pond watersheds, taking no action would result in the continued use of traditional on-site wastewater systems (except for those limited areas in Salt Pond where sewers are currently in place). Since most categories of need have been ruled out (i.e., ensuring sanitary conditions; protection of public and private drinking water supplies; addressing convenience and aesthetic issues; and enabling sustainable economic development), the only category of need that would be "un-addressed" is surface water protection.

Taking no action will result in watershed nutrient loadings which will remain above the threshold criteria established in the EPA-approved TMDL. Surface water quality will not improve and will likely be continually degraded. Algae blooms (including the associated odor issues, reduction in water clarity or poor habitat conditions) will continue to vary on a periodic and unpredictable frequency. Further, taking no action could subject the Town to eventual enforcement action by DEP for non-compliance with TMDL Report requirements.

It is important to recognize that, because the water column nitrogen concentration is relatively insensitive to increases or reductions in watershed nitrogen loading, significant nitrogen removal will be required before the water column nitrogen concentration is reduced. This factor, in conjunction with the significant natural variability in the Oyster Pond system, may require longer time frames to achieve TMDL criteria and consistent water quality improvement. Lastly, even with watershed nutrient control, the seasonal turnover of the pond when thermal and/or density stratification "sets up" or "breaks down" will result in intermittent water quality reductions.

# SECTION 4

# IDENTIFICATION AND SCREENING OF ALTERNATIVES

## 4.1 METHODOLOGY

***Note: The technical work summarized in this section of the report was completed in February 2014 and was revised in October 2017.*** This section of the report serves to identify and screen the alternatives that will be considered in this CWMP to address the aggregated wastewater management needs identified for Oyster Pond in Section 3. The various alternatives will be termed "technologies" and "approaches." We have considered "technologies" to be those items that are constructed, operated and/or monitored (i.e., structural measures) and we have considered "approaches" those items that are policies, programs, by-laws and regulations (i.e., non-structural measures). A comprehensive listing of the technologies and approaches which were considered for the Oyster Pond watershed is presented in **Table 4-1**. The applicable alternatives are organized as follows:

- "Non-structural" versus "structural" (as described above).
- "Wastewater related" versus "non-wastewater related" (e.g., stormwater, fertilizer, atmospheric, etc.).
- "Source control" (i.e., treating or removing nitrogen prior to effluent mixing with groundwater) versus "remediation" (i.e., treating, or diluting nitrogen after mixing with groundwater or surface water, such as using permeable reactive barriers to treat effluent-impacted groundwater, increasing tidal flushing due to inlet widening, etc.).

We have also identified whether each measure:

- Is an on-site measure (i.e., occurs on the same site as the wastewater is generated) or an off-site measure (i.e., involves collection and conveyance to a site which is remote from where the wastewater is generated).
- Controls nitrogen from current sources, or applies to just new sources, or both.
- Controls phosphorus from current sources, or applies to just new sources, or both.
- Is currently approved by DEP or is ready for near-term approval by DEP.

## TABLE 4-1: IDENTIFICATION OF ALTERNATIVES

| ALTERNATIVE | On-Site or Off-Site | Addresses Nitrogen | Addresses Phosphorus | Currently Approved by DEP |
|---|---|---|---|---|
| **Non-Structural** | | | | |
| Source Control | | | | |
| Zoning modifications and growth management | On-site | See Note 1 | See Note 1 | n/a |
| Fertilizer control | On-site | Y | Y | n/a |
| Water conservation | On-site | N | N | n/a |
| Garbage grinder ban | On-site | Y | Y | n/a |
| Septic system maintenance | On-site | N | N | n/a |
| Atmospheric/air quality management | Off-site | Y | N | n/a |
| **Structural** | | | | |
| Source Control | | | | |
| Wastewater Related | | | | |
| Title 5 System | On-site | See Note 2 | See Note 2 | Y |
| I/A System (<19 mg/l TN) | On-site | Y | Possible | Y |
| "Enhanced I/A" System (<13 mg/l TN) | On-site | Y | Possible | Case-by-case |
| "Advanced I/A" System (<10 mg/l TN) | On-site | Y | Possible | Case-by-case |
| Eco-toilets (e.g., composting, urine diverting, etc.) | On-site | Y | Y | Case-by-case |
| Cluster System (<10 mg/l TN, <10,000 gpd) | Off-site | Y | Possible | Y |
| Satellite System (<5 mg/l TN, <200,000 gpd) | Off-site | Y | Possible | Y |
| Constructed Wetlands (e.g., EcoMachine, etc.) | Off-site | Y | Y | Case-by-case |
| Connection to Existing Satellite System at WHOI | Off-site | Y | Possible | Y |
| Connection to Existing Blacksmith Shop Road WWTF | Off-site | Y | Possible | Note 5 |
| Components of Off-Site Methods | | | | |
| Conventional gravity/low pressure/vacuum collection | Off-site | n/a | n/a | Y |
| STEP/STEG collection | Off-site | n/a | n/a | Y |
| Disposal via rapid infiltration, subsurface infiltration | Off-site | N | N | Y |
| Disposal via drip dispersal | Off-site | Possible | Possible | Y |
| Disposal via wicks | Off-site | N | N | Y |
| Disposal via seasonal spray irrigation | Off-site | Y | Y | Y |
| Disposal via injection wells | Off-site | N | N | N |
| Disposal via phytoirrigation | Off-site | Y | Y | Y |
| Disposal via ocean outfall | Off-site | N | N | N |
| Non-Wastewater Related | | | | |
| Stormwater BMPs and Treatment | n/a | Y | Y | Y |
| Remediation | | | | |
| Permeable reactive barriers | n/a | See Note 3 | See Note 3 | Case-by-case |
| Aquaculture (i.e., shellfish, algae) | n/a | Y | Y | Case-by-case |
| Inlet modifications and dredging | n/a | Y | Y | Case-by-case |
| Phytobuffers | n/a | Y | Y | Case-by-case |
| Fertigation | n/a | Y | Y | Case-by-case |
| Habitat restoration (i.e., shellfish, salt marsh, wetlands) | n/a | Possible | Possible | Case-by-case |
| Pond mixing (e.g., floating mixers) | n/a | Possible | Possible | Case-by-case |

Notes:
1) Zoning modifications and growth management will only address new sources of nitrogen and phosphorus, not current sources of nitrogen and phosphorus.
2) While Title 5 systems do actually remove nitrogen and phosphorus, they are considered the "baseline" approach and result in no nitrogen removal in terms of TMDL compliance.
3) Permeable reactive barriers can be designed for nitrogen or phosphorus removal, but not both simultaneously.
4) Column indicates DEP approval general use; it does not indicate whether it will achieve TMDL compliance.
5) Connection to a WWTF is generally DEP approved; however, the BSR WWTF may not have sufficient capacity.

The items indicated on **Table 4-1** include most of the items from the Cape Cod Commission's Technologies and Approaches Fact Sheets (October 2013). The intent of this table is to provide a broad overview of each technology and approach. Each technology and approach are described below.

## 4.2 NON-STRUCTURAL MEASURES

### 4.2.1 Zoning Modifications and Growth Management

The Oyster Pond TMDL identifies the nitrogen removal requirements based on current conditions (i.e., 64% removal of groundwater nitrogen load). Implicit in the TMDL is that nitrogen resulting from all future flows needs to be eliminated (i.e., 100% removal). From the perspective of costs related to nitrogen removal, growth will come at a cost premium. Therefore, several approaches to minimize or control future growth were identified and discussed with the Oyster Pond Working Group (e.g., land set-asides, transfer of development rights, lower-density zoning, growth moratorium, "no net nitrogen increase," etc.). In 2012, the Town passed Flow Neutral Regulations in order to be eligible for 0% interest under the CWSRF loan program. Based on discussions with the Working Group, these are the only growth management provisions which will be incorporated into the plan.

### 4.2.2 Fertilizer Controls

When fertilizers are applied to gardens, lawns, turf and golf courses, some portion of the nitrogen nourishes the plants, another portion is converted to harmless nitrogen gas by soil organisms, and the excess nitrogen leaches to the groundwater. The Oyster Pond MEP Report documents that approximately 5% of the current Oyster Pond watershed load comes from fertilizer. Nitrogen (and phosphorus) from fertilizers is a controllable. In 2012, the Town passed a fertilizer control regulation which provides performance standards and recommended application rates (i.e., no more than 0.5 pounds of nitrogen per 1,000 square feet of turf per single application and no more than 1.0 pounds of nitrogen per 1,000 square feet of turf per year). Education of the public on the need to modify lawn care practices should continue. Based on these fertilizer control regulations, reductions in fertilizer-related nitrogen sources were incorporated in Table 3-3.

### 4.2.3 Water Conservation

Reduction in water use can be implemented by requiring low-flow plumbing fixtures and by progressive water pricing. While water conservation measures will not reduce the nitrogen or phosphorus load to the watershed, they will extend the life of an existing Title 5 system. These measures should be encouraged for all properties which continue to utilize on-site systems.

- **Low Flow Plumbing Fixtures:** Low-flow toilets, sinks, showers, and washing machines are available and can reduce water consumption by at least 10% over older devices. Reducing water consumption with modern fixtures will reduce the wastewater production but will increase the nitrogen concentration of wastewater.
- **Progressive water pricing:** Water service pricing is among the top actions to promote conservation, as stated by the Massachusetts Water Conservation Standards, and an effective tool for promoting wastewater flow reduction. Contrary to the pricing structure for most services where the more you buy, the less it costs; progressive water use pricing fees increase incrementally with increasing water consumption. A progressive pricing structure charges fees based on the size of the service and quantity of water used. The larger the service connection and water use, the higher the fee. Water pricing can also change with season. It is possible to increase rates in the summer when demand is the highest. All these practices can further the economic incentive to reduce water consumption and reduce wastewater generation.

### 4.2.4 Garbage Grinder Bans

Disposing of food waste via kitchen garbage grinders can be a significant contributor to the load of the wastewater stream. Changing this practice would reduce the organic and nutrient concentration of the wastewater stream. Many communities ban the use of garbage grinders in homes served by on-site systems. Removing food waste from the wastewater stream means that it must be incorporated into an alternative waste stream, such as a municipal refuse, a source-source organics waste or home composting. Proper disposal or reuse of food waste is important to prevent nutrients from reaching receiving waters by other means (e.g., use of home compost in addition to chemical fertilizers). No nitrogen removal credit is included for this measure.

Falmouth currently prohibits garbage grinders on new I/A systems and on new septic systems which require a variance from the Board of Health. The Town should consider expanding this prohibition to all new septic systems as well as all septic systems require rehabilitation or replacement under the jurisdiction of the Health Department. The Town should also increase public education related to the nutrient loading which results from the use of garbage grinders.

### 4.2.5 Septic System Maintenance

The Town should continue to encourage proper septic system maintenance regarding septage pumping. While proper septage management will not reduce the nitrogen or phosphorus load to the watershed, it will preserve the life of an existing Title 5 system. This measure should be encouraged for all properties which continue to utilize on-site systems. No nitrogen removal credit is included for this measure.

### 4.2.6 Atmospheric/ Air Quality Management

Atmospheric sources of nitrogen are a significant portion of the total nitrogen load to Oyster Pond. As presented in Section 3, atmospheric sources of nitrogen have been decreasing since the 1990s and should be monitored for continued decrease in the future. The Town has requested that the Cape Cod Commission or Barnstable County establish a local atmospheric deposition monitoring station for the benefit of all Cape Cod communities. Based on existing and continued future downward trends in atmospheric nitrogen sources (refer to Section 3.4.3), reductions in atmospheric nitrogen sources were incorporated in Table 3-3.

## 4.3 STRUCTURAL MEASURES – SOURCE CONTROL/ TREATMENT

### 4.3.1 On-Site Systems

On-site wastewater treatment is the existing method of treatment for the Oyster Pond watershed, including cesspools, septic systems with leaching fields, conventional Title 5 systems and Innovative and Alternative (I/A) systems. An on-site wastewater treatment system is a system that collects and treats wastewater from an individual dwelling and discharges it into the ground within the boundaries of that property. The following terms have been utilized:

- Title 5 System – can routinely meet 35 mg/l total nitrogen in septic tank effluent with further reduction in the leachfield
- I/A System – can routinely meet <19 mg/l total nitrogen with little to no further reduction in the leachfield
- "Enhanced" I/A System – anticipated to routinely meet <13 mg/l effluent total nitrogen (note there are no DEP General Use Approval systems that fall in this category at this time)
- "Advanced" I/A System – anticipated to routinely meet <10 mg/l effluent total nitrogen (note there are no DEP General Use Approval systems that fall in this category at this time)

On-site systems will be utilized in the alternatives analysis.

### 4.3.2 Eco-toilets

Eco-toilets (e.g., composting, urine diverting, incineration, and packaging toilets) are another form of on-site treatment system. Eco-toilets are paired with a conventional system for gray water (e.g., from sinks, showers, and baths) disposal and reduce both wastewater flows and pollutant loads by alternative processing of "black" and "yellow" waste streams. Eco-toilets have special installation requirements and may have issues with public acceptability; however, for some individuals, this approach will be embraced. Falmouth conducted a demonstration project to determine the advantages, disadvantages, costs, and nitrogen removal factors associated with several different eco-toilet systems. The WQMC reports that a key finding of this demonstration is that public acceptance of eco-toilets is very low currently.

Eco-toilets will be considered an allowable approach to wastewater management, where desired by the property owner and where approved by the Town (site-specific). For the purposes of this screening analysis, a residential household which converts all toilets to approved eco-toilets will be considered equivalent to Enhanced I/A Systems and Advanced I/A Systems.

### 4.3.3 Off-Site Treatment Systems

Off-site wastewater treatment systems can include shared “cluster systems” (conventional Title 5 system or I/A systems), small “decentralized” treatment systems and large "centralized" treatment systems. With any off-site treatment system, a collection system is needed.

Wastewater treatment facilities (WWTFs) with design flow rates in excess of 10,000 gpd require a DEP Groundwater Discharge Permit (GWDP). There may be some applications, especially in nutrient sensitive areas, where a GWDP could be required by DEP for a small WWTF that discharges less than 10,000 gpd. These facilities are regulated jointly by the DEP and the local Health Department. Most technical standards and design guidance can be found in the *Guidelines for the Design, Construction, Operation, and Maintenance of Small Wastewater Treatment Facilities with Land Disposal* (also known as the Small Treatment Facility Guidelines). The regulations that govern small WWTFs are primarily the Massachusetts Groundwater Discharge Permit Program (314 CMR 5.00) and the Massachusetts Groundwater Quality Standards (314 CMR 6.00).

Regardless of the technology selected, the permittee bears the ultimate responsibility of providing for the proper operation and maintenance of the permitted WWTF (314 CMR 12.00). The permittee, whether public or private, must have a WWTF Operator who is certified in accordance with the *Rules and Regulations for Certification of Operators of Wastewater Treatment Facilities* (275 CMR 2.00). The licensed operator may be part-time or full-time depending on the size of the system and the chosen technology. The operator is required to perform routine system maintenance, to record the daily influent and effluent flow, and to collect samples to determine if the facility is in compliance with its GWDP. A monthly inspection report including the results of the sampling and daily flow analysis must be submitted to the DEP and local Health Department.

Large-scale wastewater treatment systems often include more treatment processes than small scale systems, including preliminary treatment, primary treatment, disinfection, solids handling facilities, septage receiving and treatment facilities, and odor control systems. With increasing size also comes increasing economies of scale. Large-scale systems also require a DEP GWDP.

There are two existing WWTFs that could potentially serve part or all the wastewater management needs of the Oyster Pond watershed, as summarized below:

- Private WWTF at Woods Hole Oceanographic Institute (WHOI) Quissett campus. This system is permitted for a Title 5 flow rate of 32,500 gpd and includes anoxic equalization tanks, Amphidrome® reactor, Amphidrome® Plus reactor and appurtenances (e.g., blowers, alkalinity feed, methanol feed, miscellaneous pumps, and a standby generator). Effluent disposal is via a subsurface disposal system beneath an existing baseball field. The effluent disposal system is located within an unnamed watershed which DEP and MEP have determined to be a so-called "direct discharge watershed" (i.e., groundwater from this does not flow through a nitrogen sensitive waterbody). An upgrade and expansion of this existing WWTF will be considered as an alternative in the initial screening analysis.

- Public WWTF at Blacksmith Shop Road. The WWTF has a design treatment capacity of 1,200,000 gpd and includes mechanical fine screening, aerated grit removal, sequencing batch reactor (activated sludge), equalization tankage, denitrification filters and appurtenances (e.g., blowers, alkalinity feed, methanol feed, miscellaneous pumps, miscellaneous blowers, and standby generator). The WWTF also receives septage and processes thickened biosolids. Effluent disposal is via rapid infiltration basins. The WWTF also has five abandoned seasonal spray irrigation fields and some seasonal wastewater storage ponds. Effluent from the WWTF is discharged within the West Falmouth Harbor watershed, which has a TMDL for nitrogen. The TMDL limits the WWTF discharge to 5,204 pounds of nitrogen per year. This system is permitted for an effluent disposal flow rate of 450,000 gpd (2002 Modified Groundwater Discharge Permit, 2012 Settlement Agreement) to the West Falmouth Harbor watershed. In 2015, the DEP issued a Modified Groundwater Discharge Permit which reflects two additional rapid infiltration basins north of the WWTF and an additional permitted flow of 260,000 gpd, for a total permitted capacity of 710,000 gpd. This additional flow must be discharged outside of the West Falmouth Harbor watershed. Connection to the existing WWTF will be considered as an alternative in the initial screening analysis.

If a new satellite WWTF is needed within the Oyster Pond watershed, there are numerous technologies available for small- and large-scale wastewater treatment systems include fixed film processes, cyclic aeration processes, sequencing batch reactors, membrane bioreactors, and constructed wetland type systems. For the purposes of the initial screening analysis, the conventional treatment system alternative is assumed to consist of influent equalization, screening, grit removal, advanced biological nitrogen removal via membrane bioreactor (or via sequencing batch reactor with post-filtration), disinfection and appurtenant chemical feed systems (methanol, alkalinity, coagulant for chemical phosphorus removal).

### 4.3.4 Constructed Wetland Systems

Constructed wetland systems are engineered systems which use vegetation, soils, and microbial activity for the purposes of treatment wastewater and/or post-treating wastewater effluent. The advantage of this type of system is the relatively low usage of power and chemicals. The disadvantage of this type of system is the relatively large footprint and/or volume needed to effect adequate and consistent treatment for the purposes of TMDL compliance. In the New England climate, a constructed wetland system used for wastewater treatment must be enclosed and heated to allow for year-round treatment performance. Since surface water discharges are not currently permitted on Cape Cod, effluent from a constructed wetland system would also require a land-based disposal site (like a conventional treatment process).

Currently, there are several operational wastewater treatment constructed wetland systems in Massachusetts, including Weston and Ashfield. For proper operation, these systems require "conventional" pre-treatment processes (i.e., screening, grit removal, equalization) and post-treatment processes (i.e., sand filtration, disinfection). These systems also produce treatment residuals (i.e., grit, screenings, biosolids and plant biomass) at quantities like those of conventional treatment processes.

For the purposes of the initial screening analysis, a constructed wetland system with appropriate pre-treatment and post-treatment will be considered as "equivalent" to conventional treatment technologies from a performance perspective. If a satellite WWTF is selected for the watershed, a detailed cost analysis should be developed to compare a conventional treatment system to a constructed wetland system.

### 4.3.5 Expected Treatment Performance and Effluent Limits

It is important to consider the expected treatment performance for various types of treatment systems as well as the likely effluent limitations required by the state. These will govern the wastewater treatment technologies available to meet those limits as well as the residual solids that are a byproduct of treatment. The selection of the appropriate technology includes balancing cost, number of facilities, location of facilities, and effluent limitations needed to meet TMDL requirements. **Table 4-2** summarizes the effluent limits that are typically applied through the DEP Groundwater Discharge Permit process for five scenarios, as follows:

1. Traditional groundwater discharge permit standards, such as are in force for numerous small wastewater treatment plants across Cape Cod.
2. A higher level of nitrogen removal for those cases where this nutrient must be reduced to the minimum concentration achievable by current technology.
3. Conventional removal of phosphorus using low-cost chemical addition.
4. A higher level of phosphorus removal, as might be needed where phosphorus must be reduced to the lowest level possible with available technology; and
5. Effluent reuse standards, in three categories that apply to such activities as landscape irrigation, toilet flushing and agricultural activities.

The traditional limits of a groundwater discharge permit are common and well established; as are the permit requirements defined in DEP's Reclaimed Water Standards. There is less precedent for phosphorus removal limits and the higher level of nitrogen control; therefore, it will be important to gain DEP concurrence on the effluent limits that might be included in a GWDP.

The selected wastewater treatment technologies must be capable of meeting the various standards shown in **Table 4-2**. As a practical matter, most technologies are capable of even better performance with a conservatively designed system and an appropriate safety margin. Since coastal embayments are sensitive primarily to the annual average nitrogen loads, it is the average effluent concentration (as opposed to the monthly permit limit) that is pertinent to TMDL compliance. Therefore, it is important to predict the annual average performance of each technology. **Table 4-3** presents information on the expected performance of conventional technologies at various sized plants. **Table 4-3** has been reviewed by DEP, whose staff members view these effluent concentrations to be appropriate for wastewater planning.

## TABLE 4-2: EXPECTED EFFLUENT LIMITATIONS

| | Effluent Discharged to Groundwater | | | | 5. Effluent Reuse | | |
|---|---|---|---|---|---|---|---|
| | 1. Traditional GWD Permit | 2. High Level N Removal | 3. Average P Removal | 4. High Level P Removal | Class A | Class B | Class C |
| Biochemical Oxygen Demand, mg/l | 30 | 30 | 30 | 30 | 10 | 30 | 30 |
| Total Suspended Solids, mg/l | 30 | 30 | 30 | 30 | 5 | 10 | 30 |
| Nitrogen, mg/l | | | | | | | |
| Nitrate/Nitrite | 10 | 5 | 10 | 10 | --- | --- | --- |
| Total | 10 | 5 | 10 | 10 | 10 | 10 | 10 |
| Oil & Grease, mg/l | 15 | 15 | 15 | 15 | --- | --- | --- |
| pH, Standard Units | 6.5 to 8.5 | 6.5 to 8.5 | 6.5 to 8.5 | 6.5 to 8.5 | 6.5 to 8.5 | 6.5 to 8.5 | 6.5 to 8.5 |
| Phosphorus, mg/l | --- | --- | 1.0 | 0.3 | --- | --- | --- |
| Turbidity, NTU | | | | | | | |
| Average | --- | --- | --- | --- | 2 | --- | --- |
| Maximum | --- | --- | --- | --- | 10 | --- | --- |
| Fecal Coliform, #/100 ml | | | | | | | |
| Mean | 200 | 200 | 200 | 200 | --- | --- | --- |
| Median | --- | --- | --- | --- | 0 | 14 | 200 |
| Maximum | --- | --- | --- | --- | 14 | 100 | --- |
| Total Organic Carbon, mg/l | --- | --- | --- | --- | --- | --- | --- |

Notes: ‘Class A’ reclaimed water may be used for: irrigation where the public is likely to come into contact with the water, toilet flushing, agricultural use, industrial process water, commercial laundries, carwashes, fire protection and the creation of wetlands and recreational impoundments. ‘Class B’ reclaimed water may be used for: irrigation at locations where the public is not likely to come in contact with the water, unprocessed food crops where there is no contact between the water and the edible portion of the crop, dust control, soil compactions, mixing concrete and washing aggregate, and street cleaning. ‘Class C’ reclaimed water may be used for: agricultural irrigation of orchards and vineyards where there is no contact between the water and the edible portion of the crop, industrial process water, and silviculture.
Total organic carbon is currently included in permits for facilities which discharge within Public Water Supply Zone II areas; however, this could change in the future.

## TABLE 4-3: EXPECTED EFFLUENT QUALITY

| | Illustrative Flow Range, gpd | | Nitrogen, mg/l | | Phosphorus, mg/l | |
|---|---|---|---|---|---|---|
| | From | To | Effluent Limit | Expected Performance | Effluent Limit | Expected Performance |
| | | | | | | |
| **Title 5 Systems (Note 1)** | | | | | | |
| Individual | 400 | 2,000 | N/A | 35 | N/A | 10 |
| Cluster | 2,000 | 10,000 | N/A | 35 | N/A | 10 |
| | | | | | | |
| **I/A Systems (Note 1)** | | | | | | |
| Individual – “General Use” | 400 | 2,000 | N/A | 10 to 19 | N/A | 9 |
| “Enhanced” I/A (Note 2) | 400 | 2,000 | N/A | <13 | N/A | 9 |
| “Advanced” I/A (Note 2) | 400 | 2,000 | N/A | <10 | N/A | 9 |
| Cluster (Note 3) | 2,000 | 10,000 | 12 | 10 to 12 | 5 | 5 |
| | | | | | | |
| **Eco-Toilets and Blackwater Tight Tanks (Note 1)** | | | | | | |
| Composting Toilets, Urine Diverting Toilets, Blackwater Tight Tanks | 400 | 600 | N/A | 5 to 10 | N/A | 4 to 6 |
| | | | | | | |
| **Decentralized Systems** | | | | | | |
| Small | | | | | | |
| Traditional GWD Permit | 10,000 | 25,000 | 10 | 10 | N/A | 9 |
| P Removal | 10,000 | 25,000 | --- | --- | 2 | 2 |
| Medium | | | | | | |
| Traditional GWD Permit | 25,000 | 75,000 | 10 | 8 | N/A | 9 |
| P Removal | 25,000 | 75,000 | --- | --- | 1 | 1 |
| Large | | | | | | |
| Traditional GWD Permit | 75,000 | 200,000 | 10 | 5 to 8 | N/A | 9 |
| High Level N Removal | 75,000 | 200,000 | 3 to 5 | 3 to 5 | N/A | 7 |
| P Removal | 75,000 | 200,000 | --- | --- | 1 | 0.75 |
| High Level P Removal | 75,000 | 200,000 | --- | --- | 0.3 | 0.3 |
| | | | | | | |
| **Centralized Systems** | | | | | | |
| Traditional GWD Permit | 200,000 | 1,500,000 | 10 | 5 to 8 | N/A | 9 |
| High Level N Removal | 200,000 | 1,500,000 | 3 to 5 | 2 to 4 | N/A | 7 |
| P Removal | 200,000 | 1,500,000 | --- | --- | 1 | 0.5 |
| High Level P Removal | 200,000 | 1,500,000 | --- | --- | 0.3 | 0.25 |

Notes:

1) Expected performance is based on what leaves the leachfield, including other household sources.
2) “Enhanced I/A” and “Advanced I/A” systems are defined in Section 4.
3) Falmouth has a by-law which requires cluster systems to meet 12 mg/l effluent nitrogen.

In cases where phosphorus control is a concern, phosphorus removal can be achieved by chemical addition to the secondary or tertiary treatment processes. Once a nitrogen removal technology is selected, an "add-on" for phosphorus removal can be incorporated into the treatment design for those systems that require phosphorus load reduction.

### 4.3.6 Wastewater Treatment Residuals

Wastewater treatment systems (whether they are on-site systems, decentralized plants, or centralized wastewater treatment facilities) create concentrated byproducts. These "residuals" fall into the following categories: 1) septage, including grease; 2) grit and screenings; 3) biosolids (liquid or dewatered); and 4) compost, urine, or packaged wastes from alternative toilets. The CWMP assumes that these types of residuals from on-site systems would be treatment at the Blacksmith Shop Road WWTF.

## 4.4 STRUCTURAL MEASURES – SOURCE CONTROL/ COLLECTION

A wastewater collection system is a network of pipes, lift stations and appurtenances which conveys wastewater from its point of origin to a point of treatment and disposal. Whether this treatment facility is a shared Title 5 system, small decentralized system, or a larger centralized wastewater treatment facility, the wastewater must first be collected from individual properties and transported to the treatment location. The collection system is a major structural component of the wastewater management system and can represent anywhere from 50% to 75% of the total capital cost of a system. Typical collection system components are described below.

### 4.4.1 Conventional Gravity Sewers

In conventional gravity systems, wastewater flows by gravity from the house through the service connection and through a piping network to a common collection point (typically a topographic low point). It can be treated at this location, or a pump station can be used to pump the wastewater to another downstream stretch of gravity pipe, or possibly the WWTF. Gravity sewers are normally constructed of polyvinyl chloride (PVC), ductile iron, or concrete pipe materials, and are considered to have a design life of 50 years. To prevent sedimentation, they are installed with a minimum slope to ensure the wastewater maintains an adequate velocity and does not pool in the pipe. Because of the need to maintain these slopes, extremely flat or hilly terrain or areas with high groundwater and/or ledge may pose obstacles to gravity sewer installation. These conditions often result in increasingly deep excavations, increased cost, or the need for intermediate lift stations. In general, conventional gravity sewers are relatively simple to maintain, reliable, and can be sized to provide for future capacity.

### 4.4.2 Lift Stations

Wastewater lift stations are typically used with gravity sewers. Located at the low elevations in the gravity collection system, they collect and pump the wastewater to the next high point in the collection system or to a WWTF. Lift stations come in a variety of types and sizes the most common of which are discussed below.

- ***Submersible Pump Lift Stations*** - Generally used for flow rates between 50 gallons per minute (gpm) to 500 gpm, a submersible non-clog pump station includes two or three submersible pumps mounted inside a precast concrete wetwell (which collects the wastewater from the gravity sewer).

- ***Suction Lift Pump Lift Stations*** - Generally used for flow rates between 150 gpm and 750 gpm, a suction lift pump station includes either self-priming pumps or vacuum-assisted suction lift pumps that are mounted at or near ground level and draw wastewater up from the wetwell.

- ***Custom Built Wetwell/Drywell Lift stations*** - Generally used for higher flow rates or in settings where special conditions govern, custom built wetwell/drywell lift stations include a divided wetwell on one side of the building and a physically separated pump room on the other side of the building. These lift stations are generally multiple stories below grade.

### 4.4.3 Low-Pressure Sewers

With a low-pressure sewer system, each building has an individual pumping system which conveys wastewater into a low-pressure piping network where it is transported to a central location for re-pumping or treatment. In some cases, pumping systems may be provided for 2 to 3 buildings. The piping network is comprised of small-diameter pipe typically buried just below the frost line (generally 4 feet deep). Typical pipe diameters are 1.5 to 6 inches for the mains and 1.25 to 1.5 inches for individual house services. The pressure main and service pipe are generally manufactured from PVC or high-density polyethylene (HDPE). Low pressure systems have proven to be viable alternatives especially in low-lying areas with high groundwater, or shallow depth to bedrock. Low pressure sewer systems have also proven reliable in extremely hilly areas or waterfront areas where deep excavations and extensive dewatering could be problematic.

Issues for this type of system are: ownership of the components located on private property; the potential need for easements; limitations on future expansion; pumping system compatibility; and delineation of O&M responsibilities. Individual property owners typically own, operate and maintain the pumping system. Some property owners install their own backup power system to provide uninterrupted service during a power outage. Some municipalities have elected to purchase the grinder pump stations and provide them to the property owners to own, operate and maintain.

### 4.4.4 Septic Tank and Effluent Pump (STEP) or Gravity (STEG) Systems

STEP systems are a variation of the low-pressure collection system that includes septic tank pretreatment. On each property, there is a septic tank and septic tank effluent pump. The septic tank captures the solids, grit and grease that could cause problems in pumping and conveyance through the small diameter piping. Periodic removal of the sludge, scum and grease collected within the septic tank by a licensed septage hauler is essential to the long-term performance of this type of system. Some property owners install their own backup power system to provide uninterrupted service during a power outage.

STEG systems are like STEP systems, in that a septic tank is utilized as pretreatment, however, the discharge from the tank to the main is via gravity versus pump. The gravity piping is typically smaller diameter than a conventional gravity system. Other than pipe size, these systems are configured similar to conventional gravity systems which requiring straight runs between manholes and lift stations at low points. Solids settlement is less of a concern as compared to a conventional gravity system. Periodic removal of the sludge, scum and grease collected within the septic tank by a licensed septage hauler is essential to the long-term performance of this type of system.

### 4.4.5 Vacuum Sewers

Like low pressure sewer systems, a vacuum system can be used where conventional sewer systems are impractical and/or not economically feasible. Vacuum sewers are limited by the available lift and are therefore, most suited to flat terrain. Although not prevalent in New England, vacuum systems are currently being used in Provincetown, Hyannis and Plum Island, Massachusetts.

Vacuum sewers employ a central vacuum source. The collection mains are typically constructed of PVC or HDPE ranging in size from 4 to 10 inches in diameter. Vacuum systems can be buried at shallow depths (2 - 4 feet) as the high velocities (15 to 18 feet per second) attained by the system typically keep the lines from freezing. The collection mains can follow the profile of the ground provided that modest elevation changes are maintained.

A vacuum sewer system consists of three main components: (1) services, (2) wastewater collection mains, and (3) the vacuum station. After a preset time interval, the vacuum valve located on each property closes and a slug of wastewater is propelled into the collection main. Numerous cycles eventually propel the wastewater to a collection tank located at a central vacuum station. Buffer tanks are also used as holding tanks to collect and regulate large flows such as those flows from apartment buildings, schools, and other large users.

### 4.4.6 Summary of Collection System Components

The undulating topography of the Oyster Pond watershed is a challenging situation for a gravity collection system (i.e., conventional or STEG) and is much better suited to a pumped collection system approach (i.e., low pressure, vacuum, or STEP). A preliminary review of a conventional gravity system versus a low-pressure system was developed to confirm this assumption. The pertinent data is summarized below.

| | **Conventional Gravity System** | **Low Pressure System** |
|---|---|---|
| Sewer | 16,500 feet | 0 feet |
| Private Grinder Stations | 14 | 132 |
| Public Lift stations | 9 | 1 |
| Conventional Forcemains | 12,500 feet | 2,000 feet |
| Low Pressure Forcemains | 0 feet | 19,100 feet |

For this watershed, the conventional gravity system requires significantly more piping than the low-pressure system because there are numerous locations where the sewer heading "downhill" is located next to the forcemain heading "uphill" in order to convey sewage to the eventual treatment locations. A low-pressure collection system was used as the basis for the analysis.

## 4.5 STRUCTURAL MEASURES – SOURCE CONTROL/ DISPOSAL

Once wastewater is collected and treated, it must then be properly disposed of or put to productive use. Unlike other parts of the country where surface water discharge is a viable option (due to State regulations), effluent disposal on Cape Cod must be land-based and as such is land-intensive. The available disposal technologies must be carefully considered to match the availability of appropriate disposal sites. An important consideration when selecting a wastewater disposal site is whether the disposal site is within a nitrogen sensitive watershed. If the disposal site is within a nitrogen sensitive watershed, more parcels within the watershed will require alternative wastewater management due to the residual nitrogen in the treated wastewater.

### 4.5.1 Rapid Infiltration

Also referred to as open sand beds, these systems can operate at high loading rates on sites with good permeability and significant depth to groundwater. The high loading rates allow for a smaller disposal footprint than subsurface disposal facilities. Year-round application is routine, but there is little opportunity for dual use of a site. The significantly reduced footprint compared with other technologies often outweighs the benefit of dual use (provided by subsurface disposal). A smaller disposal footprint also broadens the number of parcels that could be viable disposal sites. The reduced footprint sometimes allows a single site to provide both treatment and disposal, which is less likely for other systems. Locating the treatment and disposal processes on the same site minimizes the transport costs.

### 4.5.2 Subsurface Leaching

By far the most common example of this type is the soil adsorption system found in the backyard of the typical Cape Cod home. A soil adsorption system includes a network of rigid perforated piping buried below grade that distributes effluent into surrounding gravel trenches or beds that provide dispersal of effluent over a large area at a low dosing rate. If well maintained, these systems last for at least 20 years. Land must be available for the active disposal area as well as additional space earmarked as reserve, which can be developed in the event of a failure. These systems are designed to operate year-round and work best with regular dosing of effluent. The entire disposal system is buried which eliminates the chance of human contact, and can be located under public parks or sports fields, and under parking lots with proper design. Subsurface leaching requires more land than rapid infiltration and is usually more expensive.

One innovative disposal approach is the potential to reuse and re-rate existing Title 5 leachfields for disposing of effluent from a cluster or satellite treatment facility. In this approach, sewage from a structure would be conveyed off-site, co-mingled with wastewater from other structures, treated and then conveyed to some number of existing leachfields for disposal. With the increased level of treatment provided by a cluster or satellite treatment facility, DEP guidelines would allow for a higher loading rate to be utilized than the leachfield was originally designed for. Candidate leachfields would need to be assessed to determine age and function. In addition, this approach has several legal and political complexities which would need to be discussed (e.g., the need for easements to define responsibilities associated maintenance and eventual replacement of the leachfield; the basis for selecting candidate parcels/leachfields, etc.).

### 4.5.3 Drip Dispersal (Subsurface)

Drip dispersal is a subsurface leaching approach which utilizes flexible plastic piping that provides pressure dosing of effluent to the soil. The tubing is small diameter (typically ½ inch) that is installed at a shallow depth (typically 6 to 12 inches). It can be installed in narrow trenches in areas where minimal site disturbance is desired (e.g., wooded settings, landscaped settings, areas with topographic relief, athletic fields, etc.) but can also be installed in sand beds (like a conventional leaching system) to maximize capacity in a given footprint. Loading rates are comparable to subsurface leaching fields because the concepts are similar (i.e., typically 0.5 to 1.5 gallons per day per square foot), but in cases where drip systems are installed in low permeability soils, DEP allows a higher loading rate than for traditional leaching systems. Drip systems require a pressurized application; usually a pump station is located near the disposal system and requires filtration of the effluent prior to disposal to avoid plugging. Drip dispersal/irrigation systems are designed to drain in between doses to allow for year-round operation.

While this is a relatively new technology in New England, drip dispersal systems are common in other parts of the United States. Drip dispersal has been tested at the Massachusetts Alternative Septic System Test Center on Cape Cod and has received "general use" approval by DEP. Experience with this technology has expanded significantly in recent years and it is viewed favorably by DEP in some circumstances.

### 4.5.4 Wicks

The fundamental goal of effluent disposal is to effectively introduce effluent into the groundwater. The type of soil and the depth to groundwater affect how fast surface-applied effluent reaches the groundwater table. A wick is a vertical "cylinder" of highly permeable material that provides an efficient path for effluent to travel by gravity from the wick surface to the point of discharge. A wick can be designed to disperse effluent above the groundwater table (i.e., into the vadose zone) or below the groundwater table (i.e., into the saturated zone). A wick can also be designed to "bypass" less permeable material by providing a "conduit" through the less pervious soils to more pervious soils below. Wicks are the most space-efficient method of disposal (high loading rates on a small footprint); however, wicks require a high level of pretreatment (i.e., effluent suspended solids less than 1 mg/l) in order to minimize the potential for plugging and to maximize the life of the wick. Due to the high loading rate, a wick would not provide any supplemental nitrogen removal as compared to shallow or surficial slow rate systems.

While other technologies need 3 to 5 acres per 100,000 gpd of effluent disposal capacity, the same volume could perhaps be handled by wicks on a site as small as one tenth of an acre. Wicks are not very intrusive, and the only above-grade components include an access vault and cover. This technology has been implemented at three locations in Massachusetts – Fairhaven, Tisbury, and Hingham. Fairhaven and Hingham experienced some problems initially due to high solids loadings to the wicks; however, once the high solids loadings were addressed, both installations have had many years of successful operation. Due to the high-rate nature of this disposal method, it is best considered after an unsuccessful search for sites large enough for more traditional technologies. Extensive hydrogeologic evaluations are required to determine the suitability of the soil for wicks.

This technology has a relatively limited track record, and, to date, DEP has taken a very conservative approach to permitting wick disposal systems. First, DEP has required that the design include standby wicks to provide more than 100 percent disposal capacity, so that if a wick were to fail or be overloaded, another wick can be brought on-line immediately. Second, DEP has required that another traditional disposal approach be designed and permitted so that it could be developed if the wicks failed prematurely. Given the operational record of the aforementioned facilities, DEP may not require the "second tier" or reserve capacity in the future. This would need to be discussed in greater detail with DEP. Due to their small footprint and relatively low cost, wicks can be cost effective even at a design life of 8 to 10 years.

### 4.5.5 Seasonal Spray Irrigation

Landscape irrigation is another example of technology that can be used on a site with another use. Effluent can be applied to parks, sports fields, golf courses, or landscaping. All these activities are associated with human interaction and require meeting the DEP Water Reuse Regulations, which usually adds to the cost of wastewater treatment. Irrigation is certainly restricted to seasonal operation which requires either winter storage or a complementary effluent disposal system, either of which can add substantially to the cost. This technique uses moderate application rates. Spray irrigation can also be accomplished at public-access-controlled sites if the applicable DEP Reclaimed Water Standards are met.

### 4.5.6 Ocean Outfall

Due to cost considerations, it is important to find locations for effluent disposal that are not nitrogen sensitive. Ocean outfalls are now allowed under Massachusetts General Law based on the Marine Ocean Sanctuaries Act. The Cape Cod Commission issued a document entitled *Guidance for Cape Cod Commission Review of Local Wastewater Management Plans* (December 2012) which identifies technical issues which must be understood and addressed if a municipality wants to consider an "ocean outfall", including: tides; depth; sediments; benthic surveys; fish and fowling habitat; background water quality; environmental impacts; monitoring and contingency plans; and establishment of scientific task force. Falmouth is considering an ocean outfall as one approach to be utilized for its Blacksmith Shop Road WWTF; however, this approach will not be considered for the Oyster Pond watershed.

### 4.5.7 Effluent Reuse

The fundamental premise behind any reuse program is recognition of the value of water and the nutrients it may carry, tempered by the public health aspects of public contact with wastewater-derived material. The allowable effluent disposal methods following traditional wastewater treatment (rapid infiltration, subsurface disposal, etc.) are in large part aimed at getting the effluent into the ground, and keeping it there, thus protecting the public from contact with a liquid that retains some undesirable characteristics even after tertiary treatment.

Massachusetts DEP has established a program to guide the reuse of wastewater effluents. Its publication *Interim Guidelines on Reclaimed Water* was issued in January 2000 and was superseded by *Water Reuse Regulation* in 2009. The new regulations establish 3 classes of effluent quality and permit the following uses for each:

Class A: Landscape irrigation where public contact is possible; toilet flushing; agricultural use; car washing; and fire protection.

Class B: Landscape irrigation where public contact in not likely; some agricultural uses; dust control; and concrete manufacture.

Class C: Some agricultural uses; industrial process water; and silviculture.

The new regulations give DEP the flexibility to allow other uses and to impose use-specific effluent limitation in addition to those shown in **Table 4-2**. The use of reclaimed water requires a higher level of treatment than traditional effluent disposal techniques (i.e., primarily related to BOD, TSS and bacteria). The treatment technologies described herein can be readily adapted to meet the DEP Water Reuse Standards, albeit at additional cost for enhanced solids removal and high-intensity disinfection. If membrane bioreactors are chosen for traditional wastewater treatment, they can most easily meet those reuse requirements with only minor cost increases.

There are a few possible reuse applications in the Oyster Pond watershed, including: 1) toilet flushing at public buildings; 2) lawn irrigation on public sites; and 3) lawn irrigation on private property. These potential reuse applications can be considered in the composite wastewater plans, either as primary means of effluent disposal or as seasonal supplements to traditional methods. Effluent reuse for lawn irrigation includes the approach of "phytoirrigation," as described below.

### 4.5.8 Phytoirrigation (Reclaimed Wastewater)

Phytoirrigation is combination of nutrient management, nutrient reuse, and potable water conservation. Phytoirrigation is the utilization of reclaimed wastewater, with relatively high nitrate and phosphorus concentrations, in an irrigation system to capture the fertilizer benefit of the nutrient-containing effluent. In order to determine how much nitrogen and phosphorus management would occur with this approach, the following calculations were performed:

| | **Nitrogen** | **Phosphorus** |
|---|---|---|
| Irrigation Rate | 0.5 inches/week | 0.5 inches/week |
| | 13,600 gal/week/turf acre | 13,600 gal/week/turf acre |
| Irrigation Season | 180 days | 180 days |
| Concentration Applied | 8.0 mg/l | 9.0 mg/l |
| Concentration in Recharge | 0.5 mg/l | 0.1 mg/l |
| Removal | 9.7 kg-TN/year/turf acre | 11.5 kg-TP/year/turf acre |

In comparison to the total nitrogen load to the Oyster Pond watershed of 1,609 kg/year (Table IV-4, MEP Report), phytoirrigation will have a relatively minor impact and should, therefore, be considered a supplemental technique and not a primary technique.

### 4.5.9 Summary of Effluent Disposal System Components

Based on our experience with effluent disposal systems as well as discussions with the Oyster Pond Working Group, only the following effluent disposal approaches will be considered as primary disposal methods for the Oyster Pond watershed: 1) subsurface infiltration; 2) drip dispersal; 3) wicks; and 4) phytoirrigation with reclaimed water.

## 4.6 STRUCTURAL MEASURES – REMEDIATION

In order to expedite the time frame needed to improve water quality and habitat in Oyster Pond, several remediation measures may also be warranted. These measures are not yet "proven" and, in most cases, should be expected to require demonstration projects to determine the appropriate nutrient removal rates and costs factors to apply.

### 4.6.1 Permeable Reactive Barriers

Permeable reactive barriers are narrow, deep trenches excavated along the shoreline and filled with a medium such as wood chips. The wood chips provide the substrate and organic carbon source for bacteria that remove nitrogen from the nitrate in the groundwater that is passing through the treatment barrier under anoxic (low oxygen) conditions. The nitrate is converted to nitrogen gas by microbial action and released to the atmosphere. This approach has been pilot tested at locations in Rhode Island and on Cape Cod. Drawbacks include the need to obtain property rights along the shore, the potential for construction impacts, and the uncertain frequency of media replacement. Alternatively, a permeable reactive barrier could be designed to remove phosphorus but not for nitrogen and phosphorus removal.

For the barrier to remove significant percentages of the nutrients reaching Oyster Pond, it would need to be located close to the shoreline and would need to be deep enough to intercept most of the vertical depth of the nutrient-impacted groundwater. Oyster Pond is sensitive to both nitrogen and phosphorus and permeable reactive barriers will not address both nutrients. Falmouth is currently conducting a permeable reactive barrier demonstration project elsewhere in town. The Oyster Pond Working Group has determined that permeable reactive barriers will not be considered for the Oyster Pond watershed for several reasons, including access (challenging topography, landscaped yards, not near roads), geology (documented presence of large boulders), space (not enough setback between potential PRB and water) and the need for easements if publicly owned.

### 4.6.2 Aquaculture

Generally, the term aquaculture includes both shellfish and algae growth. Shellfish are filter-feeders; they filter water to capture organic matter, and in so doing take up nitrogen. By growing and harvesting the shellfish, nitrogen is removed from the water column. Some studies have been conducted on Cape Cod to assess the viability of aquaculture systems as part of a planned nitrogen removal program; and Wellfleet, Mashpee, Orleans, and Falmouth are working on additional studies in this area. This nitrogen control option is attractive because it might generate revenue in excess of its costs, and it warrants close review of the on-going studies to document its effectiveness and economics. This approach would result in nitrogen removal from the water column during the shellfish growing season (May to November) with limited or no nitrogen removal activity during the non-growing season. Some concerns have been raised regarding the year-to-year reliability of aquaculture as a primary nitrogen control strategy. Falmouth is currently conducting a demonstration project on the effectiveness of aquaculture in Little Pond. Given the low salinity, shellfish aquaculture is not applicable in the Oyster Pond watershed and will not be considered further.

Similarly, by growing and harvesting algae, nitrogen and phosphorus would be removed from the water column. It is very unlikely that algae aquaculture would be considered acceptable by the DEP as a TMDL compliance strategy. It is also very unlikely that the aesthetic impacts of algae aquaculture would be considered acceptable by the residents of the Oyster Pond watershed as a TMDL compliance strategy or as a demonstration project. Accordingly, algae aquaculture will not be considered further.

### 4.6.3 Inlet Modifications and Dredging

The residence time of nitrogen in an embayment in part determines the susceptibility of that embayment to water quality degradation. Enhancing the flushing rate of the embayment can improve water quality and lessen the impacts of a given nitrogen load. Dredging channels, widening inlets, and replacing constricting culverts are all ways to enhance tidal flushing. Inlet modifications also have the potential to increase flooding hazards. Falmouth is currently conducting a full-scale demonstration project on inlet widening at Bournes Pond. Given that Oyster Pond is currently managed as a low-salinity brackish pond, inlet modifications (e.g., closing or opening) and dredging will not be considered further because Oyster Pond is considered protected habitat for anadromous fish and there is a regulatory requirement to maintain this habitat as a low salinity brackish pond.

### 4.6.4 Phytobuffers

Phytobuffers involve the use of plants to remove nitrogen from the groundwater (for cell growth) or convert nitrate in the groundwater to nitrogen gas (by microbial action). By definition, this requires that plants be in areas with relatively shallow depth to groundwater (say less than 10 feet to groundwater). For the Oyster Pond watershed, this requirement is met only within close proximity to the shoreline. Since the shoreline of Oyster Pond is almost entirely private property, this approach will be encouraged of property owners; however, it will not be utilized as a baseline measure.

### 4.6.5 Fertigation (Groundwater)

Similar to phytoirrigation, fertigation is combination of nutrient management, nutrient reuse, and potable water conservation. The primary difference between the two approaches is that phytoirrigation uses *reclaimed water* and fertigation uses *groundwater downgradient of septic systems*. Fertigation consists of an irrigation well(s) located in an area with relatively high nitrate concentrations, adequately spaced from existing septic systems, and an irrigation system which uses the nutrient-containing groundwater. In order to determine how much nitrogen management would occur with this approach, the following calculations were performed:

| | **Nitrogen** | **Phosphorus** |
|---|---|---|
| Irrigation Rate | 0.5 inches/week | 0.5 inches/week |
| | 13,600 gal/week/turf acre | 13,600 gal/week/turf acre |
| Irrigation Season | 180 days | 180 days |
| Concentration Applied | 2.0 mg/l | 2.0 mg/l |
| Concentration in Recharge | 0.5 mg/l | 0.1 mg/l |
| Removal | 1.9 kg-TN/year/turf acre | 2.5 kg-TP/year/turf acre |

In comparison to the present nitrogen load to the Oyster Pond watershed (1,609 kg/year, Table IV-4, MEP Report), fertigation will have a relatively minor impact and should, therefore, be considered a supplemental technique and not a primary technique.

### 4.6.6 Habitat Restoration

Over time, human development and activity has reduced the viability and health of natural habitats such as salt marshes and freshwater wetlands. A healthy salt marsh or freshwater wetlands is a productive ecosystem that has substantial ability to absorb and utilize nutrients. One approach to managing nutrient loads is restore these vital habitats. This approach requires a holistic management approach to all sources of contaminations (i.e., wastewater, stormwater, fertilizers, etc.) and all types of contaminants (i.e., nutrients, pesticides, oils, suspended solids, etc.). While explicit habitat restoration will not be incorporated in the Oyster Pond watershed, many of the baseline measures identified herein will improve the limited salt marsh and freshwater wetlands in the watershed.

### 4.6.7 Pond Mixing

The TMDL Report identifies the sentinel station as a fixed location and fixed elevation - OP-3 (south kettle hole) at the 4-meter depth. However, as described in Section 3, Oyster Pond is a dynamic waterbody which has a density and thermal stratification layer which varies in depth throughout the year. The minimum observed dissolved oxygen utilized in the TMDL Report was 2 mg/l. While we do not have the MEP data, we do have several years of OPET data. Based on our review of OPET's data, we expect that the 2 mg/l data point used in the TMDL occurred within or below the stratification. In general, dissolved oxygen data above the stratification is greater than 4 to 5 mg/l. One alternate approach to managing water quality in Oyster Pond is to use 1 or 2 solar-powered mixers to manage the elevation of the stratified layer such that the stratified layer remains below the TMDL sentinel station vertical threshold. This approach would reduce the required nitrogen removal in the watershed while achieving the same dissolved oxygen value at the compliance location. Refer to the table below for a summary of the key criteria at the sentinel station 4-m depth elevation per the TMDL.

| | **TMDL** | **Alternate** |
|---|---|---|
| Temperature | 25 degC | 25 degC |
| Salinity | 2 ppt | 2 ppt |
| Target Dissolved Oxygen | 6 | 6 |
| Minimum Observed DO | 2 | 4 |
| Maximum Saturation DO | 8.2 | 8.2 |
| % WW Nitrogen Removal Required | 65% | 48% |

If considered approvable by the DEP and the Oyster Pond watershed residents, this approach would significantly reduce the amount of nitrogen removal required. Alternatively, DEP could revise the TMDL Report to require compliance at the sentinel station above the density/ thermal stratification layer which should result in the same impact on nitrogen management without the need for a mixer. The approach has the potential disadvantage of periodically circulating some of the anoxic bottom water, with relatively high concentrations of nitrogen, ammonia, and phosphorus, into the upper water column. The approach will require discussion with DEP, MEP, and watershed residents.

### 4.6.8 Stormwater Treatment

Precipitation that falls on impervious surfaces runs off and takes with it a variety of pollutants, including nitrogen, phosphorus, sediment, and bacteria. If stormwater is discharged directly to a pond or embayment (or to a pipe or channel leading directly there) it is considered a "point source". If runoff infiltrates into the ground and transports pollutants to the groundwater it is considered a "non-point source". In either case, actions are warranted to reduce the pollutant load from stormwater. The Town should continue to eliminate point source discharges of stormwater by converting to infiltrating systems. Where infiltrating systems are not possible, constructed wetland treatment systems or "end-of-pipe" treatment systems may be warranted. Vegetated surfaces provide considerable pollutant removal. Pollutants in runoff can also be addressed at the source, through Best Management Practices such as regular street sweeping, owner control of pet wastes, and nutrient management plans prepared by larger developments. Refer to Section 2.8.1 for additional information on stormwater infrastructure in the watershed.

## 4.7 POTENTIAL TREATMENT AND DISPOSAL SITES

### 4.7.1 Site Identification Screening

The Town's geographic information system (GIS) was utilized to identify potential sites for wastewater treatment and disposal facilities. This GIS search first considered undeveloped and "under developed" parcels (or contiguous parcels) of 5 acres or greater, located entirely outside the public water supply Zone IIs and within 4,000 feet from the centroid of the Oyster Pond watershed. Emphasis was placed on sites under Town ownership; however, the search also included sites under private ownership. The sites identified in this GIS search were then reviewed using aerial photography based on numerous additional screening criteria:

- location within a flood plain or an Area of Critical Environmental Concern;
- significant development constraints or wetlands on-site;
- type of surficial soils on-site as it relates to potential disposal loading rates;
- depth to seasonal high groundwater (i.e., minimum of 10 feet separation);
- ground surface elevation (i.e., minimum elevation of 20 feet above sea level);
- distance to developed parcels and downgradient surface water (maximize spacing);
- distance to wetlands which could provide some natural attenuation;

- availability of public water for downgradient parcels with private wells;
- location relative to nitrogen-sensitive watersheds; and
- potential to serve as a “dual use” site (e.g., ballfield) or to serve multiple watersheds.

Based on these screening criteria, a total of nine parcels were identified, totaling approximately 659 acres. It is important to note that several of these parcels are identified as “conservation” or “recreation and conservation” land, which could preclude their use for this purpose. The location of these sites is identified on **Table 4-4** and shown on **Figure 4-1**. Based on regional mapping, the entire study area appears to be in glacial moraine deposits (USGS Geologic Map of Cape Cod, Mather, et.al.).

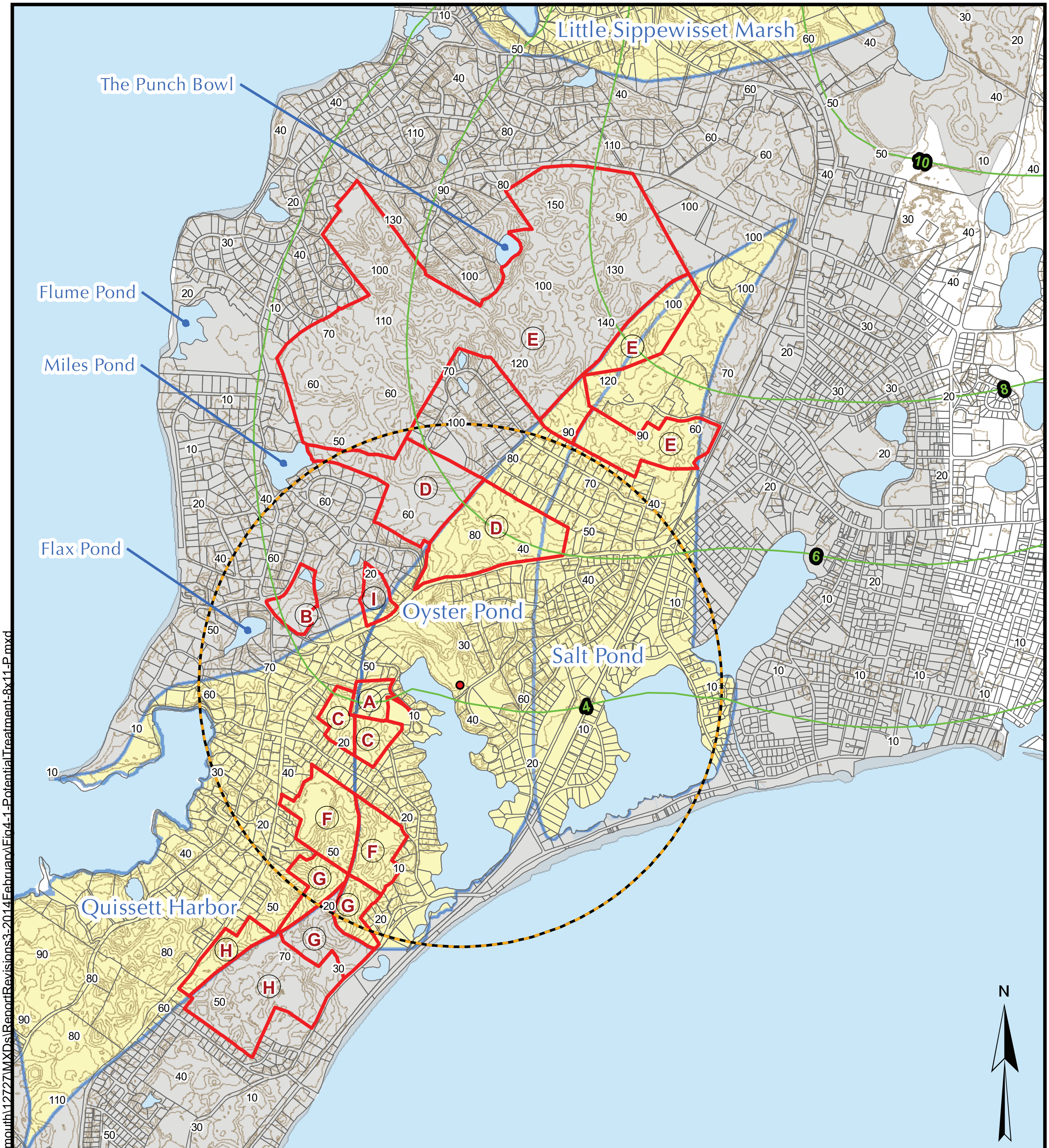
### 4.7.2 Target Effluent Disposal Capacity

All the watershed wastewater flow was utilized for the purposes of identifying potential effluent disposal sites (i.e., 29,000 gpd under current annual average conditions and 34,000 gpd at planning horizon annual average conditions, Table 3-6). In sizing any wastewater treatment and disposal system, short term peak flows must be accounted for. In the case of effluent disposal, short-term (two-day) peak flows during the summer season will govern the size of the disposal facilities. A short-term peaking factor of 2.5 was determined based on a review of the Falmouth Water Department water records (refer to Section 2.9) and was applied to the estimated annual average wastewater flows. Accordingly, this initial screening utilized *short-term peak effluent disposal flow rates* of 72,500 gpd for current conditions and 86,200 gpd at the planning horizon.

**TABLE 4-4: INITIAL SITES FOR WASTEWATER TREATMENT AND DISPOSAL**

| Map Key | Parcel ID | Owner (a.k.a) | Area (acres) | Watershed | Notes |
|---|---|---|---|---|---|
| A | 48 11 008 XXX<br>- 254<br>- 255<br>- 256<br>- 257 | Oyster Pond Environmental Trust (a.k.a., Zinn Park) | 7.5 (total)<br>*1.38 (ind.)*<br>*2.16 (ind.)*<br>*1.83 (ind.)*<br>*2.14 (ind.)* | Oyster Pond (in OP-MC) | Wetlands on-site |
| B | 48 07 007 243 | Town-ConsCom (aka, 0 RansomRd) | 10.6 | Direct | Ponds downgradient<br>***Delete from further consideration*** |
| C | 48 10 009 000C | Oyster Pond Environmental Trust | 17.5 | Upper Quissett, Oyster Pond (in OP-GT10W) | Site "RB" from Section 3 |
| D | 48 07 013 000 | Town-ConsCom (a.k.a., Peterson Farm) | 88.3 | Direct, Oyster Pond (in OP-GT10N) | Pond downgradient |
| E | 38 01 001 000 | Town-ConsCom (a.k.a., Beebe Woods) | 387.4 | Direct, Oyster Pond (in OP-GT10N) | Pond downgradient<br>***Delete from further consideration*** |
| F | 48 09 002 003 | WHOI | 43.5 | Upper Quissett, Oyster Pond (partially in OP-S and OP-GT10W) | Site "RA" from Section 3 |
| G | 50 06 009 000A | WHOI | 40.2 | Upper Quissett, Oyster Pond (in OP-S ) | Site "RC" from Section 3 |
| H | 50 04 000F 000 | WHOI | 63.9 | Direct | Site includes the WHOI WWTF & Disposal field |
| I | 48 07 011 002A | Woods Hole Research Center | 7.6 | Direct, Upper Quissett, Oyster Pond (in OP-M) | |

Town-ConsCom: Town Conservation Commission
WHOI: Woods Hole Oceanographic Institute
OP-MC: Oyster Pond-Mosquito Creek, MEP Technical Report
OP-GT10W: Oyster Pond-Greater than 10yr time of travel West, MEP Technical Report
OP-GT10N: Oyster Pond-Greater than 10yr time of travel North, MEP Technical Report
OP-M: Oyster Pond Main-Less than 10yr time of travel North, MEP Technical Report
OP-S: Oyster Pond-South, MEP Technical Report
Direct: Un-named watershed that does not recharge nitrogen-sensitive waters




- Oyster Pond Centroid
- 4000' Geographic Centroid Buffer
- Public Water Supply Zone II
- Potential Effluent Disposal Sites
- Open Water or Pond
- MEP Watershed Boundary
- Direct Discharge Watershed
- 2-Ft Groundwater Contour
- 10-Ft Ground Surface Contour

Base data obtained from Town of Falmouth (2013), Cape Cod Commission (2013)

0 2,000 4,000 Feet

Falmouth
Oyster Pond CWMP

Potential Treatment and Disposal Sites

PROJ NO: 12727 | DATE: Feb 2014

FIGURE: 4-1

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### 4.7.3 Estimated Size of Site Needed for Off-Site Effluent Disposal

A conceptual estimate of the size of the site needed for off-site effluent disposal was developed based on several key assumptions. The soil loading rate was assumed to be 3 gallons per day per square foot (gpd/sf) for subsurface leaching systems, which is typical for soils found on Cape Cod. The infiltrative land area needed (approximately 30,000 square feet at planning horizon conditions) was assumed to represent approximately one quarter to one half of the total site land area in order to account for factors such as topography, property line setbacks, reserve area, wetlands setbacks, existing earth grades, access roads, etc. Based on these assumptions, we estimate that approximately 1.5 to 3.0 acres would be necessary as a single site for disposal by subsurface leaching at the planning horizon. DEP guidelines require a minimum setback of 25 feet from property lines; however, the Town would prefer to use 100-foot setbacks. More land would be necessary if soil loading rates were lower, if property line setbacks greater than 100 feet were required and/or if a larger number of smaller sites were necessary.

Favorable soil conditions sometimes allow for the use of higher loading rates; however, these are determined based on site-specific hydrogeologic investigations. While these assumptions need to be refined, they are reasonable for this level of analysis. It is important to note that there are many reasons why the actual capacity could turn out to be less than these estimates, including:

- The soils may not allow the relatively favorable application rates that were assumed.
- Soils downgradient from the discharge site may have limiting conditions (e.g., clay lenses, tight soils, or channelized flow).
- There may be site constraints, such as steep slopes or pockets of poor soils that are not apparent from the available mapping.
- Detailed site design may find that larger setbacks are appropriate.
- Some portion of these sites may be needed for wastewater treatment facilities.
- The nitrogen control needs of certain embayments may not allow as much effluent disposal as the site would allow.
- Groundwater mounding may limit the disposal volume and/or may alter the watershed delineations if located near a watershed boundary.
- Private sites may be available only at very high cost or through an adversarial process.

- Conservation restrictions on town-owned parcels may preclude their use.

### 4.7.4 Conceptual Off-Site Effluent Disposal Systems

Conceptual layouts were developed for several different effluent disposal approaches. These layouts were reviewed and updated based on "windshield evaluation" and preliminary site walks conducted in December 2013. The effluent disposal approaches considered were:

- Reuse and re-rating of existing Title 5 systems for disposal of effluent from a new WWTF (assumed to have an application rate of 2.5 gpd/sf).

- Traditional subsurface disposal would include leaching beds, trenches, or chambers (assumed to have an application rate of 2.5 gpd/sf).

- Drip dispersal systems implemented in the woods, working around existing trees and shrubs, and drip dispersal systems implemented in open fields, meadows, or grasslands (both assumed to have an application rate of 0.5 gpd/sf).

- Wicks implemented in small pockets of land on the WHOI Quissett campus (assumed to have an application rate of 25,000 gpd/wick).

**Table 4-5** presents several scenarios, based on numerous assumptions, for the various effluent disposal approaches. The total range of disposal capacity for this scenario is between 240,000 gpd to 440,000 gpd. In aggregate, there appears to be more than enough effluent disposal capacity available; however, depending on the legal and technical feasibility of some of the sites, a combination of effluent disposal approaches may be needed. It is also important to note that the existing leachfield at the Woods Hole Research Center appears to be primarily located within the Quissett Harbor watershed.

**TABLE 4-5: SUMMARY OF CONCEPTUAL EFFLUENT DISPOSAL APPROACHES**

| Site | Reuse of Title 5 Systems | Subsurface Disposal | Drip Dispersal Woods | Drip Dispersal Fields | Wicks | Total |
|---|---|---|---|---|---|---|
| Treetops | 54,000 | 34,000 | 0 | 0 | 0 | 88,000 |
| WHRC | 7,000 | 10,000 | 0 | 0 | 0 | 17,000 |
| Peterson Farm | 0 | 0 | 18,000 | 32,000 | 100,000 | 150,000 |
| WHOI | | | | | | 185,000 |
| -Subsurface Area 1 | 0 | 15,000 | 0 | 0 | 0 | |
| -Subsurface Area 2 | 0 | 25,000 | 0 | 0 | 0 | |
| -Subsurface Area 2 | 0 | 10,000 | 0 | 0 | 0 | |
| -Subsurface Area 2 | 0 | 20,000 | 0 | 0 | 0 | |
| -Subsurface Area 2 | 0 | 15,000 | 0 | 0 | 0 | |
| -Wicks | 0 | 0 | 0 | 0 | 100,000 | |
| Total, With Wicks | 61,000 | 129,000 | 18,000 | 32,000 | 200,000 | 440,000 |
| Total, Without Wicks | 61,000 | 129,000 | 18,000 | 32,000 | 0 | 240,000 |

### 4.7.5 Estimated Size of Site Needed for Off-Site Treatment

A conceptual estimate of the size of the site needed for off-site wastewater treatment was also developed. For a facility that is less than 100,000 gpd in short-term peak flow rate, engineering guidelines suggest that a parcel as small as 1.5 to 3.0 acres would be suitable (i.e., MADEP Guidelines for Design, Construction, Operation and Maintenance of Small Wastewater Treatment Facilities with Land Disposal, WEF Manual of Practice 8). Small-scale wastewater treatment facilities can be located on the same site, or a different site, as the effluent disposal site. Buffers required for treatment sites are very site-specific and additional area could be required based on the final site location.

### 4.7.6 Site-Specific Exploration Needs

Site-specific explorations are necessary in order to refine the site capacity estimates beyond a conceptual phase. While there are advantages to keeping as many sites as possible on the list, one major disadvantage is the cost associated with conducting site-specific explorations at each site.

If effluent disposal is required for the implementation plan, the Town should undertake the following steps:

- Develop and maintain a "short list" of the best candidate sites for site-specific explorations.
- Identify whether "conservation" or "recreation and conservation" parcel will be retained for continued evaluation. If so, research whether there are land use restrictions associated with these parcels. Determine whether any of these parcels should be eliminated on this basis.
- Compile existing and available information on soils, wetlands and hydrogeologic reports from Town files.
- Begin discussions with the entities which have ownership and control of the sites.
- Determine the likely sale price of private parcels.
- Review whether smaller sites should be identified for potential cluster systems within the watershed. There are relatively few vacant parcels in the Oyster Pond watershed which are not currently designated as "conservation" or "recreation and conservation."

## 4.8 BASELINE MEASURES

Based on discussions with the Oyster Pond Working Group, the following non-structural measures will be considered as "baseline measures" (i.e., they should be implemented regardless of which additional measures are selected):

- Existing Fertilizer and Flow Neutral Regulations.
- Stormwater management best management practices (BMPs) for public and private property (including phytobuffers).
- Atmospheric/air quality trends of reduced atmospheric nitrogen emission or deposition.
- Water conservation measures and septic system maintenance measures for all properties which continue to utilize on-site systems.
- Periodic maintenance dredging of the Trunk River in order to maintain proper outflow from, and target salinity within, Oyster Pond.

## 4.9 COMBINED TECHNOLOGIES AND APPROACHES

The individual technologies and approaches can be applied in numerous combinations in order to customize the solution to the Oyster Pond watershed. We have developed the following listing of combined technologies and approaches:

- Baseline measures plus collection and conveyance to the Blacksmith Shop Road WWTF (68% of homes in critical subwatersheds).

- Baseline measures plus collection, conveyance, treatment, and disposal at the WHOI WWTF, or new satellite WWTF, with out-of-watershed disposal (68% of homes in critical subwatersheds).

- Baseline measures plus collection, conveyance, treatment, and disposal at a new satellite WWTF with a combination of in-watershed disposal (84% of homes in critical subwatersheds).

- Baseline measures plus mechanical mixing of Oyster Pond and Enhanced I/A systems ("I/A<13 mg/l") or approved eco-toilet systems. This will impact all homes in the watershed, except for those in the OP-South subwatershed (which has no nitrogen removal requirement per the MEP report). (***Note: this approach does not explicitly meet the TMDL and will require MEP modeling to confirm that the approach meets the goals of the TMDL***)

- Baseline measures plus Advanced I/A systems ("I/A<10 mg/l") or approved eco-toilet systems. This will impact all homes in the watershed, except for those in the OP-South subwatershed (which has no nitrogen removal requirement per the MEP report).

The combined technologies and approaches will be developed in greater detail based on "Load Reduction Scenario 3" (Table 3-3) in Section 5.

# SECTION 5

# IDENTIFICATION AND SCREENING OF COMPOSITE PLANS

## 5.1 FORMULATION OF INITIAL PLANS

***Note: The technical work summarized in this section of the report was completed in February 2014, was revised in October 2017 and was revised again in March 2019. The March 2019 revisions adjust for the purchase of the large WHOI parcel by OPET (parcel "RB" on Figure 3-5) and the construction of the WHOI graduate dorms off Allenby Road within the Oyster Pond Main subwatershed.***

Section 4 reviewed the elements of wastewater and nutrient management planning and recommended those elements that were most applicable to the Oyster Pond watershed. Those elements were compiled into composite plans for further evaluation. As a result of this analysis, including discussions with the Oyster Pond Working Group, several broad principles emerged as important to the formulation of the composite alternatives:

- Section 3 concluded that the only wastewater management category of need for the Oyster Pond watershed is surface water protection (from nutrients).
- Section 3 further concluded that both nitrogen and phosphorus should be managed.
- Effluent disposal outside of Oyster Pond watershed will reduce the number of homes that require alternative wastewater management to achieve the TMDL.
- Since siting of treatment and disposal facilities takes a significant effort, no more than one new decentralized wastewater treatment facility will be considered.
- The Blacksmith Shop Road WWTF will be considered; however, the lack of effluent disposal capacity may preclude this as a viable alternative for the Oyster Pond watershed.
- The Woods Hole Oceanographic Institution (WHOI) has an existing wastewater treatment facility on its Quissett campus which may be an alternative. This public-private partnership will need to be explored further with WHOI; however, it was agreed that this potential

partnership was evaluated conceptually for this initial identification and screening of alternatives to determine if it warranted more detailed consideration.

- As described in Section 4, there are numerous potential in-watershed and out-of-watershed disposal alternatives. While several of the sites appear to have sufficient capacity to the watershed disposal needs, there are technical feasibility items that will need to be reviewed. Accordingly, a combination of disposal approaches was utilized in this screening analysis.

- Also as described in Section 4, several of the identified parcels have conservation restrictions. It was agreed that this evaluation would include these parcels to determine if they warrant further consideration. If they do warrant further consideration, the next step will be to identify any and all specific conservation restrictions on the use(s) of the parcel(s).

## 5.2 DESCRIPTION OF COMPOSITE PLANS

Based on input from the Oyster Pond Working Group, six composite plans were identified for initial evaluation and screening. These plans identified below and described in greater detail on the following pages.

1. Sewering to Blacksmith Shop Road WWTF (Table 5-1, Figure 5-1)
2. Sewering to New Satellite Plant with Out-of-Watershed Disposal (Table 5-2, Figure 5-2)
3. Sewering to New Satellite Plant with In-Watershed Disposal (Table 5-3, Figure 5-3)
4. Enhanced I/A Systems (I/A<13 mg/l)[1] plus Pond Mixing (Table 5-4, Figure 5-4)
5. Advanced I/A Systems (I/A<10 mg/l)[1] (Table 5-5, Figure 5-5)
6. No Action (Table 5-6)

The above referenced tables and figures summarize the conceptual wastewater collection, treatment and disposal facilities needed for each plan. It is important to note that phasing and adaptive management are not incorporated into this alternative's analysis; however, a detailed phasing and adaptive management plan is included in Section 6.

As noted previously, the total wastewater flow depends on the treatment approach (i.e., how much nitrogen is treated) and the effluent disposal location (i.e., within a nitrogen sensitive

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[1] Or approved Eco-toilets, at homeowner option and with Town approval.

watershed or not). Therefore, the wastewater flow varies among the various plans. Also, the wastewater flows reported in Section 3 relate to the wastewater quantities which are currently disposed through on-site systems. The basis for the number of parcels and dwelling units which are part of each "plan" are included in the TMDL compliance calculations in Appendix D.

The watershed has 210 total parcels with 164 developed parcels. Of these 164 developed parcels, 161 parcels are zoned residential and have 240 existing dwelling units. These residential dwelling units include single family, multi-family and condo units and produce an estimated wastewater flow of 28,893 gpd (Table 2-8, Table 3-6). For future growth in the watershed, the theoretical build-out projection was 12 new dwelling units on 12 parcels. As described in Section 3.6.3, the Town elected to set the 'planning horizon' for the study to be equal to 'practical build-out' (i.e., 8 new dwelling units on 8 parcels), resulting in an estimated new wastewater flow of 2,630 gpd. Therefore, at planning horizon, the watershed is projected to have 172 developed parcels with 248 dwelling units and an estimated wastewater flow of 31,523 gpd. (Refer to Table 3-6). GIS data used in the analysis was received from the Town of Falmouth in 2013. Water use data were provided by the Town for the period 2007 to 2011. Peaking factors (average to short-term peak) were established in Section 2.9. Future development which is prevented through the purchase of conservation land is accounted for in the implementation plan.

All plans which incorporate off-site wastewater treatment and disposal include a collection system. Since the collection system will inevitably include some amount of infiltration/inflow, wastewater flows were increased a modest amount to allow for a small infiltration/inflow allocation.

Septage from all remaining septic systems within the watershed was assumed to be trucked to the Blacksmith Shop Road WWTF (as is likely the case today). In addition, biosolids generated from any decentralized treatment systems identified herein were also assumed to be trucked to the Blacksmith Shop Road WWTF (via tanker truck).

This screening level analysis does not include evaluation of factors such as greenhouse gas emissions or nutrient recovery. Energy and chemical use are incorporated in the operation and maintenance line items.

**TABLE 5-1: SUMMARY OF PLAN 1**
**BLACKSMITH SHOP ROAD WWTF**

**Collection**
Collection system will include 15,400 feet of low-pressure collection sewers, 5,700 feet of low-pressure transmission sewers to the sewer manhole directly outside Shivrick's Pond Lift Station. A total of 189 dwelling units would be served by sewer initially to meet the TMDL and a total of 192 dwelling units would be served by sewer at the planning horizon. Low pressure pump stations are required for connected dwelling units.

**Treatment**
Treatment of 24,100 gpd (future annual average) of wastewater at the Blacksmith Shop Road WWTF, including an allowance of 1,500 gpd (annual average) of infiltration/inflow.

**Disposal**
Disposal in the same manner as the existing WWTF (out-of-watershed).

**Land Acquisition**
An easement will be needed between Fells Road and Ransom Road across OPET land. An easement will be needed between Moorland Road and Cumloden Drive across land abutting the Salt Pond Bird Sanctuary parcel. An easement will be needed to cross Treetops land from Ransom Road to Cumloden Drive. Easements for collection system components within private roads have been assumed to be conveyed at no cost to the Town.

**Remediation of Existing Groundwater and Surface Water (vs "source control")**
None.

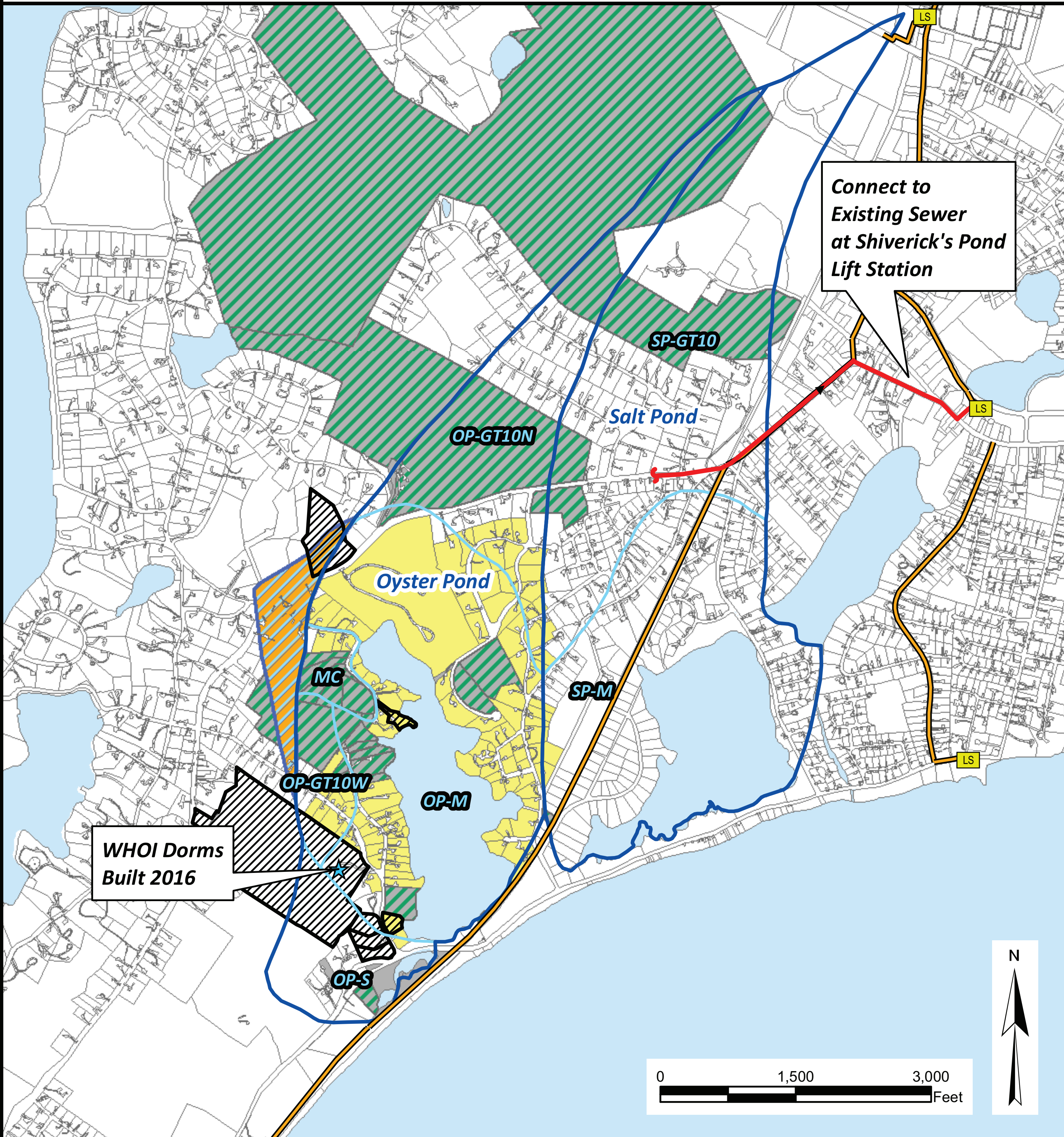
**Nitrogen TMDL Compliance**
This plan achieves compliance with the removal requirements indicated in the Oyster Pond TMDL. This plan adds an additional 220 lbs/year of Total Nitrogen to the West Falmouth Harbor watershed (assuming 24,100 gpd of wastewater treated to 3 mg/l effluent Total Nitrogen). Note: There are several on-going items which may preclude the BSR WWTF as a viable alternative.

**Phosphorus Management**
This plan removes approximately 740 lbs./year of wastewater-related phosphorus from the watershed.

**Nutrient Recovery**
Nutrient recovery could be implemented at the Blacksmith Shop Road WWTF in the future, if determined to be appropriate and cost-effective at that time.

**Water Balance**
This plan removes approximately 24,100 gallons per day from the watershed. This represents approximately 4% of the total freshwater recharge to Oyster Pond (MEP Report, Table III-1).

# Blacksmith Shop Road WWTF




LS Lift Station
Sewer Force Main
Watershed Boundary
MEP Subwatershed Boundary
Parcel with Existing I/A
Driveway
OPET Estimated Additional Surface Water Drainage Area
Properties Served Under Plan
Conservation/Recreation
Vacant/Undeveloped

Base data obtained from Town of Falmouth (2013), MassGIS (2009)

Falmouth
Oyster Pond CWMP

**Plan 1**

PROJ NO: 12727 | DATE: Mar 2019

WRIGHT-PIERCE
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FIGURE: 5-1

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## TABLE 5-2: SUMMARY OF PLAN 2
## SATELLITE PLANT WITH OUT-OF-WATERSHED DISPOSAL

**Collection**
Collection system will include 21,200 feet of low-pressure collection and transmission sewers. A total of 189 dwelling units would be served by sewer initially to meet the TMDL and a total of 192 dwelling units would be served by sewer at the planning horizon. Low pressure pump stations are required for connected dwelling units.

**Treatment**
Treatment of 24,100 gpd (future annual average) of wastewater at the expanded and upgraded Woods Hole Oceanographic Institution (WHOI) Quissett Campus, including an allowance of 1,500 gpd (annual average) of infiltration/inflow. The current design flow of the WHOI WWTF is 32,500 gpd (Title 5 basis).

**Disposal**
The existing disposal system would be expanded to add an additional 68,000 gpd (short-term peak flow) disposal capacity. The new disposal facilities would be constructed in the vicinity of the WHOI baseball fields (including existing reserve areas), basketball court and upper parking area. Site restoration of existing recreational and parking facilities is anticipated. These disposal facilities could be supplemented with wicks, if necessary.

**Land Acquisition**
Similar to Plan 1, easements will be needed between Fells Road and Ransom Road, between Ransom Road and Cumloden Drive, and between Moorland Road and Cumloden Drive. Easement or land purchase will be necessary for collection (1 acre, linear), treatment (1.5 acres) and disposal system (3 acres) components. Easements for collection system components within private roads have been assumed to be conveyed at no cost to the Town.

**Remediation of Existing Groundwater and Surface Water (vs "source control")**
None.

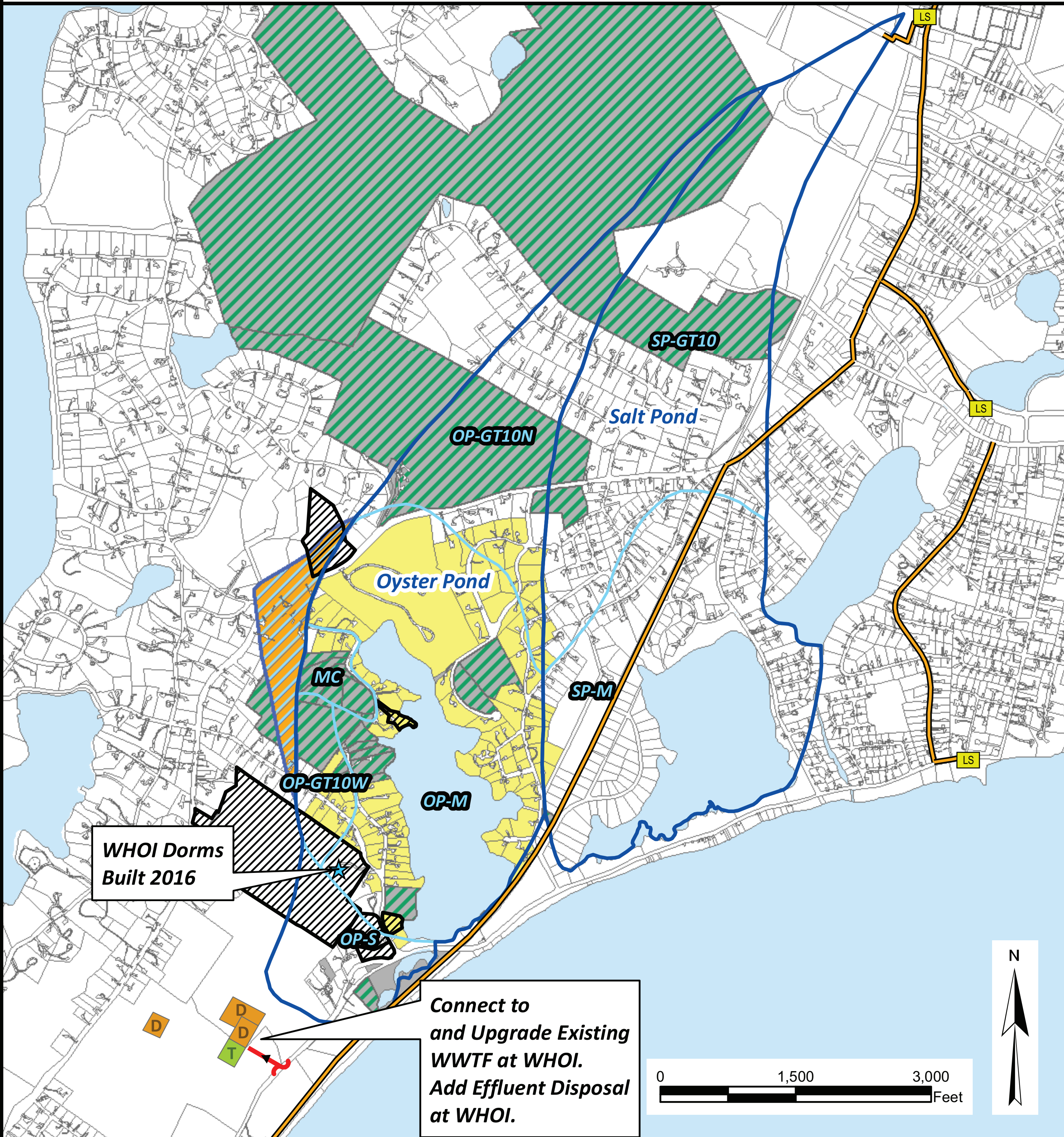
**Nitrogen TMDL Compliance**
This plan achieves compliance with the removal requirements indicated in the Oyster Pond TMDL. The existing WWTF and disposal system is in an unnamed watershed which does <u>not</u> flow through a nitrogen sensitive embayment, as determined by DEP and MEP. DEP does not plan to study this unnamed watershed.

**Phosphorus Management**
This plan removes approximately 740 lbs./year of wastewater-related phosphorus from the watershed.

**Nutrient Recovery**
Nutrient recovery could be implemented at the satellite WWTF in the future, if determined to be appropriate and cost-effective at that time.

**Water Balance**
This plan removes approximately 24,100 gallons per day from the watershed. This represents approximately 4% of the total freshwater recharge to Oyster Pond (MEP Report, Table III-1).

# Satellite Plan with Out-Of-Watershed Disposal




LS Lift Station
Treatment
Disposal
Sewer Force Main
Watershed Boundary
MEP Subwatershed Boundary
Parcel with Existing I/A
Driveway
OPET Estimated Additional Surface Water Drainage Area
Properties Served Under Plan
Conservation/Recreation
Vacant/Undeveloped

Base data obtained from
Town of Falmouth (2013),
MassGIS (2009)

Falmouth
Oyster Pond CWMP

**Plan 2**

PROJ NO: 12727
DATE: Mar 2019

**FIGURE:**
**5-2**

WRIGHT-PIERCE
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**TABLE 5-3: SUMMARY OF PLAN 3**
**SATELLITE PLANT WITH IN-WATERSHED DISPOSAL**

**Collection**
Collection system will include 22,800 feet of low pressure collection and transmission sewers. A total of 210 dwelling units would be served by sewer initially to meet the TMDL and a total of 216 dwelling units would be served by sewer at the planning horizon.

**Treatment**
Treatment of 30,500-gpd (annual average) of wastewater at a new satellite WWTF, including an allowance of 1,500-gpd (annual average) of infiltration/inflow. The treatment facility is assumed to be located at OPET's Zinn Park or on the WHOI property (Parcel C, Table 4-5).

**Disposal**
Disposal would be by a combination of methods including subsurface disposal on the Treetops property, subsurface disposal on the Wood Hole Research Center property and/or drip dispersal or wicks at Peterson Farm. Effluent disposal will also include phytoirrigation for additional nitrogen and phosphorus removal (assume 10 acres of irrigation).

**Land Acquisition**
Similar to Plan 1, easements will be needed between Fells Road and Ransom Road, between Ransom Road and Cumloden Drive, and between Moorland Road and Cumloden Drive. Easement or land purchase will be necessary for one treatment facility location (1.5 acres), and for disposal facility locations (5 acres total). Easements for collection system components within private roads have been assumed to be conveyed at no cost to the Town.

**Remediation of Existing Groundwater and Surface Water (vs "source control")**
None.

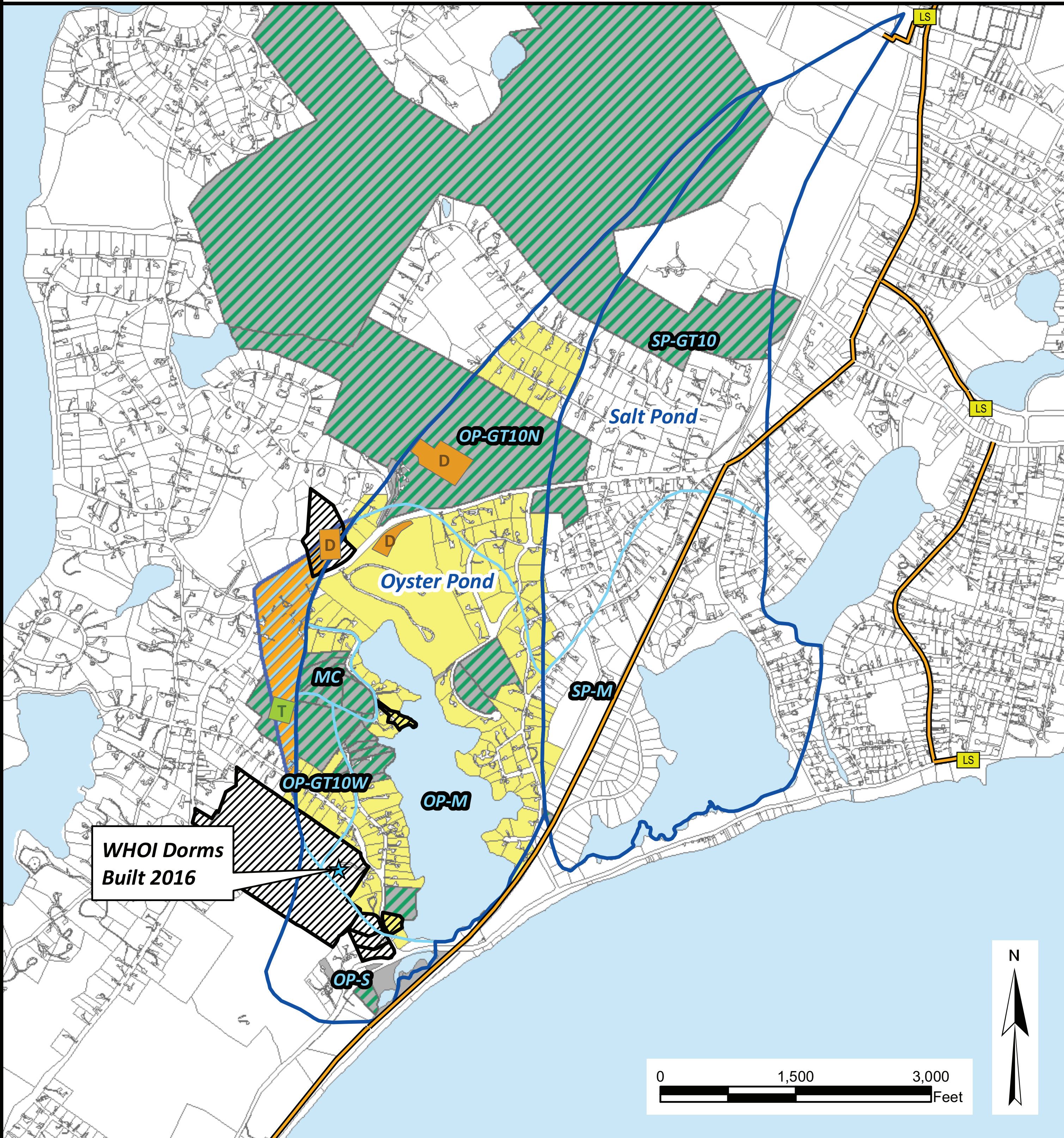
**Nitrogen TMDL Compliance**
This plan achieves compliance with the removal requirements indicated in the Oyster Pond TMDL.

**Phosphorus Management**
This plan removes approximately 670 lbs./year of wastewater-related phosphorus from the watershed.

**Nutrient Recovery**
Nutrient recovery could be implemented at the new satellite WWTF in the future, if determined to be appropriate and cost-effective at that time. Nutrient recovery is also included via phytoirrigation.

**Water Balance**
This plan results in no change to the water balance of the overall watershed.

## Satellite Plan with In-Watershed Disposal




- LS Lift Station
- Treatment
- Disposal
- Sewer Force Main
- Watershed Boundary
- MEP Subwatershed Boundary
- Parcel with Existing I/A
- Driveway
- OPET Estimated Additional Surface Water Drainage Area
- Properties Served Under Plan
- Conservation/Recreation
- Vacant/Undeveloped

Base data obtained from Town of Falmouth (2013), MassGIS (2009)

Falmouth
Oyster Pond CWMP

**Plan 3**

| PROJ NO: 12727 | DATE: Mar 2019 | FIGURE: 5-3 |
|---|---|---|

WRIGHT-PIERCE
Engineering a Better Environment

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**TABLE 5-4: SUMMARY OF PLAN 4**
**ENHANCED I/A SYSTEMS PLUS MIXING OF OYSTER POND**

**Collection**
None.

**Treatment**
Enhanced I/A systems which treat to less than 13-mg/l effluent Total Nitrogen and 9-mg/l effluent Total Phosphorus will be utilized. A total of 226 dwelling units would be served by "Enhanced I/A systems" (TN<13 mg/l) initially and a total of 233 dwelling units would be served by Enhanced I/A systems at the planning horizon. Approved eco-toilets may also be used at the homeowner's choice. Operation and maintenance costs will be borne by the homeowner.

**Disposal**
On-site disposal.

**Land Acquisition**
None.

**Remediation of Existing Groundwater and Surface Water (vs "source control")**
Implement mixing in Oyster Pond to manage the density and thermal stratification to remain below the sentinel station sampling location (OP-3 at 4-meter depth). Implement "fertigation" at Treetops and at Woods Hole Research Center (assume 10 acres of irrigation).

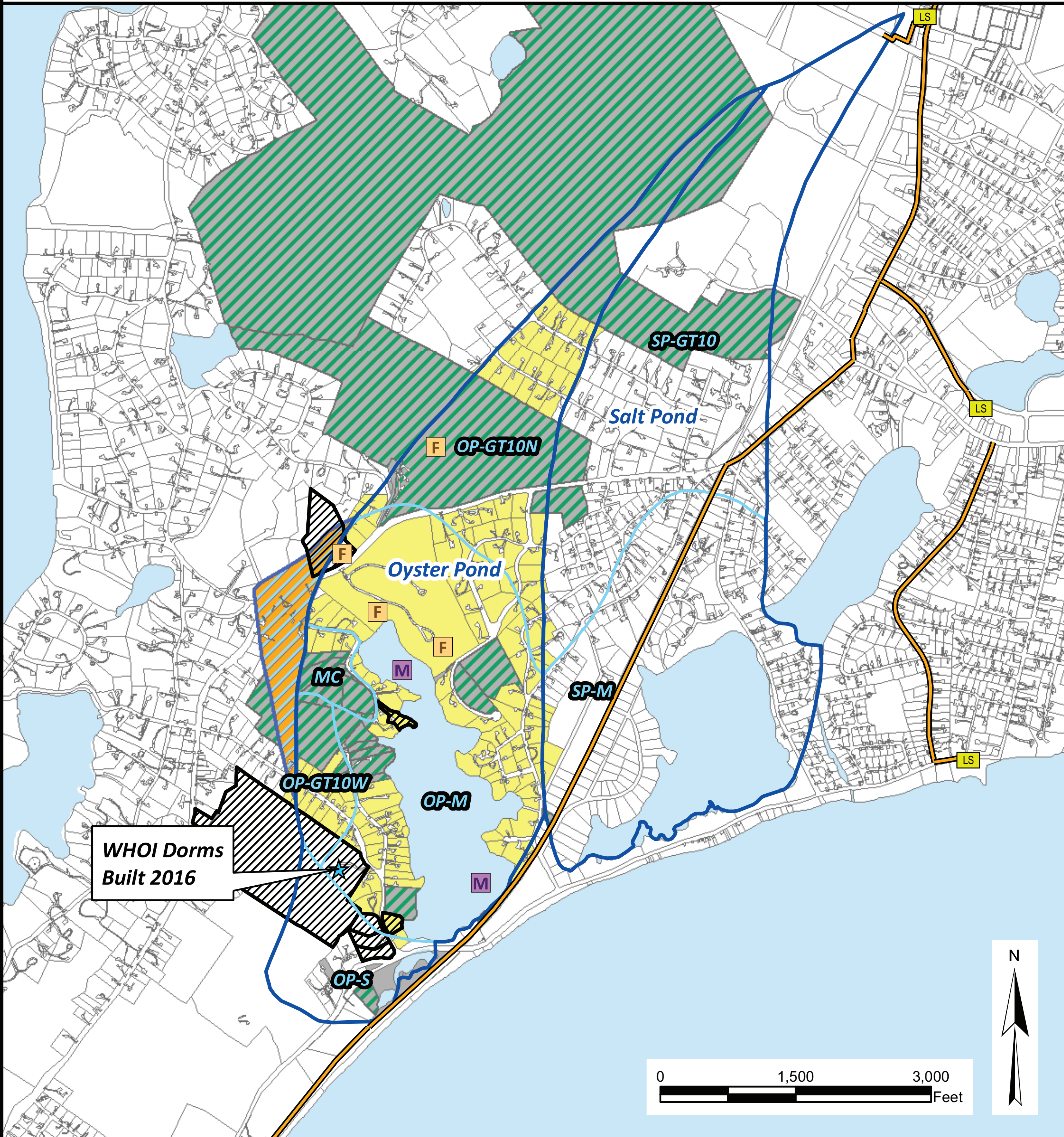
**Nitrogen TMDL Compliance**
This plan does <u>not</u> achieve compliance with the Oyster Pond TMDL as currently written; however, if DEP and MEP agree that the mixer will raise the minimum observed dissolved oxygen from 2 mg/l (used in the TMDL) to 4 mg/l (based on OPET data above the natural stratification) and that the benthic flux will not change, then the intent of the TMDL can be met. Confirmatory modeling will need to be completed by MEP for DEP to determine if the TMDL will be met.

**Phosphorus Management**
This plan removes approximately 96 lbs./year of wastewater-related phosphorus from the watershed.

**Nutrient Recovery**
Nutrient recovery could be implemented on a parcel-by-parcel basis, in accordance with State and local law which may be in-place or enacted at a future date.

**Water Balance**
This plan results in no change to the water balance.

# Enhanced I/A Systems Plus Pond Mixing




LS Lift Station
Fertigation
Mixer
Sewer Force Main
Watershed Boundary
MEP Subwatershed Boundary
Parcel with Existing I/A
Driveway
OPET Estimated Additional Surface Water Drainage Area
Properties Served Under Plan
Conservation/Recreation
Vacant/Undeveloped

Base data obtained from
Town of Falmouth (2013),
MassGIS (2009)

Falmouth
Oyster Pond CWMP

**Plan 4**

| PROJ NO: 12727 | DATE: Mar 2019 | FIGURE: |
|---|---|---|
| WRIGHT-PIERCE Engineering a Better Environment | | 5-4 |

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**TABLE 5-5: SUMMARY OF PLAN 5**
**ADVANCED I/A SYSTEMS**

**Collection**
None.

**Treatment**
Advanced I/A systems which treat to less than 10-mg/l effluent Total Nitrogen and 9-mg/l effluent Total Phosphorus will be utilized. A total of 226 dwelling units would be served by "Advanced I/A systems" (TN<10-mg/l) initially to meet the TMDL and a total of 233 dwelling units would be served by Advanced I/A systems at the planning horizon. Approved eco-toilets may also be used at the homeowner's choice. Operation and maintenance costs will be borne by the homeowner.

**Disposal**
On-site disposal.

**Land Acquisition**
None.

**Remediation of Existing Groundwater and Surface Water (vs "source control")**
None.

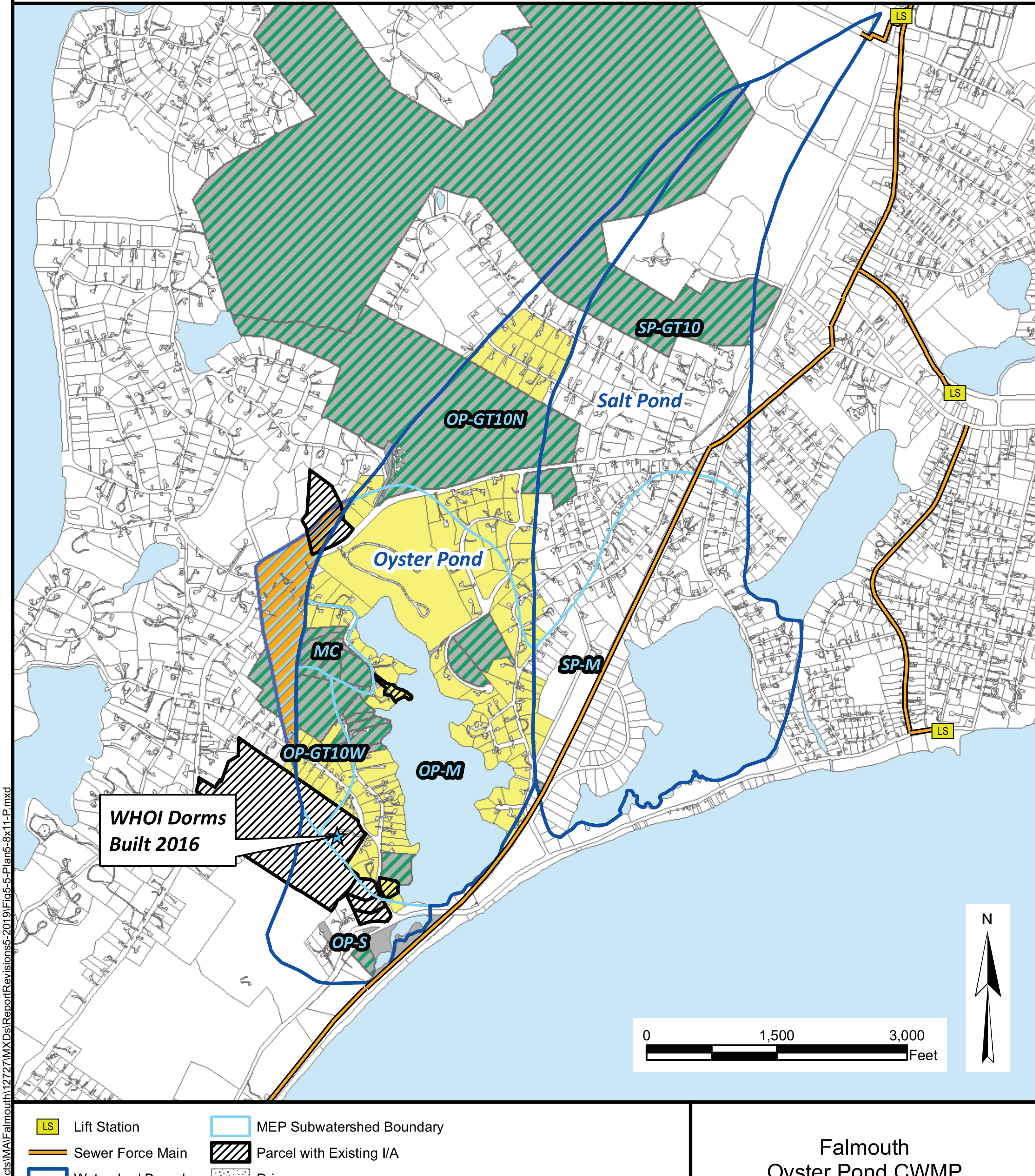
**Nitrogen TMDL Compliance**
This plan achieves compliance with the removal requirements indicated in the Oyster Pond TMDL.

**Phosphorus Management**
This plan removes approximately 96 lbs./year of wastewater-related phosphorus from the watershed.

**Nutrient Recovery**
Nutrient recovery could be implemented on a parcel-by-parcel basis, in accordance with State and local law which may be in-place or enacted at a future date.

**Water Balance**
This plan results in no change to the water balance.

# Advanced I/A Systems




Base data obtained from Town of Falmouth (2013), MassGIS (2009)

Falmouth
Oyster Pond CWMP

**Plan 5**

| PROJ NO: 12727 | DATE: Mar 2019 | FIGURE: |
|---|---|---|
| WRIGHT-PIERCE Engineering a Better Environment | | 5-5 |

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**TABLE 5-6: SUMMARY OF PLAN 6**
**NO ACTION**

**Collection**
None.

**Treatment**
Conventional Title 5 or I/A systems will be utilized on parcels when existing systems fail or upon property transfer. Approved eco-toilets may also be used at the homeowner's choice. Operation and maintenance costs will be borne by the homeowner.

**Disposal**
On-site disposal.

**Land Acquisition**
None.

**Remediation of Existing Groundwater and Surface Water (vs "source control")**
None.

**Nitrogen TMDL Compliance**
This plan will <u>not</u> achieve compliance with the Oyster Pond TMDL.

**Phosphorus Management**
This plan does not remove phosphorus.

**Nutrient Recovery**
Nutrient recovery could be implemented on a parcel-by-parcel basis, in accordance with State and local law which may be in-place or enacted at a future date.

**Water Balance**
This plan results in no change to the water balance.

## 5.3 SCREENING OF COMPOSITE ALTERNATIVES

### 5.3.1 Summary of Principal Commonalities of All Plans

The common elements of all plans are:

- All plans include the "baseline" non-structural measures identified in Sections 3 and 4.

- All plans which require a new treatment facility (Plans 2 and 3) will provide a high level of nitrogen removal (8-mg/l in effluent) and a moderate level of phosphorus removal (3-mg/l in effluent) using proven and cost-effective methods. Biosolids from the decentralized treatment facility will be brought to the Blacksmith Shop Road WWTF for post-processing and dewatering. The decentralized treatment facility will not receive septage.

### 5.3.2 Summary of Principal Differences Between All Plans

The principal differences among the three plans are:

- Plans 1, 2, 3 and 5 comply with the Oyster Pond TMDL. Plan 4 will require confirmatory modeling by MEP and review by DEP in order to determine whether it will comply with the Oyster Pond TMDL. Plan 6 does not comply with the Oyster Pond TMDL.

- Plans 1, 2 and 3 remove approximately 4% of the total groundwater recharge to Oyster Pond. Plans 4, 5 and 6 do not remove groundwater recharge from the watershed.

- Plans 1, 2 and 3 utilize existing or new public wastewater treatment facilities. Plans 4, 5 and 6 utilize private on-site systems.

- Plan 4 utilizes a solar-powered pond mixer and fertigation.

- Plans 1, 2 and 3 provide a moderate level of phosphorus control. Plans 4 and 5 provide a minor level of phosphorus control. Plan 6 does not provide any phosphorus control.

- Plan 1 offers the greatest potential for off-site nutrient recovery due to the economies of scale available at the Blacksmith Shop Road WWTF.

- Plans 4 and 5 offer the greatest potential for on-site nutrient recovery using approved Eco-toilets, to the extent Eco-toilets and/or on-site nutrient recovery are approved by the Town.

### 5.3.3 Capital Costs

Regardless of which plan is implemented, the Town will be faced with costs in two categories. The first category is "capital cost", which include the cost to design and construct the needed facilities. The second category is "operation and maintenance costs", which include the on-going annual expenses to run the facilities (refer to **Section 5.3.4**).

Capital costs were developed using cost estimating procedures consistent with industry standards utilizing conceptual layouts, unit cost information, and planning-level cost curves, as necessary. The capital costs include the following key components: wastewater collection, transport-to-treatment, wastewater treatment, transport-to-disposal, effluent disposal, land acquisition, and technical services and contingencies. Key technical data were compiled for all three plans, based on conceptual designs. Next, typical "unit costs" were applied (e.g., dollars per foot of pipe, dollars per lift station) using recent experience from publicly-bid wastewater projects across New England. Unit costs for treatment and disposal facilities were taken from the Barnstable County Cost Report (*Comparison of Costs for Wastewater Management Systems Applicable to Cape Cod*, April 2010). Once basic construction costs were estimated, allowances were added for contingencies, technical services, legal and administrative services, site investigation costs, and land costs.

For the purposes of this analysis, the following assumptions were used:

- All the facilities would be built at one time because it provides a simple basis for comparison and creates a platform for later phasing analyses. Costs are presented for the needs at the planning horizon (i.e., more than needed under current conditions).
- The “contingency, administration, legal and technical services” allowance was set at 60% for public project components and at 15% for project components on private property.
- Low-pressure pump stations are required for each parcel/dwelling unit that is connected to off-site wastewater treatment and disposal systems. [Note: Approaches for Treetops can involve continuing to group condos into “pods” for wastewater solutions (e.g., group LPS

pumping station or group I/A system). The cost analysis treats these as 62 dwelling units, and 16 buildings which can be refined based on the selected plan.

- Costs associated with the first-year operations, maintenance and performance monitoring of low pressure lift stations and Advanced I/A systems were assumed to be included in the capital costs.
- Costs for private property work (e.g., trenching, redirecting drain, abandoning septic system, etc.) were included; however, costs for landscaping were not included.
- Costs for sewer connection fees were included, where applicable.
- Septic systems that are not abandoned/replaced by either a sewer connection or new Advanced I/A system will require replacement in the planning period. Costs for these are carried as an annualized maintenance cost based on unit costs included in the Barnstable County Cost Report.
- The Eco-toilet Working Group developed a cost database for eco-toilet local installations. To date there are five installations. Given this limited dataset, for the purposes of this analysis, Eco-toilets were assumed to have the same capital cost as Advanced I/A systems but to have a lower annual operating and maintenance cost.

**Table 5-7** summarizes the capital costs for each plan (presented in April 2019 dollars). Appendix D, E and F provide backup information used in the cost analysis.

### 5.3.4 Operation and Maintenance Costs

Annual operation and maintenance (O&M) costs were developed for each plan for the purposes of comparison among the plans. These planning-level costs were developed using the anticipated wastewater flow rates for each plan. Next, unit O&M costs for “centralized” and “private I/A” treatment and disposal facilities were taken from the Barnstable County Cost Report (April 2010). These O&M estimated include the following types of expenses: labor, including fringe benefits; electrical energy for powering pumps and treatment equipment; fuel for building heating and vehicular use; chemicals; disposal of dewatered sludge; laboratory testing and other permit compliance costs; administrative costs such as insurance; and equipment maintenance and replacement. **Table 5-7** summarizes the annual O&M costs for each plan (presented in April 2019 dollars). Key O&M unit cost information is provided in Appendix D.

**TABLE 5-7: SUMMARY OF COMPARATIVE COST ESTIMATES (Rev. Sept 2019)**
**Meet TMDL at Planning Horizon**

| | Plan 1<br>Sewer to BSR WWTF | Plan 2<br>Sewer to WHOI WWTF | Plan 3<br>Sewer to Local WWTF | Plan 4<br>Enhanced I/A plus Pond Mixing | Plan 5<br>Advanced I/A ("Watershed Management") | Plan 6<br>No Action |
|---|---|---|---|---|---|---|
| Capital Cost | | | | | | |
| Construction - Collection and Transport | $6,470,000 | $5,950,000 | $6,500,000 | $0 | $0 | $0 |
| Construction - Treatment (On-Site or Off-Site) | $0 | $2,360,000 | $3,190,000 | $5,770,000 | $5,770,000 | $0 |
| Construction - Disposal (Note 7) | $330,000 | $960,000 | $1,520,000 | in above | in above | $0 |
| Contingency, Admin, Legal & Technical Services | $4,080,000 | $5,560,000 | $6,730,000 | $1,730,000 | $870,000 | $0 |
| Land Acquisition | $125,000 | $1,375,000 | $1,750,000 | $0 | $0 | $0 |
| Other (Note 1) | $590,000 | $590,000 | $660,000 | $470,000 | $470,000 | $0 |
| **Total Capital Cost** | **$11,595,000** | **$16,795,000** | **$20,350,000** | **$7,970,000** | **$7,110,000** | **$0** |
| Total Annual O&M Cost | | | | | | |
| Collection, Treatment & Disposal, Off-Site System | $143,000 | $335,000 | $440,000 | $0 | $0 | $0 |
| On-Site Systems (pumping and replacement) | $45,000 | $45,000 | $27,000 | $717,000 | $717,000 | $229,000 |
| Oyster Pond Responsible Municipal Mgmt Entity | $36,000 | $36,000 | $36,000 | $96,000 | $96,000 | $0 |
| **Total Annual O&M Cost** | **$224,000** | **$416,000** | **$503,000** | **$813,000** | **$813,000** | **$229,000** |
| Total Annual Debt Service on Capital Cost (Note 2) | $580,000 | $840,000 | $1,018,000 | $568,000 | $523,000 | $0 |
| **Total Equivalent Annual Cost** (Note 3) | **$804,000** | **$1,256,000** | **$1,521,000** | **$1,381,000** | **$1,336,000** | **$229,000** |
| | | | | | | |
| **Metrics** | | | | | | |
| No. of Dwelling Units Served | 192 | 192 | 216 | 233 | 233 | 0 |
| Capital Cost per Dwelling Unit Served | $60,400 | $87,500 | $94,200 | $34,200 | $30,500 | $0 |
| Equivalent Annual Cost per Dwelling Unit Served | $4,190 | $6,540 | $7,040 | $5,930 | $5,730 | n/a |
| Meets Nitrogen TMDL? (Note 4) | Yes | Yes | Yes | No | Yes | No |
| Nitrogen Removed from Watershed (lbs/year) | 2,300 | 2,300 | 2,300 | 1,990 | 2,300 | 0 |
| Phosphorus Removal? | Significant | Significant | Significant | Minor | Minor | None |
| Phosphorus from Watershed (lbs/year) | 740 | 740 | 670 | 96 | 96 | 0 |

**Notes:**
1) For Plans 1, 2, 3 and 4, "other" includes connection fees and private property plumbing and waste piping work.
2) For Plans 1/2/3, debt service is based on 0% at 20 years.
For Plans 4/5/6, debt service is based on 2%, 20 years for public costs/public property and 4%, 20 years for public or private costs/private property.
3) Equivalent Annual Cost equals Annual O&M Cost plus the Annual Debt Service on Capital Cost.
4) Plan 5 will meet the TMDL at the Planning Horizon (practical build-out) but not at full theoretical build-out. Plan 4 will only "alternate TMDL criteria".
5) Costs are presented in current dollars based on Engineering News Record Construction Cost Index 11228 (April 2019).
6) Plan 5 uses the 'conservative' O&M assumptions. O&M and equivalent annual costs will decrease if 'optimistic' assumptions are used. See Table 5-9.
7) Costs for Plan 1 Sewer are contingent on the availability of disposal capacity at the Blacksmith Shop Road WWTF.

### 5.3.5 Watershed Monitoring Costs/ Municipal Management Framework

The cost associated with performance monitoring and maintenance for an individual I/A system has historically been the responsibility of property owner. In the circumstance where the waterbody has a TMDL requirement (as does Oyster Pond), a significant number of property owners in the same watershed would need to perform similar monitoring and maintenance activities. The Barnstable County Cost Report (Table 2) indicates that I/A system operations, maintenance and monitoring costs in a TDML-compliance watershed were estimated at approximately $3,200 per year in 2010 dollars (or approximately $4,300 is 2019 dollars).

If a formal "watershed management framework" (or municipal management framework) could be developed and approved by DEP, then significant cost could be saved through economies of scale and through a systematic approach. The Oyster Pond Working Group has been developing such a framework, including several meetings with DEP representatives. A summary of the proposed management framework is included in Appendix F and serves as the basis for the costs included herein.

The costs utilized in this alternatives analysis were developed based on Working Group input and experience from Falmouth (e.g., septage tipping fees, the West Falmouth Harbor Shoreline Septic System Remediation Project). Advanced I/A system operation, maintenance and monitoring costs were estimated at approximately $1,600 per year in 2013 dollars (or approximately $1,800 in 2019 dollars) using the watershed management framework. Refer to Appendix D for additional information on this cost basis. Key assumptions include monitoring 1/12 of the watershed homes each month (versus each home several times per year) and only 25% of systems requiring retesting due to non-compliance.

Watershed monitoring costs also include efforts associated with implementing the environmental monitoring program, technology monitoring progress, annual progress reporting, adaptive management reporting as well as day-to-day coordination with homeowners and contractors for system operation and maintenance. Refer to Appendix D for additional information on this cost basis.

### 5.3.6 Equivalent Annual Cost

The “equivalent annual cost" is a standard economic tool that allows for the calculation of a single "cost" to represent the combination of capital costs and annual expenses for operation and maintenance. The equivalent annual cost is the sum of the annual O&M cost plus the annualized debt service on the capital costs. For the purposes of this study, the equivalent annual cost has been computed assuming the following:

- 0% interest rate and a 20-year loan for publicly funded project components on public property for Plans 1, 2 and 3;
- 2% interest rate and a 20-year loan for publicly funded project components on public property for Plan 4;
- 4% interest rate and a 20-year loan for publicly funded project components on private property for Plans 4, 5 and 6;
- 4% interest rate and a 20-year loan for privately funded project components on private property for Plans 4, 5 and 6; and
- 30% of the capital cost for Plan 4 and 5 were assumed to paid by the Town (i.e., treated as a public cost).

As noted previously, these figures assume a single project; however, it is expected that the projects will be phased over an extended period and that the actual debt service in any given year will be lower. The equivalent annual cost for each alternative is summarized in **Table 5-7**.

## 5.4 WORKSHOP RESULTS

A workshop was held with the WQMC Oyster Pond Working Group and members of the interested public on July 30, 2014 and August 15, 2018. The purpose of the workshop was to review the composite plans and the evaluative criteria and to solicit input from the interested public. Approximately 40 people attended and provided comments.

In addition, the members of the WQMC have discussed the potential for a shared wastewater solution between the Oyster Pond watershed and the WHOI wastewater facilities. WHOI has told the members of the WQMC that it is not able to commit to this approach due to the need to maintain its limited land and wastewater facilities to fulfill the WHOI mission.

## 5.5 FOCUSED REVIEW OF PLAN 1 AND PLAN 5

The Oyster Pond Working Group requested a focused follow-on review of just Plan 1 and Plan 5 showing the costs for meeting the TMDL under current conditions only as well as for a range of assumptions for the watershed management framework. The range of assumptions for Plan 5 watershed management framework are summarized below:

- The watershed framework assumes 3 sets of monitoring samples sets per year, 2 inspections per year, and that 25% of the systems requiring return visits by an operations contractor to fine-tune the operation and retest due to failure to meet specified effluent nitrogen limits.
- The "optimistic" watershed framework assumes a lesser level of baseline testing (1 sample set per year), less frequent inspections (1 inspection per year) and that 10% of the systems require return visits by an operations contractor to fine-tune the operation and retest due to failure to meet specified limits.
- "Optimistic A" also assumes that shared costs on private property could be borrowed at 2% interest through DEP SRF. "Optimistic B" assumes that shared costs on private property could be borrowed at 0% interest through DEP SRF.

A summary of this cost analysis is presented in **Table 5-8**. In this analysis, the capital costs for the four alternatives are all similar; however, the O&M costs vary significantly. Using the "equivalent annual cost per dwelling unit served" metric as the basis for comparison, Plan 1 is the least cost, followed by Plan 5 Optimistic B, Plan 5 Optimistic A and Plan 5 Watershed Management.

The cost effectiveness of Plan 5 is very sensitive to the assumptions made for the watershed management framework. These cost assumptions may need to be adjusted based on DEP comments or requirements related to the watershed management framework.

**TABLE 5-8: SUMMARY OF COMPARATIVE COST ESTIMATES (Rev Sept 2019)**
**Meet TMDL Under Current Conditions for Plan 1 and Plan 5**

| | Plan 1 - Sewer to BSR<br>Meet TMDL at Current Conditions | Plan 5 - Advanced I/A<br>Meet TMDL at Current Conditions ("Watershed Management") | Plan 5 - Advanced I/A<br>Meet TMDL at Current Conditions ("Optimistic A O&M") | Plan 5 - Advanced I/A<br>Meet TMDL at Current Conditions ("Optimistic B O&M") |
|---|---|---|---|---|
| Capital Cost | | | | |
| Construction - Collection and Transport | $6,430,000 | $0 | $0 | $0 |
| Construction - Treatment (including I/A systems) | $0 | $5,560,000 | $5,560,000 | $5,560,000 |
| Construction - Disposal (Note 7) | $330,000 | in above | in above | in above |
| Contingency, Admin, Legal & Technical Services | $4,060,000 | $830,000 | $830,000 | $830,000 |
| Land Acquisition | $125,000 | $0 | $0 | $0 |
| Other (Note 1) | $580,000 | $450,000 | $450,000 | $450,000 |
| **Total Capital Cost** | **$11,525,000** | **$6,840,000** | **$6,840,000** | **$6,840,000** |
| Total Annual O&M Cost | | | | |
| Collection, Treatment & Disposal, Off-Site System | $141,000 | $0 | $0 | $0 |
| On-Site Systems (pumping and replacement) | $38,000 | $691,000 | $513,000 | $513,000 |
| Oyster Pond Responsible Municipal Mgmt Entity | $36,000 | $96,000 | $96,000 | $96,000 |
| **Total Annual O&M Cost** | **$215,000** | **$787,000** | **$609,000** | **$609,000** |
| Total Annual Debt Service on Capital Cost (Note 2) | $576,000 | $503,000 | $478,000 | $455,000 |
| **Total Equivalent Annual Cost** (Note 3) | **$791,000** | **$1,290,000** | **$1,087,000** | **$1,064,000** |
| | | | | |
| **Metrics** | | | | |
| No. of Dwelling Units Served | 189 | 226 | 226 | 226 |
| Capital Cost per Dwelling Unit Served | $61,000 | $30,300 | $30,300 | $30,300 |
| Equivalent Annual Cost per Dwelling Unit Served | $4,190 | $5,710 | $4,810 | $4,710 |

**Notes:**

1) For Plans 1, 2, 3 and 4, "other" includes connection fees and private property plumbing and waste piping work.
2) For Plan 1, debt service is based on 0%, 20 years. For Plan 5, refer to debt service assumptions stated in Section 5.5.
3) Equivalent Annual Cost equals Annual O&M Cost plus the Annual Debt Service on Capital Cost.
4) Plan 5 will meet the TMDL at the Planning Horizon (practical build-out) but not at full theoretical build-out.
5) Costs are presented in current dollars based on Engineering News Record Construction Cost Index 11228 (April 2019).
6) Costs for Plan 1 Sewer are contingent on the availability of disposal capacity at the Blacksmith Shop Road WWTF.

# SECTION 6

# IMPLEMENTATION PLAN

## 6.1 INTRODUCTION

Previous sections of this report describe the water resource protection needs, identify management alternatives and identify and evaluate composite management plans. This section of the report presents the implementation plan, including plan elements, phasing, adaptive management, and estimated costs.

## 6.2 DEVELOPMENT OF IMPLEMENTATION PLAN

### 6.2.1 Activities of the WQMC and Oyster Pond Working Group

The Oyster Pond Working Group met regularly during the development of the Oyster Pond CWMP. At those meetings, the Working Group reviewed technical documentation, made interim decisions as the planning has progressed, and methodically narrowed its search for the best plan for the Town of Falmouth. Section 5 of this report summarizes the six composite wastewater plans that the Working Group evaluated in detail between 2014 and 2018. During this same time frame, the WQMC was also working on the CWMP for South Coastal Watershed as well as the effluent disposal capacity assessment for the Blacksmith Shop Road WWTF.

### 6.2.2 Public Input

The Oyster Pond CWMP has benefited from public input and consultation. Public consultation has taken several forms, including:

- The initial project kick-off meeting was held in March 2013.
- An initial meeting was held with the Oyster Pond Environmental Trust in April 2013;
- Public presentations were made to the WQMC (televised and recorded) in October 2013 (Needs Assessment), in June 2014 (Alternatives Analysis) and in August 2019 (Implementation Plan); and
- Progress reports by the WQMC and the consultant were given to the interested public at "watershed meetings" (televised and recorded) in July 2014 and August 2018.

- Many members of the public expressed support for on-site I/A systems as a solution in this watershed. Some members of the public were more supportive of off-site solutions.

### 6.2.3 Plan Selection

Based on its deliberations following the August 2018 public presentation, the WQMC has elected to proceed with Plan 5, Advanced I/A Systems, as described in Section 5.

### 6.2.4 Statement of Consistency with the 208 Plan

The Cape Cod Commission requires that wastewater management plans be consistent with the *208 Water Quality Management Plan Update* and *2017 Implementation Report*. Appendix G of the *2017 Implementation Report* provides specific guidance on the requirements for obtaining a consistency determination from the Commission. Appendix G was supplemented by a Cape Cod Commission April 2018 document entitled *Obtaining a Consistency Determination*. These guidance documents require that the CWMP be consistent with the following 10 requirements.

- Waste Management Agency (WMA) assumes responsibility for controllable nitrogen for any part of the watershed within its jurisdiction. – ***Confirmed***
- Plan meets applicable nutrient reduction targets. – ***Included***
- Planning occurs at a watershed level with consideration of a hybrid approach. – ***Included***
- Public was engaged to gain plan consensus. – ***Included***
- Plan includes strategies to manage nitrogen loading from new growth. – ***Included***
- Plan includes adaptive management plans – ***Included***
- Plan includes a pre- and post-implementation monitoring program – ***Included***
- Plan includes a description and assessment of the town's proposed funding strategy – ***Included***
- WMA commits to regular 208 Update Consistency reviews until water quality goals are achieved, generally reviewed at least every five years. – ***Confirmed***
- In shared watersheds, WMA seeking 208 Consistency Review collaborates with neighboring WMA(s) on nitrogen allocation, shared solutions and cost saving measures. – ***Not applicable***

## 6.3 IMPLEMENTATION PLAN

As noted in Section 5, this implementation plan accounts for changes in the watershed such as the purchase of the large WHOI parcel by OPET (parcel "RB" on Figure 3-5) in 2014 and the construction of the WHOI graduate dorms off Allenby Road within the Oyster Pond Main subwatershed in 2016. This implementation plan also aligns the watershed parcel selection with the MEP watershed delineation. Parcels that have existing I/A systems, as identified by the Barnstable County Department of Health and Environment, are shown on the implementation phasing plan. Limited performance data have been obtained for these specific I/A systems. A description of the overall approach and of each component of the implementation plan is provided below.

### 6.3.1 Overall Approach to TMDL Compliance

The TMDL does not dictate the methodology or approach to achieving TMDL compliance. As described in Section 3, the Town considered several scenarios to achieve the TMDL (i.e., ranging from addressing *only* septic systems loads to addressing each of the major sources of nitrogen to the Oyster Pond watershed). The Town selected Scenario 3, which addresses each of the major sources of nitrogen to the Oyster Pond watershed, which utilizes the following watershed load reductions by source category:

- 70% reduction in wastewater loads that existed at the time of the MEP work (MEP present wastewater loads 1280 kg/yr);
- 100% reduction in the wastewater loads that were added after the MEP, including future loads;
- 25% reduction in nitrogen loads from fertilizer use (MEP present fertilizer loads 72 kg/yr);
- 25% reduction is stormwater runoff from impervious and natural surfaces based on stormwater best management practices (MEP present impervious and natural surface loads 169 kg/yr);
- 40% reduction in nitrogen load from 1999 atmospheric deposition levels (MEP present atmospheric deposition loads 282 kg/yr); and
- Changes in benthic flux as predicted by MEP.

Based on the selection of Plan 5 (Advanced I/A Systems), owners of <u>all</u> developed watershed parcels will need to install an Advanced I/A System in order to the meet the TMDL for current and future conditions described in Section 3 of this report. Note that parcels located in the Oyster Pond South subwatershed do not require Advanced I/A Systems because, according to MEP, no nitrogen from those parcels contributes to Oyster Pond. Refer to **Section 6.3.8** below for more information regarding Advanced I/A Systems.

In DEP and CCC parlance, this selected plan consists of "non-traditional measures." In such cases, DEP requires that the "Waste Management Agency" (i.e., the Town of Falmouth in this case) secure a Watershed Permit to provide a framework for long-term implementation towards TMDL compliance in the Oyster Pond watershed. As a part of the Watershed Permit, DEP will require a "traditional backup plan" in the event some or all the non-traditional measures do not work out as well as planned. The components of a Watershed Permit are described in **Section 6.5.2** below.

As noted in Section 3 and Section 5, phosphorus may occasionally play a role in algae blooms in Oyster Pond. Since there is no Phosphorus TMDL or "MEP Technical Report equivalent" for phosphorus for the Oyster Pond watershed, there are no data regarding watershed phosphorus loading sources, phosphorus fractionation in the environment, bioavailability of phosphorus in the environment, attenuation mechanisms, or benthic sources/sinks. Accordingly, it is not possible to provide specific conclusions on the expected changes in N:P ratio in Oyster Pond. Refer to Section 3 and Appendix C for additional information on this topic.

### 6.3.2 Lawn Fertilizer (Residential)

The Town's 2012 Fertilizer Control Regulation will serve to mitigate fertilizer use and reduce nitrogen loads from the source under the implementation plan. The Town will utilize the 25% credit allowed under the CCC 208 Plan.

### 6.3.3 Lawn Fertilizer (Condominium, Institutional and Municipal)

The Town, Treetops, WHOI, and WHRC will record fertilizer application on their properties in this watershed for inclusion in the annual report (described below). These values will be compared to the values identified in the MEP data disk. This will be used to document additional reduction in fertilizer use since the MEP data set (2002-2004), if possible.

### 6.3.4 Stormwater Management

The Town will perform stormwater best management practices in accordance with MS4 permit and 208 Plan, in general, and for specific point sources items identified on page 2-24 of the CWMP and will utilize the 25% credit allowed under the CCC 208 Plan. Note, OPET has developed an estimated area of surface water contribution to Oyster Pond. The area is indicated on Figure 6-1.

### 6.3.5 Atmospheric Deposition Monitoring

The Town has requested that the Cape Cod Commission or Barnstable County establish an atmospheric monitoring station for the benefit of all Cape Cod communities. The Town will continue to monitor atmospheric deposition trends through review of publicly available data generated at established atmospheric monitoring stations in the region. Monitoring results will be reported in the annual progress reports and will be compared to the 1999 wet and dry deposition data.

### 6.3.6 Water Conservation and Septic System Maintenance

The Town may promote water conservation and septic system maintenance through low-flow plumbing fixtures and progressive water pricing. While these measures won't reduce nutrient loadings, they will prolong the life of septic systems. In addition, the Town Board of Health already promotes proper septic system maintenance.

### 6.3.7 Dredging of the Trunk River

The Town will inspect and maintain/dredge the Trunk River channel. Oyster Pond salinity needs to be maintained between 2 ppt and 4 ppt to provide for optimal health of the anadromous herring and resident population of white perch and to minimize or eliminate the propagation of algal blooms. This is accomplished by maintaining a free-flowing channel from the Oyster Pond outlet, through the Trunk River to the Vineyard Sound. Flow in the Trunk River can be obstructed by sand and gravel and/or by mats of eelgrass caused by longshore currents and storm surge. Based on input from the Oyster Pond Working Group and from OPET, the primary constraints to dredging operations are as follows:

- Dredging should not be performed during the herring run, typically between March 15 to June 15, except in emergency situations.

- Dredging should not be performed between June 1 and September 15 due to intensive seasonal use of parking areas in the vicinity of the Trunk River, except in emergency situations.

Given these constraints, a minimum of two inspections per year are recommended. The first inspection should be made in early September to allow for dredging to occur during the late Fall, if required. A second inspection should be made in February to allow for dredging to occur just prior to the spring herring run, if required. Dredging should be completed under the direction of the Director of Public Work and the Director of Marine and Environmental Services and in accordance with applicable dredging permits.

### 6.3.8 Advanced I/A Systems

In order to achieve the wastewater load reductions for current and future wastewater-related nitrogen loads utilizing the selected approach (i.e., Plan 5, Advanced I/A Systems), <u>all</u> watershed parcels, excluding those in the Oyster Pond South subwatershed, will need to install an Advanced I/A system. These Advanced I/A systems need to be capable of achieving less than 10 mg/l effluent TN.

The Town intends to implement Advanced I/A systems in accordance with the document entitled *Implementation Plan to Meet TMDL Compliance for the Oyster Pond Watershed, Falmouth, MA Using Advanced Innovative/Alternative Septic Systems* (see Appendix F). The "watershed management approach" will be implemented by the Responsible Management Entity, as described in Section 6.6.1 below.

Key elements of the Advanced I/A Plan include:

- 151 Advanced I/A systems for all single and multi-family parcels (except those in the Oyster Pond South subwatershed). [Note: 105 systems in Phase 1 and 44 systems in Phase 2]
- 1 Advanced I/A system (recirculating sand filter) installed at the WHOI Dorms in 2016.
- 16 Advanced I/A systems (or a decentralized treatment system) at Treetops under a Groundwater Discharge Permit issued by DEP or the Town.

Refer to Table 4-3 for expected effluent quality for on-site and off-site treatment systems. It is important to note that there are no Advanced I/A system which have DEP "General Use Approval" status as of the date of this report. The Town will work to advance this topic during Phase 0, as described below.

Some lots in the watershed are small and may require Falmouth Board of Health variances in order to install Advanced I/A Systems. For example, there are 3 lots (2% of the total) with less than 15,000 sf of land area and 24 lots (15% of the total) with less than 20,000 sf of land area. Refer to Figure 3-1.

Eco-toilets and blackwater holding tanks will be considered as allowable alternative approaches to Advanced I/A Systems where desired by the property owner and where approved by the Town and the DEP. The property owner must demonstrate that the systems serving the property (i.e., the combination of eco-toilets and other Title 5 systems for grey water and black water plumbing) will meet the target effluent TN requirements. Currently, DEP only allows a 50% nitrogen removal credit from these systems (due to the potential for nitrogen to be 'bypassed to the leachfield' in a poorly maintained system via the overflow pipe between the black water tank and the grey water tank) even though recent data from the West Falmouth Harbor Septic System Remediation Project shows greater nitrogen removals.

## 6.4 TRADITIONAL BACKUP PLAN

The Traditional Backup Plan will be to sewer enough parcels to achieve TMDL compliance under current and future conditions, to send the sewage to the Blacksmith Shop Road WWTF for treatment and disposal at the supplemental effluent disposal area identified as a part of the South Coastal Ponds CWMP. This will result in 106 parcels being sewered with an estimated sewer flow of 24,100 gallons per day for off-site and out-of-watershed treatment and disposal. The need for and timing of the Traditional Backup Plan will be determined through adaptive management and phased implementation. Key elements of the Traditional Backup Plan include:

- Low pressure sewer system for 106 parcels and 189 dwelling units. One low-pressure lift station at each residential dwelling unit, one low-pressure lift station at the WHOI Graduate Dorms, and 16 low-pressure lift stations at Treetops.

- Low pressure sewer piping along Oyster Pond Road, Fells Road, Ransom Road, Landfall Road, Shipswatch Road, Woods Hole Road, Sakonnet Road, Elm Road, Quonset Road, Moorland Road, Cumloden Drive, Damon Drive and Main Street to the manhole outside of Shiverick's Pond Lift Station (below the liquid level to maximize odor containment).

The Town passed the 2014 Flow Neutral Regulation which is intended to control more intensive development of a parcel than would be allowed under Title 5 if a parcel was to be served by off-site sewerage. This regulation is applicable to the traditional back-up plan and is required for 0% loans from DEP.

The Blacksmith Shop Road WWTF currently has limited effluent disposal capacity in the West Falmouth Harbor watershed. As a part of a separate project, the Town is advancing efforts to secure additional effluent disposal capacity for this Traditional Backup Plan.

If the Traditional Backup Plan is implemented, the Town should consider the following items:

- As noted in Section 3, at some point the Salt Pond watershed will require significant reduction of septic nitrogen in addition to modifications to the flushing characteristics of the pond. Low-pressure sewers in the Salt Pond watershed could be directed to the Shiverick's Pond Lift Station. Accordingly, it would be prudent to consider an increase in size of any piping which may convey future flows from this area.
- It may also be prudent to consider a "hybrid approach" to Oyster Pond parcels selected for sewering. Specifically, the parcels on the west side of Oyster Pond could receive I/A systems (i.e., Advanced, Enhanced or "standard") while enough parcels on the east side of Oyster Pond, including Treetops Condominiums, could be sewered. This approach becomes more cost-effective in the scenario where the Salt Pond watershed is sewered to some extent.

## 6.5 PHASED IMPLEMENTATION/ ADAPTIVE MANAGEMENT FRAMEWORK

### 6.5.1 Adaptive Management Framework

In dealing with complex environmental problems, precisely determining the optimum solution can take many years and require extensive study. At some point, enough information is available to embark on a solution, even though all aspects of the optimum solution have not yet been determined. At that point, the risk/cost of inaction is greater than the cost of embarking on the initial phase of a multi-phase solution. Adaptive management is the formulation and implementation of a plan that begins to solve the problem while further information is gained to guide later phases toward the best overall solution.

The key elements of a successful adaptive management framework are: a phased implementation plan and long-term compliance schedule; a monitoring program to collect and evaluate data over time in order to establish the effectiveness of the early phases of the solution; and a formal mechanism to re-assess and adjust the plan based on the data gathered. Each of these key elements is described on the following pages.

### 6.5.2 Watershed Permit

DEP will require that the Town secure a Watershed Permit for implementation plans that consist of non-traditional elements. A Watershed Permit identifies the following items:

- Responsible Management Entity (RME)
- Implementation schedule
- Monitoring requirements for environmental parameters (e.g., water quality) and plan component performance (i.e., advanced I/A performance, fertilizer use reduction, etc.)
- Reporting requirements (annual reports and five-year adaptive management reports)
- Methodology for determining TMDL compliance
- Traditional Backup Plan
- Financial plan

Each of these Watershed Permit components are described in this Section of the report and as referenced.

### 6.5.3 Phased Implementation

Based on discussions with the WQMC, the implementation plan is outlined in 3 phases occurring over a 30-year period. In general:

- Phase 0 addresses municipal activities which will occur prior to the initiation of Phase 1 design and construction, including activities related to addressing uncertainties, addressing proof-of-concept for the RME, addressing proof-of-availability of Advanced I/A systems (including initial Request for Qualifications and conceptual designs from candidate vendors) and securing additional backup disposal capacity for the Blacksmith Shop Road WWTF. At the end of Phase 0, the Town will attempt to secure Town Meeting funding approvals and decide whether to advance the Advanced I/A Plan or the Traditional Backup Plan.
- Phase 1 addresses properties closest to Oyster Pond (i.e., within the 10-year groundwater travel time established by MEP) and initiates long-term monitoring and reporting. Phase 1 is sized to address approximately 80% of the TMDL for the Alternative I/A plan (i.e., 189 dwelling units out of 233 dwelling units future total) and 100% of the TMDL for the Traditional Backup Plan. Since the Oyster Pond hydraulic residence time is approximately 9 months (See Section 2.1.4) and since Phase 1 is focused on properties within the 10-year travel time subwatersheds (and in many cases waterfront properties), it is reasonable to provide 10 years between the completion of Phase 1 installations and the start date of Phase 2 in order to assess the effectiveness of Phase 1 and to implement Adaptive Management.
- Phase 2 addresses the remainder of the properties in the Oyster Pond watershed for the Advanced I/A Plan and continue monitoring and reporting. Phase 2 is not expected to be needed for the Traditional Backup Plan.
- The need or desire to implement the Traditional Backup Plan will be reassessed prior to the beginning of Phase 1 and Phase 2. If the Traditional Backup Plan is implemented and if a property has already installed an Advanced I/A System, the Town will allow for that Advanced I/A System to remain-in-place until the Health Agent and/or Board of Health determine that connection to the sewer is required due to failure or until 50 years has elapsed from the date of installation/certification, whichever is sooner. This may require changes to the Town's sewer use regulations and/or Board of Health regulations.
- Similar to the precedent established in the Little Pond Service Area for low-pressure sewer grinder pump replacements, future replacement costs of Advanced I/A System treatment equipment (not tanks or leach field) and future replacement of Traditional Backup Plan pumping equipment (not tanks) will be paid for by the Town.

Table 6-1 summarizes the preliminary phasing plan and the general components of the plan. Figure 6-1A depicts the geographic location of the phasing for the Advanced I/A Plan. Figure 6-1B depicts the geographic location of the phasing for the Traditional Backup Plan (note that Phase 2 parcels and Phase 2 sewers are potential future connection and are not required for calculated TDML compliance and are not included in the project costs).

### 6.5.4 Addressing Uncertainties

There are numerous elements of uncertainty in the TMDL, the MEP analysis and the CWMP analysis. This uncertainty is addressed by a series of assumptions governed by DEP, MEP and engineering judgment. The table below identifies items that are typically estimated or assumed versus items that are typically measured.

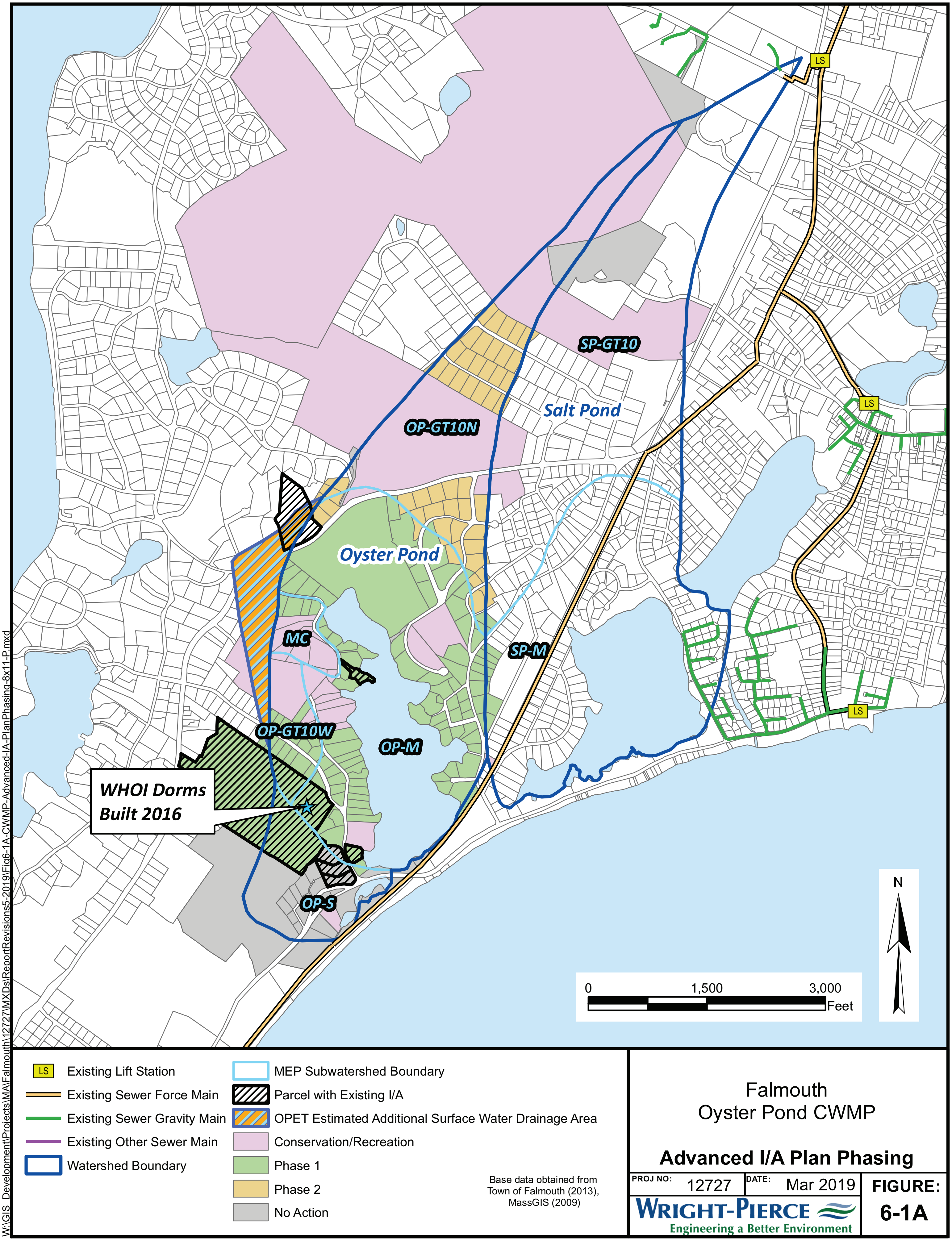
| **Items that are Typically Estimated/Assumed** | **Items that are Typically Measured** |
|---|---|
| Consumptive Use | Water use |
| Raw, black water concentration | Effluent concentration |
| Nitrogen transformation in the septic system and through the bottom of the leachfield | - |
| Soil aquifer treatment (attenuation) vertically and horizontally in environment | - |
| Nitrogen transformation in surface water | - |
| Mixing and hydrodynamics in surface water | - |
| Surface water and habitat response | Water column concentration, benthic habitat |
| Residency in homes (other than from the US Census) | - |

Comments are often raised related to several of the assumptions related to on-site treatment systems. For example:

- Recent publications (WERF, 2009, Influent Constituent Characteristics of the Modern Waste Stream from Single Sources) indicate that concentrations of black water to septic systems may be higher than what has been historically utilized for the MEP Technical Reports. This makes it challenging to estimate removals required.

## TABLE 6-1: PRELIMINARY PHASING PLAN

| Phase | Years | Description | Wastewater TN Removed (lb./ year) |
|---|---|---|---|
| 0 | 2019 to 2024 | Complete CWMP/SEIR<br>• Obtain 208 Consistency Determination, obtain MEPA Certificate and obtain Watershed Permit<br>• Implement Responsible Management Entity (RME)<br>• Identify Advanced I/A Systems to meet treatment criteria and secure bids with performance bonds<br>• Initiate environmental monitoring program<br>• Confirm decision to implement Advanced I/A Plan or Traditional Backup Plan<br>• Obtain dredging permits for Trunk River | - |
| 1 | 2025 to 2039 | Initiate Phase 1 Start Date<br>• Property owners to complete design and obtain Disposal System Construction Permit within 1 year of Phase 1 Start Date<br>• Property owner complete installation within 3 years of Disposal System Construction Permit<br>• Continue RME<br>• Continue environmental monitoring program | 1,820 lb./yr removed at end of Phase 1 construction |
| - | 2039 | First Major Adaptive Management Decision Point<br>• Evaluate TMDL compliance, including dissolved oxygen criteria and/or compliance elevation<br>• Continue with Advanced I/A Systems or switch to Traditional Backup plan (or other approach that may be available at that time) or postpone/eliminate Phase 2 if the TMDL has been achieved. | - |
| 2 | 2040 to 2050 | Initiate Phase 2 Start Date<br>• Property owners to complete design and obtain Disposal System Construction Permit within 1 year of Phase 2 Start Date<br>• Property owner complete installation within 3 years of Disposal System Construction Permit<br>• Continue RME<br>• Continue environmental monitoring program | Additional 460 lb./yr removed at end of Phase 2 construction |

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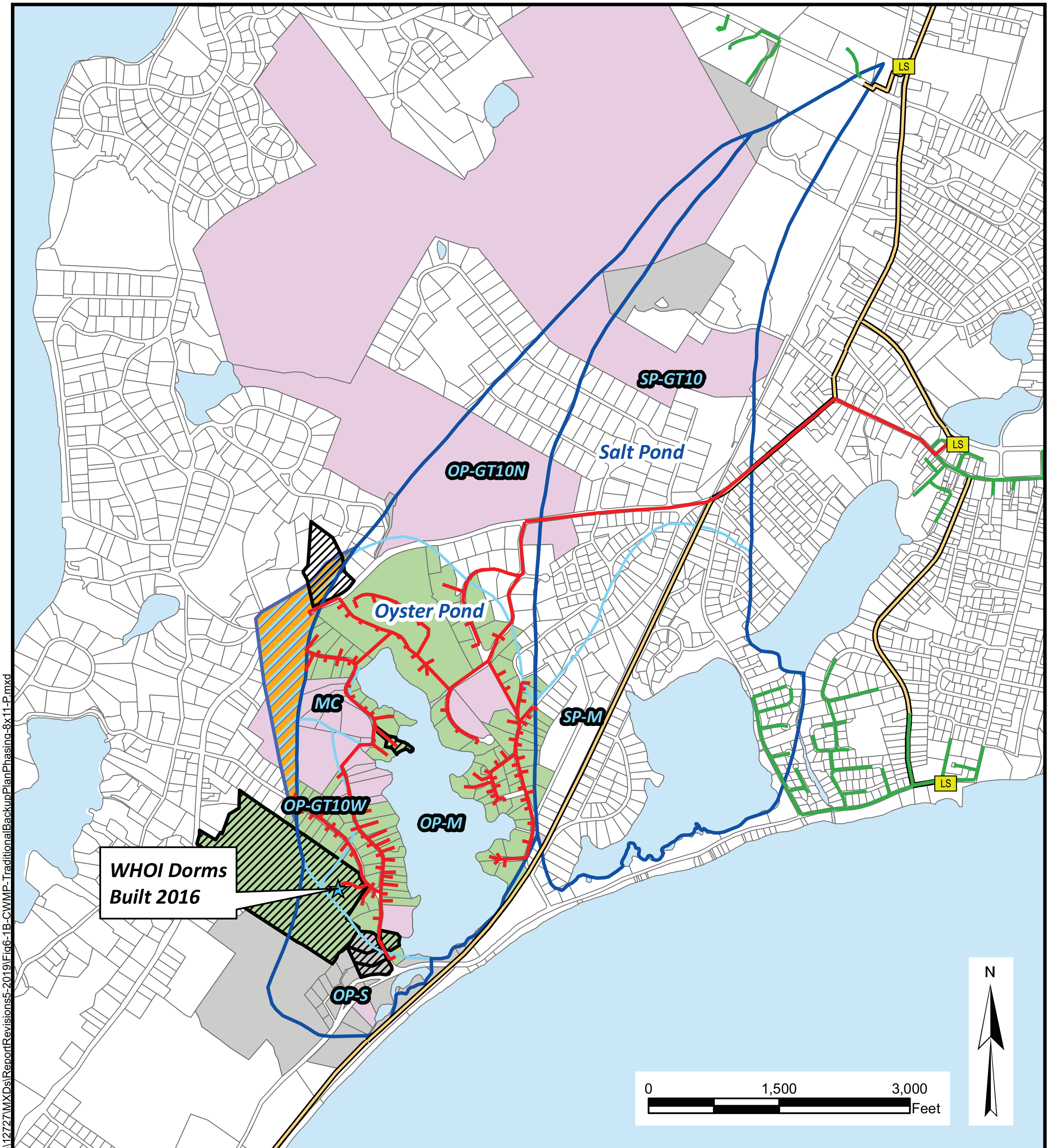




Falmouth
Oyster Pond CWMP

**Traditional Backup Plan Phasing**

| PROJ NO: 12727 | DATE: Mar 2019 | FIGURE: 6-1B |
|---|---|---|

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- Conventional septic systems produce negligible reductions in nitrogen from settling in the septic tank as well as more significant removals from biological activity in the biomat that develops in a leachfield. This is driven by the prevalence of carbon and nitrogen in the effluent. In contrast, denitrifying systems have substantially lower carbon and nitrogen concentrations in the effluent and DEP does not give any credit for further nitrogen reduction through the leachfield in the absence of site-specific data.
- It is possible that there is natural attenuation via soil aquifer treatment between the leachfield and groundwater interface and between the septic system location and the downstream receptor (unless the pathway goes through a freshwater pond). Given the prevalence of uniform sandy soils on Cape Cod, DEP does not give any credit for this removal in the absence of site-specific data; however, a discussion could be had with DEP if site-specific data were collected and made available.
- Changes in water use due to low-flow fixtures and inter-annual changes in consumptive use due to changes in weather or seasonal population will change the black water concentration and nitrogen loading.

Phase 0 activities as well as the environmental monitoring program and reporting are intended to address the elements of uncertainty. Key activities in Phase 0 which are related to addressing uncertainties include:

- Identify I/A treatment system types that appear to meet the effluent concentration criteria and town goals. Potentially consider methods to incentivize vendors to obtain "General Use Approval" for their systems through the DEP. Develop documentation regarding performance requirements and warranty/guarantee language for vendors to review and follow.
- Consider implementing septic system effluent and plume monitoring protocols to fill data gaps and to generate site-specific data for this watershed.
- Consider quantifying the nutrient reduction measures which have been implemented since the MEP Report was completed. Specific examples include: how much "credit" can be accrued for physical improvements made in the watershed (e.g., fertilizer reductions, stormwater infrastructure modifications) since the MEP data set was collected (late 1990s to 2003); how much credit can be accrued for reduction in atmospheric sources of nitrogen related to EPA air

pollution control regulations which have been in-force since the late 1990s; and how much credit can be accrued for water quality improvements based on the OPET monitoring data collected since 2005.

### 6.5.5 Sensitivity Analysis on Nitrogen Removal Requirements

As noted in Section 3, there is a significant difference between the MEP water use analysis and the CWMP water use analysis. This may have resulted in an over-prediction of septic loads. In addition, the amount of non-septic watershed loads reductions may be more or less than assumed in Section 3. Table 6-2 outlines a sensitivity analysis conducted to assess the implications of these variables using a linear relationship between base case and the alternate cases. This should be reviewed with DEP and MEP at the appropriate time.

**TABLE 6-2: SENSITIVITY ANALYSIS ON NITROGEN REMOVAL REQUIREMENTS**

| | Total Septic load | Required Load Removal for MEP Existing** | Required Load Removal for MEP Existing** | Required Load Removal for Future** | Required Load Removal for Future** |
|---|---|---|---|---|---|
| MEP Existing Septic Load in N-Sensitive Subwatersheds | 1280 kg/yr | - | - | - | - |
| New WW Load between 2004 to 2016 | 37.3 kg/yr | - | - | - | - |
| Future WW Load to Planning Horizon | 110.9 kg/yr | - | - | - | - |
| Total Septic Load | 1428.2 kg/yr | - | - | - | - |
| Target Septic Load IF non-septic watershed load reductions are negligible (i.e., Scenario 1) | 205 kg/yr | 1,075 kg/yr | 84% (5.5 mg/l) | 1,223 | 86% (5 mg/l) |
| Target Septic Load IF non-septic watershed load reductions are as planned (i.e., Scenario 3) | 397 kg/yr | 883 kg/yr | 69% (11 mg/l) | 1,031 | 72.2% (9.8 mg/l) |
| Target Septic Load IF non-septic watershed load reductions are as planned (i.e., Scenario 3) and MEP model over-predicted existing septic load by 20% | 397 kg/yr | 627 kg/yr | 61% (14 mg/l) | 746 | 65% (12 mg/l) |

** Note: Load removal required is calculated between existing leachfield effluent and future leachfield effluent and not between house drain effluent and leachfield effluent.

Based on this analysis, if non-septic watershed loads reductions end up being negligible and the septic watershed load is as predicted by MEP, then the Advanced I/A Plan will not remove enough nitrogen and the Traditional Backup Plan will be required. If, on the other hand, non-septic watershed loads are as predicted and the septic watershed load is over-predicted, then the Advanced I/A Plan will be more than adequate.

### 6.5.6 Environmental Monitoring

The environmental monitoring program is intended to address the following questions:

- Does the reduction in watershed nitrogen loading improve the water column nitrogen concentration in the impacted embayment? Is the water column concentration more or less sensitive to watershed load than predicted by the MEP model?
- Does the benthic community respond to the reduction in water column nitrogen concentration? Are those benthic communities more or less sensitive to water column nitrogen concentration than predicted in the MEP model?
- Are the non-traditional measures more or less effective than estimated in the CWMP?
- Are atmospheric nitrogen deposition rates continuing to drop over time?
- Have there been changes in storm surge and/or sea level rise trends that warrant a revised analysis of the existing hydrodynamic regime (i.e., managed salinity to 2-7 ppt)?

The environmental monitoring program should consist of several key components:

- Septic system effluent flow and quality parameters Consider implementing septic system effluent and plume monitoring protocols to fill data gaps and to generate site-specific data for this watershed.
- Surface water quality parameters at the Sentinel Station (OP-3). Consider the use of a sonde at OP-3 at the 4m depth interval to collect continuous data record for salinity, temperature and dissolved oxygen. This data collection would serve to establish baseline information for eventually assessing TMDL compliance, including the variability in the density/thermal stratification layer over time.
- Pond sediment parameters to assess benthic source of nitrogen

- Algae bloom conditions to assess pond conditions and weather conditions during and just before an algae bloom event.
- Benthic habitat survey using a methodology consistent with the MEP protocol.
- The environmental monitoring program *could* also include irrigation flow monitoring which would reduce the amount of water use attributed to wastewater.

Table 6-3 summarizes the elements of the proposed environmental monitoring program.

### 6.5.7 Technology Monitoring

In addition to the environmental monitoring program, the Town will also monitor changes in technology that may help or hinder the implementation plan. Technology monitoring will address the following questions:

1. Is more or less effluent disposal capacity available at the Blacksmith Shop Road WWTF?
2. Has development in the watershed followed the progression identified during planning?
3. Does new research provide a basis to change the approach for future phases?
4. Have new DEP-approved Advanced I/A Systems become available?
5. Have pilot programs for non-traditional measures provided sufficient data to consider full-scale application in this watershed?

### 6.5.8 Progress Reporting

A watershed permit will require the submittal of an annual progress report. Every fifth year, an expanded progress report will be required. These progress reports will be used to document progress towards TMDL compliance and watershed permit compliance. The ***Annual Progress Report*** should document the items listed below and should be distributed to the DEP, CCC, MEP technical team, and interested watershed associations.

- The status of activities called for in the CWMP (traditional and non-traditional);
- A description of the capital expenditures that were made in the current year, including a description of infrastructure which was constructed, stormwater BMPs which were constructed or implemented, and regulations which were implemented;

# TABLE 6-3: PRELIMINARY ENVIRONMENTAL MONITORING PROGRAM

| Location | Media Sampled | Analyses Performed | Frequency of Analyses | Reporting Mechanism | Coordination Needs | Input to Adaptive Management Framework |
|---|---|---|---|---|---|---|
| **Septic System Effluent and Disposal Sites** | On-Site System Effluent | Flow, BOD, TSS, TN, Nitrate, Alkalinity, pH | Refer to Appendix F (RME) | Annual Progress Report | Property Owners | Reduction in septic N |
| | Leachfield Underflow or Ground Water (Phase 0 only) | TS, SpCond, TN, Water table elevation | TBD | Annual Progress Report | Property Owner(s) | Migration of septic system plumes |
| **Coastal Embayment** | Surface Water at Sentinel Station (OP-3) | TN, TDN, PON, TP, TDP, DIP, TSS, DO, chlorophyll a, Salinity, secchi depth<br><br>DO, temperature, salinity | 3X per year<br><br>Continuous via sonde | Annual Progress Report | DEP, MEP, OPET, PW | Water quality changes<br>Frequency of Trunk River dredging |
| | Sediment | TDN, NO2, NO3, NH4 | 1X per year | Annual Progress Report | DEP, MEP, OPET, PW | Benthic nutrient flux |
| | Algae Blooms | None, document dates and circumstances of blooms | As blooms occur | Annual Progress Report | OPET | Water quality changes |
| | Benthic Habitat Assessment | Benthic habitat survey | 1X per 5 years, starting at Yr 5 | Five Year Progress Report | DEP, MEP, OPET, PW | Benthic habitat changes |
| **Air Quality** | None | None, research of publicly available data on atmospheric N levels | TBD | Annual Progress Report | CCC | Atmospheric N source trends |

Abbreviations:

| | |
|---|---|
| N | Nitrogen species (total, total dissolved nitrogen, particulate organic nitrogen) |
| P | Phosphorus species (total, total dissolved phosphorus, dissolved inorganic phosphorus) |
| BOD | Biochemical oxygen demand |
| TSS | Total suspended solids |
| DEP/MEP | Mass. Department of Environmental Protection, Mass. Estuaries Project |
| OPET | Oyster Pond Environmental Trust |
| DO | Dissolved Oxygen |
| SPCond | Specific conductance |
| CCC | Cape Cod Commission |
| TS | Total solids |
| TBD | To be determined |
| PW | Pond Watchers |

- A description of the CWMP-related activities funded for the upcoming year;
- A summary of parcel-level water use and building permit information for growth/development/redevelopment which has occurred in the watershed in the current year;
- Summary of town-wide water use trends and growth/development/redevelopment trends which occurred in the current year;
- Summary of environmental monitoring program data collected for the current year.
- Identification of new technologies or successful pilot tests which warrant evaluation in the CWMP; and
- Summary of septic watershed load monitoring for the current year, including: water metering readings for all properties; "probationary I/A system" and "compliant I/A system" monitoring (refer to Appendix F for definitions); and calculated annual watershed nitrogen load.
- Summary of septic system pumping records for the current year.

The ***Expanded Progress Report/ Adaptive Management Update Report*** should document the items listed below and should be distributed to the same group as the Annual Progress Report.

- All the items in the Annual Progress Report;
- Analysis of trends in the septic watershed load monitoring, environmental monitoring and technology monitoring programs;
- Proposed changes in traditional and non-traditional measures, including rationale, as well as updates to the anticipated environmental impacts outlined in Section 7 of the CWMP; and
- Proposed changes in implementation schedule (such as acceleration or delay of upcoming segments of the plan), including rationale.

The original approved CWMP and approved Adaptive Management Update Reports will document the Town's adaptive management framework approach at 5-year intervals for the first 20 years.

### 6.5.9 Determining TMDL Compliance

TMDL compliance will be confirmed by DEP when the TMDL-mandated water column nitrogen concentration is met at the sentinel station and the benthic habitat is restored. Using the water management framework described herein, the Town will demonstrate TMDL compliance to DEP by the following: all systems meet the effluent standard of 10-mg/l effluent TN; or, systems that fail to meet the standard are balanced by systems that exceed the standard; or, the TMDL-mandated water column nitrogen concentration is met at the sentinel station; or, the watershed load meets the target load established by the TMDL. Refer to Appendix F for additional information. The following equation may be used to track progress towards meeting the TMDL requirements:

*Attenuated TN Removal from Groundwater (lb./d) = Qw * (1-CU) * (TNb – TNact) * 8.34 * NA*

Where:

Qw = Water use at the home, as measured in gallons per day

CU = % of water use that does not result in wastewater (e.g., car washing, irrigation, etc.), assume 10%

TNb = Baseline effluent TN concentration to groundwater, (i.e., 35.4 mg/l, refer to Table 2-6)

TNact = Effluent TN concentration from Advanced I/A system, as measured in mg/l

NA = Natural attenuation factor (i.e., 30% natural attenuation for Mosquito Creek subwatershed and 0% natural attenuation for others (i.e., based on MEP Technical Report)

## 6.6 ADMINISTRATIVE ITEMS

### 6.6.1 Establishment of a Management Entity

The Board of Selectmen is the management entity in the Town of Falmouth. The Board will designate an appropriate department as the “Responsible Management Entity” (RME) for the Oyster Pond watershed implementation plan and Oyster Pond watershed permit. The RME will be responsible for administration, oversight, inspection, monitoring, maintenance, septic system pumping, enforcement, record keeping and reporting for the Oyster Pond watershed. The level of effort associated with this responsibility is estimated at one half-time equivalent staff for the Oyster Pond watershed.

### 6.6.2 Easements and Land Acquisition

It is generally advisable for a town to identify all parcels it must acquire for the project and then to acquire them (fee simple interest or easement) at the beginning of the project to ensure land availability for future phases of the project. Final parcel identification should occur as part of

Phase 1 preliminary design activities. The following easement and land acquisitions are anticipated for the Advanced I/A Plan:

- Access easement to each property for the purpose of monitoring, inspections and repairs to Advanced I/A systems.

The following easement and land acquisitions are anticipated for the Traditional Backup Plan:

- Easements for low-pressure sewer pipes between Fells Road and Ransom Road, across OPET conservation land.
- Easements for low-pressure sewer pipes between Moorland Road and Cumloden Drive Road, adjacent to Salt Pond Bird Sanctuary conservation land.
- Easements for low pressure sewer pipes between Ransom Road and Cumloden Drive, across Treetops Condominium land.
- Easements for low pressure sewer pipes along Woods Hole Road, Locust Street and Main Street, Post Office Road for sewage forcemains to Shiverick's Pond Lift Station.

### 6.6.3 Regulations, Bylaws, and Policies

For the Advanced I/A Plan, the Town is currently updating the Board of Health Regulations related to I/A installations. In addition, the Town will need to implement the RME and obtain a Watershed Permit. No other new regulations, bylaws or policies are anticipated for the Advanced I/A Plan. The Board of Health Regulations may require updates from time to time based on the experiences of the RME with the Oyster Pond Watershed Permit.

For the Traditional Backup plan, no new regulations, bylaws or policies are required; however, the Town may want to evaluate some adjustments to the existing Sewer Regulations to clarify responsibility and ownership for service laterals (e.g., to the right-of-way or to the centerline of main)may be desired or warranted and for mandatory connections (e.g., for conventional gravity sewers, low pressure sewers, or both).

### 6.6.4 Permitting and Approvals

There are numerous regulatory programs with permitting and approval requirements that apply to the planning, design and implementation of the CWMP recommended plan. For the Advanced I/A Plan, these include:

- DEP regulatory approval of the CWMP and DEP Watershed Permit.
- Cape Cod Commission (CCC) 208 Plan Consistency review and determination.
- Massachusetts Environmental Policy Act (MEPA) review, which includes input from the Massachusetts Natural Heritage & Endangered Species Program (pursuant to the Massachusetts Endangered Species Act), Massachusetts Wetland Protection Act, and Massachusetts Historical Commission reviews need to be conducted.
- Activities must be consistent with the permits and requirements of the Town's Board of Health, Planning Board, Conservation Commission and Historic District Commission.

For the Traditional Backup Plan, these include:

- All items required for the Advanced I/A Plan.
- New or modified DEP Groundwater Discharge Permits for the additional effluent disposal capacity required.
- DEP Plan Review is required for proposed traditional wastewater infrastructure, once plans and specifications have been prepared.
- DEP Sewer Extension Permits may be needed for system expansion.
- The Department of Transportation will issue permit for construction in State roads.
- The Town must issue building permits for treatment systems and lift stations after compliance with the State Building Code is demonstrated.

Compliance with these programs must be demonstrated at various stages of project development.

## 6.7 COSTS, FUNDING, AND FINANCING

### 6.7.1 Estimated Capital Costs

Using the methodology described in Section 5, capital costs were developed for the Alternative I/A plan and the Traditional Backup Plan. The capital costs include the following key components:

wastewater collection, transport-to-treatment, wastewater treatment (whether off-site or on-site), transport-to-disposal, effluent disposal, land acquisition, and technical services and contingencies. Once basic construction costs were estimated, allowances were added for contingencies, technical services, legal and administrative services, site investigation costs, and land costs. For the purposes of this analysis, the following assumptions were used:

- Costs are presented for Phase 1 only. The Advanced I/A plan the Traditional Backup plan are equivalent in number of dwelling units addressed in Phase 1; however, as described previously, the Advanced I/A plan is expected to require Phase 2 to meet the TMDL.
- For the Traditional Backup Plan, paving represents a significant portion of the cost because full-width overlay has been assumed for State roads impacted by the project and half-width overlay has been assumed for Town roads and private roads impacted by the project. There may be opportunities to reduce these planning-level paving costs during the implementation phase and/or to align implementation with other utility work, road reconstruction or paving needs at that time.
- The "contingency, administration, legal and technical services" allowance was set at 20% for the Advanced I/A Plan and at 30% for the Traditional Backup Plan.
- Advanced I/A systems were included for each building except for the WHOI dorms (which has one unit for three buildings) and Treetops (which was assumed to be one unit for the 16 buildings, located in the vicinity of the tennis court, plus a small low-pressure sewer system within Treetops). This approach should be refined during Phase 0.
- For the Traditional Backup Plan, low pressure lift stations were included for each building except for the WHOI dorms (which was assumed to be one unit for three buildings) and Treetops (which was assumed to be one unit for each building based on input from the pump system manufacturer). This approach can be refined during Phase 0.
- No costs have been included for flood proofing of private I/A systems or private low-pressure lift stations.
- Costs associated with the first-year operations, maintenance, performance monitoring and warranty/ performance guarantee for low-pressure lift stations and Advanced I/A systems were included in the construction costs. Remote monitoring systems were not included for the Advanced I/A systems.

- Costs for Title 5 compliant systems are assumed to be a baseline cost. These costs are carried herein but are assumed to paid for entirely by the property owner.
- Costs for private property work (e.g., trenching, redirecting drain, abandoning septic system, basic site restoration, etc.) were included; however, costs for landscaping (plants, stone walls, water features, etc.) are not included.

The estimated capital costs are summarized in Table 6-4 and are presented in 2026 dollars (based on the projected midpoint of Phase 1 construction). Additional supporting information is included in Appendix D. Note that the cost estimates presented in Section 5 and Section 6 are similar but are not directly comparable. Section 5 is an alternatives analysis developed on a comparative basis for the entire watershed; whereas Section 6 is an estimate for the Advanced I/A Plan and Traditional Backup Plan, for Phase 1 only, as described in this section of the report.

### 6.7.2 Estimated Annual Operation and Maintenance Costs

Using the methodology described in Section 5, annual operation and maintenance (O&M) costs were developed for the Alternative I/A plan and the Traditional Backup Plan. These annual O&M costs are based on the "conservative O&M assumptions" approach outlined in Section 5.5. The estimated annual O&M costs are summarized in Table 6-4 and are presented in 2026 dollars (based on the projected midpoint of Phase 1 construction). Additional supporting information is included in Appendix D.

### 6.7.3 Massachusetts DEP State Revolving Loan Fund Program

The Massachusetts Department of Environmental Protection (DEP) has the Clean Water State Revolving Fund (SRF) loan program available to municipalities for the planning and construction (i.e., not design) of water pollution abatement projects. The SRF loan program provides low-interest loans for eligible projects, which includes traditional wastewater infrastructure as well as landfill capping, upgrading septic systems and stormwater remediation. The program offers 20-year loans at 2% interest including potential principal forgiveness (in some cases 30-year loans can be obtained). Additional funds are available for designated "environmental justice" communities (applicable to small portions of Falmouth and Barnstable). The SRF program has a prescribed time table for submissions which must be followed in order to get proposed projects on the eligible and funded list.

## TABLE 6-4: ESTIMATED CAPITAL AND OPERATING COSTS (PHASE 1)

| Item | | Advanced I/A Plan | | Traditional Backup Plan |
|---|---|---|---|---|
| **CAPITAL COSTS** | | | | |
| Construction, including Contingency | | $5,313,000 | | $7,640,000 |
| Design | 0% | in above | 10% | $764,000 |
| Survey and Borings Allowance | 0% | in above | 4% | $306,000 |
| Construction Engineering and Inspection | 2% | $106,000 | 12% | $917,000 |
| Fiscal, Legal, Administration, Police Detail | 2% | $106,000 | 6% | $458,000 |
| Land and Easement Acquisition | | $0 | | $125,000 |
| *Total Project Costs (2019 dollars, ENR CCI 11228)* | | *$5,525,000* | | *$10,210,000* |
| ***Total Project Costs (2026 dollars)*** | | ***$6,800,000*** | | ***$12,560,000*** |
| | | | | |
| **ANNUAL OPERATING COSTS** | | | | |
| Advanced I/A System | 189 | $340,000 | 189 | $0 |
| Sewer User Rates | 189 | $0 | 189 | $90,000 |
| Low Pressure Sewer Lift Station Operating Costs | 189 | $0 | 189 | $76,000 |
| Oyster Pond RME - Advanced I/A Tracking | | $60,000 | | $0 |
| Oyster Pond RME - Reporting | | $16,000 | | $16,000 |
| Oyster Pond RME - Dredging Trunk River | | in DPW Budget | | in DPW Budget |
| Oyster Pond RME - Environmental Monitoring | | $20,000 | | $20,000 |
| *Total Annual Operating Costs (2019 dollars)* | | *$436,000* | | *$202,000* |
| *Total Annual Operating Costs (2026 dollars)* | | ***$536,000*** | | ***$248,000*** |
| | | | | |

Notes:
1. Costs are presented in April 2019 dollars (ENR Construction Cost Index 11228), except where noted.
2. Costs indicated as 2026 dollars assume 3% per year inflation to the year 2026.
3. Refer to Appendix A for additional information on capital and annual operating costs.
4. Operating costs for Advanced I/A Plan are based on the "Conservative O&M Assumptions" described in Section 5 and
5. Sewer user rates assumed at $475/year and LPS pump station costs assumed at $400/year for residential users.

DEP also has an "enhanced SRF loan program" to include 20-year loans at 0% interest for nutrient management related projects (in some cases 30-year loans can be obtained). In order to qualify for the enhanced funding program, a municipality must: 1) have a project that is primarily intended to remediate or prevent nutrient enrichment of a surface water body or a source of water supply; 2) not be subject to any on-going enforcement action associated with nutrient management; 3) have a Comprehensive Wastewater Management Plan (CWMP) approved pursuant to regulations adopted by MassDEP; 4) receive a determination of consistency with the regional management plan (i.e., in this case the CCC 208 Plan Update); and 5) adopt land use controls to govern increases in nutrient loads due to growth ("flow neutral").

Portions of the Oyster Pond implementation plan could be funded via SRF loan. Falmouth has previously met the criteria for Enhanced SRF loans from DEP.

### 6.7.4 Barnstable County Septic Management Loan Program

Barnstable County has a Community Septic Management Loan Program that can be utilized by residential property owners to finance septic system upgrades on "failed septic systems". If eligible, all costs directly associated with carrying out a project required by Title 5 are eligible. Loans have a 5% interest rate and a maximum 20-year repayment term. The loan is secured via a betterment assessment on the property. Property owners could apply to this program under the Advanced I/A Plan.

### 6.7.5 General Taxation

A common method for funding on-going study, monitoring, and planning activities related to nutrient management on Cape Cod is general municipal taxation. In some cases, portions of the design and construction are also covered through general taxation (especially for stormwater elements). The general fund covers a full range of municipal services and is subject to competing municipal demands. The general fund is also subject to the requirements of Massachusetts General Laws Chapter 59 § 21C (i.e., "Proposition 2½"). Certain activities related to the Oyster Pond implementation plan could be funded via general taxation.

### 6.7.6 Municipal Water Infrastructure Investment Fund

Chapter 259/ Section 26 of the Acts of 2014 authorizes municipalities to impose a surcharge on real property at a rate of up to a 3 percent of the real estate tax levy. All monies collected from this surcharge shall be placed in a separate account to be named the Municipal Water Infrastructure Investment Fund. Expenditures from this fund shall only be used for municipal drinking water, wastewater and stormwater infrastructure assets. Most or all activities related to the Oyster Pond implementation plan could be funded via a municipal water infrastructure investment fund.

### 6.7.7 Project Financing Scenario

A project financing scenario will need to be developed by the Town with input from the Finance Department. The Town will continue to work on methods to reduce the capital and annual operating costs during Phase 0.

## 6.8 IMPLEMENTATION SCHEDULE

The following implementation schedule is outlined for the CWMP.

| Milestone | Timeframe |
|---|---|
| Complete Draft CWMP/SEIR | Summer 2019 |
| Public Input | Summer 2019 |
| Final CWMP/SEIR | Fall 2019 |
| Complete MEPA review | December 2019 to Spring 2020 |
| Initiate Phase 0 and RME work | 2020 to 2024 |
| Town Meeting Vote on Funding and Approach | 2024 |
| Phase 1 Design and Bidding | 2024 to 2025 |
| Phase 1 Construction | 2025 to 2027 |

## 6.9 NEXT STEPS

The implementation plan requires numerous administrative steps in order to properly implement the plan. The following action items are provided for the implementation plan:

1) Submit the final CWMP to DEP for review, to MEPA for review and to the Cape Cod Commission for a 208 Plan Consistency review determination. Initiate discussions with DEP regarding a Watershed Permit.

2) Initiate Phase 0 implementation tasks outlined in Table 6-1, Section 6.5.3 and 6.5.4, including:

   - 2020-2022
     - Develop proof-of-concept for RME, including DEP review
     - Develop proof-of-availability of Advanced I/A systems with effluent TN<10-mg/l, including on-going data review from WFHSSSR project and MassTech testing.
     - Seek additional effluent disposal capacity for Blacksmith Shop Road WWTF for the Oyster Pond Traditional Backup Plan
     - Dredge the Trunk River
     - Further develop policies related to system cost allocation and future replacement costs
     - Refine present policies for early replacement of failing septic systems
     - Monitor septic system effluent plumes to fill data gaps and generate site-specific data for this watershed
     - Consider limited monitoring program of a small subset of septic systems to determine actual nitrogen and phosphorous impact on the watershed
     - Conduct Neighborhood Meetings in 2020, 2021, and 2022 to provide status updates
     - Initiate discussions on efforts to obtain a draft Watershed Permit for Advanced I/A Plan
   - 2023-2024
     - Quantify nutrient reduction measures which have been implemented since the MEP Report was completed.
     - Conduct Neighborhood Meetings in 2023 and 2024 to provide status update.

3) Review the final results of the West Falmouth Harbor Shoreline Septic System Remediation Project when the final report is issued.

4) Continue to advance efforts to secure additional effluent disposal capacity for the Traditional Backup Plan.

5) Initiate efforts to secure easements for the Advanced I/A Plan and Traditional Backup Plan.

6) Develop the project financing scenario with the Town Finance Department. Identify and pursue grant funding sources for planning and capital projects.

7) Work with OPET and Falmouth Pond Watchers regarding on-going pond monitoring efforts and the CWMP Environmental Monitoring Plan in Table 6-3.

8) Prepare for Annual Town Meeting in 2024. Upon receipt of funding authorization, initiate design and permitting activities.

9) Consider adding attribute fields to the Assessor's GIS database to indicate the type of wastewater disposal system, age of system and whether there are any environmentally significant Title 5 variances.

10) Consider scanning the paper copy records maintained by the Health Department and Board of Health for data security purposes.

# SECTION 7

# EVALUATION OF ENVIRONMENTAL IMPACTS

## 7.1 INTRODUCTION

The purpose of this section of the report is to identify the environmental impacts of the implementation plan, as described in Section 6, and the "no action" plan. Impacts are considered for both initial project construction and long-term project operation. This section of the report is presented in the format of an Environmental Impact Report, which will eventually be filed with the Massachusetts Environmental Policy Act (MEPA) unit of the Executive Office of Energy and Environmental Affairs (EOEEA).

## 7.2 ALTERNATIVES TO THE IMPLEMENTATION PLAN

The Town considered five comprehensive plans for TMDL compliance in the Oyster Pond watershed, which represent a range of approaches from all on-site systems, to off-site treatment and disposal within the watershed, to off-site treatment and disposal outside the watershed. These five plans were compared to the "No Action Plan," which involves continued reliance on cesspools and standard Title 5 systems which do not address nitrogen removal. The implementation plan consists of upgrading all on-site system to Advanced I/A systems for significant nitrogen reductions.

## 7.3 ASSESSMENT OF ENVIRONMENTAL IMPACTS

Impacts of the plans under consideration fall in the general categories of "direct", "indirect" and "cumulative". The <u>direct impacts</u> are those that occur as a direct result of either the construction of the proposed wastewater facilities, or their ongoing operation. The <u>indirect impacts</u> are those land use or demographic changes that eventually occur as a result of implementation of the plans, or as a consequence of taking no action. <u>Cumulative effects</u> result from the incremental impact of the proposed project when added to other past, present, or future actions, regardless of who undertakes those other actions.

This section of the report identifies direct, indirect, and cumulative impacts for a wide range of environmental issues. Direct impacts are discussed as either "short-term" (generally related to project construction) or "long-term" (generally related to on-going operations of the completed plan).

### 7.3.1 Surface Water Quality

No significant negative short-term impacts on surface water quality are expected. There is the possibility of erosion and sedimentation problems during the construction of on-site Advanced I/A systems (as well as off-site, low pressure sewers under the Traditional Backup Plan); however, those impacts will be closely controlled by requiring appropriate construction techniques and with close contractor oversight.

There are significant long-term benefits for surface water quality associated with the implementation plan, and there are major detriments to the No Action Plan. One of the driving forces behind this project is the current and expected future overloading of coastal waters from wastewater-related nitrogen. The plan under consideration will allow for compliance with nitrogen-based TMDLs and will reduce phosphorus loadings. Additional long-term benefits of water quality improvements include improved recreational uses, improved benthic habitat and improved fish habitat.

### 7.3.2 Groundwater Quality

No short-term impacts on groundwater quality are expected.

There are significant long-term benefits to groundwater quality. It is that improvement in groundwater quality that will eventually lead to better surface water quality.

These threats to surface water and private drinking water will continue in a No Action Plan.

### 7.3.3 Wetlands

There are mapped wetlands around the perimeter of Oyster Pond. None of the project work is expected to impact wetlands directly; however, some of the improvements are expected to encroach on buffers around regulated wetlands. The Conservation Commission will review these elements and addressed by standard mitigation measures. No significant short-term or long-term wetland impacts are expected.

### 7.3.4 Floodplains

Several of the properties in the project area are within the 100-year or 500-year floodplain. Under the Advanced I/A Plan, there is no public infrastructure as all infrastructure is located on private property. Under the Traditional Backup Plan, all properties would have a private lift station and the only public infrastructure in the floodplains would be buried low pressure sewer piping in public rights-of-way. In either case, the private I/A systems or private low pressure lift stations would need to meet all Town requirements for siting systems in the floodplain. Since all properties are currently served by on-site systems, the implementation plan is neutral on short-term or long-term impacts on floodplains.

### 7.3.5 Coastal Resources

There will be no construction in or close to any coastal resources. The implementation plan provides protection for these resources, primarily through improved water quality. Conversely, the No Action Plan allows current water quality degradation to continue.

### 7.3.6 Open Space and Recreation

The implementation plan will not have any short-term or long-term impacts on open space or recreation.

### 7.3.7 Rare and Endangered Species

A preliminary assessment of MESA regulatory implications, conducted by LEC Environmental Consultants, Inc., is presented in Appendix B. No construction would occur in the estimated habitat areas under the implementation plan or the Traditional Backup Plan.

### 7.3.8 Archaeological and Historic Resources

Under the Advanced I/A Plan, private properties will have additional construction disruption. Under the Traditional Backup Plan, private properties will have additional construction disruption as will existing roadways and rights-of-way. Since all existing properties are currently served by private wastewater management systems and since any public infrastructure will occur largely within the rights of way of public roads, there are anticipated short-term or long-term impacts on historic and archaeological sites and resources. The Town will perform more detailed reviews during the design phase.

### 7.3.9 Traffic

One of the most significant direct short-term impacts of any infrastructure project is the traffic congestion resulting from construction activities in or near public and private roadways. Under the implementation plan, there would be no significant traffic impacts other than construction materials deliveries to properties and contractor vehicles, like any residential home construction or renovation project. Under the Traditional Backup Plan, there would be low-pressure sewer forcemains in public and private roads and there would be one sewage lift station constructed in a municipal parking lot. These activities would result in short-term traffic disruption. The Town will attempt to schedule this work between October to May, when traffic is generally less intense, and will segment the work to avoid disruption of lengthy stretches of principal roads at any one time.

There will be no long-term impacts on traffic.

### 7.3.10 Air Quality

Construction vehicles can be the source of added air emissions and represent a direct short-term impact. Dust from construction sites is another common source of air quality concern. These impacts are generally mitigated by requiring appropriate construction techniques and with close contractor oversight.

Direct long-term impacts include potential odor releases at malfunctioning I/A systems or at sewage lift stations. None of these sources of air emissions is considered significant, since all can be subject to routine odor control equipment.

### 7.3.11 Noise

Much like air quality, noise impacts can occur both during construction and as a result of routine operation. As a direct short-term impact, construction noise is unavoidable. Control of work hours for noisier activities is the conventional method to address construction-related noise.

Pumps, blowers, standby generators, and other equipment emit noise at on-site I/A systems, off-site treatment plants and lift stations. All can be fitted with noise control devices that are largely successful in avoiding nuisance noise conditions. Noise mitigation will be considered in the design phase with input from the Town.

### 7.3.12 Erosion Control

During construction, temporary erosion control measures will be used to control sediment migration. This is commonly achieved with the use of hay bales, siltation fencing, and geotextile materials. During the design process, detailed drawings and specifications will outline the controls required to be used by the contractors for I/A system installation or low-pressure lift station and piping systems.

### 7.3.13 Waste Material

During the construction process, waste materials will be generated including, brush, excess soil material and construction debris (e.g., scraps of wood, metal, and plastics) will be collected and removed from the construction sites by the contractor at periodic intervals. Collection and removal of such material must be by authorized individuals.

### 7.3.14 Existing Vegetation

During the construction process, portions of the individual sites will be cleared to make room for new I/A system treatment tanks and to leave adequate space for construction access. The extent of clearing will be minimized to that required to construct and permanently operate the facility; areas outside of this limit of construction will be preserved in their natural state. Disturbed areas will be re-vegetated with the same or similar species as were initially present except in cases where supplemental vegetation is desired for visual or noise buffers for adjacent properties.

### 7.3.15 Energy and Greenhouse Gas Emissions

Energy use during construction is unavoidable. The implementation plan will result in limited additional electrical energy use at the individual I/A systems and slightly increased septage generation rates based on the additional treatment over the No Action Plan. The following greenhouse gas emission reduction measures will be considered during the design phase for the implementation plan:

- Use the most current version of the Massachusetts State Building Code and Stretch Energy Code during the design phase;
- Use of low horsepower equipment;
- Use of denitrifying media which has a design life of greater than 5 years; and
- Use of local systems installers and products to minimize hauling distances.

The following greenhouse gas emission reduction measures will be considered during the design phase for the Traditional Backup Plan if there are any sewage lift stations incorporated:

- Use the most current version of the Massachusetts State Building Code and Stretch Energy Code during the design phase;
- Use Leadership in Energy and Environmental Design (LEED) and/or Envision principles as a guide during the design phase;
- Orient buildings to maximize natural lighting and to maximize the potential for solar photovoltaic/ solar hot water systems;
- Use motion sensors for interior lighting and climate control;
- Consider design strategies to minimize need for chemicals and odor control systems;
- Consider additional insulation beyond that required by the building code (e.g., walls, attics, windows; ductwork; hot water piping);
- Consider high albedo roofing systems/colors;

### 7.3.16 Generation of Solid Waste

The implementation plan will result in sludge pumping from I/A systems and septage removal from septic tanks. All properties that continue to be served by on-site septic system will continue to have septage pumped and disposed of off-site in accordance with local, state, and federal laws. The No Action Plan will also result in the continued disposal of septage.

### 7.3.17 Public Health

Continued surface disposal via on-site septic systems in accordance with Title 5 addresses public health issues under the implementation plan and the No Action Plan.

### 7.3.18 Community Growth and Land Use

The implementation plan and the Traditional Backup Plan will not allow for growth beyond that which would be allowed by Town Zoning and Massachusetts Title 5 requirements under the No Action Plan. The implementation plan will continue to be governed by Massachusetts Title 5 and Falmouth Health Regulations. The Town's flow-neutral bylaw will govern the Traditional Backup Plan.

### 7.3.19 Climate Adaptation

Oyster Pond is a coastal pond that is susceptible to the pressures of climate change. The Town will need to continue to monitor climate science and climate guidance issued by the Commonwealth. As it pertains to wastewater infrastructure, the Town will consider the following modifications to planning and permitting processes to manage development is vulnerable areas:

- Locate above-grade portions of I/A systems above the flood elevation.
- Use low-pressure lift stations and low-pressure sewers in areas susceptible to sea level rise as this will minimize the public expenditure and require the pumping system to be directly associated with the private property.
- Give preference to lift station sites that are more than 3 feet above the 100-year flood elevation and flood protect those that cannot/ are not.

## 7.4 REGULATORY STANDARDS AND REQUIREMENTS

There are several regulatory programs and permitting requirements that apply to the implementation plan. These requirements are described in Section 6.6.3 and 6.6.4 of this report.

## 7.5 MITIGATION MEASURES

There are many mitigation measures that will be employed as a part of the implementation plan. These include:

- Restricting work hours on construction sites near residential areas;
- Requiring contractors to implement dust control measures;
- Requiring erosion controls at all construction sites;
- Requiring compliance with all orders of conditions for work in wetland buffers;
- Potentially requiring odor and noise control systems at I/A systems and lift stations;
- Complying with applicable standards for construction activities near historic structures;
- Complying with requirements of Town Board of Health, Planning Board and Conservation Commission;
- Restricting sewerage construction work in private roads and public roads and rights-of-way to the period between October and May to avoid periods of high traffic;
- Segmenting sewerage construction work on public streets to avoid protracted closures;
- Designing sewerage lines and lift station to avoid floodplains and to minimize encroachment on the buffers of wetlands and other protected resource areas;
- Siting facilities to avoid, minimize, and mitigate impacts to habitat of rare and endangered species, including compliance with all NHESP conditions, and archaeological and historic resources, including compliance with any MHC; and

- Selecting treatment equipment to minimize energy use and maximize nitrogen removal.

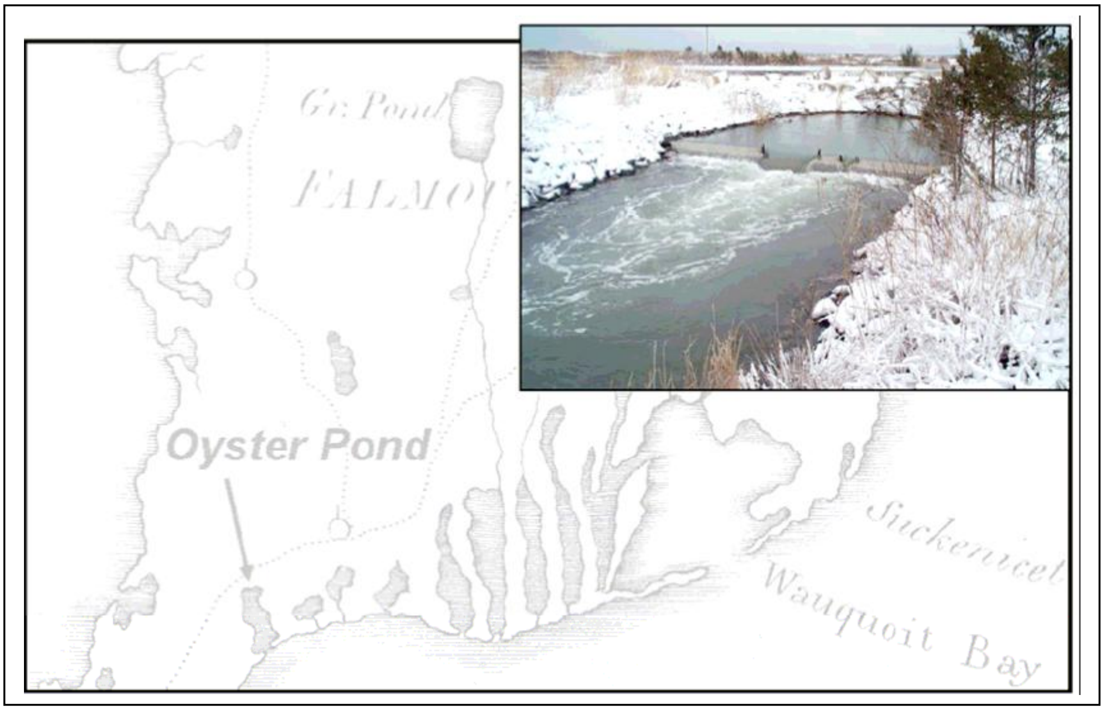
## 7.6 IMPLICATIONS OF A "NO ACTION PLAN"

The "No Action Plan" is described in Section 5 of this report. The No Action Plan will result in continued deterioration of surface water quality, reduced recreational opportunities on Oyster Pond and potentially reduction in property values.

# APPENDIX A
# Relevant Massachusetts Estuaries Project Work Products

# FINAL

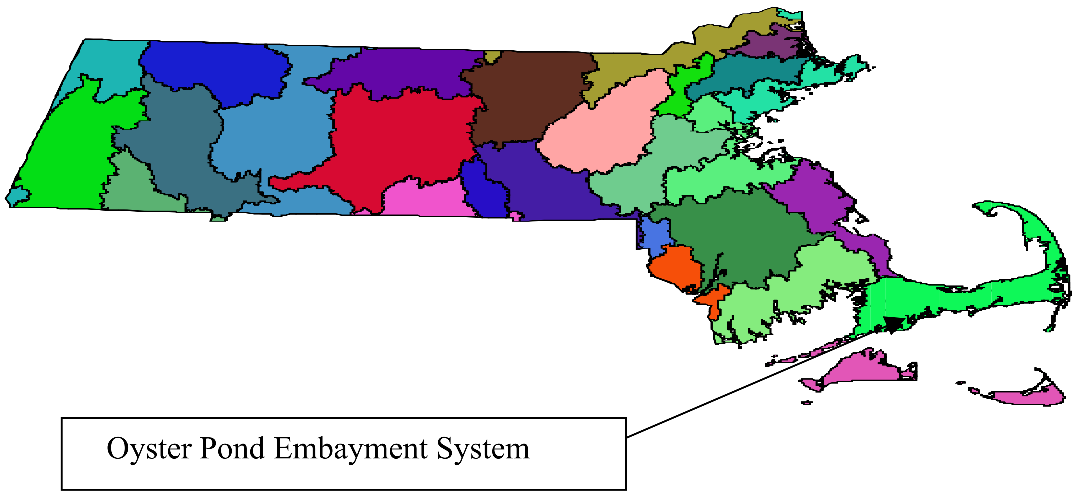
# Oyster Pond
# Embayment System
# Total Maximum Daily Loads
# For Total Nitrogen
## (Report # 96-TMDL-7 Control #245)




**COMMONWEALTH OF MASSACHUSETTS**
**EXECUTIVE OFFICE OF ENERGY AND ENVIRONMENTAL AFFAIRS**
IAN A. BOWLES, SECRETARY
**MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION**
LAURIE BURT, COMMISSIONER
**BUREAU OF RESOURCE PROTECTION**
GLENN HAAS, ACTING ASSISTANT COMMISSIONER

February 7, 2008

# Oyster Pond Embayment
# Total Maximum Daily Loads
# For Total Nitrogen




**Key Feature:** Total Nitrogen TMDL for Falmouth
**Location:** EPA Region 1
**Land Type:** New England Coastal
**303d Listing:** The waterbody segments impaired and on the Category 5 list includes Oyster Pond.

**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 Falmouth
**Data Mechanism:** Massachusetts Surface Water Quality Standards, Ambient Data, and Linked Watershed Model
**Monitoring Plan:** Town of Falmouth monitoring program (possible assistance from SMAST)
**Control Measures:** Sewering, Storm Water Management, Attenuation by Impoundments and Wetlands, Fertilizer Use By-laws

# EXECUTIVE SUMMARY

## Problem Statement

Excessive nitrogen (N) originating primarily from on-site wastewater disposal (both conventional septic systems and innovative/alternative systems) has led to significant decreases in the environmental quality of coastal rivers, ponds, and harbors in many communities in southeastern Massachusetts. In the coastal waters of Massachusetts the problems include:

- Loss of eelgrass beds, which are critical habitats for macroinvertebrates and fish
- Undesirable increases in macro algae, which are much less beneficial than eelgrass
- Periodic extreme decreases in dissolved oxygen concentrations that threaten aquatic life
- Reductions in the diversity of benthic animal populations
- 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

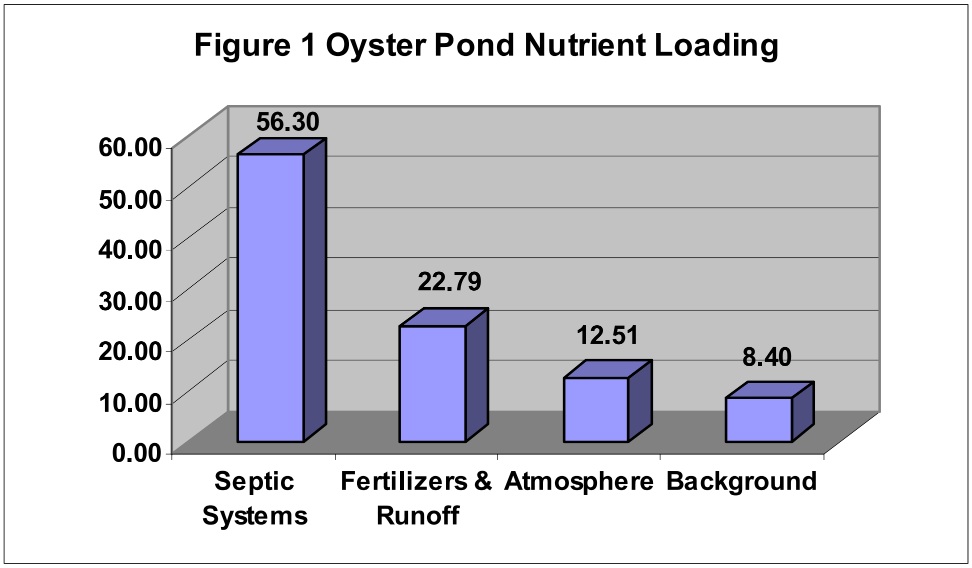
Coastal communities, including Falmouth, rely on clean, productive, and aesthetically pleasing marine and estuarine waters for tourism, recreational swimming, fishing, and boating, as well as for commercial fin fishing and shellfishing. Failure to reduce and control N loadings will result in complete replacement of eelgrass by 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 embayment. As a result of these environmental impacts, commercial and recreational uses of Oyster Pond Embayment System coastal waters will be greatly reduced, and could cease altogether.

## Sources of nitrogen

Nitrogen enters the waters of coastal embayments from the following sources:

- The watershed
  - On-site subsurface wastewater disposal systems
  - Natural background
  - Runoff
  - Fertilizers
  - Wastewater treatment facilities
- Atmospheric deposition
- Nutrient-rich bottom sediments in the embayments

Most of the present controllable N load originates from individual subsurface wastewater disposal (septic) systems, primarily serving individual residences, as seen in the following figure.




**Target Threshold Nitrogen Concentrations and Loadings**
The N loadings (the quantity of nitrogen) to this embayment system range from 0.12 kg/day in Mosquito Creek, to 4.07 kg/day in Oyster Pond. The resultant concentrations of N in this embayment range from 0.67 mg/L (milligrams per liter of nitrogen) in the middle of Oyster Pond to 0.71 mg/L in the lower section of Oyster Pond.

In order to restore and protect this embayment system, N loadings, and subsequently the concentrations of N in the water, must be reduced to levels below the thresholds that cause the observed environmental impacts. This concentration will be referred to as the target threshold concentration. It is the goal of the TMDL to reach this target threshold concentration, as it has been determined for each impaired waterbody segment. The Massachusetts Estuaries Project (MEP) has determined that, for this embayment system, an N concentration of 0.55 mg/L is protective of water quality standards. The mechanism for achieving these target threshold N concentrations is to reduce the N loadings to the embayment. Based on the MEP work and their resulting Technical Report, the MassDEP has determined that the Total Maximum Daily Load (TMDL) of N that will meet the target threshold concentration is 1.44 kg/day. This document presents the TMDL for this water body segment and provides guidance to Falmouth on possible ways to reduce the nitrogen loadings to within the recommended TMDL, and protect the waters for this embayment.

**Implementation**
The primary goal of implementation will be lowering 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.

These strategies, plus ways to reduce N loadings from stormwater runoff and fertilizers, are explained in detail in the "MEP Embayment Restoration Guidance for Implementation Strategies", that is available on the MassDEP website (http://www.mass.gov/dep/water/resources/coastalr.htm 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.

Finally, growth within the community of Falmouth that would exacerbate the problems associated with N loadings, should be guided by considerations of water quality-associated impacts.

SMAST
University of Massachusetts Dartmouth
The School for Marine Science and Technology

Massachusetts
Department of
Environmental
Protection

# Massachusetts Estuaries Project

# Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Thresholds for Oyster Pond Falmouth, Massachusetts

# Executive Summary

## 1. Background

This report presents the results generated from the implementation of the Massachusetts Estuaries Project's Linked Watershed-Embayment Approach to the Oyster Pond embayment system, a coastal embayment within the Town of Falmouth, Massachusetts. Analyses of the Oyster Pond embayment system was performed to assist the Town with up-coming nitrogen management decisions associated with the Towns' current and future wastewater planning efforts, as well as wetland restoration, anadromous fish runs, shell fishery, open-space, and harbor maintenance programs. As part of the MEP approach, habitat assessment was conducted on the embayment based upon available water quality monitoring data, historical changes in eelgrass distribution, time-series water column oxygen measurements, and benthic community structure. Nitrogen loading thresholds for use as goals for watershed nitrogen management are the major product of the MEP effort. In this way, the MEP offers a science-based management approach to support the Town of Falmouth resource planning and decision-making process. The primary products of this effort are: (1) a current quantitative assessment of the nutrient related health of the Oyster Pond embayment, (2) identification of all nitrogen sources (and their respective N loads) to embayment waters, (3) nitrogen threshold levels for maintaining Massachusetts Water Quality Standards within embayment waters, (4) analysis of watershed nitrogen loading reduction to achieve the N threshold concentrations in embayment waters, and (5) a functional calibrated and validated Linked Watershed-Embayment modeling tool that can be readily used for evaluation of nitrogen management alternatives (to be developed by the Town) for the restoration of the Oyster Pond embayment system.

***Wastewater Planning:*** As increasing numbers of people occupy coastal watersheds, the associated coastal waters receive increasing pollutant loads. Coastal embayments throughout the Commonwealth of Massachusetts (and along the U.S. eastern seaboard) are becoming nutrient enriched. The elevated nutrients levels are primarily related to the land use impacts associated with the increasing population within the coastal zone over the past half-century.

The regional effects of both nutrient loading and bacterial contamination span the spectrum from environmental to socio-economic impacts and have direct consequences to the culture, economy, and tax base of Massachusetts's coastal communities. The primary nutrient causing the increasing impairment of our coastal embayments is nitrogen, with its primary sources being wastewater disposal, and nonpoint source runoff that carries nitrogen (e.g. fertilizers) from a range of other sources. Nitrogen related water quality decline represents one of the most serious threats to the ecological health of the nearshore coastal waters. Coastal embayments, because of their shallow nature and large shoreline area, are generally the first coastal systems to show the effect of nutrient pollution from terrestrial sources.

In particular, the Oyster Pond embayment system within the Town of Falmouth is at risk of eutrophication (over enrichment) from enhanced nitrogen loads entering through groundwater and surface water from the increasingly developed watersheds to these coastal salt ponds. Eutrophication is a process that occurs naturally and gradually over a period of tens or hundreds of years. However, human-related (anthropogenic) sources of nitrogen may be introduced into ecosystems at an accelerated rate that cannot be easily absorbed, resulting in a phenomenon known as cultural eutrophication. In both marine and freshwater systems, cultural eutrophication results in degraded water quality, adverse impacts to ecosystems, and limits on the use of water resources.

The Town of Falmouth has recognized the severity of the problem of eutrophication and the need for watershed nutrient management and is currently developing a Comprehensive Wastewater Management Plan, which it plans to rapidly implement. The Town of Falmouth has also completed and implemented wastewater planning in other regions of the Town not associated with the Oyster Pond embayment system. The Town has nutrient management activities related to their tidal embayments, which have been associated with the MEP effort in Great/Perch Pond, Green Pond and Bournes Pond embayment systems as well as other embayments in the Town of Falmouth such as Little Pond and West Falmouth Harbor. The Town of Falmouth and work groups have recognized that a rigorous scientific approach yielding site-specific nitrogen loading targets was required for decision-making and alternatives analysis. The completion of this multi-step process has taken place under the programmatic umbrella of the Massachusetts Estuaries Project, which is a partnership effort between all MEP collaborators and the Town. The modeling tools developed as part of this program provide the quantitative information necessary for the Towns' nutrient management groups to predict the impacts on water quality from a variety of proposed management scenarios.

***Nitrogen Loading Thresholds and Watershed Nitrogen Management:*** Realizing the need for scientifically defensible management tools has resulted in a focus on determining the aquatic system's assimilative capacity for nitrogen. The highest-level approach is to directly link the watershed nitrogen inputs with embayment hydrodynamics to produce water quality results that can be validated by water quality monitoring programs. This approach when linked to state-of-the-art habitat assessments yields accurate determination of the "allowable N concentration increase" or "threshold nitrogen concentration". These determined nitrogen concentrations are then directly relatable to the watershed nitrogen loading, which also accounts for the spatial distribution of the nitrogen sources, not just the total load. As such, changes in nitrogen load from differing parts of the embayment watershed can be evaluated relative to the degree to which those load changes drive embayment water column nitrogen concentrations toward the "threshold" for the embayment system. To increase certainty, the "Linked" Model is independently calibrated and validated for each embayment.

***Massachusetts Estuaries Project Approach:*** The Massachusetts Department of Environmental Protection (DEP), the University of Massachusetts – Dartmouth School of Marine Science and Technology (SMAST), and others including the Cape Cod Commission (CCC) have undertaken the task of providing a quantitative tool to communities throughout southeastern Massachusetts (the Linked Watershed-Embayment Management Model) for nutrient management in their coastal embayment systems. Ultimately, use of the Linked Watershed-Embayment Management Model tool by municipalities in the region results in effective screening of nitrogen reduction approaches and eventual restoration and protection of valuable coastal resources. The MEP provides technical guidance in support of policies on nitrogen loading to embayments, wastewater management decisions, and establishment of nitrogen Total Maximum Daily Loads (TMDLs). A TMDL represents the greatest amount of a pollutant that a waterbody can accept and still meet water quality standards for protecting public health and maintaining the designated beneficial uses of those waters for drinking, swimming, recreation and fishing. The MEP modeling approach assesses available options for meeting selected nitrogen goals that are protective of embayment health and achieve water quality standards.

The core of the Massachusetts Estuaries Project analytical method is the Linked Watershed-Embayment Management Modeling Approach, which links watershed inputs with embayment circulation and nitrogen characteristics.

The Linked Model builds on well-accepted basic watershed nitrogen loading approaches such as those used in the Buzzards Bay Project, the CCC models, and other relevant models. However, the Linked Model differs from other nitrogen management models in that it:

- requires site-specific measurements within each watershed and embayment;
- uses realistic "best-estimates" of nitrogen loads from each land-use (as opposed to loads with built-in "safety factors" like Title 5 design loads);
- spatially distributes the watershed nitrogen loading to the embayment;
- accounts for nitrogen attenuation during transport to the embayment;
- includes a 2D or 3D embayment circulation model depending on embayment structure;
- accounts for basin structure, tidal variations, and dispersion within the embayment;
- includes nitrogen regenerated within the embayment;
- is validated by both independent hydrodynamic, nitrogen concentration, and ecological data;
- is calibrated and validated with field data prior to generation of "what if" scenarios.

The Linked Model Approach's greatest assets are its ability to be clearly calibrated and validated, and its utility as a management tool for testing "what if" scenarios for evaluating watershed nitrogen management options.

For a comprehensive description of the Linked Model, please refer to the *Full Report: Nitrogen Modeling to Support Watershed Management: Comparison of Approaches and Sensitivity Analysis*, available for download at http://www.state.ma.us/dep/smerp/smerp.htm. A more basic discussion of the Linked Model is also provided in Appendix F of the *Massachusetts Estuaries Project Embayment Restoration Guidance for Implementation Strategies*, available for download at http://www.state.ma.us/dep/smerp/smerp.htm. The Linked Model suggests which management solutions will adequately protect or restore embayment water quality by enabling towns to test specific management scenarios and weigh the resulting water quality impact against the cost of that approach. In addition to the management scenarios modeled for this report, the Linked Model can be used to evaluate additional management scenarios and may be updated to reflect future changes in land-use within an embayment watershed or changing embayment characteristics. In addition, since the Model uses a holistic approach (the entire watershed, embayment and tidal source waters), it can be used to evaluate all projects as they relate directly or indirectly to water quality conditions within its geographic boundaries. Unlike many approaches, the Linked Model accounts for nutrient sources, attenuation, and recycling and variations in tidal hydrodynamics and accommodates the spatial distribution of these processes. For an overview of several management scenarios that may be employed to restore embayment water quality, see *Massachusetts Estuaries Project Embayment Restoration Guidance for Implementation Strategies*, available for download at http://www.state.ma.us/dep/smerp/smerp.htm.

***Application of MEP Approach:*** The Linked Model was applied to the Oyster Pond embayment system by using site-specific data collected by the MEP and water quality data from the Falmouth PondWatch Program (see Chapter 2). Evaluation of upland nitrogen loading was conducted by the MEP, data was provided by the Town of Falmouth Planning Department, and watershed boundaries delineated by USGS. This land-use data was used to determine watershed nitrogen loads within the Oyster Pond embayment system and each systems sub-embayments as appropriate (current and build-out loads are summarized in Table IV-3). Water quality within a sub-embayment is the integration of nitrogen loads with the site-specific estuarine circulation. Therefore, water quality modeling of this controlled estuary included a thorough evaluation of the hydrodynamics of the estuarine system. Estuarine hydrodynamics control a variety of coastal processes including tidal flushing, pollutant dispersion, tidal currents, sedimentation, erosion, and water levels. In Oyster Pond, the hydrodynamic regime is dominated by freshwater inputs to the system from groundwater recharge, surface flow run-off from the watershed, and direct precipitation to the pond's surface. Though tides in Vineyard Sound are only occasionally high enough to cause seawater flows into the pond, tidal flushing is still important to the stability and health of this estuary, mostly by its effect on salinity in the pond. Once the hydrodynamics of the system was quantified, transport of nitrogen was evaluated from current information developed by the numerical models.

A two-dimensional depth-averaged hydrodynamic model based upon the tidal currents and water elevations was employed for the Oyster Pond embayment system. The hydrodynamic modeling effort for Oyster Pond was similar to other estuarine systems modeled as part of the MEP, though the tidally restricted nature of this system required modifications to the modeling and analysis techniques that have been applied to simpler embayments. From the perspective of hydrodynamics, the most important difference between the Oyster Pond system and other estuaries in Falmouth is the adjustable salinity control/fish weir in the inlet channel to the Pond.

Once the hydrodynamic properties of the estuarine system were computed, two-dimensional water quality model simulations were used to predict the dispersion of the nitrogen at current loading rates. Using standard dispersion relationships for estuarine systems of this type, the water quality model and the hydrodynamic model was then integrated in order to generate estimates regarding the spread of total nitrogen from the site-specific hydrodynamic properties. The distributions of nitrogen loads from watershed sources were determined from land-use analysis while nitrogen entering Falmouth's coastal embayment was quantified by direct measurement of stream nutrient concentrations and freshwater flow, predominantly groundwater, in streams discharging directly to the embayment. Boundary nutrient concentrations in Vineyard Sound source waters were taken from water quality monitoring data. Measurements of current salinity distributions throughout the estuarine waters of the Oyster Pond embayment system was used to calibrate the water quality model, with validation using measured nitrogen concentrations (under existing loading conditions). The underlying hydrodynamic model was calibrated and validated independently using water elevations measured in time series throughout the embayments.

***MEP Nitrogen Thresholds Analysis:*** The approach for determining nitrogen loading rates, which will maintain acceptable habitat quality throughout an embayment system, is to first identify a sentinel location within the embayment and second, to determine the nitrogen concentration within the water column which will restore that location to the desired habitat quality. The sentinel location is selected such that the restoration of that one site will necessarily bring the other regions of the system to acceptable habitat quality levels. Once the sentinel site and its target nitrogen level are determined, the Linked Watershed-Embayment Model is used to sequentially adjust nitrogen loads until the targeted nitrogen concentration is achieved.

Oyster Pond differs from most other estuaries in its lack of horizontal gradients in salinity, nitrogen, and nitrogen related parameters (chlorophyll a, D.O., transparency, etc.). Therefore, selection of the sentinel station was not based on horizontal gradients and their response to changing nitrogen loads. Instead, the sentinel station was selected to best capture the overall conditions of the Pond waters.

The nitrogen thresholds developed in Section VIII-2 were used to determine the amount of total nitrogen mass loading reduction required for restoration of Oyster Pond to a series of dissolved oxygen values. Due to the existing salinity levels in the Pond (historically between 0 and 4 ppt), eelgrass cannot be established within this brackish water body. Instead, development of an appropriate threshold to restore infaunal habitat was based on minimum dissolved oxygen within the lower basin of Oyster Pond. It was determined that a linear relationship was appropriate to assess the expected changes in dissolved oxygen relative to total nitrogen for the site-specific conditions within the main basin of the Pond. Minimum dissolved oxygen thresholds derived in Section VIII.1 were used to adjust the calibrated constituent transport model developed in Section VI. It is important to note that load reductions can be produced by reduction of any or all sources or by increasing the natural attenuation of nitrogen within the freshwater systems to the embayment. The load reductions presented in the report represent only one of a suite of potential reduction approaches that need to be evaluated by the community. The presentation in this report of load reductions aims to establish the general degree and spatial pattern of reduction that will be required for restoration of this nitrogen impaired embayment.

The Massachusetts Estuaries Project's thresholds analysis, as presented in this technical report, provides the site-specific nitrogen reduction guidelines for nitrogen management of the Oyster Pond embayment system in the Town of Falmouth. Future water quality modeling scenarios should be run which incorporate the spectrum of strategies that result in nitrogen loading reduction to the embayment. The MEP analysis has initially focused upon nitrogen loads from on-site septic systems as a test of the potential for achieving the level of total nitrogen reduction for restoration of each embayment system. The concept was that since septic system nitrogen loads generally represent 75%-85% of the watershed load to the Oyster Pond embayment system and are more manageable than other of the nitrogen sources, the ability to achieve needed reductions through this source is a good gauge of the feasibility for restoration of these systems.

## 2. Problem Assessment (Current Conditions)

A habitat assessment was conducted throughout Oyster Pond based upon available water quality monitoring data, macroalgae distribution, time-series water column oxygen measurements, and benthic community structure. At present the bulk of the Oyster Pond is showing moderately to significantly impaired habitat quality. All of the indicators show a consistent pattern of moderate to significant impairment throughout the basins of Oyster Pond. While the Pond does not show strong gradients in salinity or water quality parameters, the enclosed nature of the northern basin appears to increase the duration of stratification and subsequent hypoxia. The deep southern basin (~6 m) is salinity stratified for months to years at a time and is generally anoxic as a result of this natural process. Based primarily on the infaunal communities and the bottom water hypoxia, it was concluded that Oyster Pond habitat is presently moderately to significantly impaired. Since the ultimate cause of the low dissolved oxygen (≤4m) results from nitrogen enrichment, it can also be concluded that the system is nitrogen overloaded at present.

The following is a brief synopsis of the present habitat quality within the salt pond. The underlying quantitative data is presented on nitrogen (Section VI.1.3), oxygen and chlorophyll *a* (Section VII.2), eelgrass (Section VII.3), and benthic infauna (Section VII.4).

The effect of nitrogen enrichment is to cause oxygen depletion; however, with increased phytoplankton (or epibenthic algae) production, oxygen levels will rise in daylight to above atmospheric equilibration levels in shallow systems (generally ~7-8 mg $L^{-1}$ at the mooring sites). The clear evidence of oxygen levels above atmospheric equilibration indicates that the upper tidal reach of the Oyster Pond System is eutrophic.

Unlike many of the other embayments in southeastern Massachusetts, Oyster Pond showed a relatively consistent pattern of low oxygen in its bottom waters throughout its basins. The deep, southern basin (6 meters) is consistently anoxic during summer months due to its salinity stratification which persists for months to years. However, this represents only ~10% of the pond bottom. The remaining areas, ≤4 meters depth are only periodically anoxic or hypoxic. The northern basin was periodically anoxic between1998-2004. However, this basin is enclosed and this anoxia is driven mainly by stratification. The majority of the sediments in the pond (~80%) are represented by the oxygen levels observed in the upper and lower main basin (OP-2 3.25 m, OP-3 4 m). These regions are more open to wind-driven mixing and showed oxygen levels 3 mg/L or above in 96% of samplings and 2 mg/L as a minimum level. Restoration of this system will require an improvement of oxygen levels in this lower basin, which represents most of the benthic habitat and which does not appear to support long periods of stratification shallower than 4 meters depth (as opposed to the northern basin)..

The low salinity waters of Oyster Pond are not supportive of eelgrass bed formation. The DEP Eelgrass Mapping Program has conducted no surveys in Oyster Pond. However, observations have been made by PondWatch from 1987 to present which support the lack of eelgrass in this system. Similarly, a complete system data collection and analysis effort conducted in the 1960's throughout the main basin of Oyster Pond did not indicate the presence of eelgrass (Emery, 1997). This latter effort included a census of submerged aquatic vegetation, which did not indicate eelgrass, but did indicate that the dominant SAV in 2004, *Ceratophyllum demersum*, was also dominant in the 1960's. Therefore, the most likely reason for the absence of eelgrass in the main basin of Oyster Pond is the low salinity. This indicates that eelgrass cannot be used as a habitat restoration indicator for this system.

The Benthic Infaunal Study indicated that Oyster Pond is not presently supportive of either diverse (H' 0-1.12, mean 0.65) or evenly distributed (mean E = 0.46) benthic infauna. More telling is the low number of species (0-6, mean=3) compared to nearby healthy estuarine areas (~30 species per sample). Due to its brackish waters, Oyster Pond sediments supported both freshwater and estuarine invertebrate populations. The freshwater species were generally insect larvae and these tended to dominate the community. Also notable was that almost half of the samples (5 of 11) had only 0-84 individuals, indicative of an impoverished community. Although the remaining samples had dense populations, they were distributed among a very few species, 6 or less, indicating a stressed community. Overall, the infauna community was consistent with the low dissolved oxygen and organic matter deposition observed in this relatively closed estuarine basin.

## 3. Conclusions of the Analysis

The threshold nitrogen level for an embayment represents the average watercolumn concentration of nitrogen that will support the habitat quality or dissolved oxygen conditions being sought. The watercolumn nitrogen level is ultimately controlled by the integration of the watershed nitrogen load, the nitrogen concentration in the inflowing tidal waters (boundary condition) and dilution due to ground or surface water flows and (in the case of Oyster pond limited flushing via tidal flows. The water column nitrogen concentration is modified by the extent of sediment regeneration and by direct atmospheric deposition.

The nitrogen threshold for Oyster Pond is based upon restoring benthic habitat for infaunal animals. Given the natural stratification of Pond waters, sediments < 4 meters depth representing ~80% of the pond bottom were targeted. This depth is based upon the depth distribution of the bottom and the depth of the mixed layer. Since the present nitrogen levels result in periodic hypoxia at 4 meters depth, the nitrogen threshold was set to improve and maintain oxygen levels $\geq$6 mg/L at 4 meters depth in the main basin (OP-3). At present, the minimum dissolved oxygen at this station is most likely 3 mg/L, although a single reading of 2 mg/L was recorded. Given the uncertainties in determining minimum D.O. in any estuary, the nitrogen threshold was set using 2 mg/L as the current minimum D.O. level.

Watershed nitrogen loads (Tables ES-1 and ES-2) for the Town of Falmouth Oyster Pond embayment system was comprised primarily of wastewater nitrogen. Land-use and wastewater analysis found that generally about 75%-85% of the watershed nitrogen load to the embayment was from wastewater.

The threshold nitrogen levels for the Oyster Pond embayment system in Falmouth were determined as follows:

***Oyster Pond Threshold Criteria***

- Since at summer temperatures (25$^{o}$C) and salinities (2 ppt), dissolved oxygen saturation is 8.2 mg/L and current oxygen minimum is 2 mg/L then raising the minimum oxygen level to 6 mg/L would require 4/6.2 or 65% reduction in the rate of oxygen uptake during stratification. This assumes that the present duration and frequency of stratification of waters overlying sediments 4 meters or less deep will remain as at present. This is a safe assumption as long as the management plan does not allow the pond salinity levels to climb above target 2-4 ppt range. Given the link between nitrogen load and oxygen uptake rate, this 65% reduction in oxygen uptake would require a 65% reduction in nitrogen loading to Oyster Pond. Using a similar analysis, raising the periodic minimum dissolved oxygen to 3.8 mg/L (Chesapeake Bay value) or the SB criteria of 5 mg/L would require reductions in nitrogen **loading** of 29% and 48%, respectively.

- As shown in Table VIII-2, the nitrogen load reductions within the system necessary to achieve the threshold dissolved oxygen concentrations were higher for higher minimum dissolved oxygen levels. Since the nitrogen concentrations are generally uniform across the entire surface of Oyster Pond (i.e. there is virtually no spatial gradient in nitrogen concentration), the nitrogen load was removed uniformly. Distributions of tidally-averaged nitrogen concentrations associated with the threshold analysis are shown in Section VIII.

- To achieve the threshold dissolved oxygen concentrations at the sentinel stations, a reduction in TN **concentration** of approximately 9%, 15%, and 21% is required for dissolved oxygen concentrations of 3.8 mg/l (based on the EPA's Chesapeake Bay limit), 5.0 mg/l (Massachusetts SB waters), and 6.0 mg/l (Massachusetts SA waters), respectively. Although the above modeling results provide one manner of achieving the selected threshold levels within the Oyster Pond system, the specific examples do not represent the only method for achieving this goal. However, the thresholds analysis provides general guidelines needed for the nitrogen management of this embayment

It is important to note that the analysis of future nitrogen loading to the Oyster Pond estuarine systems focuses upon additional shifts in land-use from forest/grasslands to residential and commercial development. However, the MEP analysis indicates that significant increases in nitrogen loading can occur under present land-uses, due to shifts in occupancy, shifts from seasonal to year-round usage and increasing use of fertilizers (presently less than half of the parcels use lawn fertilizers). Therefore, watershed-estuarine nitrogen management must include management approaches to prevent increased nitrogen loading from both shifts in land-uses (new sources) and from loading increases of current land-uses. The overarching conclusion of the MEP analysis of the Oyster Pond estuarine system is that restoration will necessitate a reduction in the present (2002) nitrogen inputs and management options to negate additional future nitrogen inputs.

Table ES-1. Existing total and sub-embayment nitrogen loads to the estuarine waters of the Oyster Pond system, observed nitrogen concentrations, and sentinel system threshold nitrogen concentrations. Loads to estuarine waters of Oyster Pond include both upper watershed regions contributing to the major surface water inputs (Mosquito Creek).

| Sub-embayments | Natural Background Watershed Load [1] (kg/day) | Present Land Use Load [2] (kg/day) | Present Septic System Load (kg/day) | Present WWTF Load [3] (kg/day) | Present Watershed Load [4] (kg/day) | Direct Atmospheric Deposition [5] (kg/day) | Present Net Benthic Flux (kg/day) | Present Total Load [6] (kg/day) | Observed TN Conc. [7] (mg/L) | Threshold TN Conc. (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|
| ***OYSTER POND SYSTEM*** | | | | | | | | | | |
| Oyster Pond[a] | 0.490 | 1.367 | 3.587 | 0.00 | 4.181 | 0.773 | -1.733 | 3.220 | 0.67-0.71 | -- |
| Oyster Pond Lagoon | 0.047 | 0.090 | 0.023 | 0.00 | 0.293 | 0.027 | -0.048 | 0.273 | | -- |
| **Oyster Pond System Total** | 0.537 | 1.457 | 3.610 | 0.000 | 4.474 | 0.800 | -1.781 | 3.493 | 0.67-0.71 | **0.633**[8] |

1 assumes entire watershed is forested (i.e., no anthropogenic sources)
2 composed of non-wastewater loads, e.g. fertilizer and runoff and natural surfaces and atmospheric deposition to lakes
3 existing wastewater treatment facility discharges to groundwater
4 composed of combined natural background, fertilizer, runoff, and septic system loadings
5 atmospheric deposition to embayment surface only
6 composed of natural background, fertilizer, runoff, septic system atmospheric deposition and benthic flux loadings
7 average of 1997 – 2004 data, ranges show the upper to lower regions (highest-lowest) of an sub-embayment.
8 Threshold loading for Oyster Pond is based upon removal required to achieve 3.8, 5.0 or 6.0 mg/L DO concentration in the deepest basin of the Pond. Resulting TN concentrations in the lower Pond basin for these three scenarios are 0.633, 0.588 an d0.548 mg/L, respectively.
a Include loads from surface water sources (i.e., Mosquito Creek).

Table ES-2. Present Watershed Loads, Thresholds Loads, and the percent reductions necessary to achieve the Thresholds Loads for the Oyster Pond system, Town of Falmouth, Massachusetts. Threshold loading for Oyster Pond is based upon removal required to achieve 3.8, 5.0 or 6.0 mg/L DO concentration in the deepest basin of the Pond.

| Sub-embayments | Present Watershed Load [1] (kg/day) | Target Threshold Watershed Load [2] (kg/day) | Direct Atmospheric Deposition (kg/day) | Benthic Flux Net [3] (kg/day) | TMDL [4] (kg/day) | Percent watershed reductions needed to achieve threshold load levels |
|---|---|---|---|---|---|---|
| ***GREAT POND SYSTEM*** | | | | | | |
| Oyster Pond | 4.181 | *DO 3.8*: 2.855<br>*DO 5.0*: 1.967<br>*DO 6.0*: 1.233 | 0.773 | *DO 3.8*: -1.342<br>*DO 5.0*: -1.080<br>*DO 6.0*: -0.863 | *DO 3.8*: 2.286<br>*DO 5.0*: 1.660<br>*DO 6.0*: 1.143 | *DO 3.8*: -31.7%<br>*DO 5.0*: -53.0%<br>*DO 6.0*: -70.5% |
| Oyster Pond Lagoon | 0.293 | 0.293 | 0.027 | *DO 3.8*: -0.037<br>*DO 5.0*: -0.030<br>*DO 6.0*: -0.024 | *DO 3.8*: 0.283<br>*DO 5.0*: 0.290<br>*DO 6.0*: 0.296 | *DO 3.8*: 0.0<br>*DO 5.0*: 0.0<br>*DO 6.0*: 0.0 |
| **Oyster Pond System Total** | 4.474 | *DO 3.8*: 3.148<br>*DO 5.0*: 2.260<br>*DO 6.0*: 1.526 | 0.800 | *DO 3.8*: -1.379<br>*DO 5.0*: -1.110<br>*DO 6.0*: -0.887 | *DO 3.8*: 2.569<br>*DO 5.0*: 1.950<br>*DO 6.0*: 1.439 | *DO 3.8*: -29.6%<br>*DO 5.0*: -49.5%<br>*DO 6.0*: -65.9% |

(1) Composed of combined natural background, fertilizer, runoff, and septic system loadings.
(2) Target threshold watershed load is the load from the watershed needed to meet the embayment threshold concentration identified in Table ES-1.
(3) Projected future flux (present rates reduced approximately proportional to watershed load reductions).
(4) Sum of target threshold watershed load, atmospheric deposition load, and benthic flux load.

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Massachusetts Department of Environmental Protection

# Massachusetts Estuaries Project

# Linked Watershed-Embayment Approach to Determine Critical Nitrogen Loading Thresholds for the Salt Pond Embayment System, Falmouth, Massachusetts

# Executive Summary

## 1. Background

This report presents the results generated from the implementation of the Massachusetts Estuaries Project's Linked Watershed-Embayment Approach to the Salt Pond embayment system, a coastal embayment within the Town of Falmouth, Massachusetts. Analyses of the Salt Pond embayment system was performed to assist the Town of Falmouth with up-coming nitrogen management decisions associated with the current and future wastewater planning efforts of the Town, as well as wetland restoration, anadromous fish runs, shell fishery, open-space, and harbor maintenance programs. As part of the MEP approach, habitat assessment was conducted on the embayment based upon available water quality monitoring data, historical changes in eelgrass distribution, time-series water column oxygen measurements, and benthic community structure. Nitrogen loading thresholds for use as goals for watershed nitrogen management are the major product of the MEP effort. In this way, the MEP offers a science-based management approach to support the Town of Falmouth resource planning and decision-making process. The primary products of this effort are: (1) a current quantitative assessment of the nutrient related health of the Salt Pond embayment, (2) identification of all nitrogen sources (and their respective N loads) to embayment waters, (3) nitrogen threshold levels for maintaining Massachusetts Water Quality Standards within embayment waters, (4) analysis of watershed nitrogen loading reduction to achieve the N threshold concentrations in embayment waters, and (5) a functional calibrated and validated Linked Watershed-Embayment modeling tool that can be readily used for evaluation of nitrogen management alternatives (to be developed by the Town) for the restoration of the Salt Pond embayment system.

***Wastewater Planning:*** As increasing numbers of people occupy coastal watersheds, the associated coastal waters receive increasing pollutant loads. Coastal embayments throughout the Commonwealth of Massachusetts (and along the U.S. eastern seaboard) are becoming nutrient enriched. The elevated nutrients levels are primarily related to the land use impacts associated with the increasing population within the coastal zone over the past half-century.

The regional effects of both nutrient loading and bacterial contamination span the spectrum from environmental to socio-economic impacts and have direct consequences to the culture, economy, and tax base of Massachusetts's coastal communities. The primary nutrient causing the increasing impairment of our coastal embayments is nitrogen, with its primary sources being wastewater disposal, and nonpoint source runoff that carries nitrogen (e.g. fertilizers) from a range of other sources. Nitrogen related water quality decline represents one of the most serious threats to the ecological health of the nearshore coastal waters. Coastal embayments, because of their shallow nature and large shoreline area, are generally the first coastal systems to show the effect of nutrient pollution from terrestrial sources.

In particular, the Salt Pond embayment system within the Town of Falmouth is at risk of eutrophication (over enrichment) from enhanced nitrogen loads entering through groundwater from the increasingly developed watershed to this coastal system. Eutrophication is a process that occurs naturally and gradually over a period of tens or hundreds of years. However, human-related (anthropogenic) sources of nitrogen may be introduced into ecosystems at an accelerated rate that cannot be easily absorbed, resulting in a phenomenon known as cultural eutrophication. In both marine and freshwater systems, cultural eutrophication results in degraded water quality, adverse impacts to ecosystems, and limits on the use of water resources.

The Town of Falmouth has recognized the severity of the problem of eutrophication and the need for watershed nutrient management and is currently developing a Comprehensive Wastewater Management Plan which the Town plans to implement upon its completion. The Town of Falmouth has been working with the Town of Mashpee that has also completed and implemented wastewater planning in other nearby regions not associated with the Salt Pond system, specifically the Waquoit Bay embayment system. In this manner, this analysis of the Salt Pond system is yielding results which can be utilized by the Town of Falmouth along with MEP results developed for the other estuaries of the town (specifically, Rands Harbor, Fiddlers Cove, Wild Harbor, West Falmouth Harbor, Falmouth Inner Harbor, Little Pond, Quissett Harbor, Oyster Pond, Great Pond, Green Pond, Bournes Pond, Eel Pond/Childs River and Waquoit Bay) in order to give the Town of Falmouth the necessary results to plan out and implement a unified town-wide approach to nutrient management. The Town of Falmouth with associated working groups has recognized that a rigorous scientific approach yielding site-specific nitrogen loading targets was required for decision-making and alternatives analysis. The completion of this multi-step process has taken place under the programmatic umbrella of the Massachusetts Estuaries Project, which is a partnership effort between all MEP collaborators and the Towns. The modeling tools developed as part of this program provide the quantitative information necessary for the Towns' nutrient management groups to predict the impacts on water quality from a variety of proposed management scenarios.

***Nitrogen Loading Thresholds and Watershed Nitrogen Management:*** Realizing the need for scientifically defensible management tools has resulted in a focus on determining the aquatic system's assimilative capacity for nitrogen. The highest-level approach is to directly link the watershed nitrogen inputs with embayment hydrodynamics to produce water quality results that can be validated by water quality monitoring programs. This approach when linked to state-of-the-art habitat assessments yields accurate determination of the "allowable N concentration increase" or "threshold nitrogen concentration". These determined nitrogen concentrations are then directly relatable to the watershed nitrogen loading, which also accounts for the spatial distribution of the nitrogen sources, not just the total load. As such, changes in nitrogen load from differing parts of the embayment watershed can be evaluated relative to the degree to which those load changes drive embayment water column nitrogen concentrations toward the "threshold" for the embayment system. To increase certainty, the "Linked" Model is independently calibrated and validated for each embayment.

***Massachusetts Estuaries Project Approach:*** The Massachusetts Department of Environmental Protection (DEP), the University of Massachusetts – Dartmouth School of Marine Science and Technology (SMAST), and others including the Cape Cod Commission (CCC) have undertaken the task of providing a quantitative tool to communities throughout southeastern Massachusetts (the Linked Watershed-Embayment Management Model) for nutrient management in their coastal embayment systems. Ultimately, use of the Linked Watershed-Embayment Management Model tool by municipalities in the region results in effective screening of nitrogen reduction approaches and eventual restoration and protection of valuable coastal resources. The MEP provides technical guidance in support of policies on nitrogen loading to embayments, wastewater management decisions, and establishment of nitrogen Total Maximum Daily Loads (TMDLs). A TMDL represents the greatest amount of a pollutant that a waterbody can accept and still meet water quality standards for protecting public health and maintaining the designated beneficial uses of those waters for drinking, swimming, recreation and fishing. The MEP modeling approach assesses available options for meeting selected nitrogen goals that are protective of embayment health and achieve water quality standards.

The core of the Massachusetts Estuaries Project analytical method is the Linked Watershed-Embayment Management Modeling Approach, which links watershed inputs with embayment circulation and nitrogen characteristics.

The Linked Model builds on well-accepted basic watershed nitrogen loading approaches such as those used in the Buzzards Bay Project, the CCC models, and other relevant models. However, the Linked Model differs from other nitrogen management models in that it:

- requires site-specific measurements within each watershed and embayment;
- uses realistic "best-estimates" of nitrogen loads from each land-use (as opposed to loads with built-in "safety factors" like Title 5 design loads);
- spatially distributes the watershed nitrogen loading to the embayment;
- accounts for nitrogen attenuation during transport to the embayment;
- includes a 2D or 3D embayment circulation model depending on embayment structure;
- accounts for basin structure, tidal variations, and dispersion within the embayment;
- includes nitrogen regenerated within the embayment;
- is validated by both independent hydrodynamic, nitrogen concentration, and ecological data;
- is calibrated and validated with field data prior to generation of "what if" scenarios.

The greatest assets of the Linked Model Approach are its ability to be clearly calibrated and validated, and its utility as a management tool for testing "what if" scenarios for evaluating watershed nitrogen management options.

For a comprehensive description of the Linked Model, please refer to the *Full Report: Nitrogen Modeling to Support Watershed Management: Comparison of Approaches and Sensitivity Analysis*, available for download at http://www.state.ma.us/dep/smerp/smerp.htm. A more basic discussion of the Linked Model is also provided in Appendix F of the *Massachusetts Estuaries Project Embayment Restoration Guidance for Implementation Strategies*, available for download at http://www.state.ma.us/dep/smerp/smerp.htm. The Linked Model suggests which management solutions will adequately protect or restore embayment water quality by enabling towns to test specific management scenarios and weigh the resulting water quality impact against the cost of that approach. In addition to the management scenarios modeled for this report, the Linked Model can be used to evaluate additional management scenarios and may be updated to reflect future changes in land-use within an embayment watershed or changing embayment characteristics. In addition, since the Model uses a holistic approach (the entire watershed, embayment and tidal source waters), it can be used to evaluate all projects as they relate directly or indirectly to water quality conditions within its geographic boundaries. Unlike many approaches, the Linked Model accounts for nutrient sources, attenuation, and recycling and variations in tidal hydrodynamics and accommodates the spatial distribution of these processes. For an overview of several management scenarios that may be employed to restore embayment water quality, see *Massachusetts Estuaries Project Embayment Restoration Guidance for Implementation Strategies*, available for download at http://www.state.ma.us/dep/smerp/smerp.htm.

***Application of MEP Approach:*** The Linked Model was applied to the Salt Pond embayment system by using site-specific data collected by the MEP and water quality data from the volunteer efforts of scientists and graduate researchers within the Coastal Systems Program-SMAST. CSP staff and students undertook the collection of the necessary minimum three years baseline data in order to support entry of Salt Pond into the MEP. These "research volunteers" at CSP-SMAST initiated data collection in summer 2006 and created a 7 year baseline of summer water quality for the pond (2006-2012). Evaluation of upland nitrogen loading was conducted by the MEP, data were provided by the Town of Falmouth Planning Department, and watershed boundaries delineated by USGS. These land-use data were used to determine watershed nitrogen loads within the Salt Pond embayment system (current and build-out loads are summarized in Table IV-3). Water quality within an embayment is the integration of nitrogen loads with the site-specific estuarine circulation. Therefore, water quality modeling of this tidally influenced estuary included a thorough evaluation of the hydrodynamics of the estuarine system. Estuarine hydrodynamics control a variety of coastal processes including tidal flushing, pollutant dispersion, tidal currents, sedimentation, erosion, and water levels. Once the hydrodynamics of the system was quantified, transport of nitrogen was evaluated from tidal current information developed by the numerical models.

A two-dimensional depth-averaged hydrodynamic model based upon the tidal currents and water elevations was employed for the Salt Pond embayment system. Once the hydrodynamic properties of the estuarine system were computed, two-dimensional water quality model simulations were used to predict the dispersion of the nitrogen at current loading rates. Using standard dispersion relationships for estuarine systems of this type, the water quality model and the hydrodynamic model were then integrated in order to generate estimates regarding the spread of total nitrogen from the site-specific hydrodynamic properties. The distributions of nitrogen loads from watershed sources were determined from land-use analysis. Boundary nutrient concentrations in Vineyard Sound source waters were taken from water quality monitoring data. Measurements of current salinity distributions throughout the estuarine waters of the Salt Pond embayment system were used to calibrate the water quality model, with validation using measured nitrogen concentrations (under existing loading conditions). The underlying hydrodynamic model was calibrated and validated independently using water elevations measured in time series throughout the embayment.

***MEP Nitrogen Thresholds Analysis:*** The threshold nitrogen level for an embayment represents the average water column concentration of nitrogen that will support the habitat quality being sought. The water column nitrogen level is ultimately controlled by the watershed nitrogen load and the nitrogen concentration in the inflowing tidal waters (boundary condition).

The water column nitrogen concentration is modified by the extent of sediment regeneration. Threshold nitrogen levels for the embayment systems in this study were developed to restore or maintain SA waters or high habitat quality. High habitat quality was defined as supportive of eelgrass and infaunal communities. Dissolved oxygen and chlorophyll-*a* were also considered in the assessment.

The nitrogen thresholds developed in Section VIII-2 were used to determine the amount of total nitrogen mass loading reduction required for restoration of infaunal habitats (no documented historical eelgrass but for one observation of very limited eelgrass by the inlet in 2007, see Section VII for detail) in the Salt Pond system. Tidally averaged total nitrogen thresholds derived in Section VIII.1 were used to adjust the calibrated constituent transport model developed in Section VI. Watershed nitrogen loads were sequentially lowered, using reductions in septic effluent discharges only, until the nitrogen levels reached the threshold level at the sentinel station chosen for the Salt Pond system. It is important to note that load reductions can be produced by reduction of any or all sources, enhancing flushing of the system or by increasing the natural attenuation of nitrogen within the freshwater systems to the embayment. The load reductions presented in Section VIII represent only one of a suite of potential reduction approaches that need to be evaluated by the community. The presentation is to establish the general degree and spatial pattern of reduction that will be required for restoration of this nitrogen impaired embayment.

The Massachusetts Estuaries Project's thresholds analysis, as presented in this technical report, provides the site-specific nitrogen reduction guidelines for nitrogen management of the Salt Pond embayment system in the Town of Falmouth. Future water quality modeling scenarios should be run which incorporate the spectrum of strategies that result in nitrogen loading reduction to the embayment. For Illustrative purposes, the MEP analysis has initially focused upon nitrogen loads from on-site septic systems as a test of the potential for achieving the level of total nitrogen reduction for restoration of the embayment system. The concept was that since nitrogen loads associated with wastewater generally represent 76% of the controllable watershed load to the Salt Pond embayment system and are more manageable than other of the nitrogen sources, the ability to achieve needed reductions through this source is a good gauge of the feasibility for restoration of the system.

## 2. Problem Assessment (Current Conditions)

A habitat assessment was conducted throughout the Salt Pond embayment system based upon available water quality monitoring data, time-series water column oxygen measurements of dissolved oxygen and chlorophyll, and benthic community structure (changes in eelgrass distribution could not be used as a metric due to lack of historical eelgrass presence). Salt Pond is currently functioning as a typical coastal embayment with restricted tidal exchange with the waters of Vineyard Sound. Each of type of functional component to an estuary (salt marsh basin, embayment, tidal river, deep basin {sometimes drown kettles}, shallow basin, etc.) has a different natural sensitivity to nitrogen enrichment and organic matter loading. Evaluation of eelgrass and infaunal habitat quality must consider the natural structure of the specific basin and its ability to support eelgrass beds and infaunal communities. At present, the Salt Pond Estuary is beyond its ability to assimilate nitrogen without further impairment. The system is showing a high level of nitrogen enrichment, with no eelgrass habitat and moderate to significantly impaired benthic animal habitats (depending on location in the pond), regions of periodic hypoxia and phytoplankton blooms and a stratified deep basin with prolonged anoxia (Table VIII-1), these findings indicate that nitrogen management of this system will be for restoration rather than for protection or maintenance of an unimpaired system.

The measured levels of oxygen depletion and enhanced chlorophyll-*a* levels follows the spatial pattern of total nitrogen levels in this system (Chapter VI), and the parallel variation in these water quality parameters is consistent with watershed based nitrogen enrichment and restriction of tidal flows. The spatial pattern indicated that the magnitude of oxygen depletion, enhancement of chlorophyll-*a* levels and total nitrogen concentrations were affected by the watercolumn stratification stemming from the basin geomorphology and reduced tidal action such that waters and sediments below 3 meters depth are subjected to prolonged anoxia and potential infaunal habitat is only in the shallow margins of the main basin and in the region of the tidal channel.

The level of oxygen depletion and the magnitude of daily oxygen excursion and chlorophyll-*a* levels indicate moderate to high nutrient enriched waters within the margins of the main basin and tidal channel region of Salt Pond, respectively. The oxygen data is consistent with organic matter enrichment, primarily from phytoplankton production as seen from the parallel measurements of chlorophyll-*a* and in the tidal channel, which also has patchy accumulations of macroalgae. The measured levels of oxygen depletion and enhanced chlorophyll-*a* levels follows the spatial pattern of total nitrogen levels in this system (Section VI), and the parallel variation in these water quality parameters is consistent with watershed based nitrogen enrichment of the Salt Pond Estuary.

Salt Pond is functionally a basin with very limited fringing wetland habitat along its shoreline to the main basin. The sediments are currently soft muds rich in organic matter in the center deep portion of the pond, which has had periods of prolonged anoxia since at least the 1970's. The primary factor in the oxygen depletion of the deep waters is the strong salinity stratification of the deep basin, which restricts ventilation with the atmosphere. It is the shallower (<3m) margins of the basin that support some sandy areas and compacted muds with oxidized surface layers. All of the available information related to eelgrass within the Salt Pond Estuary, including the 2007 survey, indicate that no eelgrass is present within Salt Pond and eelgrass beds have not been observed historically, although small sparse patches of *Ruppia* occur in some shoreline areas. The absence of eelgrass beds is expected in this system given the high chlorophyll-*a* (averages 14-15 ug $L^{-1}$) and periodic low dissolved oxygen levels and high water column nitrogen concentrations. Given the absence of eelgrass at present and the lack of evidence of prior eelgrass habitat within this system, management should focus on benthic animal habitat, primarily within the marginal areas.

Overall, the infauna survey indicated that the shallow margin (<3 m) around the deep kettle "hole" is supportive of the moderate quality infaunal habitat within Salt Pond, showing areas that are moderately and significantly impaired. The sediments within the deep basin (>3 m) are overlain by anoxic bottom water and are devoid of benthic animals. Intermediate to these 2 regions, the tidal channel is depositional, with significant oxygen declines and significantly impaired benthic habitat.

Classification of habitat quality necessarily included the structure of the estuarine basin, specifically that it is fully representative of a tidal embayment, as opposed to a tidal river or salt marsh basin and if a basin is structurally impaired or impaired by nitrogen enrichment.. Integration of all of the metrics clearly indicates that the shallow areas of Salt Pond are generally supporting benthic animal habitat that is moderately or significantly impaired. The proximate cause of impairment is organic matter enrichment and oxygen depletion, stemming ultimately from nitrogen enrichment. Total nitrogen levels within the estuary at present are >0.90 mg TN $L^{-1}$, a level generally found associated with a significant level of impairment of benthic animal habitat in southeastern Massachusetts estuaries. The lack of historical eelgrass beds in Salt Pond and the present impairment to benthic animal habitat from nitrogen enrichment makes restoration of infauna habitat resource the primary focus for nitrogen management.

## 3. Conclusions of the Analysis

The threshold nitrogen level for an embayment represents the average water column concentration of nitrogen that will support the habitat quality being sought. The water column nitrogen level is ultimately controlled by the integration of the watershed nitrogen load, the nitrogen concentration in the inflowing tidal waters (boundary condition) and dilution and flushing via tidal flows. The water column nitrogen concentration is modified by the extent of sediment regeneration and by direct atmospheric deposition.

Threshold nitrogen levels for this embayment system were developed to restore or maintain SA waters consistent with the recreational use of this water body. In this system, high habitat quality was defined as supportive of diverse benthic animal communities. Dissolved oxygen and chlorophyll-*a* were also considered in the assessment.

Watershed nitrogen loads (Tables ES-1 and ES-2) for the Town of Falmouth Salt Pond embayment system was comprised primarily of wastewater nitrogen. Land-use and wastewater analysis found that generally about 76% of the controllable watershed nitrogen load to the embayment was from wastewater (septic and WWTF).

A major finding of the MEP clearly indicates that a single total nitrogen threshold can not be applied to Massachusetts' estuaries, based upon the results of the Fiddlers Cove, Rands Harbor, Wild Harbor, Little Pond, Falmouth Inner Harbor, Great, Green and Bournes Pond Systems, Popponesset Bay System, and the nearby Eel Pond and Hamblin / Jehu Pond / Quashnet River analysis in eastern Waquoit Bay, among many other systems analyzed by the MEP. This is almost certainly going to be true for the other embayments within the MEP area, as well, inclusive of Salt Pond.

The threshold nitrogen levels for the Salt Pond embayment system in Falmouth were determined as follows:

***Salt Pond Threshold Nitrogen Concentrations***

- Following the MEP protocol, the restoration target for the Salt Pond Embayment system should reflect both recent pre-degradation habitat quality and be reasonably achievable. The approach for determining nitrogen loading rates, which will maintain acceptable habitat quality throughout and embayment system, is to identify a sentinel location within the embayment or sub-embayment (as necessary) and second, to determine the nitrogen concentration within the water column which will restore that location to the desired habitat quality. Within the Salt Pond Estuary the most appropriate sentinel "station" was to use the average of the 3 long-term monitoring stations (<3 m) in Figure VI-1. This average approach has been used in other open single basin estuaries throughout the MEP region. The average was selected because of the heterogeneity in the benthic animal habitat in this stratified basin and the need to meet acceptable quality conditions throughout the basin.

- Following the MEP protocol, since eelgrass has not been documented in Salt Pond, restoration of infaunal habitat is the restoration goal. Infaunal animal habitat is a critical resource to the Salt Pond Estuary and estuaries in general. Since there are no unimpaired infaunal animal habitat areas remaining in the Salt Pond system, comparisons to the soft bottom basins of other nearby estuarine systems were relied upon for setting the nitrogen threshold for healthy infaunal habitat at a nitrogen level of TN <0.5 mg TN $L^{-1}$. This level was found for Popponesset Bay where based upon the infaunal analysis coupled with the nitrogen data (measured and modeled), nitrogen levels on the order of 0.4 to 0.5 mg TN L-1 were found to be supportive of high infaunal habitat quality in this system. Similarly, in the Three Bays System, healthy infaunal areas are found at nitrogen levels of TN <0.42 mg TN $L^{-1}$ (Cotuit Bay and West Bay), with impairment in areas where nitrogen levels of TN >0.5 mg TN $L^{-1}$ (North Bay), and severe degradation at nitrogen levels of TN >0.6 mg TN $L^{-1}$. Present TN levels within the Salt Pond mixed layer during summer are ~0.90 mg TN $L^{-1}$, consistent with the observed lack of eelgrass beds and impaired benthic animal habitat.

It is important to note that the analysis of future nitrogen loading to the Salt Pond estuarine system focuses upon additional shifts in land-use from forest/grasslands to residential and commercial development. However, the MEP analysis indicates that significant increases in nitrogen loading can occur under present land-uses, due to shifts in occupancy, shifts from seasonal to year-round usage and increasing use of fertilizers. Therefore, watershed-estuarine nitrogen management must include management approaches to prevent increased nitrogen loading from both shifts in land-uses (new sources) and from loading increases of current land-uses. The overarching conclusion of the MEP analysis of the Salt Pond system is that given the relatively low watershed nitrogen load to Salt Pond, it will be difficult to lower TN levels by ~0.4 mg $L^{-1}$ to meet the threshold. The nitrogen load reductions within the system necessary to achieve the threshold nitrogen concentrations were not attainable even with 100% removal of septic load (associated with direct groundwater discharge to the embayment) for the systems watershed. The limited circulation within the system prevents the threshold goals from being achieved. This is consistent with the MEP measurements of significantly restricted tidal flows between Salt Pond and Vineyard Sound. This has been found in other estuaries with similar restrictions (e.g. Rushy Marsh Pond, Farm Pond). In such cases a reduction of the tidal restriction is needed to lower the level of nitrogen enrichment and restore the impaired habitats. This will likely be the case for Salt Pond, as well.

Table ES-1. Existing total and sub-embayment nitrogen loads to the estuarine waters of Salt Pond system, observed nitrogen concentrations, and sentinel system threshold nitrogen concentrations.

| Sub-embayments | Natural Background Watershed Load [1] (kg/day) | Present Land Use Load [2] (kg/day) | Present Septic System Load (kg/day) | Present WWTF Load [3] (kg/day) | Present Watershed Load [4] (kg/day) | Direct Atmospheric Deposition [5] (kg/day) | Present Net Benthic Flux (kg/day) | Present Total Load [6] (kg/day) | Observed TN Conc. [7] (mg/L) | Threshold TN Conc. (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|
| ***SYSTEMS*** | | | | | | | | | | |
| Salt Pond | 0.241 | 1.263 | 3.488 | -- | 4.751 | 0.789 | 1.439 | 6.979 | 0.35-1.41 | -- |
| **System Total** | **0.241** | **1.263** | **3.488** | **--** | **4.751** | **0.789** | **1.439** | **6.979** | **0.35-1.41** | **0.50[8]** |

1 assumes entire watershed is forested (i.e., no anthropogenic sources)
2 composed of non-wastewater loads, e.g. fertilizer and runoff and natural surfaces and atmospheric deposition to lakes
3 existing wastewater treatment facility discharges to groundwater
4 composed of combined natural background, fertilizer, runoff, and septic system loadings
5 atmospheric deposition to embayment surface only
6 composed of natural background, fertilizer, runoff, septic system atmospheric deposition and benthic flux loadings
7 average of 2006 – 2012 data, ranges show the upper to lower regions (highest-lowest) of an sub-embayment. individual yearly means and standard deviations in Table VI-1.
8 Threshold for sentinel site located in Salt Pond was determined to be the average of the 3 long-term monitoring stations.

Table ES-2. Present Watershed Loads, Thresholds Loads, and the percent reductions necessary to achieve the Thresholds Loads for Salt Pond systems, Town of Falmouth, Massachusetts.

| Sub-embayments | Present Watershed Load [1] (kg/day) | Target Threshold Watershed Load [2] (kg/day) | Direct Atmospheric Deposition (kg/day) | Benthic Flux Net [3] (kg/day) | TMDL [4] (kg/day) | Percent watershed reductions needed to achieve threshold load levels |
|---|---|---|---|---|---|---|
| ***SYSTEMS*** | | | | | | |
| Salt Pond | 4.751 | -- | 0.789 | -- | -- | -- |
| **System Total** | **4.751** | -- | **0.789** | -- | -- | -- |

(1) Composed of combined natural background, fertilizer, runoff, and septic system loadings.
(2) Target threshold watershed load is the load from the watershed needed to meet the embayment threshold concentration identified in Table ES-1.
(3) Projected future flux (present rates reduced approximately proportional to watershed load reductions).
(4) Sum of target threshold watershed load, atmospheric deposition load, and benthic flux load.

# <u>APPENDIX B</u>
# Technical Memorandum – LEC Environmental Consultants

# MEMORANDUM

**DATE:** **May 29, 2013**

**TO:** **Ed Leonard (Wright Pierce)**

**FROM:** **Brian Madden (LEC)**

**Re:** **Oyster Pond Comprehensive Wastewater Management Plan Falmouth, MA**

**PROJECT #:** **WP\13-089.01**

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LEC has prepared this Memo to review potential state-listed rare species regulatory implications associated with preliminary planning of the Oyster Pond Comprehensive Wastewater Management Plan (CWMP).

According to the 13th edition of the *Massachusetts Natural Heritage Atlas* (effective October 1, 2008) published by the Massachusetts Natural Heritage and Endangered Species Program (NHESP), portions of the Oyster Pond Watershed are located within a Priority Habitat of Rare Species and/or Estimated Habitat of Rare Wildlife (see 4/8/13 Aerial Orthophoto and Figure 2-10). In response to a MESA Information Request, NHESP confirmed that northern portion of the Watershed extends into Priority Habitat 15 (PH 15)/Estimated Habitat 115 (EH 115), mapped for the presence of the Eastern Box Turtle (*Terrapene carolina*). The southwesterly tip of the Watershed also minimally extends into PH 385, mapped for the Common Tern (*Sterna hirundo*), Least Tern (*Sterna antillarum*), and Roseate Tern (*Sterna dougallii*). Roseate Tern is protected as an "Endangered" species under the *Massachusetts Endangered Species Act* (MESA, M.G.L. c. 131A) and its implementing *Regulations* (321 CMR 10.00), while the three (3) remaining are species of "Special Concern". The Roseate Tern is also protected under the federal Endangered Species Act (16 U.S.C. 1531-1544, 87 Stat. 884), as amended.

LEC understands that following a review of Baseline Conditions and a Needs Assessment, alternative traditional and non-traditional technologies and approaches will be explored. Technology options may include traditional and nontraditional sewer systems (e.g. gravity, vacuum, low pressure, step/steg), as well as transport to existing conveyance systems and the main wastewater treatment plant. On-site technologies, such as denitrifying systems and cluster systems will also be evaluated. The goal of the project is a CWMP that demonstrates a detailed analysis of the most cost effective and environmentally sound means of meeting the nitrogen reduction requirements of the Total Maximum Daily Load (TMDL) required by the MA DEP.

It is likely that elements of potential CWMP work activities within Priority Habitat will be exempt from MESA Project Review. Potential applicable exempt activities under 321 CMR 10.14 may include:

*(6) construction, repair, replacement or maintenance of septic systems, private sewage treatment facilities, utility lines, sewer lines, or residential water supply wells within existing paved areas and lawfully developed and maintained lawns or landscaped areas, provided there is no expansion of such existing paved, lawn and landscaped areas;*

*(7) repair, replacement or maintenance of existing, properly maintained stormwater detention basins or other stormwater management systems;*

*(8) construction of new stormwater management systems that are designed to improve stormwater management at previously developed sites, provided that the plans for the system are submitted to the Division for prior review, and the Division makes a written determination that such systems will not have an adverse impact on state-listed species or their habitats;*

*(9) repair, replacement or maintenance of existing, properly maintained dry hydrant pipe systems;* or

*(10) 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, and the repair and maintenance of overhead utility lines (phone, electrical) for which all associated work is within ten feet from the edge of existing unpaved roads, provided, however, that unpaved utility access roads associated with exempt activities under 321 CMR 10.14(11) shall be addressed in and subject to the Division-approved operation and maintenance plan required thereunder;*

Any non-exempt CWMP work activities within Priority Habitat require MESA Project Review. NHESP always recommends that rare species habitat concerns be addressed during the preliminary project design phase prior to submission of a formal filing, as avoidance and minimization of impacts to rare species and their habitats is likely to expedite endangered species regulatory review under MESA.

Potential CWMP work activities within PH 385 are unlikely to materially impact potential *Sterna* spp. habitat. PH 385 is essentially mapped as a potential *Sterna* spp. flyover between Vineyard Sound (south) and Quissett Harbor/Buzzards Bay (north). Nevertheless, non-exempt CWMP work activities within PH 385 will require MESA Project Review.

Non-exempt CWMP work activities within PH 15/ EH 115 will be evaluated in the context of potential impacts to Eastern Box Turtle habitat that may rise to the level of a "take" of the state-listed species. A "take", in reference to animals, means to "harass, harm, pursue, hunt, shoot, hound, kill, trap, capture, collect, process, disrupt the nesting, breeding, feeding or migratory activity or attempt to engage in any such conduct, or to assist such conduct". Activities resulting in Eastern Box Turtle habitat modification, degradation, or destruction may result in the disruption of nesting, breeding, feeding or migratory activity, thus constituting a "take".

NHESP's positive determinations may come in three forms:

1) No "take"; the project is approved as proposed.

2) Conditional no "take"; the project is approved as proposed along with specific conditions (e.g., work timing considerations, construction protection measures, restrictive covenants—Declaration of Restrictions or Conservation Restrictions, etc.)

3) Permitted "take"; the Applicant has avoided, minimized, and mitigated impacts to state-listed species, exhausted all viable alternatives, the project results in an insignificant impact to the local population, and the Applicant provides a long-term net benefit to the state-listed species. NHESP will issue a Conservation & Management Permit for an authorized "take". Additionally, if a "take" occurs on a project site of 2 or more areas within a Priority Habitat, an Applicant will need to file with MEPA.

Please note that potential CWMP work activities within EH 115 that require submission of a Notice of Intent to the Falmouth Conservation Commissions and DEP, also necessitate NHESP review under the *Massachusetts Wetlands Protection Act* (WPA, M.G.L. c. 131, § 40) and its implementing Regulations (310 CMR 10.00).

LEC is pleased to provide this preliminary overview of potential state-listed rare species regulatory implications associated with the CWMP and we look forward to further review as the Needs Assessment and Alternatives Analysis are evaluated. Should you have any immediate questions or comments, feel free to contact me at 508-746-9491 or bmadden@lecenvironmental.com.

*Commonwealth of Massachusetts*

# Division of Fisheries & Wildlife

MassWildlife

Wayne F. MacCallum, *Director*

May 07, 2013

Brian Madden
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12 Resnik Road, Suite 1
Plymouth MA 02360

RE: Project Location: Oyster Pond Watershed Area
Town: FALMOUTH
**NHESP Tracking No.: 13-32156**

To Whom It May Concern:

Thank you for contacting the Natural Heritage and Endangered Species Program of the MA Division of Fisheries & Wildlife (the "Division") for information regarding state-listed rare species in the vicinity of the above referenced site. Based on the information provided, this project site, or a portion thereof, is located **within** *Priority Habitat 15 & 385* (PH 15 & 385) and *Estimated Habitat 115* (EH 115) as indicated in the *Massachusetts Natural Heritage Atlas* (13th Edition). Our database indicates that the following state-listed rare species have been found in the vicinity of the site:

*Priority Habitat 15* (PH 15) and *Estimated Habitat 115* (EH 115):

| Scientific name | Common Name | Taxonomic Group | State Status |
|---|---|---|---|
| *Terrapene carolina* | Eastern Box Turtle | Reptile | Special Concern |

*Priority Habitat 385* (PH 385):

| Scientific name | Common Name | Taxonomic Group | State Status |
|---|---|---|---|
| *Sterna hirundo* | Common Tern | Bird | Special Concern |
| *Sternula antillarum* | Least Tern | Bird | Special Concern |
| *Sterna dougallii* | Roseate Tern | Bird | Endangered |

The species listed above are protected under the Massachusetts Endangered Species Act (MESA) (M.G.L. c. 131A) and its implementing regulations (321 CMR 10.00). State-listed wildlife are also protected under the state's Wetlands Protection Act (WPA) (M.G.L. c. 131, s. 40) and its implementing regulations (310 CMR 10.00). Fact sheets for most state-listed rare species can be found on our website (www.nhesp.org).

Please note that projects and activities located within Priority and/or Estimated Habitat **must** be reviewed by the Division for compliance with the state-listed rare species protection provisions of MESA (321 CMR 10.00) and/or the WPA (310 CMR 10.00).

## Wetlands Protection Act (WPA)

If the project site is within Estimated Habitat and a Notice of Intent (NOI) is required, then a copy of the NOI must be submitted to the Division so that it is received at the same time as the local conservation commission. If the Division determines that the proposed project will adversely affect the actual Resource Area habitat of state-protected wildlife, then the proposed project may not be permitted (310

CMR 10.37, 10.58(4)(b) & 10.59). In such a case, the project proponent may request a consultation with the Division to discuss potential project design modifications that would avoid adverse effects to rare wildlife habitat.

A streamlined joint MESA/WPA review process is available. When filing a Notice of Intent (NOI), the applicant may file concurrently under the MESA on the same NOI form and qualify for a 30-day streamlined joint review. For a copy of the NOI form, please visit the MA Department of Environmental Protection's website: http://www.mass.gov/dep/water/approvals/wpaform3.doc.

**MA Endangered Species Act (MESA)**

If the proposed project is located within Priority Habitat and is not exempt from review (see 321 CMR 10.14), then project plans, a fee, and other required materials must be sent to Natural Heritage Regulatory Review to determine whether a probable "take" under the MA Endangered Species Act would occur (321 CMR 10.18). Please note that all proposed and anticipated development must be disclosed, as MESA does not allow project segmentation (321 CMR 10.16). For a MESA filing checklist and additional information please see our website: www.nhesp.org ("Regulatory Review" tab).

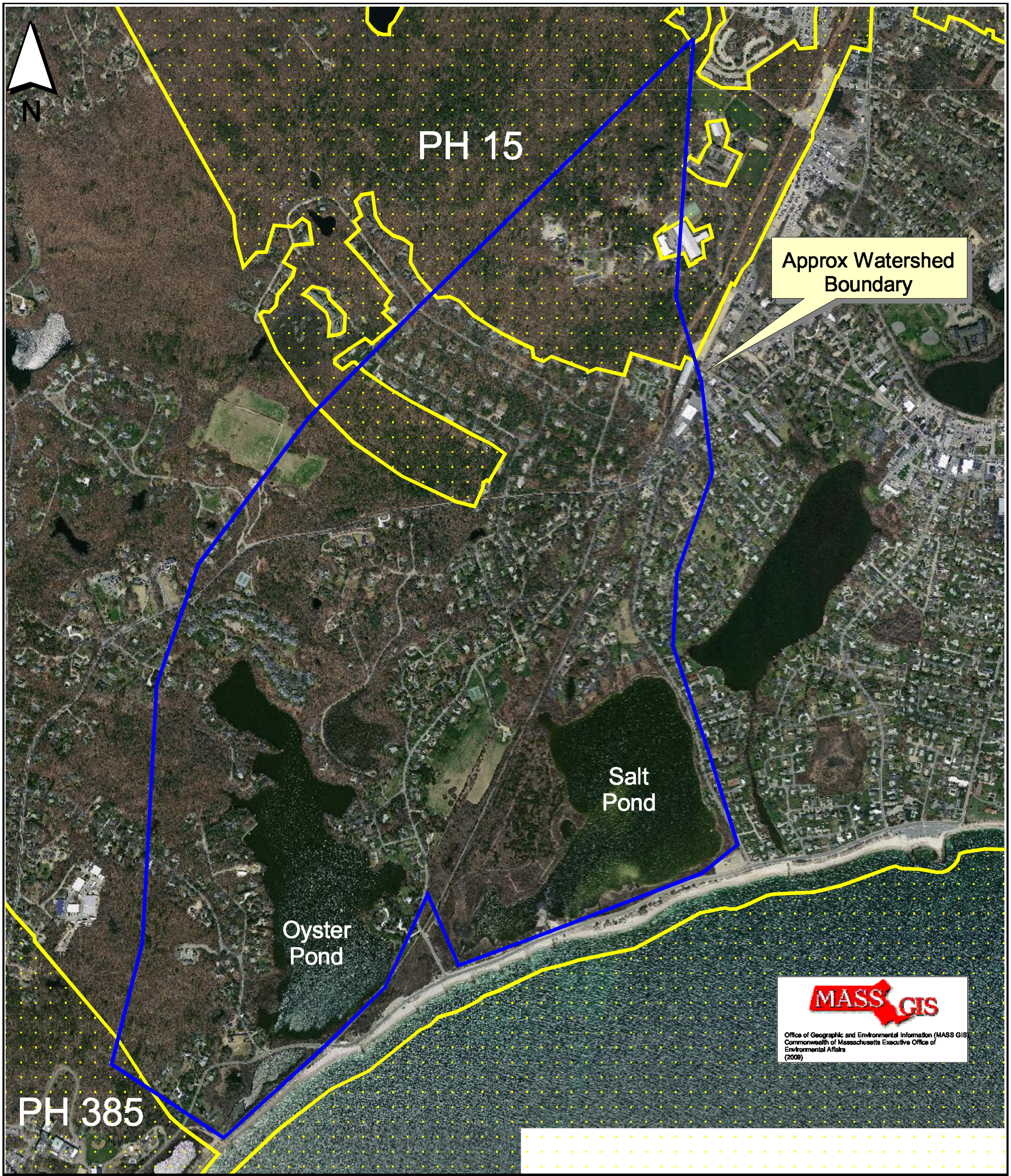
We recommend that rare species habitat concerns be addressed during the project design phase prior to submission of a formal MESA filing, as avoidance and minimization of impacts to rare species and their habitats is likely to expedite endangered species regulatory review.

This evaluation is based on the most recent information available in the Natural Heritage database, which is constantly being expanded and updated through ongoing research and inventory. If you have any questions regarding this letter please contact Amy Coman-Hoenig, Endangered Species Review Assistant, at (508) 389-6364.

Sincerely,

Thomas W. French

Thomas W. French, Ph.D.
Assistant Director




LEC

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508-746-9491
www.lecenvironmental.com

# Aerial Orthophoto

Oyster Pond CWMP
Falmouth, MA

Approx Scale
1:850

April 8, 2013

# APPENDIX C
# Technical Report – Woods Hole Group

# Oyster Pond Review

Prepared For:

Wright- Pierce
40 Shattuck Way, Suite 305
Andover, MA 01810

Prepared By:

Woods Hole Group, Inc.
81 Technology Park Drive
East Falmouth, MA 02536

July 2013

# Oyster Pond Review

**July 2013**

**Prepared for:**
Wright- Pierce
40 Shattuck Way, Suite 305
Andover, MA 01810

**Prepared by:**
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81 Technology Park Drive
East Falmouth MA  02536
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## 1.0 INTRODUCTION/BACKGROUND

The purpose of this technical memo is to summarize changes in the conditions of water quality, or other environmental conditions, in Oyster Pond (Falmouth, MA) since the baseline studies were conducted and reported by UMASS Dartmouth's School of Marine Science and Technology (SMAST) in 2006. The monitoring work that supported the associated Massachusetts Estuary Project (MEP) report, and subsequent Oyster Pond Total Maximum Daily Load (TMDL), took place from 1997 through 2004. The monitoring effort was a combination of long-term monitoring through the Falmouth Pond Watchers organization, a non-profit community group with ties to Woods Hole Sea Grant, and the SMAST department of UMASS Dartmouth.

Oyster Pond is unique in character due to its physical and hydrodynamic setting. Physical characteristics include two distinct bathymetric features located in both the northern and southern portions of the pond. These are composed of two deep basins that contribute to the commonly observed stratified condition in the pond where roughly 3 to 4 meters of the surface water "floats" over the remaining bottom water (at between 3 to 6 meters depth) and exchange between the two layers is only periodic when temperature and wind conditions allow mixing. These deep basins typically hold cooler, saltier water that is not significantly mixed through tidal action or wind.

The nature of tidal communication with Vineyard Sound water is limited through a constructed water control system at its connection with a small tidal lagoon. There is a relatively small outlet, the Trunk River that connects this lagoon to Vineyard Sound. Seawater from Vineyard Sound is delivered to the pond from occasional wash over events during storms and periodic extreme astronomical tides.

These physical characteristics have resulted in the pond's surface waters having salinities typically between 2 and 4 parts per thousand (ppt). The bottom waters (about 20% of total pond volume) are typically more saline (4 ppt to 13 ppt) and, as described above, only mix with surface waters on a periodic basis.

The MEP report concluded that Oyster Pond is impaired from excessive nutrient loads from its contributing watershed. The nutrient of importance is nitrogen (determined through nutrient limitation studies). Unlike most other south Cape estuarine systems studied under the MEP, Oyster Pond does not support eelgrass (*Zostera marina*) habitat due to low salinities within the photic zone. Therefore, dissolved oxygen (DO) was selected as the ecological endpoint to base nitrogen load reductions on in order to support Oyster Pond's benthic community. The target reduction was associated with sustaining a minimum DO concentration of 6.0 mg/l at the base of the surface water column layer (4.0 m depth) where salinity ranges between 2 to 4 ppt. The load reduction was calculated as a linear (1:1) relationship with the percent increase in minimum DO concentrations required to get to the target concentration of 6.0 mg/l.

The Falmouth Pond Watchers have continued to monitor water quality in Oyster Pond since the MEP report was released in 2006. This memo summarizes these subsequent data (2005 through 2012) in context with the historical conditions described by SMAST in the MEP report. Oyster Pond is a unique estuarine system and the job of determining critical nitrogen loads is certainly challenging given the physical nature of this system. The additional Pond Watcher data, along with the documentation of changes in the watershed and Trunk River allow further study of the system's variability and current water quality and ecological conditions.

# 2.0 OYSTER POND

## 2.1 OYSTER POND CHANGE SUMMARY

This section provides a summary of important changes in conditions within Oyster Pond since the MEP field assessment was completed (data applied from 1997 through 2004).

### Nitrogen Data Review

The MEP process involves a two-step modeling approach to establish nitrogen reductions (from watershed sources) necessary to achieve a specified condition at points that are identified as "sentinel" stations. Watershed loads to Oyster Pond are based on a watershed loading model that uses inputs from land use and land parcel data to derive estimates of total nitrogen (TN) that Oyster Pond receives on an annual basis. Field monitoring for a minimum period of 3 years produces data to (1) characterize existing conditions and (2) help calibrate (tune) a hydrodynamic/water quality model. The hydrodynamic model is used to simulate physical flushing within the estuary and the expected mean TN concentrations at various sections of the system. Typically, the MEP process is to average the observed TN data, calibrate the hydrodynamic model to fit these observed data (by station) through changing some physical parameters within the model (e.g., dispersion coefficient). Once calibrated, the model is used to predict the TN loading rate from the watershed (while recognizing the tidal flux of offshore nitrogen) that corresponds to a TN target concentration.

This process was conducted on Oyster Pond using field data collected from 1997 through 2004. Although the raw data have not been made available for this review exercise, the TN concentrations are summarized, by station, in the MEP report. The following is a summary of findings.

The MEP report used measured TN concentrations from 3 sampling stations[1]: OP1, OP2, and OP3 (Figure 1). The concentrations are summarized and compared to modeled concentrations in Table VI-1 on page 82 of the MEP report (Table 1, below). The report shows TN concentrations in the surface layer (<4 m depth) ranging very little from 0.70 mg/l. The model was calibrated to within a very small difference of reported mean TN values.

[1] Additional stations were monitored by Falmouth Pond Watchers; however, these three stations form the basis of model calibration and the subsequent TMDL.

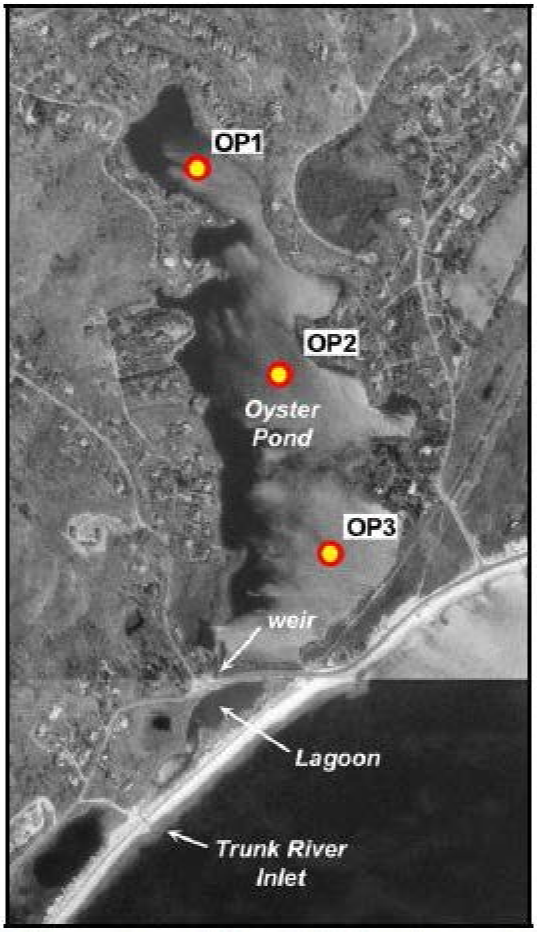


**Figure 1. Oyster Pond MEP sampling locations.**

**Table 1. Oyster Pond MEP summary of TN concentrations and model performance.**

Table VI-1. Falmouth PondWatch measured data, and modeled Nitrogen concentrations for the Oyster Pond system used in the model calibration plots of Figure VI-2. All concentrations are given in mg/L N. "Data mean" values are calculated as the average of the separate yearly means.

| Sub-Embayment | monitoring station | data mean | s.d. all data | N | model min | Model max | model average |
|---|---|---|---|---|---|---|---|
| Oyster Pond - Head | OP1 | 0.695 | 0.026 | 50 | 0.646 | 0.747 | 0.696 |
| Oyster Pond - Mid | OP2 | 0.669 | 0.018 | 81 | 0.644 | 0.746 | 0.694 |
| Oyster Pond – Lower, deep basin | OP3 | 0.705 | 0.157 | 84 | 0.641 | 0.746 | 0.693 |
| Vineyard Sound | VS | 0.280 | 0.065 | 196 | - | - | 0.280 |

The number of samples shown in Table 1 corresponds to a collection period of 1997 through 2004; however, at this time we do not have access to the raw data so the timing and frequency of sampling within this period is unknown. It is assumed that sampling occurred on at least a monthly basis from April through October, with occasional winter sampling, each year. The MEP report states that the model was calibrated with average summer season TN concentrations.

The results of subsequent OPET sampling depict inter-annual variability in total dissolved nitrogen (TDN) trends in Oyster Pond. The difference between TN and TDN is the amount of particulate organic nitrogen (PON) present in the water. Therefore, the OPET data cannot be directly compared with the TN summary of means that have been reported in the MEP report. Having the full suite of water quality data that supported the MEP work would offer the possibility for comparisons of TDN and specific species of N ($NO_3$, $NH_4$, and dissolved organic N). In a review of limited historical data published in the 1998 annual Pond Watchers summary report of 1997 data, PON composed between 12% and 43% of TN. At the old site OP3, PON comprised 16% of TN. At this time information is insufficient to accurately characterize the relationship between TN and TDN in Oyster Pond. Furthermore, without the entire suite of water quality data associated with the MEP report, and subsequent TMDL, it is difficult to assess the extent to which changes in TDN and subspecies of nitrogen have occurred since the period covering the MEP assessment. However, the following is a summary of the OPET data covering the period 2005 through 2012.

Figure 2 shows the average surface mixed layer (OP1, OP2, and OP3) TDN concentrations throughout the entire Falmouth Pond Watcher monitoring program from 2005 through 2012. The summer values of TDN are consistently lower than the means reported by the MEP (Figure 1, Table 1) which is due to the omission of PON in these surveys.

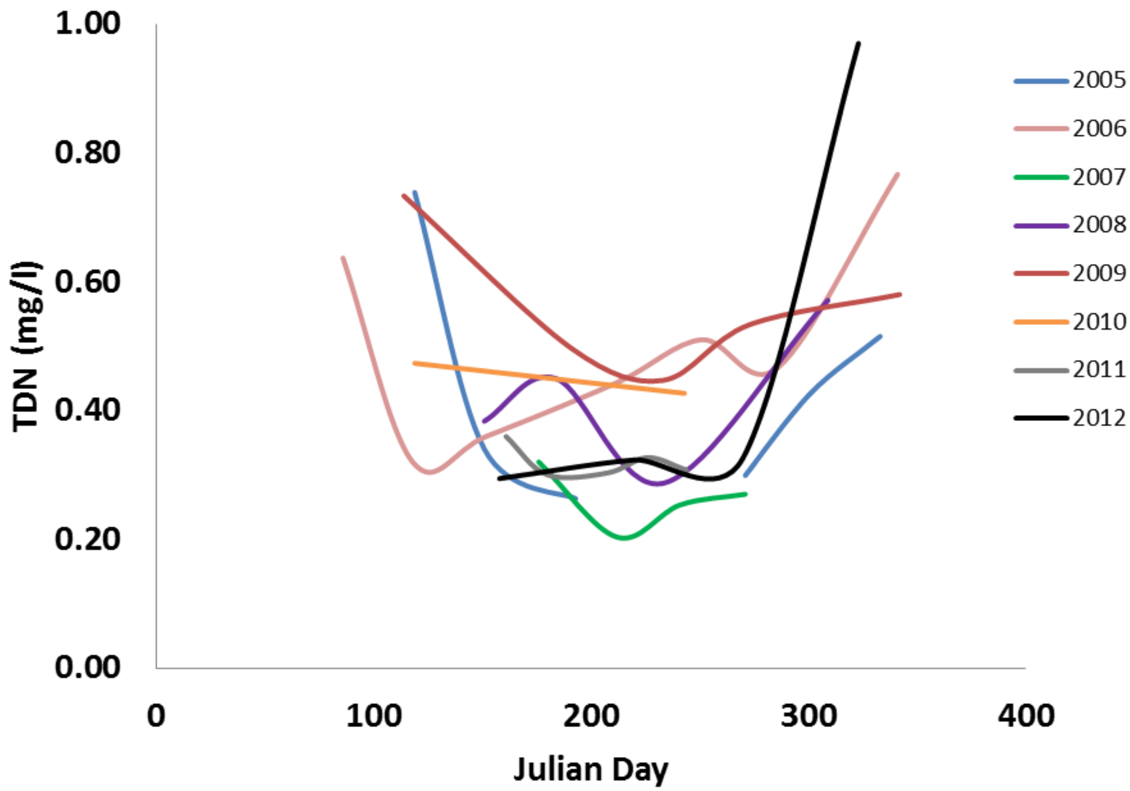


**Figure 2.** **Average surface mixed layer total dissolved nitrogen concentrations in Oyster Pond from 2005 through 2012. Average of surface observations from stations OP1, OP2, and OP3.**

For comparison, Figure 3 shows the summer, or growing season, averaged TDN concentrations for all 7 years of the recent monitoring period (2005 through 2012). Corresponding values (mean and standard deviation) are shown in Table 2 and compared with the MEP values.

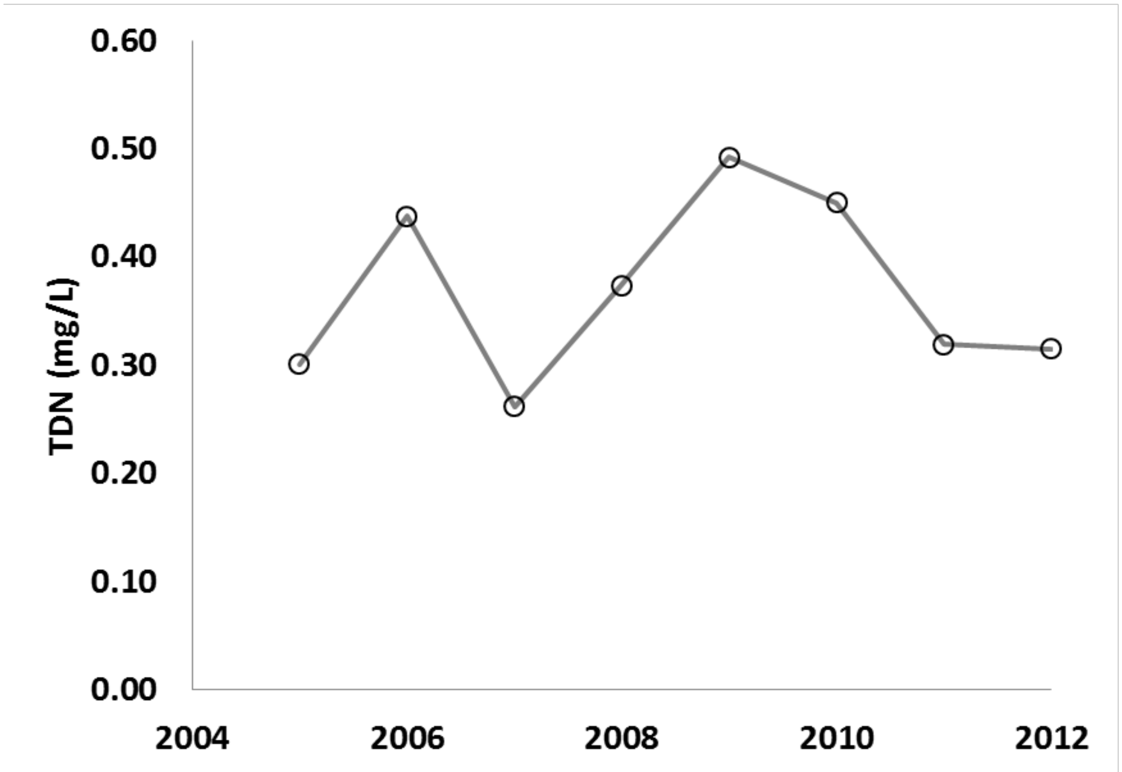


**Figure 3. Mean summer (May through September) surface layer TDN concentrations for Oyster Pond sampling stations OP1, OP2, and OP3.**

**Table 2. Summary and comparison of TDN and estimated TN concentration data from two different sampling periods. Estimated TN values for 2005 through 2012 shown in parentheses.**

| Monitoring Station | 2005 – 2012 mean | s.d. | N | 1997 – 2004 mean | s.d. | N |
|---|---|---|---|---|---|---|
| OP1 | 0.360 (0.537) | 0.087 | 25 | 0.695 | 0.026 | 50 |
| OP2 | 0.353 (0.527) | 0.101 | 25 | 0.669 | 0.018 | 81 |
| OP3 | 0.347 (0.518) | 0.103 | 25 | 0.705 | 0.157 | 84 |
| All Combined | 0.35 (n/a) | 0.09 | 75 | - | - | 215 |

The MEP TN means are not directly comparable to the OPET TDN data because PON is not accounted for. The limited historical data show a range of 12% and 43% of PON in TN and a review of other pond data (Little Pond, Green Pond) resulted in a mean of 33% PON in TN. A graphical summary of nitrogen species within the water column in K.O. Emery's *A Coastal Pond* reports PON as approximately 35% of the pond's surface water TN concentration. The estimate that PON is 33% of TN applied to the values shown in

Table 2

~~Table 12~~ suggest a possible improvement in water quality since the MEP report data set (shown in parentheses). Historically, there was a trend of decreasing TN at OP2 where it dropped from about 1.2 to 0.6 mg/l in the 1990s (Figure 4). The Pond Watchers report attributes this to the successful restoration of the salinity structure of the pond (surface maintained at 2 to 4 ppt) – a condition that allows the separation of the surface and bottom layers of water and the maintenance of higher water quality in the surface mixed layer.

There have also been documented changes to the Oyster Pond watershed and the Trunk River inlet throughout this more recent time frame. These are summarized in Table 3. Note that tidal exchange was more frequently maintained throughout this period (1998 through 2012) despite some significant storm events that temporarily closed the inlet or resulted in overwash.

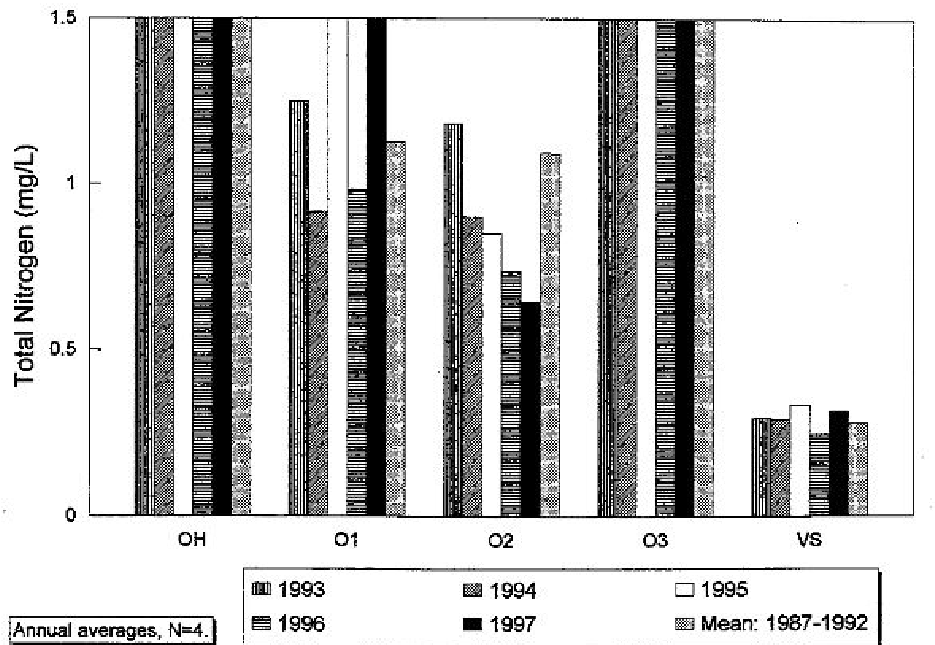


Figure 8. Oyster Pond average bottom water oxygen (Top) and total nitrogen (Bottom) levels during 1997. The freshening of the pond, 1995-1997 (Fig. 7), has resulted in a decrease in summer stratification such that the mid-basin has been oxygenated since the fall of 1994 and nitrogen levels have declined. The depth of the top of the hydrogen sulfide-high nitrogen zone of the deep basin has also declined from 4 m to 6 m over this same period (not shown).

**Figure 4. From the 1998 annual Falmouth Pond Watchers report: summary of TN concentrations in Oyster Pond from 1993 through 1997.**

**Table 3. Relevant changes to Oyster Pond and environs (1979 through 2012). Source: OPET.**

| Date/Year | Relevant Changes to Oyster Pond and Environs |
|---|---|
| 1979-1980 | Treetops built |
| 1987 – Present | Pond Watchers monitoring of Oyster Pond. |
| 1989/1990 | Culvert collapses and forms blockage for several months. |
| 1990 | Culvert replaced roughly 3 times larger than previous one. |
| TBD | Woods Hole Rd. stormwater improvements. |
| 1998 | Weir is constructed to control the amount of sea water entering the pond. |
| 2001 | Trunk River dredged, the bottom lined, and jetties repaired and rebuilt. |
| 2004 | Trunk River dredged due to severe algal growth in the lagoon. |
| 2005, 2006, 2007 | Additional hand dredging of Trunk River to maintain outflow. |
| 2005 | OPET initiates independent water quality sampling program. |
| 2010 | Major dredging of Trunk River and lagoon. |
| 2010 | A second major dredging of Trunk river after storm event. |
| 2010 | Ransom Rd. drainage and paving completed. |
| 2010 | Final drain adjustments made to Ransom Rd. improvements. |
| 2011 | Treetops Condos begins transition to an organic landscaping regime. |
| 2011 | More dredging of lagoon by OPET due to buildup of dead eelgrass. |
| 2011 | Tropical Storm Irene. (August 2011) |
| 2012 | Hurricane Sandy. (October 2012) |

The activities associated with increasing drainage from the pond, stabilizing the salinity regime, and controlling stormwater and fertilizer delivery to the pond appear to have contributed to lower nitrogen concentrations that have been observed in Oyster Pond since the late 1990s.

**Phosphorus Data Review**

OPET includes phosphorus in their monitoring program. Initially, total phosphorus (TP) was reported from 2005 through April 2006. From April 2006 to the present OPET reports total dissolved phosphorus (TDP) and/or dissolved inorganic phosphorus (DIP, reported as phosphate) at varying frequencies (i.e., sometimes one or the other, or both).

Trends of TP, TDP, and phosphate ($PO_4$) concentrations in the surface waters of Oyster Pond are shown in Figures 5, 6, and 7.

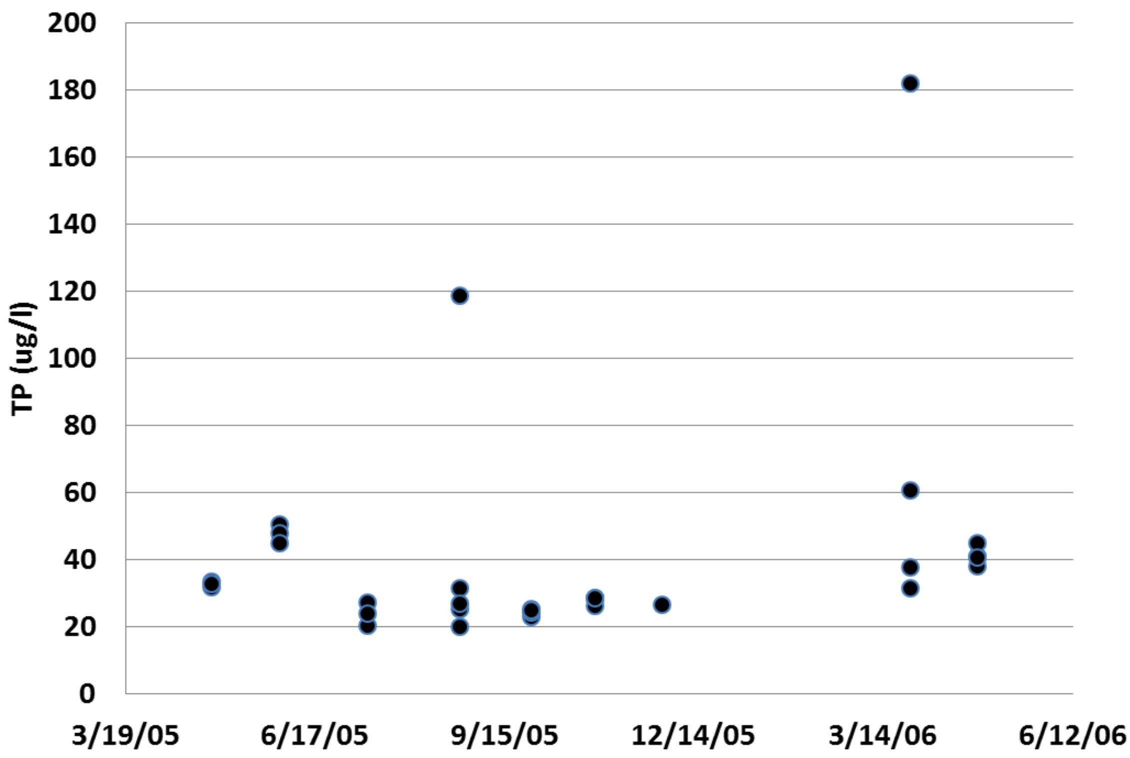


**Figure 5.** **Total phosphorus (TP) concentrations in the surface layer of Oyster Pond.**

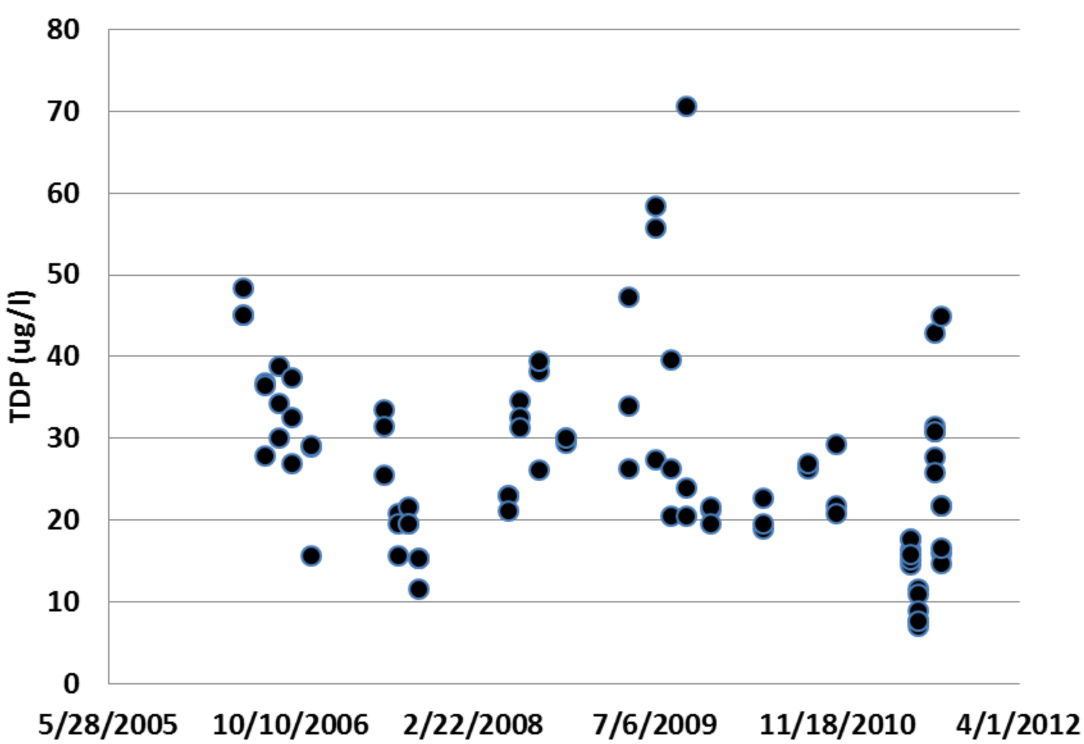

**Figure 6. Total dissolved phosphorus (TDP) concentrations in the surface layer of Oyster Pond.**

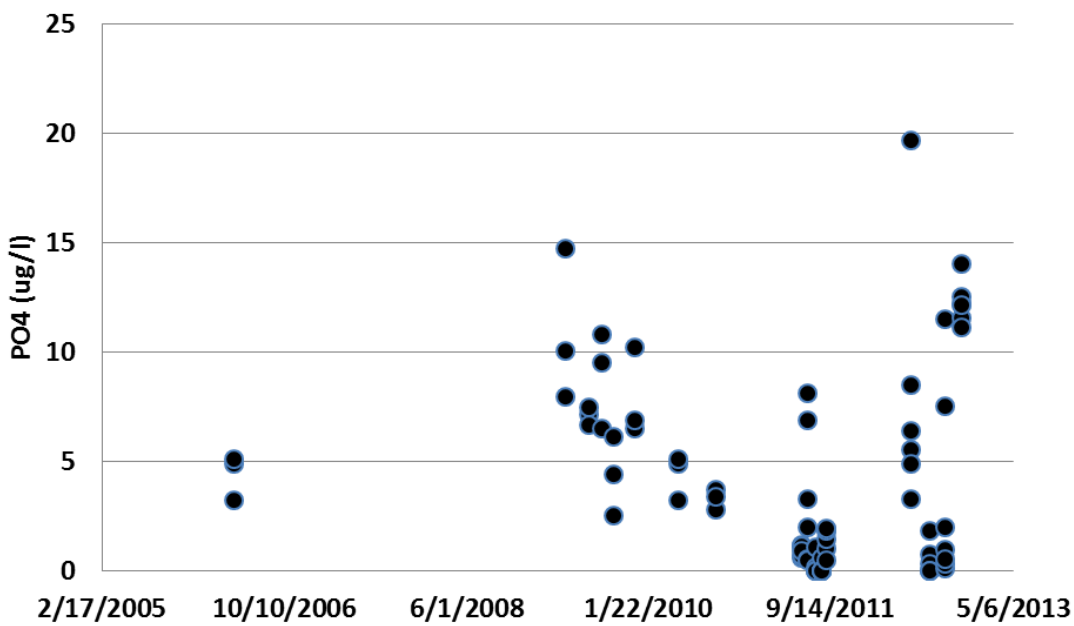


**Figure 7. Phosphate ($PO_4$) concentrations in the surface layer of Oyster Pond.**

## N:P and Nutrient Limitation

The phosphorus concentration in the surface layer (to 4 meters in depth) is important with regard to determining which nutrient, N or P, limits growth of algae and macrophytes within Oyster Pond. In general, marine systems are nitrogen limited and freshwater systems are phosphorus limited. This has to do, primarily, with the nature of how phosphorus is cycled within each type of environment. Typically, when the N:P falls below 10 then nitrogen is considered limiting. If N:P is greater than 17 then phosphorus is considered limiting. Previous unpublished studies on Oyster Pond have suggested that both N and P limit phytoplankton production. In an enrichment study conducted by Erlitz et al. (unpublished) the results suggested that phytoplankton growth increased with the addition of both N and P rather than from either one alone. The authors cite Dixon et al. (2002) as reporting that the "current" N:P ratio in Oyster Pond is 6:1. A review of the OPET nutrient data suggest that nutrient limitation can shift from nitrogen to phosphorus and can be considered equally limited (N:P between 10 and 17) (Figure 8)

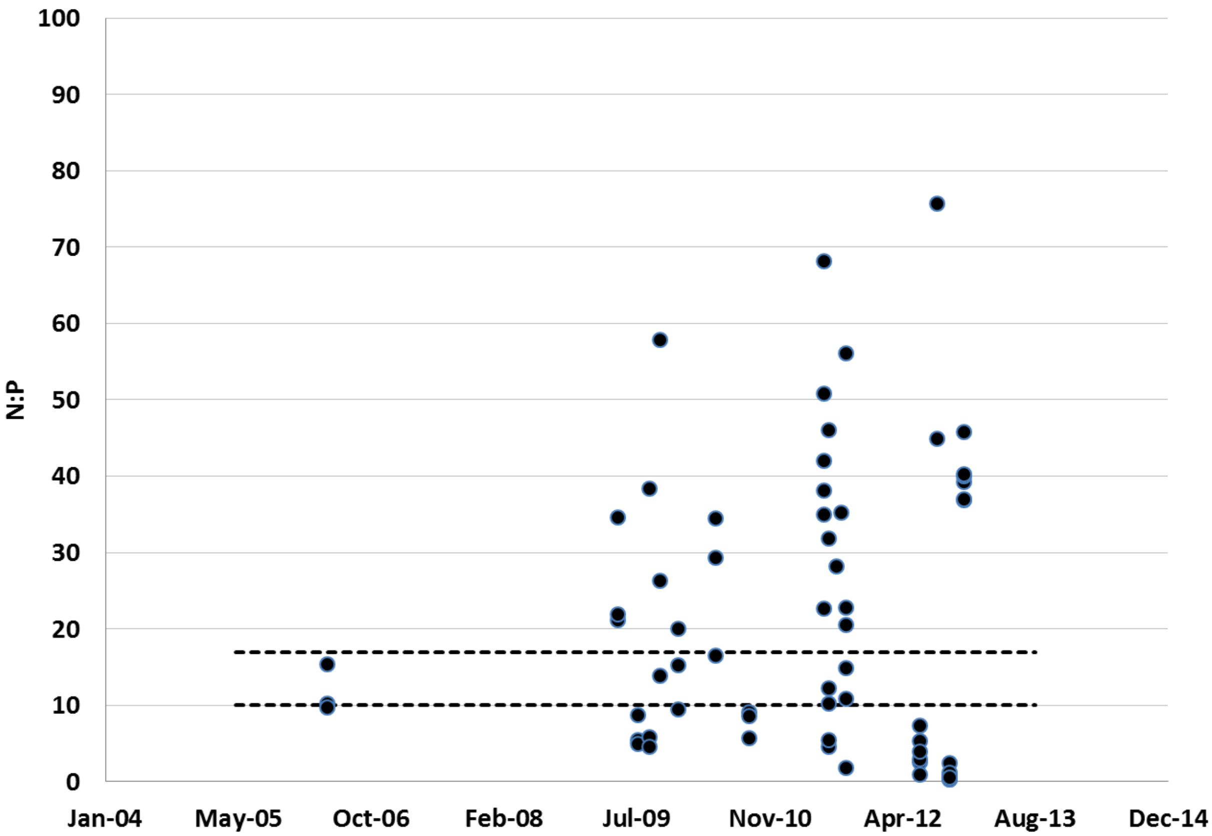


**Figure 8. N:P ratio in Oyster Pond's surface layers. Dashed lines indicate approximate limitation thresholds (10 and 17) for nitrogen and phosphorus, respectively.**

The mean and median values of N:P in Oyster Ponds surface layer, not including three extremely high values reported in the data set[2], are 22 and 15, respectively. This suggests that the pond may be more limited by phosphorus than nitrogen at times. Therefore, management of both nutrients is warranted.

## Dissolved Oxygen and Stratification

As described above, the MEP report concluded that a desired sustainable target of at least 6.0 mg/l DO concentration at 4 m depth at sampling station OP3 would serve to improve water quality to the extent that the surface mixed layer would be relatively healthy and support a healthy benthic habitat. The nitrogen load reduction necessary to achieve this, based on MEP modeling, was estimated with the application of the following equation:

*%N Reduction = (Target DO – Min. Observed DO)/(Max. Saturation – Min. Obs. DO) *100*

[2] Values were 392, 2,468, and 1,507.

According to the MEP (p. 102): *"Since the present nitrogen levels result in periodic hypoxia at 4 meters depth, the nitrogen threshold was set to improve and maintain oxygen levels >6 mg/L at 4 meters depth in the main basin (OP-3). At present, the minimum dissolved oxygen at this station is most likely 3 mg/L, although a single reading of 2 mg/L was recorded. Given the uncertainties in determining minimum D.O. in any estuary, the nitrogen threshold was set using 2 mg/L as the current minimum D.O. level. This adds a level of safety to the analysis."*

According to the resulting reduction calculations, the selection of 2 mg/l rather than 3 mg/l for the existing minimum observed DO accounts for a 65% reduction vs. a 58% reduction associated with a 3 mg/l minimum. It should be noted that these calculations are assuming temporally consistent, or static, salinity and temperature conditions (2 ppt at 25C).

There are several considerations associated with this load reduction scenario:

- Current DO and salinity conditions
- Variability of water column salinity and DO concentrations
- Benthic-pelagic exchanges of DO and nutrients
- Change in nutrient loadings

In the more recent years, the minimum observed DO concentration at station OP3 at the 4 m depth was 0.06 mg/l (August 7, 2012) and there are several others that are below the 2.0 mg/l minimum reported by MEP. Therefore, based on the MEP approach to determine the nitrogen threshold, the MEP load reductions would be an underestimate based on more recent data associated with the 4 m depth. But there are a few things to consider about the MEP approach. It assumes a static condition in the water column; that the 4 m depth is characteristic of the location of the pond's summer time pycnocline (the zone within the water column that separates less dense, lower salinity surface water from deeper, denser higher salinity water). However, the data do not necessarily support this. The observed 0.06 mg/l minimum corresponds to an observed salinity of 7.2 ppt which is not considered indicative of the 2-4 ppt mixed surface layer. A review of data from 2005 through 2012 reveals that the summertime pyncnocline varies in depth from 3 to 6 m (Figure 9).

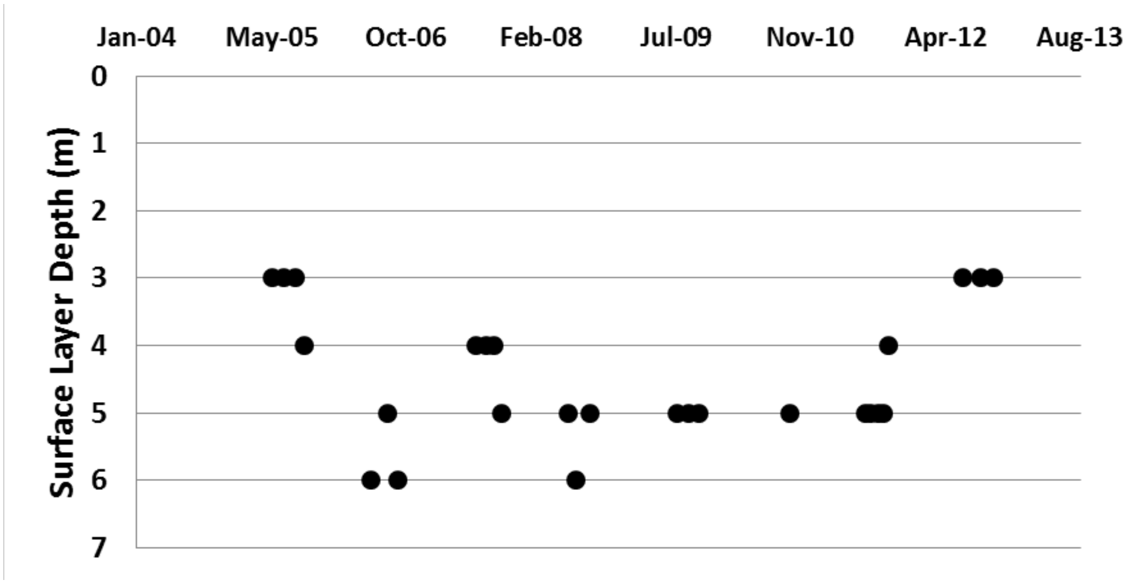


**Figure 9. Depths of summer pyncnoclines at station OP3 between 2005 and 2012 (defined as depth where salinity< 4 ppt).**

The data reveal that DO concentrations do vary with salinity and that the depth of the division between the pond's surface and bottom layers can vary significantly. This suggests that the variability of the location of the pyncnocline and corresponding DO concentrations should be more closely evaluated in the attempt to characterize the ability to (1) determine nitrogen concentration thresholds and (2) sufficiently determine the degree of compliance to these thresholds. In other words, without a probabilistic approach that integrates observed variability, there is a chance that low DO events could occur at the 4 m depth at any rate of nitrogen loading. Figure 6 shows the relationship between the location of the 4 ppt salinity pyncnocline and the corresponding observed DO values. It suggests that DO concentrations decline with depth of the 4 ppt salinity boundary and that DO varies widely at each boundary depth.

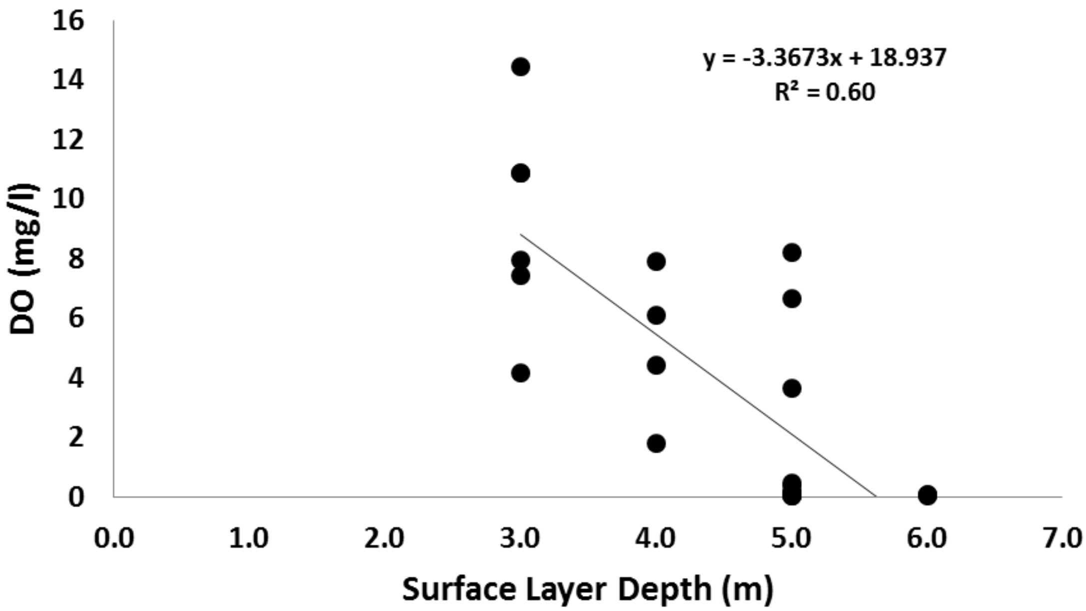


**Figure 10. The relationship between Oyster Pond surface layer depth (4 ppt salinity) and corresponding DO concentrations.**

The mean summertime DO value at 4 m depth from this period is 5.07 mg/l. The Massachusetts regulations are based on a minimum value, not the mean, which makes the timing of monitoring very important in determining whether Oyster Pond is below the Class SA designated use threshold of 6.0 mg/L. Oyster Pond, like most coastal aquatic systems, exhibits variability in DO concentrations. Figure 10 provides one example of the variability in DO concentrations based on discrete samplings. DO can also vary considerably throughout the daily (diel) period; very low DO can occur just before sunrise while supersaturating conditions can occur during the mid-afternoon. Although the MEP report does not report diel DO conditions in the pond, recent continuous measurements in the surface layer of Salt Pond depict this characteristic cycle (Figure 11). Therefore, the timing of sampling can have a significant impact on the understanding of DO dynamics in Oyster Pond. Certainly, with enough samples over the years it is possible that the mean conditions can be determined with some level of certainty. However, this should be demonstrated in Oyster Pond and the variability of DO in this water body should be better understood toward assessing the level of ecological impairment and the subsequent development of management plans.

Other states have integrated time-dependent variability in developing ecological thresholds associated with DO levels. For example, the DO criteria for Chesapeake Bay are based on five separate designated uses that are associated with defined geographical and bathymetrical features. The criteria also integrate frequency and duration such that variability in DO is accounted for. They also have temporal periods (e.g., migratory fish spawning periods) that are protective of specific ecological endpoints (Figure 12).

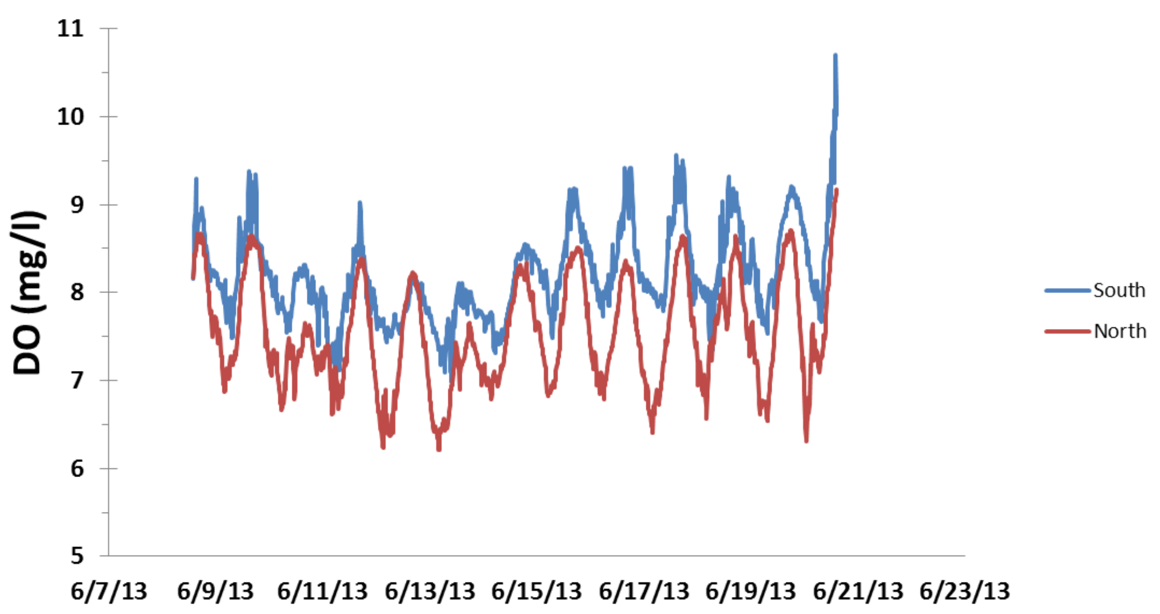


**Figure 11. Diel DO values at two shallow locations in Salt Pond, Falmouth. These are continuous observations (every 15 minutes) for a period of about 10 days in June 2013.**

Some measure of system variability should be considered with DO rather than random discrete values. DO concentrations can vary rapidly over time a space (on an hourly scale). This suggests that an approach to integrate frequency and duration of low DO events should be considered, such as a percentile approach. The effective boundary of the surface water layer in Oyster Pond varies vertically and, therefore, directly influences its horizontal (areal) extent.

| Designated Use | Criteria Concentration/Duration | Protection Provided | Temporal Application |
|---|---|---|---|
| Migratory fish spawning and nursery use | 7-day mean ≥ 6 mg liter$^{-1}$ (tidal habitats with 0-0.5 ppt salinity) | Survival/growth of larval/juvenile tidal-fresh resident fish; protective of threatened/endangered species. | February 1 - May 31 |
| | Instantaneous minimum ≥ 5 mg liter$^{-1}$ | Survival and growth of larval/juvenile migratory fish; protective of threatened/endangered species. | |
| | Open-water fish and shellfish designated use criteria apply | | June 1 - January 31 |
| Shallow-water bay grass use | Open-water fish and shellfish designated use criteria apply | | Year-round |
| Open-water fish and shellfish use | 30-day mean ≥ 5.5 mg liter$^{-1}$ (tidal habitats with 0-0.5 ppt salinity) | Growth of tidal-fresh juvenile and adult fish; protective of threatened/endangered species. | Year-round |
| | 30-day mean ≥ 5 mg liter$^{-1}$ (tidal habitats with >0.5 ppt salinity) | Growth of larval, juvenile and adult fish and shellfish; protective of threatened/endangered species. | |
| | 7-day mean ≥ 4 mg liter$^{-1}$ | Survival of open-water fish larvae. | |
| | Instantaneous minimum ≥ 3.2 mg liter$^{-1}$ | Survival of threatened/endangered sturgeon species.[1] | |
| Deep-water seasonal fish and shellfish use | 30-day mean ≥ 3 mg liter$^{-1}$ | Survival and recruitment of bay anchovy eggs and larvae. | June 1 - September 30 |
| | 1-day mean ≥ 2.3 mg liter$^{-1}$ | Survival of open-water juvenile and adult fish. | |
| | Instantaneous minimum ≥ 1.7 mg liter$^{-1}$ | Survival of bay anchovy eggs and larvae. | |
| | Open-water fish and shellfish designated-use criteria apply | | October 1 - May 31 |
| Deep-channel seasonal refuge use | Instantaneous minimum ≥ 1 mg liter$^{-1}$ | Survival of bottom-dwelling worms and clams. | June 1 - September 30 |
| | Open-water fish and shellfish designated use criteria apply | | October 1 - May 31 |

[1] At temperatures considered stressful to shortnose sturgeon (>29°C), dissolved oxygen concentrations above an instantaneous minimum of 4.3 mg liter$^{-1}$ will protect survival of this listed sturgeon species.

**Figure 12. Chesapeake Bay dissolved oxygen criteria.**

The mathematical relationship between mean DO and surface layer depth at station OP-3 is shown in Figure 13. Class SA and SB thresholds are shown for comparative purposes. The relatively steep slope of the curve suggests that mean DO is very sensitive (drops rapidly) with depth and that the 3.0 m value exceeds the threshold by a large margin (only one observation was below 6 mg/L, see Figure 10 above). Based on the variability in the summer salinity profile shown in Figure 9, it may be worthwhile for decision makers to consider a probabilistic approach to managing nitrogen load reductions. This could result in a more definitive and consistent approach to determining compliance of future load reductions to TMDL targets and overall water quality goals.

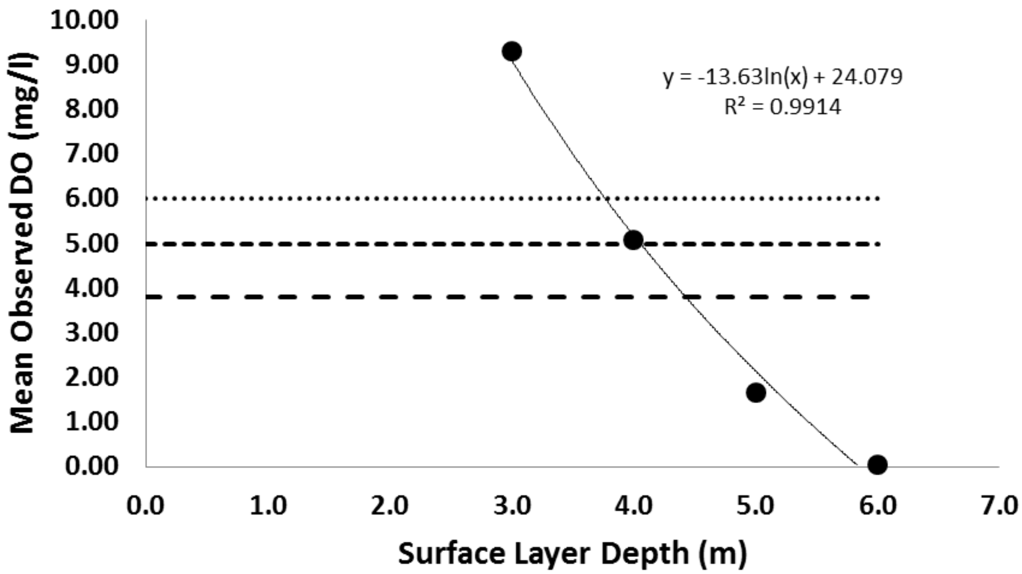


**Figure 13. The relationship between surface layer depth (4 m) and mean observed summer DO concentrations (mg/l) from 2005 through 2012 data. Dashed lines indicate DO thresholds for Chesapeake Bay (3.8), SB (5.0), and SA (6.0). Logarithmic trend is also shown.**

## 2.2 MEP CONCLUSION SUMMARY

The MEP report on Oyster Pond provides a summary of conditions observed 1997 through 2004. Based on the data collected and modeling work applied to the pond, the MEP calculated the nitrogen load reductions necessary to restore water quality to the surface mixed layer of the pond. The reductions were based on the following assumptions:

- The salinity regime will remain near-constant in the surface layer (at about 2-4 ppt).
- That station OP-3 is the best representative for basing TMDL compliance.
- The depth of 4 meters (at station OP-3) is the point where TMDL compliance should be met to assure water quality improvement throughout the entire pond.
- The SA classified designated use category, and criteria, should be applied to station OP-3 at depth of 4 m (DO maintained at or above 6 mg/L).
- Assumed that the nitrogen load reduction is a linear 1:1 relationship between percent increase in DO necessary for compliance and nitrogen load.
- The percent DO increase necessary to maintain 6 mg/L at 4 m depth at station OP-3 is based on a relationship between the minimum observed value of DO (assumed 2 mg/L), mean summer water temperature of 25C, and salinity of 2 ppt.
- DO consumption in the water column was assumed to be directly proportional to the amount of organic matter in Oyster Pond which was assumed to be proportional to nitrogen load.

- The final percent reduction of nitrogen load (65%) was based on the assumption that mean summer conditions would remain constant in the future due to the controlled salinity regime in the pond.

The nature of Oyster Pond certainly provides a challenge to ecological modelers because of the unique features of its bathymetry and stratification. However, the data collected by OPET in the years subsequent to the MEP work provides an insight to the natural variability of salinity and DO at depth and this variability would certainly affect the application of the model results.

### 2.3 CLIMATE CHANGE AND SLR

The predictions associated with are ripe with uncertainty. The benthic habitat of Oyster Pond may encounter changes in the frequency and duration of thermal stress events, including low DO that can be associated with increased temperature. The fauna may also respond to milder winters with fewer freezing events through changes in competition among existing fauna and the introduction and sustainability of non-native species. Sea level is maintained by the weir above the lagoon. However, the frequency and duration of flood events could increase as a result of sea level rise, especially during periodic increases in sea level that already naturally occur (Figures 14 and 15).

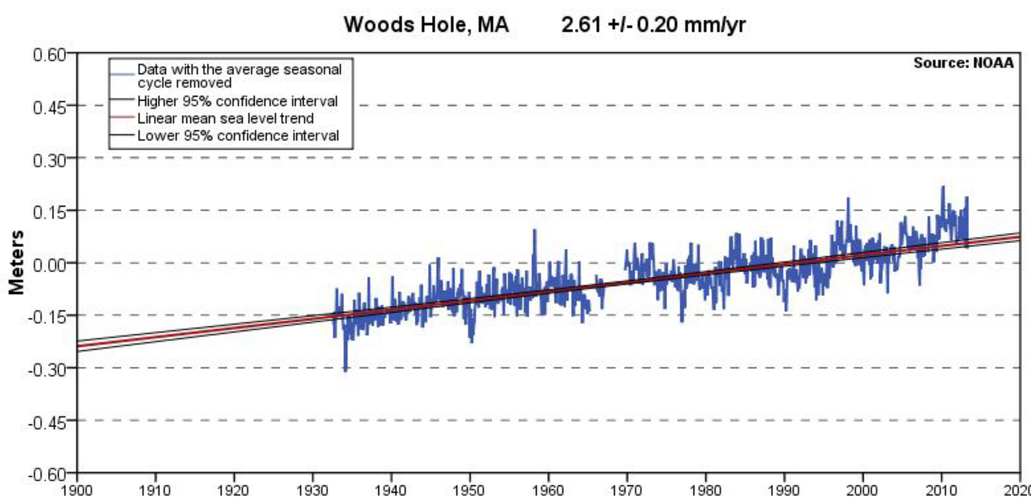


**Figure 14. The mean sea level trend is 2.61 millimeters/year with a 95% confidence interval of +/- 0.20 mm/yr based on monthly mean sea level data from 1932 to 2006 which is equivalent to a change of 0.86 feet in 100 years.**

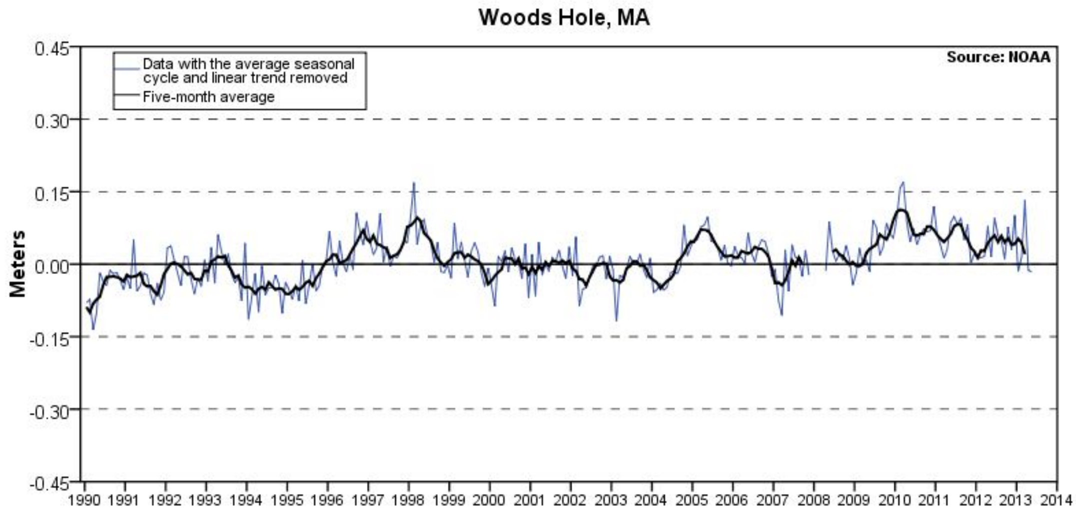


**Figure 15. The interannual variation of monthly mean sea level and the 5-month running average. The average seasonal cycle and linear sea level trend have been removed. Interannual variation is caused by irregular fluctuations in coastal ocean temperatures, salinities, winds, atmospheric pressures, and ocean currents. The interannual variation for some stations is closely related to the** El Niño Southern Oscillation (ENSO)**.**

The management of thermal stress and related ecological changes is somewhat limited because it is due to external environmental conditions. Increasing the flushing rate of Oyster Pond could ameliorate thermal stress events, but this would also alter the salinity of the surface waters and be contrary to current management of the pond. Sea level rise can be managed through engineering solutions (barrier dunes, reconstruction of the weir) to some extent and preparations for these types of responses could be explored now.

### 2.4 THERMAL AND DENSITY-INDUCED STRATIFICATION

The current conditions of summer stratification effectively segregates Oyster Pond's water column into two classes: relatively good surface water and organic-rich hypoxic and anoxic bottom waters. The margin between the surface and bottom can vary significantly (based on a review of OPET data) and each layer may influence each other depending upon their extent of physical or diffusive exchange. The current management of the pond allows for the preservation of the surface layer habitat (across up to 80% of the pond) at the cost of enhancing deleterious effects within the bottom layer. Preserving this salinity regime, as much as possible, will limit the exchange of hypoxic and anoxic bottom waters from the deeper regions of the pond to the surface. However, periodic turnovers or exchange events may result in temporary summer and seasonal declines in Oyster Pond's surface layer water quality. The nitrogen load reductions necessary to achieve improved water quality in the pond's surface waters will always depend upon the frequency and extent of surface and bottom mixing (note that ammonium concentration in the deeper regions of the pond can be quite high). Load reductions should also be practical to avoid unnecessary capital projects. To avoid this, a probabilistic approach that incorporates natural variability, pond-specific designated uses, and monitoring sufficient to have some acceptable level of confidence in the pond's conditions is recommended.

### 2.5 MONITORING METHODS

The monitoring methods employed by the MEP and OPET work are sufficient to characterize mean conditions and some of the variability along depth intervals in the pond. If dissolved oxygen continues to be the indicator of water quality, and benthic habitat quality, then continuous logging of DO should be applied to understand and quantify diel and event-driven influences on DO. Continued monitoring at the designated stations will allow comparisons to historical data and trends. The OPET database doesn't included PON which is an important nitrogen constituent in the MEP work. The dissolved nitrogen data from the MEP work, if made available, could be compared to the more recent OPET data in, perhaps, a more effective effort to track changes in the pond.

### 2.6 CONSEQUENCES OF NO ACTION FOR OYSTER POND

The consequences of not abating nutrient inputs to Oyster Pond likely include the continuation of good, but marginal, water quality. Benthic habitat will be marginal and may decrease over time with the accumulation of organic matter. Periodic nuisance macroalgal blooms are likely to continue due to the existing level of nutrient enrichment in the pond's surface waters. The bottom waters will continue to exhibit hypoxic and anoxic conditions even with modest to significant nutrient reductions due to the nature of this unique system. This persistent condition, due to the stratification of the water column, will continue to support periodic enrichment events because the pyncnocline is variable by nature and some exchange along the boundary of surface and bottom waters is likely.

### 2.7 SUGGESTED MONITORING PROGRAM

The monitoring program should be based on one or more hypotheses and planned through a rigorous statistical approach. In recent work in Little Pond, the Town has been encouraged to determine the minimum level of samples to collect over time to sufficiently determine whether the data will detect significant changes in water quality (e.g., TN concentration). Inter-annual differences in TN (and other important water quality indicators) occur frequently (see Figures 2, 3, and 4). The confidence in detecting independent and measurable changes in water quality is dependent upon the number of samples from Oyster Pond, and other environmental data (meteorological). This can be done by analyzing the variability in the MEP and OPET data. This requires the raw data such as reported online by OPET.

# APPENDIX D
## TMDL Compliance Calculations and Cost Model Backup
## Wright-Pierce

**WRIGHT-PIERCE**
Engineering a Better Environment™

# MEMORANDUM

| | | | |
|---|---|---|---|
| **TO:** | File | **DATE:** | 9/3/2019 |
| **FROM:** | Ed Leonard | **PROJECT NO.:** | 12727C |
| **SUBJECT:** | Oyster Pond CWMP – Appendix D Material | | |

The following information is contained in Appendix D:

- D1-Septic Load Removals for TMDL Compliance by Subwatershed (1 page)
- D2-Alternatives Analysis, Costs for Various Wastewater Management Alternatives (3 pages)
- D3-Estimated Annual Costs for Title 5, I/A Systems and Low-Pressure Lift Stations (1 page)
- D4-Quantities and Costs for Advanced I/A Plan, Phase 1 Only (1 page)
- D5-Quantities and Costs for Traditional Backup Plan, Phase 1 Only (2 pages)
- D6-Estimated Annual Costs for Responsible Management Entity (1 page)
- D7-Estimated Annual Costs for Sewer User Fees (1 page)
- D8-Traditional Backup Plan, E/One Lift Station Planning Level Analysis (30 pages)
- D9-Potential Project Financing Scenario (3 pages)

**FALMOUTH - OYSTER POND CWMP**
**SEPTIC LOAD REMOVALS FOR TMDL COMPLIANCE**

*Wright-Pierce, 6 Nov 2013, rev 7 Apr 2019, rev 28 June 2019*

| Oyster Pond Embayment | Existing MEP WW Load, Unattenuated (kg/yr) | New WW Load Between 2004 to 2016 (kg/yr) | Future WW Load over Planning Horizon (kg/yr) | Removal of Existing MEP WW Load | Removal of New and Future WW Load | Remaining Load, Unattenuated (kg/yr) | Natural Attenuation | Remaining Load, Attenuated (kg/yr) | No. of Developed Parcels (2016) | No. of Developed Parcels thru Planning Horizon | Total Developed Parcels at Planning Horizon | Total Parcels | Current Dwelling Units | Future Dwelling Units at Planning Horizon | Current Dwelling Units Managed | Future Dwelling Units Managed | Future Developed Parcels Managed at Planning Horizon |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Plan 1/ Plan 2 - BSR WWTF or WHOI Quisset WWTF with Out-of-Watershed Disposal** | | | | | | | | | | | | | | | | | |
| 1-Oyster Pond GT10N | 366.46 | - | 23.67 | 0% | 50% | 378.29 | 0% | 378.29 | 45 | 2 | 47 | 51 | 42 | 44 | - | 1 | 1 |
| 2-Oyster Pond GT10W | 43.06 | - | 11.81 | 100% | 100% | - | 0% | - | 15 | 1 | 16 | 19 | 15 | 16 | 16 | 16 | 16 |
| 3-Mosquito Creek_Oyster Pond | 10.10 | - | 1.72 | 100% | 100% | - | 30% | - | 4 | - | 4 | 9 | 4 | 4 | 4 | 4 | 4 |
| 4-Oyster Pond_Main | 860.53 | 37.33 | 73.71 | 100% | 100% | - | 0% | - | 85 | 4 | 89 | 109 | 165 | 169 | 169 | 171 | 87 |
| 5-Oyster Pond_South | 83.85 | 23.18 | 10.78 | n/a | n/a | n/a | n/a | n/a | 15 | 1 | 16 | 22 | 14 | 15 | - | - | - |
| **Total** | **1,364.00** | **60.52** | **121.70** | | | | | | 164 | 8 | 172 | 210 | 240 | 248 | 189 | 192 | 108 |
| **Total, excluding OP South** | **1,280.14** | **37.33** | **110.91** | | | 378.29 | | **378.29** | 149 | 7 | 156 | 188 | 226 | 233 | 189 | 192 | 108 |
| | | | **1,428.39** | **ptic Nitrogen Remaining per Table 3-3, Scenario 3 >>** | | | | **379.00** | | | | | | | | | |
| | | | | | | | | | | | | | | | | % of Total Developed Parcels at Planning Horizon >> | **63%** |
| | | | | | | | Removed>> | 1,050.09 | kg/yr | | | | | | | % of Total Developed Parcels at Planning Horizon, excluding OP South >> | **69%** |
| | | | | | | | | 2,310.21 | lbs/yr | | | | | | | % of Total Developed Dwelling Units at Planning Horizon, excluding OP South >> | **82%** |
| **Plan 3 - Satellite Plant with In-Watershed Disposal** | | | | | | | | | | | | | | | | | |
| Oyster Pond Embayment | | | | | | | | | | | | | | | | | |
| 1-Oyster Pond GT10N | 366.46 | - | 23.67 | 52.0% | 100.0% | 175.90 | 0% | 175.90 | 45 | 2 | 47 | 51 | 42 | 44 | 23 | 25 | 25 |
| 2-Oyster Pond GT10W | 43.06 | - | 11.81 | 100.0% | 100.0% | - | 0% | - | 15 | 1 | 16 | 19 | 15 | 16 | 16 | 16 | 16 |
| 3-Mosquito Creek_Oyster Pond | 10.10 | - | 1.72 | 100.0% | 100.0% | - | 30% | - | 4 | - | 4 | 9 | 4 | 4 | 4 | 4 | 4 |
| 4-Oyster Pond_Main | 860.53 | 37.33 | 73.71 | 100.0% | 100.0% | - | 0% | - | 85 | 4 | 89 | 109 | 165 | 169 | 169 | 171 | 87 |
| New effluent from WWTF | | 167.39 | | 0.0% | 0.0% | 201.35 | 0% | 201.35 | | | | | | | - | - | |
| 5-Oyster Pond_South | 83.85 | 23.18 | 10.78 | n/a | n/a | n/a | n/a | n/a | 15 | 1 | 16 | 22 | 14 | 15 | 212 | - | - |
| **Total** | **1,364.00** | **227.90** | **121.70** | | | | | | 164 | 8 | 172 | 210 | 240 | 248 | 212 | 216 | 132 |
| **Total, excluding OP South** | **1,280.14** | **37.33** | **110.91** | | | 377.25 | | **377.25** | 149 | 7 | 156 | 188 | 226 | 233 | | 216 | 132 |
| | | | **1,428.39** | **ptic Nitrogen Remaining per Table 3-3, Scenario 3 >>** | | | | **379.00** | | | | | | | | | |
| | | | | | | | | | | | | | | | | % of Total Developed Parcels at Planning Horizon >> | **77%** |
| | | | | | | | Removed>> | 1,051.14 | kg/yr | | | | | | | % of Total Developed Parcels at Planning Horizon, excluding OP South >> | **85%** |
| | | | | | | | | 2,312.50 | lbs/yr | | | | | | | % of Total Developed Dwelling Units at Planning Horizon, excluding OP South >> | **93%** |
| **Plan 4 - Enhanced I/A** | | | | | | | | | | | | | | | | | |
| Oyster Pond Embayment | | | | | | | | | | | | | | | | | |
| 1-Oyster Pond GT10N | 366.46 | - | 23.67 | 63.3% | 63.3% | 143.18 | 0% | 143.18 | 45 | 2 | 47 | 51 | 42 | 44 | 42 | 44 | 47 |
| 2-Oyster Pond GT10W | 43.06 | - | 11.81 | 63.3% | 63.3% | 20.14 | 0% | 20.14 | 15 | 1 | 16 | 19 | 15 | 16 | 15 | 16 | 16 |
| 3-Mosquito Creek_Oyster Pond | 10.10 | - | 1.72 | 63.3% | 63.3% | 4.34 | 30% | 3.04 | 4 | - | 4 | 9 | 4 | 4 | 4 | 4 | 4 |
| 4-Oyster Pond_Main | 860.53 | 37.33 | 73.71 | 63.3% | 63.3% | 356.57 | 0% | 356.57 | 85 | 4 | 89 | 109 | 165 | 169 | 165 | 169 | 85 |
| 5-Oyster Pond_South | 83.85 | 23.18 | 10.78 | n/a | n/a | n/a | n/a | n/a | 15 | 1 | 16 | 22 | 14 | 15 | - | | |
| **Total** | **1,364.00** | **60.52** | **121.70** | | | | | | 164 | 8 | 172 | 210 | 240 | 248 | 226 | 233 | 152 |
| **Total, excluding OP South** | **1,280.14** | **37.33** | **110.91** | | | 524.22 | | **522.92** | 149 | 7 | 156 | 188 | 226 | 233 | 226 | 233 | 152 |
| | | | **1,428.39** | **ptic Nitrogen Remaining per Table 3-3, Scenario 3 >>** | | | | **379.00** | | | | | | | | | |
| | | | | | | | | | | | | | | | | % of Total Developed Parcels at Planning Horizon >> | **88%** |
| | | | | | | | Removed>> | 905.47 | kg/yr | | | | | | | % of Total Developed Parcels at Planning Horizon, excluding OP South >> | **97%** |
| | | | | | | | | 1,992.04 | lbs/yr | | | | | | | % of Total Developed Dwelling Units at Planning Horizon, excluding OP South >> | **100%** |
| **Plan 5 - Advanced I/A** | | | | | | | | | | | | | | | | | |
| Oyster Pond Embayment | | | | | | | | | | | | | | | | | |
| 1-Oyster Pond GT10N | 366.46 | - | 23.67 | 73.5% | 73.5% | 103.38 | 0% | 103.38 | 45 | 2 | 47 | 51 | 42 | 44 | 42 | 44 | 47 |
| 2-Oyster Pond GT10W | 43.06 | - | 11.81 | 73.5% | 73.5% | 14.54 | 0% | 14.54 | 15 | 1 | 16 | 19 | 15 | 16 | 15 | 16 | 16 |
| 3-Mosquito Creek_Oyster Pond | 10.10 | - | 1.72 | 73.5% | 73.5% | 3.13 | 30% | 2.19 | 4 | - | 4 | 9 | 4 | 4 | 4 | 4 | 4 |
| 4-Oyster Pond_Main | 860.53 | 37.33 | 73.71 | 73.5% | 73.5% | 257.47 | 0% | 257.47 | 85 | 4 | 89 | 109 | 165 | 169 | 165 | 169 | 85 |
| 5-Oyster Pond_South | 83.85 | 23.18 | 10.78 | n/a | n/a | n/a | n/a | n/a | 15 | 1 | 16 | 22 | 14 | 15 | - | - | - |
| **Total** | **1,364.00** | **60.52** | **121.70** | | | | | | 164 | 8 | 172 | 210 | 240 | 248 | 226 | 233 | 152 |
| **Total, excluding OP South** | **1,280.14** | **37.33** | **110.91** | | | 378.52 | | **377.58** | 149 | 7 | 156 | 188 | 226 | 233 | 226 | 233 | 152 |
| | | | **1,428.39** | **ptic Nitrogen Remaining per Table 3-3, Scenario 3 >>** | | | | **379.00** | | | | | | | | | |
| | | | | | | | | | | | | | | | | % of Total Developed Parcels at Planning Horizon >> | **88%** |
| | | | | | | | Removed>> | 1,050.81 | kg/yr | | | | | | | % of Total Developed Parcels at Planning Horizon, excluding OP South >> | **97%** |
| | | | | | | | | 2,311.77 | lbs/yr | | | | | | | % of Total Developed Dwelling Units at Planning Horizon, excluding OP South >> | **100%** |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **FALMOUTH - OYSTER POND CWMP** | | *Wright-Pierce, 20 Dec 2013* | | | | ENR CCI | 8600 | | | | 4/1/2010 |
| **ALTERNATIVES ANALYSIS** | | *Revised 18 Feb 2014, 7 July 2014* | | | | ENR CCI | 11228 | | | | 9/3/2019 |
| | | *Revised June 2017, Apr 2019, July 2019* | | | | | | | | | |
| **COSTS FOR VARIOUS WASTEWATER MANAGEMENT ALTERNATIVES (SECTION 5 OF REPORT)** | | | | | | | | | | | |
| **Model developed based on Barnstable County Cost Report, April 2010** | | | | | | **Projected to Apr 2019 dollars** | | | | | |
| **Meet TMDL at Planning Horizon** | | | | | | | | **Conserv** | **Optim-A** | **Optim-B** | |
| | | Plan 1 | Plan 1 CU | Plan 2 | Plan 3 | Plan 4 | Plan 5 | Plan 5 CU | Plan 5 CU | Plan 5 CU | Plan 6 |
| | | BSR | BSR | WHOI | OPET | ENH I/A | ADV I/A | ADV I/A | ADV I/A | ADV I/A | No Action |
| **Wastewater Connections & Flows (Current & Future** | | LPS | LPS | LPS | LPS | | | CON | OPT | OPT | |
| Number of Dwelling Units, Total | | 252 | 240 | 252 | 252 | 252 | 252 | 240 | 240 | 240 | 252 |
| Number of Dwelling Units involved in plan: | | | | | | | | | | | |
| Off-Site Management// Connections | | 192 | 189 | 192 | 216 | 0 | 0 | 0 | 0 | 0 | 0 |
| On-Site (I/A or Alt Toilets)// Systems | | 0 | 0 | 0 | 0 | 233 | 233 | 226 | 226 | 226 | 0 |
| Total - involved in plan | | 192 | 189 | 192 | 216 | 233 | 233 | 226 | 226 | 226 | 0 |
| Total - stay with Title 5 | | 60 | 51 | 60 | 36 | 19 | 19 | 14 | 14 | 14 | 252 |
| Gallons for: | | | | | | | | | | | |
| Off-Site Management | | 22,600 | 22,200 | 22,600 | 29,000 | 0 | 0 | 0 | 0 | 0 | 0 |
| Infiltration/Inflow | | 1,500 | 1,500 | 1,500 | 1,500 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total Gallons - Average flow (gpd) | | 24,100 | 23,700 | 24,100 | 30,500 | 0 | 0 | 0 | 0 | 0 | 0 |
| Avg flow per connection, gpd | | 126 | 125 | 126 | 141 | 0 | 0 | 0 | 0 | 0 | 0 |
| Peaking Factor, Avg to Short-term peak | | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 |
| Short-term peak flow//off-site disposal, mgd | | 0.060 | 0.059 | 0.060 | 0.076 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Peaking Factor, Avg to Peak | | 5.8 | 5.8 | 5.8 | 5.8 | 5.8 | 5.8 | 5.8 | 5.8 | 5.8 | 5.8 |
| Pump Station Sizing, gpm (Oyster Pond flows) | | 97 | 95 | 97 | 123 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | | | | | | | | | |
| **Capital Costs for Collection, Treatment and Disposal** | | | | | | | | | | | |
| **Sewers (State and Town road)** | | | | | | | | | | | |
| Distance, 1000 ft | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Cost per foot | | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 |
| Construction cost | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Low Pressure Sewers (All Laterals - Private)** | | | | | | | | | | | |
| Distance, 1000 ft | | 8.60 | 8.60 | 8.60 | 8.60 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Cost per foot | | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 |
| Construction cost | | 430,000 | 430,000 | 430,000 | 430,000 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Low Pressure Sewers (Mains - Treetops Property)** | | | | | | | | | | | |
| Distance, 1000 ft | | 3.00 | 3.00 | 3.00 | 3.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Cost per foot | | 140 | 140 | 140 | 140 | 140 | 140 | 140 | 140 | 140 | 140 |
| Construction cost | | 420,000 | 420,000 | 420,000 | 420,000 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Low Pressure Sewers (Mains - Town and Private Roads)** | | | | | | | | | | | |
| Distance, 1000 ft | | 15.10 | 15.10 | 15.20 | 18.30 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Cost per foot | | 190 | 190 | 190 | 190 | 190 | 190 | 190 | 190 | 190 | 190 |
| Construction cost | | 2,870,000 | 2,870,000 | 2,890,000 | 3,480,000 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Pump Stations** | | | | | | | | | | | |
| Low Pressure Lift Station (Private, Treetops | 100% | 16 | 16 | 16 | 16 | 0 | 0 | 0 | 0 | 0 | 0 |
| Unit Cost | | 11,000 | 11,000 | 11,000 | 11,000 | 11,000 | 11,000 | 11,000 | 11,000 | 11,000 | 11,000 |
| Low Pressure Lift Station (Private, Others) | 100% | 130 | 127 | 130 | 154 | 0 | 0 | 0 | 0 | 0 | 0 |
| Unit Cost | | 11,000 | 11,000 | 11,000 | 11,000 | 11,000 | 11,000 | 11,000 | 11,000 | 11,000 | 11,000 |
| Small PS (100-200 gpm) | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Unit Cost | | 400,000 | 400,000 | 400,000 | 400,000 | 400,000 | 400,000 | 400,000 | 400,000 | 400,000 | 400,000 |
| Medium PS (200-500 gpm) | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Unit Cost | | 900,000 | 900,000 | 900,000 | 900,000 | 900,000 | 900,000 | 900,000 | 900,000 | 900,000 | 900,000 |
| Large PS (500+ gpm) | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Unit Cost | | 1,500,000 | 1,500,000 | 1,500,000 | 1,500,000 | 1,500,000 | 1,500,000 | 1,500,000 | 1,500,000 | 1,500,000 | 1,500,000 |
| Construction cost, pump stations | | 1,610,000 | 1,570,000 | 1,610,000 | 1,870,000 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Transport to Off-Site Treatment (State roads)** | | | | | | | | | | | |
| Distance, 1000 ft | | 5.70 | 5.70 | 3.00 | 1.50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Cost per foot | | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 |
| Construction cost | | 1,140,000 | 1,140,000 | 600,000 | 300,000 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Treatment// On-Site (Title 5, I/A or Eco-Toilets)** | | | | | | | | | | | |
| No of Dwelling Units at Treetops | | | | | | 62 | 62 | 62 | 62 | 62 | |
| No of Dwelling Units at WHOI Dorms | | | | | | 20 | 20 | 20 | 20 | 20 | |

| | Plan 1 | Plan 1 CU | Plan 2 | Plan 3 | Plan 4 | Plan 5 | Plan 5 CU | Plan 5 CU | Plan 5 CU | Plan 6 |
|---|---|---|---|---|---|---|---|---|---|---|
| **FALMOUTH - OYSTER POND CWMP** | *Wright-Pierce, 20 Dec 2013* | | | | ENR CCI | 8600 | | | | 4/1/2010 |
| **ALTERNATIVES ANALYSIS** | *Revised 18 Feb 2014, 7 July 2014* | | | | ENR CCI | 11228 | | | | 9/3/2019 |
| | *Revised June 2017, Apr 2019, July 2019* | | | | | | | | | |
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| **Model developed based on Barnstable County Cost Report, April 2010** | | | | | **Projected to Apr 2019 dollars** | | | | | |
| **Meet TMDL at Planning Horizon** | | | | | | | **Conserv** | **Optim-A** | **Optim-B** | |
| | Plan 1 | Plan 1 CU | Plan 2 | Plan 3 | Plan 4 | Plan 5 | Plan 5 CU | Plan 5 CU | Plan 5 CU | Plan 6 |
| | BSR | BSR | WHOI | OPET | ENH I/A | ADV I/A | ADV I/A | ADV I/A | ADV I/A | No Action |
| No of Remaining SF/MF Dwelling Units | 0 | 0 | 0 | 0 | 151 | 151 | 144 | 144 | 144 | 0 |
| Cost per SF/MF connection (BCCR, Apr 2010) | 12,400 | 12,400 | 12,400 | 12,400 | | | | | | 12,400 |
| Cost per SF/MF connection (Current $$) | 16,200 | 16,200 | 16,200 | 16,200 | 30,000 | 30,000 | 30,000 | 30,000 | 30,000 | 16,200 |
| Cost for SF/MF Systems | 0 | 0 | 0 | 0 | 4,530,000 | 4,530,000 | 4,320,000 | 4,320,000 | 4,320,000 | 0 |
| Cost per Treetops connection (Current $$) | | | | | 20,000 | 20,000 | 20,000 | 20,000 | 20,000 | |
| Cost for Treetops | | | | | 1,240,000 | 1,240,000 | 1,240,000 | 1,240,000 | 1,240,000 | |
| Cost for WHOI | | | | | 0 | 0 | 0 | 0 | 0 | |
| Construction cost | 0 | 0 | 0 | 0 | 5,770,000 | 5,770,000 | 5,560,000 | 5,560,000 | 5,560,000 | 0 |
| **Treatment// Off-Site** | | | | | | | | | | |
| "Basis" flow rate (mgd) | 1.75 | 1.75 | 0.092 | 0.076 | | | | | | |
| Cost per unit flow (BCCR, April 2010) | 0.00 | 0.00 | 30.00 | 32.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Cost per unit flow (Corrected to Current) | 0.00 | 0.00 | 39.17 | 41.78 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Flow, mgd | 0.060 | 0.059 | 0.060 | 0.076 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Construction cost | 0 | 0 | 2,360,000 | 3,190,000 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Transport to Disposal** | | | | | | | | | | |
| Distance, 1000 ft | 0.00 | 0.00 | 2.00 | 5.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Cost per foot | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 |
| Construction cost | 0 | 0 | 300,000 | 750,000 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Disposal** | | | | | | | | | | |
| Cost per unit flow (based on short-term peak flow) | 5.50 | 5.50 | 11.00 | 8.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Flow, gpd (Short-Term Peak Flow) | 60,250 | 59,250 | 60,250 | 76,250 | 0 | 0 | 0 | 0 | 0 | 0 |
| Subtotal, Disposal construction cost | 330,000 | 330,000 | 660,000 | 610,000 | 0 | 0 | 0 | 0 | 0 | 0 |
| Effluent reuse, % Premium (on treatment cost) | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 |
| Increase for Disposal Cost | 0 | 0 | 0 | 160,000 | 0 | 0 | 0 | 0 | 0 | 0 |
| Construction Cost | 330,000 | 330,000 | 660,000 | 770,000 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Total Construction Cost** | 6,800,000 | 6,760,000 | 9,270,000 | 11,210,000 | 5,770,000 | 5,770,000 | 5,560,000 | 5,560,000 | 5,560,000 | 0 |
| **Contingencies, Admin., Legal, & Technical** | 60 | 60 | 60 | 60 | 30 | 15 | 15 | 15 | 15 | 0 |
| Cost | 4,080,000 | 4,060,000 | 5,560,000 | 6,730,000 | 1,730,000 | 870,000 | 830,000 | 830,000 | 830,000 | 0 |
| **Land** | | | | | | | | | | |
| Total area, acres | 0.5 | 0.5 | 5.5 | 7.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Cost per acre | 250,000 | 250,000 | 250,000 | 250,000 | 250,000 | 250,000 | 250,000 | 250,000 | 250,000 | 250,000 |
| Cost | 125,000 | 125,000 | 1,375,000 | 1,750,000 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Costs on Private Property** | | | | | | | | | | |
| Allowance for site restoration | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 | 0 |
| Allowance for septic system abandonment | 1,000 | 1,000 | 1,000 | 1,000 | 0 | 0 | 0 | 0 | 0 | 0 |
| Connection fee | 50 | 50 | 50 | 50 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cost | 590,000 | 580,000 | 590,000 | 660,000 | 470,000 | 470,000 | 450,000 | 450,000 | 450,000 | 0 |
| **Pond Mixing - Allowance** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Phytoirrigation/Fertigation - Allowance** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Total Capital Cost** | 11,595,000 | 11,525,000 | 16,795,000 | 20,350,000 | 7,970,000 | 7,110,000 | 6,840,000 | 6,840,000 | 6,840,000 | 0 |
| Cost reduction for future technology | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **CAPITAL COST SUMMARY** | 11,595,000 | 11,525,000 | 16,795,000 | 20,350,000 | 7,970,000 | 7,110,000 | 6,840,000 | 6,840,000 | 6,840,000 | 0 |
| | | | | | | | | | | |
| **ANNUAL OPERATING COSTS** | | | | | | | | | | |
| **Wastewater Collection, Treatment & Disposal** | | | | | | | | | | |
| "Basis" flow rate (gpd) | | | 37,400 | 30,500 | | | | | | |
| Unit cost, $/yr per gpd (BCCR, Apr 2010) | | | 9.00 | 9.50 | - | - | - | - | - | - |
| Unit cost, $/yr per gpd (Current $$) | | | 11.75 | 12.40 | 0 | - | - | - | - | - |
| Annual average flow, gpd | 24,100 | 23,700 | 24,100 | 30,500 | 0 | 0 | 0 | 0 | 0 | 0 |
| Unit cost for BSR WWTF Sewer User Rate, $/yr | 475 | 475 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| O&M cost for BSR WWTF, $/yr | 91,200 | 89,775 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| O&M cost for Public C/T/D, $/yr | 91,000 | 90,000 | 283,000 | 378,000 | 0 | 0 | 0 | 0 | 0 | 0 |
| Unit cost for Private LPS PS, $/yr | 400 | 400 | 400 | 400 | 0 | 0 | 0 | 0 | 0 | 0 |

**FALMOUTH - OYSTER POND CWMP** | *Wright-Pierce, 20 Dec 2013* | ENR CCI 8600 | 4/1/2010

**ALTERNATIVES ANALYSIS** | *Revised 18 Feb 2014, 7 July 2014* | ENR CCI 11228 | 9/3/2019

*Revised June 2017, Apr 2019, July 2019*

**COSTS FOR VARIOUS WASTEWATER MANAGEMENT ALTERNATIVES (SECTION 5 OF REPORT)**

**Model developed based on Barnstable County Cost Report, April 2010** — **Projected to Apr 2019 dollars**

**Meet TMDL at Planning Horizon**

| | | Plan 1 | Plan 1 CU | Plan 2 | Plan 3 | Plan 4 | Plan 5 | Conserv Plan 5 CU | Optim-A Plan 5 CU | Optim-B Plan 5 CU | Plan 6 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | BSR | BSR | WHOI | OPET | ENH I/A | ADV I/A | ADV I/A | ADV I/A | ADV I/A | No Action |
| O&M cost for Private LPS PS, $/yr | | 52,000 | 50,800 | 52,000 | 61,600 | 0 | 0 | 0 | 0 | 0 | 0 |
| O&M cost for Overall C/T/D, $/yr | | 143,000 | 141,000 | 335,000 | 440,000 | 0 | 0 | 0 | 0 | 0 | 0 |
| **I/A System and Eco-Toilet Households** | | | | | | | | | | | |
| Number, Total | | 0 | 0 | 0 | 0 | 233 | 233 | 226 | 226 | 226 | 0 |
| Number, I/A System households | 98% | 0 | 0 | 0 | 0 | 228 | 228 | 221 | 221 | 221 | 0 |
| Unit cost, $/yr per gpd (Current $$) | | - | - | - | - | 1,800 | 1,800 | 1,800 | 1,000 | 1,000 | - |
| O&M cost, $/yr | | 0 | 0 | 0 | 0 | 411,000 | 411,000 | 399,000 | 221,000 | 221,000 | 0 |
| Number, Eco-toilet households | 2% | 0 | 0 | 0 | 0 | 5 | 5 | 5 | 5 | 5 | 0 |
| Unit cost, $/yr per unit (BCCR, Apr 2010) | | 350 | 350 | 350 | 350 | 350 | 350 | 350 | 350 | 350 | 350 |
| Unit cost, $/yr per gpd (Current $$) | | 457 | 457 | 457 | 457 | 457 | 457 | 457 | 457 | 457 | 457 |
| O&M cost, $/yr | | 0 | 0 | 0 | 0 | 2,100 | 2,100 | 2,100 | 2,100 | 2,100 | 0 |
| **Septic System Pumping (for Title 5; I/A and Ecotoilet including in above)** | | | | | | | | | | | |
| Number | | 60 | 51 | 60 | 36 | 19 | 19 | 14 | 14 | 14 | 252 |
| Frequency (every XX years) | | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Unit cost, $/pumping | | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 |
| Annualized Cost (simple) | | 6,000 | 5,100 | 6,000 | 3,600 | 1,900 | 1,900 | 1,400 | 1,400 | 1,400 | 25,200 |
| **Septic System Future Replacement - Annualized** | | | | | | | | | | | |
| Number | | 60 | 51 | 60 | 36 | 252 | 252 | 240 | 240 | 240 | 252 |
| Frequency (every XX years) | | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 20 |
| Unit cost, $/replacement | | 16,200 | 16,200 | 16,200 | 16,200 | 30,000 | 30,000 | 30,000 | 30,000 | 30,000 | 16,200 |
| Annualized Cost (simple) | | 39,000 | 33,000 | 39,000 | 23,000 | 302,000 | 302,000 | 288,000 | 288,000 | 288,000 | 204,000 |
| **Oyster Pond Responsible Management Entity (RME)** | | | | | | | | | | | |
| Cost for All Options (e.g., Env Monitoring) | | 36,000 | 36,000 | 36,000 | 36,000 | 36,000 | 36,000 | 36,000 | 36,000 | 36,000 | |
| Additional Costs for I/A Options | | | | | | 60,000 | 60,000 | 60,000 | 60,000 | 60,000 | |
| Cost | | 36,000 | 36,000 | 36,000 | 36,000 | 96,000 | 96,000 | 96,000 | 96,000 | 96,000 | 0 |
| **O&M Cost summary** | | **224,000** | **215,100** | **416,000** | **502,600** | **813,000** | **813,000** | **786,500** | **608,500** | **608,500** | **229,200** |
| | | | | | | | | | | | |
| **Equivalent Annual Cost** | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Period, yr - Loan Town | | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| Interest rate, % - Loan Town | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| PW Factor - Loan Town Costs on Public Property | | 20.00 | 20.00 | 20.00 | 20.00 | 20.00 | 20.00 | 20.00 | 20.00 | 20.00 | 16.35 |
| Period, yr - Loan Town | | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| Interest rate, % - Loan Town | | 0 | 0 | 0 | 0 | 4 | 4 | 4 | 2 | 0 | 2 |
| PW Factor - Loan Town Costs on Private Property | | 20.00 | 20.00 | 20.00 | 20.00 | 13.59 | 13.59 | 13.59 | 16.35 | 20.00 | 16.35 |
| Period, yr - Loan Private | | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| Interest rate, % - Loan Private | | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| PW Factor - Loan Private on Private Property | | 13.59 | 13.59 | 13.59 | 13.59 | 13.59 | 13.59 | 13.59 | 13.59 | 13.59 | 13.59 |
| Capital cost - Loan Town, Cost on Public Property | | 11,595,000 | 11,525,000 | 16,795,000 | 20,350,000 | 797,000 | 0 | 0 | 0 | 0 | 0 |
| Capital cost - Loan Town, Cost on Private Property | | 0 | 0 | 0 | 0 | 1,594,000 | 2,133,000 | 2,052,000 | 2,052,000 | 2,052,000 | 0 |
| Capital cost - Loan Private | | 0 | 0 | 0 | 0 | 5,579,000 | 4,977,000 | 4,788,000 | 4,788,000 | 4,788,000 | 0 |
| O&M cost | | 224,000 | 215,000 | 416,000 | 503,000 | 813,000 | 813,000 | 787,000 | 609,000 | 609,000 | 229,000 |
| Equivalent Annual Cost of Capital | | 580,000 | 576,000 | 840,000 | 1,018,000 | 568,000 | 523,000 | 503,000 | 478,000 | 455,000 | 0 |
| **Total Equivalent Annual Cost** | | **804,000** | **791,000** | **1,256,000** | **1,521,000** | **1,381,000** | **1,336,000** | **1,290,000** | **1,087,000** | **1,064,000** | **229,000** |

**FALMOUTH, MA - OYSTER POND CWMP**

**ESTIMATED ANNUAL COSTS FOR TITLE 5, I/A SYSTEMS AND LOW-PRESSURE LIFT STATIONS**

*Wright-Pierce, June 2017, rev April 2019, rev July 2019*

ENR CCI 11228 (APRIL 2019)

| | BREAKDOWN OF COSTS FROM BARNSTABLE CTY COST REPORT (2010) | | | | BREAKDOWN OF COSTS FOR OYSTER POND CWMP (2014) | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Items | Title 5 | N Removing Current Practice | N Removing Enhanced Practice | N Removing Enhanced Practice for TMDL Compliance | Title 5 | Advanced I/A TMDL Compliance (First Yr) | Advanced I/A TMDL Compliance (Remaining Yr) | Advanced I/A TMDL Compliance (Remaining Yr) Optimistic | LPS Lift Station to Sewer (Annual) |
| Pumping Frequency | 4 yrs | 3 yrs | 3 yrs | 3 yrs | 5 yrs | 5 yrs | 3 yrs | 5 yrs | n/a |
| Septage | $110 | $125 | $125 | $125 | $75 | $75 | $125 | $75 | n/a |
| Electricity | $0 | $300 | $350 | $350 | $0 | $125 | $125 | $125 | $50 |
| Chemicals | $0 | $0 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| Maintenance/ Inspections | $0 | $200 | $400 | $400 | - | - | - | - | - |
| Repairs and Supplies | $0 | $100 | $200 | $200 | - | - | - | - | - |
| Maintenance/Parts | - | - | - | - | $0 | $300 | $300 | $300 | $300 |
| Inspections | - | - | - | - | $0 | $700 | $350 | $175 | n/a |
| Monitoring/Sampling/Lab | $0 | $425 | $700 | $700 | $0 | $900 | $450 | $150 | n/a |
| Engineering | $0 | $0 | $125 | $125 | - | - | - | - | - |
| Admin (Insurance, etc.) | $0 | $100 | $100 | $100 | - | - | - | - | - |
| Return Visits/Monitoring & Fine Tuning | | - | - | $1,200 | $0 | $500 | $200 | $33 | n/a |
| County - Annual Fee/ Records | | - | - | - | - | $50 | $50 | $50 | n/a |
| Total (BCCR-$$2010) | $110 | $1,250 | $2,000 | $3,200 | - | - | - | - | - |
| Total ($$2014) | $165 | $1,375 | not incl. | $3,850 | $75 | $2,650 | $1,600 | $908 | $350 |
| **Total ($$2019)** | $200 | $1,500 | not incl. | $4,300 | **$100** | **$3,000** | **$1,800** | **$1,000** | **$400** |
| | | | | | | Notes 1,2 | Notes 1,4,6 | Notes 1,3,5 | |

**Notes**

1) Assumes watershed monitoring program managed by the Town or watershed organization.
2) Assumes 6 samples for BOD, TSS, TN, Nitrate, alkalinity, pH for first year or if system fails to meet TN limits.
   Assumes 4 O&M visits for first year or if system fails to meet TN limits.
3) Assumes 1 samples per year for BOD, TSS, TN, Nitrate, alkalinity, pH for routine sampling.
   Assumes 1 O&M visit for routine years.
4) Assumes 3 samples per year for BOD, TSS, TN, Nitrate, alkalinity, pH for routine sampling for conservative.
   Assumes 2 O&M visits for routine years (conservative) and 1 O&M visit for routine years.
5) Assumes that 10% of systems fail to meet TN (value shown is 10% of inspection and monitoring/sampling/lab).
6) Assumes that 25% of systems fail to meet TN (value shown is 25% of inspection and monitoring/sampling/lab).

## FALMOUTH, MA OYSTER POND CWMP (12727C) - IMPLEMENTATION PLAN
## ESTIMATED QUANTITIES AND COSTS FOR ADVANCED I/A PLAN - PHASE 1 ONLY (ENR CCI 11228, APRIL 2019)
*Wright-Pierce, April 2019, rev Sept 2019*

| ITEM | DWELLING UNITS | QUANTITY | UNIT | BASIS FLOW (T5 GPD) | INSTALLED UNIT COST | EXTENDED COST | SUBTOTALS | % PAID BY TOWN |
|---|---|---|---|---|---|---|---|---|
| **TREATMENT SYSTEMS** | | | | | | | | |
| Single Family | 105 | 105 | EA | 440 | $10,000 | $1,050,000 | | |
| Multi Family | 2 | 1 | EA | 550 | $12,000 | $12,000 | | |
| WHOI Dorms (Note 1) | 20 | 1 | EA | 2,600 | $0 | $0 | | |
| Treetops (Note 2) | 62 | 16 | EA | 15,500 | $20,000 | $320,000 | | |
| | 189 | 123 | | | **Subtotal Treatment:** | | **$1,382,000** | **100%** |
| **PRIVATE PROPERTY SITE WORK - SINGLE FAMILY/ MULTI FAMILY** | | | | | | | | |
| ADDER FOR TITLE 5 SYSTEM AS NEEDED - ALLOWANCE (Note 3) | | 27 | EA | N/A | $10,000 | $270,000 | | |
| SYSTEM INSTALLATION | | 106 | EA | N/A | $18,000 | $1,908,000 | | |
| SITE RESTORATION | | 106 | EA | N/A | $2,000 | $212,000 | | |
| | | | | | | | **$2,390,000** | **0%** |
| **PRIVATE PROPERTY - TREETOPS** | | | | | | | | |
| ADDER FOR TITLE 5 SYSTEM AS NEEDED - ALLOWANCE (Note 3) | | 16 | EA | N/A | $20,000 | $320,000 | | |
| SYSTEM INSTALLATION | | 16 | EA | N/A | $36,000 | $576,000 | | |
| SITE RESTORATION | | 16 | EA | N/A | $4,000 | $64,000 | | |
| PAVING | | 1 | AL | N/A | $100,000 | $100,000 | | |
| | | | | **Subtotal Private Property Site Work:** | | | **$1,060,000** | **0%** |
| | | | | | | | | |
| | | | | | **Subtotal All:** | $4,830,000 | $4,830,000 | |
| | | | | 0% | GC General Conditions: | $0 | | |
| | | | | | Subtotal Construction Cost: | $4,830,000 | | |
| | | | | 10% | Contingency: | $483,000 | | |
| | | | | | **Total Construction Cost:** | **$5,313,000** | | |

Notes:

1) WHOI Dorms - Recirculating Sand Filter, Holmes & McGrath, as-built May 2016.
Average water use 244 gpd and avg Eff TN 10.6 mg/l (email 2/6/2019, Joel Kubick)

2) Unit cost for treatment are estimated at $10,000, $12,000 and $20,000 for single family, multi-family and Treetops buildings, respectively.

3) Adder for baseline Title 5 systems and cost for single/multi family treatment based on Buzzards Bay Coalition presentation at Cape Coastal Conference, Dec 2018.
Assume 25% of total single family and multi-family need new Title 5 system. Assume 100% of Treetops need new Title 5 system.

4) Installation costs include engineering (design, test pitting, permitting, inspection, as-builts), electrical and first year monitoring.

**FALMOUTH, MA OYSTER POND CWMP (12727C) - IMPLEMENTATION PLAN**

**ESTIMATED QUANTITIES AND COSTS FOR TRADITIONAL BACKUP PLAN - PHASE 1, VERSION 2 (ENR CCI 11228, APRIL 2019)**

*Wright-Pierce, April 2019, rev Sept 2019*

| ITEM | | PIPE SIZE (IN) | PIPE MATERIAL | PIPE PER PROPERTY | QUANTITY | UNIT | ROAD TYPE | ROAD NAME | UNIT COST | EXTENDED COST | SUBTOTALS | % PAID BY TOWN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **LATERALS (EONE LS TO SEWER MAIN)** | | | | | | | | | | | | |
| | Blue Zone - 28 | 1.25 | HDPE | 50 | 1400 | FT | Private Property | N/A | $36 | $50,400 | | |
| | Red Zone - 12 | 1.25 | HDPE | 120 | 1440 | FT | Private Property | N/A | $36 | $51,840 | | |
| | Purple Zone - 43 | 1.25 | HDPE | 60 | 2580 | FT | Private Property | N/A | $36 | $92,880 | | |
| Orange Zone (Treetop) - 16 | | 1.25 | HDPE | 65 | 1040 | FT | Private Property | N/A | $36 | $37,440 | | |
| | Green Zone - 4 | 1.25 | HDPE | 95 | 380 | FT | Private Property | N/A | $36 | $13,680 | | |
| | Yellow Zone -1 | 1.25 | HDPE | 300 | 300 | FT | Private Property | N/A | $36 | $10,800 | | |
| | Aqua Zone - 3 | 1.25 | HDPE | 190 | 570 | FT | Private Property | N/A | $36 | $20,520 | | |
| | Black - 13 | 1.25 | HDPE | 40 | 520 | FT | Private Property | N/A | $36 | $18,720 | | |
| | Gray - 2 | 1.25 | HDPE | 200 | 400 | FT | Private Property | N/A | $36 | $14,400 | | |
| | | | | | | | | **Subtotal Sewer Laterals Cost:** | | | **$310,680** | **0%** |
| **SEWER MAINS - V2 (LPS ZONES) - IN PRIVATE AND TOWN ROADS** | | | | | | | | | | | | |
| | 1 | 2 | HDPE | 810 | 810 | FT | Town | Oyster Pond Rd | $36 | $29,160 | | |
| | 2 | 2 | HDPE | 157 | 157 | FT | Town | Oyster Pond Rd | $36 | $5,650 | | |
| | 3 | 2 | HDPE | 381 | 381 | FT | Town | Oyster Pond Rd | $36 | $13,720 | | |
| | 4 | 3 | HDPE | 966 | 966 | FT | Town | Oyster Pond Rd | $38 | $36,710 | | |
| | 5 | 3 | HDPE | 601 | 601 | FT | Town | Fells Rd | $38 | $22,840 | | |
| | 6 | 3 | HDPE | 2072 | 2072 | FT | Town | Fells Rd, Ransom Rd | $38 | $78,740 | | |
| | 6 | 3 | HDPE | 470 | 470 | FT | Easement | N/A | $32 | $15,040 | | |
| | 7 | 2 | HDPE | 248 | 248 | FT | Town | Ransom Rd | $36 | $8,930 | | |
| | 7.1 | 2 | HDPE | 360 | 360 | FT | Town | Ransom Rd | $36 | $12,960 | | |
| | 8 | 4 | HDPE | 555 | 555 | FT | Easement | N/A | $34 | $18,870 | | |
| TREETOP | 9 | 2 | HDPE | 380 | 380 | FT | Private | Landfall Rd | $36 | $13,680 | | |
| TREETOP | 10 | 2 | HDPE | 366 | 366 | FT | Private | Landfall Rd | $36 | $13,180 | | |
| TREETOP | 11 | 4 | HDPE | 399 | 399 | FT | Private | Landfall Rd | $49 | $19,550 | | |
| TREETOP | 12 | 2 | HDPE | 545 | 545 | FT | Private | Shipswatch Rd | $36 | $19,620 | | |
| TREETOP | 12.1 | 2 | HDPE | 785 | 785 | FT | Private | Shipswatch Rd | $36 | $28,260 | | |
| TREETOP | 12.2 | 4 | HDPE | 560 | 560 | FT | Easement | N/A | $34 | $19,040 | | |
| | 14 | 2 | HDPE | 73 | 73 | FT | Town | Sakonet Rd | $36 | $2,630 | | |
| | 15 | 2 | HDPE | 1073 | 1073 | FT | Town | Elm Rd | $36 | $38,630 | | |
| | 16 | 3 | HDPE | 392 | 392 | FT | Town | Elm Rd | $38 | $14,900 | | |
| | 17 | 2 | HDPE | 189 | 189 | FT | Town | Quonset Rd | $36 | $6,800 | | |
| | 18 | 2 | HDPE | 321 | 321 | FT | Town | Quonset Rd | $36 | $11,560 | | |
| | 19 | 3 | HDPE | 243 | 243 | FT | Town | Quonset Rd | $38 | $9,230 | | |
| | 20 | 3 | HDPE | 379 | 379 | FT | Town | Elm Rd | $38 | $14,400 | | |
| | 21 | 2 | HDPE | 236 | 236 | FT | Town | Elm Rd | $36 | $8,500 | | |

**FALMOUTH, MA OYSTER POND CWMP (12727C) - IMPLEMENTATION PLAN**

**ESTIMATED QUANTITIES AND COSTS FOR TRADITIONAL BACKUP PLAN - PHASE 1, VERSION 2 (ENR CCI 11228, APRIL 2019)**

*Wright-Pierce, April 2019, rev Sept 2019*

| ITEM | PIPE SIZE (IN) | PIPE MATERIAL | PIPE PER PROPERTY | QUANTITY | UNIT | ROAD TYPE | ROAD NAME | UNIT COST | EXTENDED COST | SUBTOTALS | % PAID BY TOWN |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 22 | 3 | HDPE | 92 | 92 | FT | Town | Elm Rd | $38 | $3,500 | | |
| 24 | 2 | HDPE | 358 | 358 | FT | Town | Moorland Rd | $36 | $12,890 | | |
| 25 | 3 | HDPE | 696 | 696 | FT | Easement | N/A | $32 | $22,270 | | |
| 26 | 2 | HDPE | 745 | 745 | FT | Private | Cumloden Dr | $36 | $26,820 | | |
| 26.1 | 4 | HDPE | 555 | 555 | FT | Private | Cumloden Dr | $49 | $27,200 | | |
| 27 | 4 | HDPE | 1107 | 1107 | FT | Private | Cumloden Dr | $49 | $54,240 | | |
| 28 | 2 | HDPE | 386 | 386 | FT | Private | Damon Rd | $36 | $13,900 | | |
| 29 | 2 | HDPE | 1046 | 1046 | FT | Private | Damon Rd | $36 | $37,660 | | |
| 30 | 4 | HDPE | 645 | 645 | FT | Private | Cumloden Dr | $49 | $31,610 | | |
| | | | | | | | **Subtotal Sewer Mains Cost:** | | | **$692,690** | **30%** |
| **SEWER MAINS - V2 (LPS ZONES) - IN STATE ROUTES** | | | | | | | | | | | |
| 31 | 4 | HDPE | 844 | 844 | FT | State | Woods Hole Rd | $50 | $42,200 | | |
| 39 | 4 | HDPE | 3123 | 3123 | FT | State | Woods Hole Rd, Locust St | $50 | $156,150 | | |
| 39 | 4 | HDPE | 1593 | 1593 | FT | Town | W Main St, Post Office Rd | $38 | $60,530 | | |
| | | | | | | | Parking Lot | | | | |
| | | | | | | | **Subtotal Sewer Mains Cost:** | | | **$258,880** | **100%** |
| **EONE APPURTENANCES - EQUIPMENT AND INSTALLATION** | | | | | | | | | | | |
| AIR RELEASE VALVE | | | | 8 | EA | | | $2,880 | $23,040 | | |
| CLEAN OUT VALVE | | | | 33 | EA | | | $12,000 | $396,000 | | |
| CORP STOP | | | | 123 | EA | | | $232 | $28,540 | | |
| BALL AND CHECK VALVE ASSEMBLY | | | | 123 | EA | | | $472 | $58,060 | | |
| VALVE STRUCTURES | | | | 41 | EA | | | $7,500 | $307,500 | | |
| | | | | | | | **Subtotal EONE Lift Stations and Appurtenances:** | | | **$813,140** | **30%** |
| **EONE LIFT STATIONS - EQUIPMENT** | | | | | | | | | | | |
| **EONE LIFT STATION SIZES** | | | | | | | | | | | |
| TYPE 1 - SINGLE FAMILY | | | | 105 | EA | | | $4,000 | $420,000 | | |
| TYPE 2 - MULTI FAMILY | | | | 1 | EA | | | $4,500 | $4,500 | | |
| TYPE 3 - TREETOP | | | | 16 | EA | | | $4,500 | $72,000 | | |
| TYPE 4 - DORM | | | | 1 | EA | | | $4,500 | $4,500 | | |
| TYPE 5 - INTERMEDIATE | | | | 1 | EA | | | $4,000 | $4,000 | | |
| SENTRY ADVISOR MONITORING SYSTEM | | | | 123 | EA | | | $400 | $49,200 | | |
| | | | | | | 0 | **Subtotal EONE Lift Stations and Appurtenances:** | | | **$554,200** | **100%** |
| **EONE LIFT STATIONS - INSTALLATION** | | | | | | | | | | | |
| **EONE LIFT STATION SIZES** | | | | | | | | | | | |
| TYPE 1 - SINGLE FAMILY | | | | 105 | EA | | | $6,000 | $630,000 | | |
| TYPE 2 - MULTI FAMILY | | | | 1 | EA | | | $6,000 | $6,000 | | |

**FALMOUTH, MA OYSTER POND CWMP (12727C) - IMPLEMENTATION PLAN**

**ESTIMATED QUANTITIES AND COSTS FOR TRADITIONAL BACKUP PLAN - PHASE 1, VERSION 2 (ENR CCI 11228, APRIL 2019)**

*Wright-Pierce, April 2019, rev Sept 2019*

| ITEM | PIPE SIZE (IN) | PIPE MATERIAL | PIPE PER PROPERTY | QUANTITY | UNIT | ROAD TYPE | ROAD NAME | UNIT COST | EXTENDED COST | SUBTOTALS | % PAID BY TOWN |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TYPE 3 - TREETOP | | | | 16 | EA | | | $6,000 | $96,000 | | |
| TYPE 4 - DORM | | | | 1 | EA | | | $6,000 | $6,000 | | |
| TYPE 5 - INTERMEDIATE | | | | 1 | EA | | | $6,000 | $6,000 | | |
| SENTRY ADVISOR MONITORING SYSTEM | | | | 123 | EA | | | $500 | $61,500 | | |
| DEMOLITION OF EXISTING SEPTIC SYSTEM, PIPING, ETC | | | | 123 | EA | | | $1,000 | $123,000 | | |
| SITE RESTORATION | | | | 123 | EA | | | $2,000 | $246,000 | | |
| | | | | | | | **Subtotal EONE Lift Stations and Appurtenances:** | | | **$1,174,500** | **0%** |
| **PAVING - PRIVATE AND TOWN ROADS** | | | | | | | | | | | |
| PRIVATE ROADS - LATERALS | | | | N/A | SY | | | N/A | $0 | | |
| PRIVATE ROADS - MAINS (TRENCH BINDER, 1.5") | | | | 0 | SY | | | $20 | $0 | | |
| PRIVATE ROADS - MAINS (HALF WIDTH OVERLAY, 1") | | | | 0 | SY | | | $8 | $0 | | |
| TOWN ROADS (TRENCH BINDER, 1.5") | | | | 16,394 | SY | | | $25 | $409,860 | | |
| TOWN ROADS (HALF WIDTH OVERLAY, 1") | | | | 30,318 | SY | | | $10 | $303,180 | | |
| | | | | | | | **Subtotal Paving - Private and Town Roads:** | | | **$713,040** | **30%** |
| **PAVING - STATE ROADS** | | | | | | | | | | | |
| STATE ROADS (TRENCH BINDER, 2") | | | | 5,011 | SY | | | $33 | $165,360 | | |
| STATE ROADS (FULL WIDTH OVERLAY, 1.5") | | | | 21,622 | SY | | | $40 | $864,890 | | |
| | | | | | | | **Subtotal Paving - State Roads:** | | | **$1,030,250** | **100%** |
| | | | | | | | | | | | |
| **TREATMENT AND DISPOSAL** | | | | | | | | | | | |
| TREATMENT | | | | | | | | | **$0** | | |
| DISPOSAL | | | | | | | | | **$330,000** | | |
| | | | | | | | **Subtotal Treatment & Disposal:** | | | **$330,000** | **100%** |
| | | | | | | | | | | | |
| | | | | | | | | **Subtotal All:** | $5,880,000 | $5,880,000 | |
| | | | | | | 0% | | GC General Conditions: | $0 | | |
| | | | | | | | | Subtotal Construction Cost: | $5,880,000 | | |
| | | | | | | 30% | | Contingency: | $1,760,000 | | |
| | | | | | | | | **Total Construction Cost:** | **$7,640,000** | | |

| **Pipe Length by Pipe Size (LF):** | |
|---|---|
| 1.25" (laterals) | 8,630 |
| 2" | 8,459 |
| 3" | 5,911 |
| 4" | 7,788 |

| **Pipe Length by Road Type (LF):** | | | | |
|---|---|---|---|---|
| Private Laterals | 8,630 | | Other Town & Private Rds | 15156 |
| Town & Private | 18,191 | >>> | Treetops Rds | 3035 |
| State | 5,560 | | | |

**FALMOUTH, MA - OYSTER POND CWMP**

**ESTIMATED ANNUAL COSTS FOR RESPONSIBLE MANAGEMENT ENTITY**

*Wright-Pierce, March 2019, rev July 2019* ENR CCI 11228 (APRIL 2019)

| **ANNUAL STAFF TIME ESTIMATE** | Quan | Unit | Hrs/Unit | Hrs | Comments |
|---|---|---|---|---|---|
| Collect and organize as-built records | 233 | DU | 0 | 0.0 | one time effort, not included |
| Collect and organize water readings | 233 | DU | 0.5 | 116.5 | data from Water Department, organize/manipulate for reporting |
| Collect and tabulate I/A monitoring results | 233 | DU | 1 | 233.0 | data from lab, organize/file/tabulate/graph for reporting |
| Collect and organize O&M records | 233 | DU | 0.5 | 116.5 | organize/file/tabulate for reporting |
| Collect and organize pump records | 47 | DU | 1 | 47.0 | pump out every 5 years, organize/file/tabulate for reporting |
| Coordinate with property owner | 233 | DU | 0.5 | 116.5 | for annual inspections |
| Coordinate with contract O&M | 233 | DU | 0.5 | 116.5 | for annual inspections |
| Coordinate environmental monitoring | 1 | Each | 40 | 40.0 | see below for contractor costs |
| Inspect Trunk River, coordinate with DPW | 2 | Each | 2 | 4.0 | |
| Literature and data search for Atmos. Dep. | 1 | Each | 10 | 10.0 | |
| Collect and organize data from SW BMP (DPW) | 1 | Each | 10 | 10.0 | |
| Prepare draft annual report | 1 | Each | 80 | 80.0 | |
| Review with Oyster Pond WG and RME | 1 | Each | 4 | 4.0 | |
| Update draft annual report | 1 | Each | 20 | 20.0 | |
| Review with Oyster Pond WG and RME | 1 | Each | 4 | 4.0 | |
| Finalize and submit annual report | 1 | Each | 10 | 10.0 | |
| **TOTAL** | | | | **928.0** | 45% |
| | | | **SAY** | **950** | hrs/year |
| | | | | **$76,000** | Annual cost for labor, assumes $80/hr |
| | | | | | |
| **ENVIRONMENTAL MONITORING COSTS** | Quantity | Unit | Unit Cost | Cost | Comments |
| Surface Water at Sentinel Stations | 2 | rounds/yr | $5,250 | $10,500 | Allowance, to be confirmed |
| Sediment | 1 | rounds/yr | $5,500 | $5,500 | Allowance, to be confirmed |
| Habitat Assessment (every 5 years) | 0.2 | rounds/yr | $10,000 | $2,000 | Allowance, to be confirmed |
| Groundwater | 1 | rounds/yr | $2,000 | $2,000 | Allowance, to be confirmed |
| Air Monitoring | 0 | rounds/yr | $0 | $0 | Literature search, covered in RME costs |
| **TOTAL** | | | | **$20,000** | |

**FALMOUTH, MA - OYSTER POND CWMP**

**ESTIMATED ANNUAL COSTS FOR SEWER USER FEES**

*Wright-Pierce, March 2019, rev July 2019*

ENR CCI 11228 (APRIL 2019)

| **Items** | **Watershed Average** | **Single Family Residential** |
|---|---|---|
| Watershed Residential Water Use (gpd) | 32,000 | 26800 |
| Watershed Residential Dwelling Units | 224 | 160 |
| Usage per dwelling unit (gpd/du) | 143 | 168 |
| | | |
| Gallons covered in Base Charge | 82 | 82 |
| Gallons at additional charge | 61 | 86 |
| | | |
| Base Charge ($134/ 6 months) | $268 | $268 |
| Additional Charge ($6.70/HCF) | $199 | $280 |
| Total Annual Sewer User Fee per dwelling unit ($$2019) | $467 | $548 |
| | | |
| **For Alternatives Analysis and Recommended Plan, use ($$2019)** | **$475** | |

**Notes**

1) Based on "Town of Falmouth, Water and Sewer Rates as of June 2016".

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# E/ONE Pressure System Design Report

## For

## Oyster Pond Sub-development

## Treetop V1 & V2

## Falmouth, MA

## April 17, 2019

E/ONE
EXTREME
SERIES

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April 17, 2019

Kendra Fox
**Wright-Pierce** | Project Engineer
Portland, ME Office

RE: Treetop Version 1 & 2 Reports, Oyster Pond Sub-development, Falmouth, MA

Dear Kendra;

This preliminary design analysis examines the use of the E/One Pressure Sewer System for your project. E/One is celebrating 50 years of installation and O&M experience along with considerable research and development leading to continuous product and system improvements. E/One remains the worldwide industry standard and industry leader in the pressure sewer technology. The unique characteristics of the E/One Pressure Sewer approach provides not only a technical solution, but also an economic advantage to be realized with low up front and O&M costs.



**System Analysis**

This project proposes to collect wastewater from approximately 164 connections and discharge to the Shiverick's Pond Lift Station. We looked at two routes labeled herein as Version 1 and Version 2.

Using the information you provided, we ran the enclosed preliminary pressure sewer pipe sizing analyses. These were run through our Low Pressure Sewer Design Software that employs our Flow Velocity and Friction Head Loss vs. Pumps in Simultaneous Operation Spreadsheet. We have used the surface topography provided to make our analyses.

**Zone Layout**

Using your site plan we laid out a system with a total of 39 flow Zones leading to the final discharge point. The routes are slightly altered in Version 2 to avoid some high spots on Main Street. Version 2 is slightly shorter and results reduced the Total Dynamic Head in several of the flow zones. The layouts assumed we are only servicing the Phase 1 and Phase 2 areas marked on your plan. If there is a potential to add in flow from abutting service areas, then the line size in final zones currently showing as 4-inch pipe would be increased. The side benefit would be the reduction in friction losses in the current proposed project.

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Computations are based on the Hazen-Williams formula for friction loss, using calculations of cross-sectional area and flow rate to determine pipe sizes that create ”self-cleaning” velocities of 2.0 fps or higher. A "C" factor of 150, SDR 11 HDPE pipe and the average expected daily volumes for single family homes are also used in this analysis.

The highest Total Dynamic Heads in Version 1 are somewhat higher than Version 2. We believe that small intermediate lift station at the further ends of the project area of Zones 1-6 may be required. This would be much smaller in cost and impact than the larger lift station shown on your plan.

Our pumps are rated to continuous duty heads to 185 feet and can operate at intermittent heads that can be much higher. I would point out that for general preliminary design reports we assume all pumps operate at 11 GPM based on mid-point of our performance curve. Our program does allow us to adjust the flow output based on the actual heads with an iteration function. At this early stage we would not make this adjustment. Going forward we can look at this and adjust accordingly. The result is a lower flow rate in some of these higher head zones. So at this time we are not concerned by the heads found in the Version 2 report.

Flow velocity throughout the system meets or exceeds 2 fps. These characteristics and low retention time indicate that this will be a reliable, low-maintenance system.

**Design Flows & System Velocity**

We normally use average daily flows for system designs rather than the peak design flows commonly used for gravity sewer sizing. We do this because the system is sealed and void of inflow and infiltration commonly allowed for in gravity sewer designs. We size the system for an average daily flow of 200+/- gpd generally for single family homes. The pumps selected are rated to flows up to 700 gpd thus peak flows are easily handled. We size the pipelines for the proper scouring velocity based on the pump’s output which has a consistent flow rate over a wide range of head conditions. We then look at the pipeline retention time to optimize the line size for the lowest retention that will pass wastewater in a short period of time to reduce sediment in the lines and prevent odor issues. This makes for a very reliable and maintenance free wastewater collection system.

Often we are asked to use the published “State” design values from various flow tables in order to secure approval. We can do this; but then we run the reports based on the actual predicted average flow to optimize the line size as mentioned above.

Many of our installations have seen flows that more closely mirror the EPA water use goals of 70 gpd/capita. We also look at seasonal uses a little more closely due to greater reductions in flow in the offseason. In applications of this type we look to

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find the best for both seasons.

The flow rates listed in your 4-2-19 email fall within the 700 GPD rating of our simplex pumps. For the larger 20 unit dorm this may be a duplex or triplex alternating pump that might slightly alter the simultaneous pump cycles in that zone. This can be refined further in design, if necessary.

**Appurtenances**

Our normal recommendations for valve placement are as follows: flushing connections at 1,000' to 1,500' intervals and at branch ends and junctions; isolation valves at branch junctions; and air release valves at peaks of 25 ft. or more and/or at intervals of 2,000 to 2,500 ft.

Common practice in pressure sewers requires the ability to isolate each lot with a corporation stop off the main and service lateral kit to the lot line. E/One has developed a true wastewater rated check valve which is built in to our stainless steel lateral kit shown in this report. These components are rated to 235 psi and with standard connection fittings rated to 150 psi. These items are included in the budget analyses and shown in this report.



We strongly advise against the use of waterworks check valves as they are not rated for sewage environments. We do not like to recommend brass due to concerns for corrosion. **WEF Manual of Practice FD-12, Second Edition**, page 45 speaks to the limited success of brass or bronze alloys.

> "Besides corrosion considerations, brass is subject to de-alloying, while some bronze, such as 85-5-5, will give better performance. The terms *brass* and *bronze* are used loosely, despite having different meanings; the engineer is advised to evaluate these materials with caution."

We have also seen PVC body check valves with pressure rating to 150 psi that do not have the same rating for back pressure on the check valve. This can result in damage to the check valve and pumping issues as the check valve disc can become dislodged under pressure and then become a line obstruction.

Connections to the main pressure line do not require WYE type fittings. We commonly use a TEE or saddle connection. We isolate each connection to the main line with a stainless steel corporation valve in the same manner used for other utilities such as gas and water services.

An estimated quantity of cleanouts and air/vacuum release assemblies, corporation stops and laterals are part of the budget pages included in the Version 2 report. We can supply details and specifications for these items as needed.

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**Budget Notes**

We show both our outdoor Model DH071-93 pumps and indoor Model IH091 pumps as options in this report. We have used the DH071-93 in the budget/takeoff.

Costs of pipeline excavation and pump installation are best obtained from sources in your region. We have some recent bid tabs from area projects that we can share to help with budget planning. Both Falmouth and Chatham have some good pressure sewer prices that can be used to prepare the project budget.

I am looking forward to working with you on this and future projects. Please contact me if you have any questions or require additional information.

Best regards,
*Henry S. Albro*
West Townsend Office
781-982-9300, Ext. 222
henryalbro@frmahony.com

Enclosures

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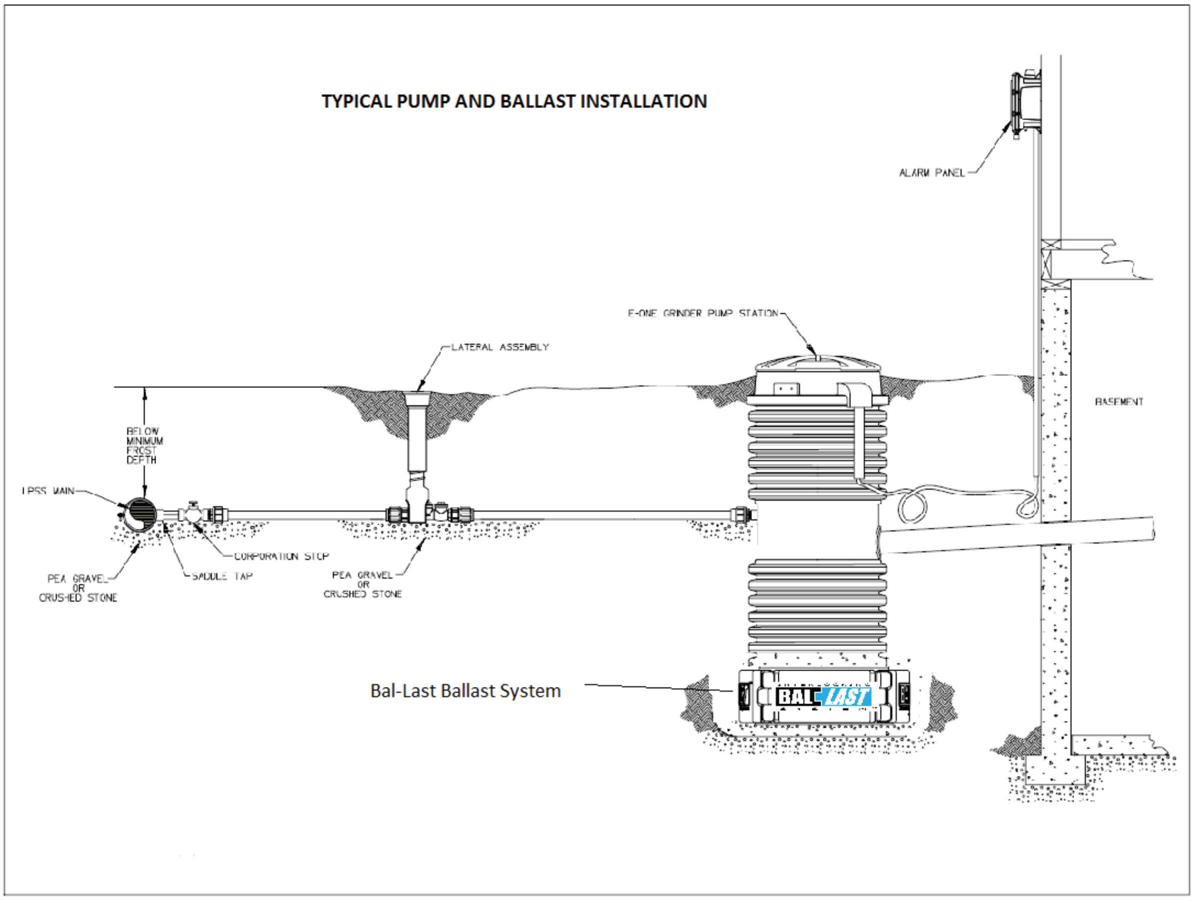


This image shows the typical layout of an outdoor pump unit for single-family home use. The pump unit is furnished complete, ready for installation. The installer needs to confirm the power cord length and discharge and inlet configuration. Standard products are supplied with 32 foot power supply cable. Standard inlets are 4-inch Schedule 40 Grommets (@ zero degrees) with 1-1/4 inch discharge (@ 180 degrees). Other configurations are available.

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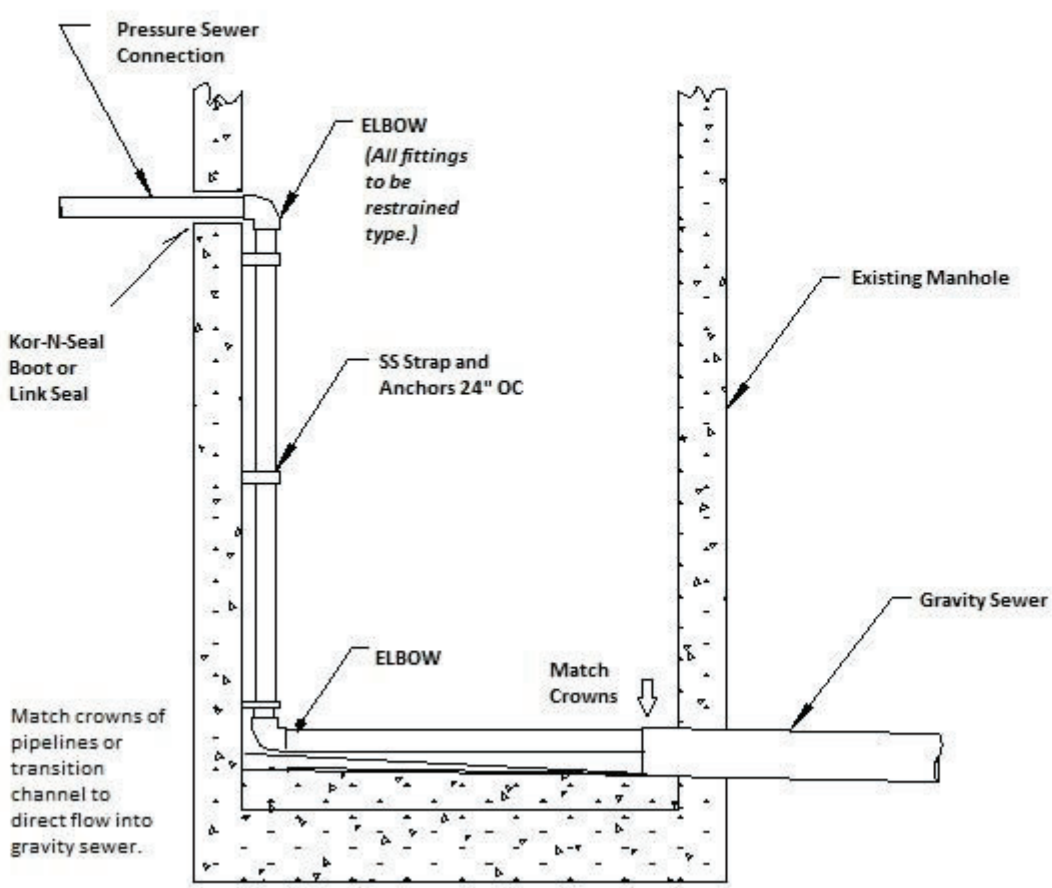
## TYPICAL INSIDE DROP DETAIL



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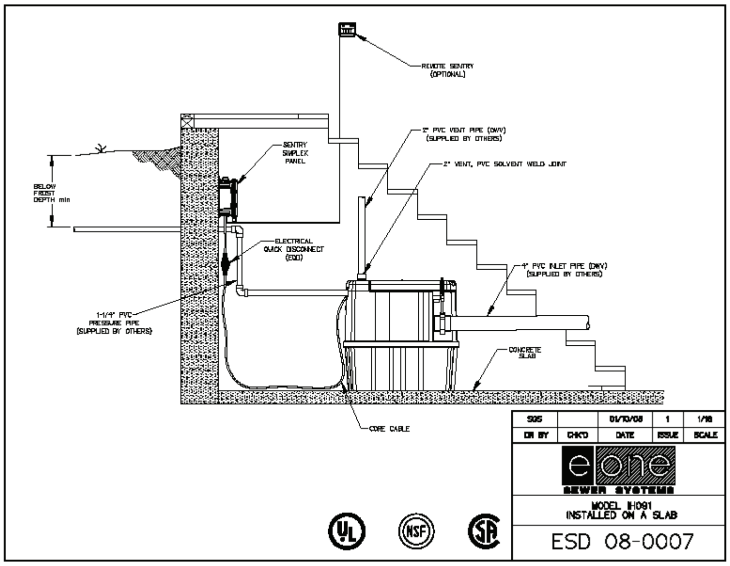
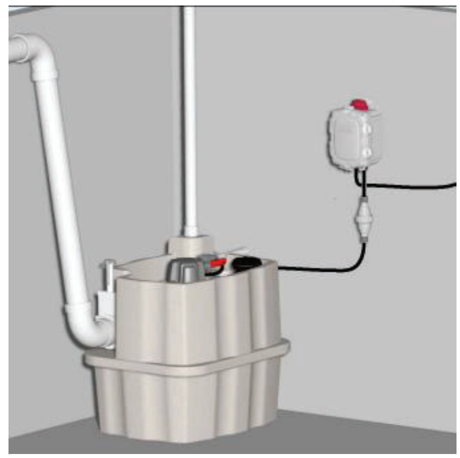
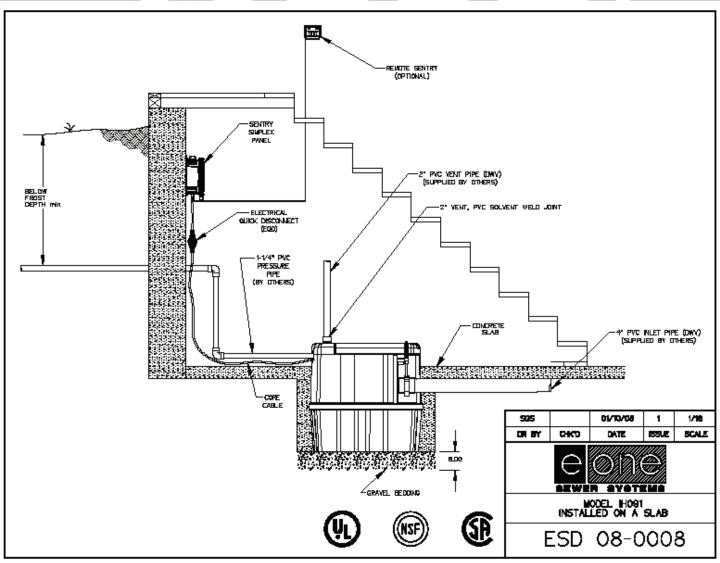
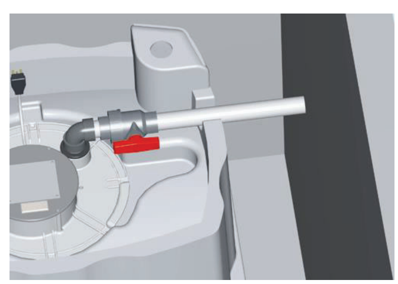
**Model IH091 Indoor Pump** Connection options for this station can be adapted to connect above the sill plumbing or below slab plumbing as seen in the sketches below.





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Standard alarm panels are the Sentry® panel mounted outside of the home as shown in the drawing (above).
Options include emergency generator connection (see photo) and Redundant alarm Remote Sentry® panel shown. Other panel configurations are available. See the partial listing of panel options below.

- Basic Panels include circuit breaker for the pump and separate breaker for the alarm. These panels include alarm light, alarm buzzer and alarm silence button. ***All F. R. Mahony panels are equipped with dry contacts to enable the connection of the Remote Sentry® (battery powered redundant alarm panel option)***

- Standard options include auto transfer generator connection shown above. This panel provides automatic power transfer without having to open the alarm panel or having to operate any manual transfer switching. This feature can be added to the basic panel or the panels offered below.

- Popular options include the **"Protection Package"** which monitors and protects the system from:
  - Pump Run Dry Condition (Pump running out of water)
  - Pump Overpressure Condition (Closed valve)
  - Brownout Condition (Main voltage under 12% of nameplate)
  - High Liquid Level

- The **"Protect Plus"** panel features offer the same items in the "Protection Package" plus the following:
  - High & Low Amperage draw by the pump
  - High & Low voltage to the pump
  - Extended Runtime by the pump (indicating wear or excessive flow) (field adjustable settings)
  - Monitoring of:
    - Real-time Pump Voltage and Current
    - Cycles & Hours (can be reset)
    - Minimum & Maximum Amperage (can be reset)
  - Minimum, Maximum, Average, and Last Run Cycle (in minutes, can be reset)

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**Emergency Generator Transfer Options.**

The indoor pump units may be furnished with a receptacle for connection of emergency power supplies. The image to the right shows the connection receptacle on the right side of our Sentry panels. This connection may be connected by your electrician to a remote connection port outside of the home.

Wiring must be performed by a licensed electrician and conforming to NEC and local electrical codes.

The box (left) is shown in the face view (face up) and is intended to be mounted on the outside wall to permit connection of a portable generator to the receptacle on the bottom. Generator operation must always be in well ventilated areas outside of any living space.

The pump may be operated under emergency power provided the automatic transfer option is selected with the Sentry® panel. Normal pump run times are short and should not require the continuous connection of a generator. A single portable generator may be used to service several homes effectively.

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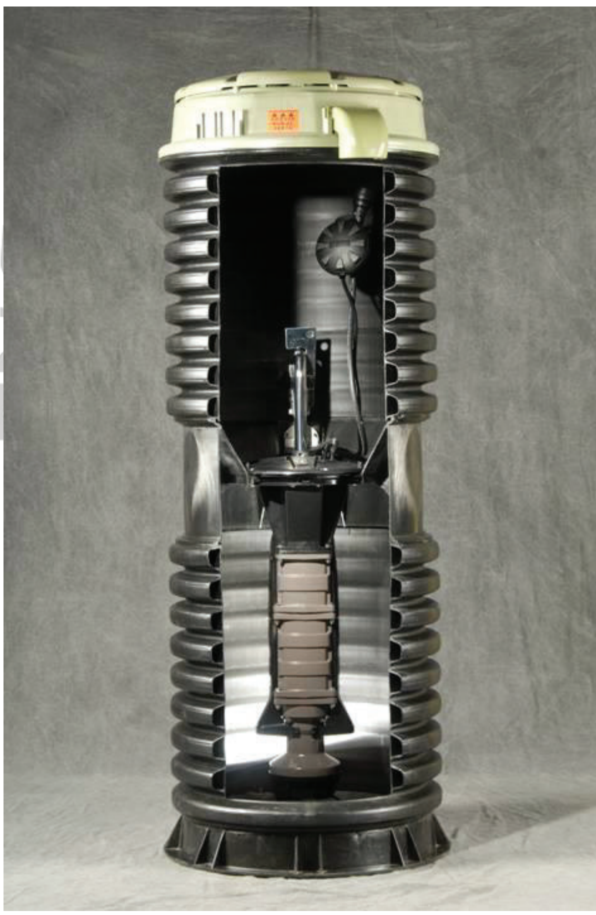
Pump models may be the DH071-93 (standard height) for outdoor use or the Model IH091 indoor unit. Both products are UL listed NSF and CSA certified.

## Model DH071-93 Outdoor Pump With Bal-Last™

The outdoor model is complete - ready for installation and connection to exterior plumbing and power supply. This unit is fully tested for operation and factory leak tested. No assembly is required and there are no floats to adjust. The pump is furnished complete with the alarm panel and direct bury power supply cable. Standard cable length is 32 feet with 50, 75, and 100 and up to 150 foot cables available. (See Alarm Panel options above)



Other station configurations are available for higher flow requirements. Please contact us for more information. Additional information may be found at www.eone.com

f.r. mahony & associates, inc.
frma
water supply and pollution control equipment
273 Weymouth Street • Rockland, MA 02370

tel. 781.982.9300
fax. 781.982.1056

info@frmahony.com
www.frmahony.com

## Operation Conditions

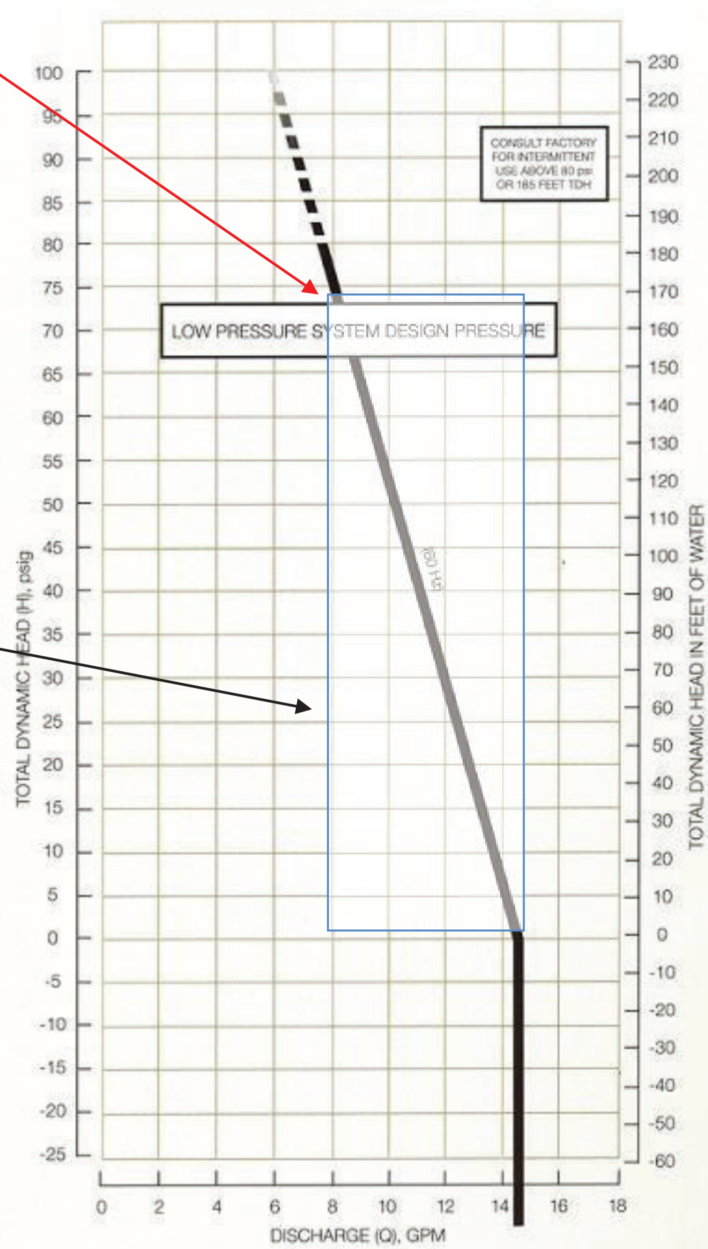
169.98 Feet is the highest TDH at simultaneous operating conditions with the expected number of pumps operating in each zone, or the head of an individual pump operating in a single zone condition.

Operating range of E/One pumps from 0-185 feet TDH and from 0 to -60 feet TDH.

**Your System Range**

Anti-siphon valves in E/One cores provide for negative head pumping. In common systems with negative heads of 25-30 feet or more we recommend the use of combination air/vacuum release valves as described below.

GRINDER PUMP PERFORMANCE CHARACTERISTICS




SEWER SYSTEMS
Environment One Corporation

30 DuPaul Street
Southbridge, MA 01550
tel. 508.765.0051
fax 508.765.1244

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W. Townsend, MA 01474
tel. 978.597.0703
fax 978.597.0704

1071 Floral Avenue
Schenectady, NY 12306
tel. 774-402-0354
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188 Pine Hill Road
South Kingstown, RI 02879
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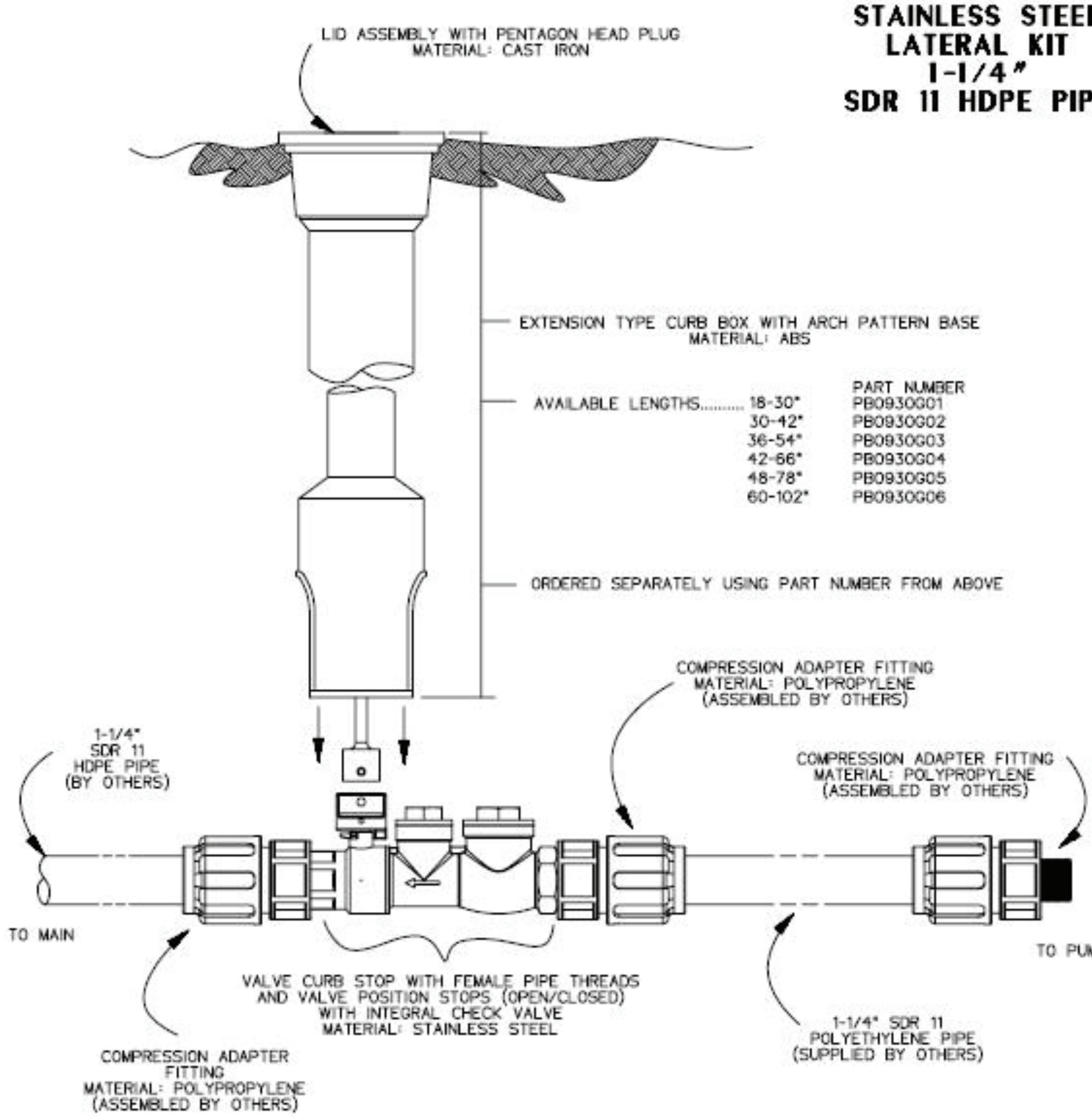
# STAINLESS STEEL LATERAL KIT 1-1/4" SDR 11 HDPE PIPE




KIT PARTS ARE NOT ASSEMBLED

NOTES:

1. SS CURB STOP/CHECK VALVE AND FITTINGS ARE PROVIDED SEPARATELY, TO BE ASSEMBLED BY OTHERS
2. TO ASSEMBLE, APPLY A DOUBLE LAYER OF TEFLON TAPE, AND A LAYER OF PIPE DOPE (SUPPLIED BY OTHERS) TO THE THREADS ON THE PLASTIC FITTINGS AND INSTALL PER THE MANUFACTURER'S INSTRUCTIONS
3. ASSEMBLY IS TO BE PRESSURE TESTED (BY OTHERS)
4. ASSEMBLY IS TO BE USED WITH SDR11 HDPE PIPE
5. TO ORDER SS LATERAL KIT, USE PART NUMBER NC0193G01
6. CURB BOX IS TO BE ORDERED SEPARATELY, SEE ABOVE

| SGS | DN | 11/02/11 | A | 3/16 |
|---|---|---|---|---|
| DR BY | CHK'D | DATE | ISSUE | SCALE |

eone SEWER SYSTEMS

STAINLESS STEEL LATERAL KIT
1-1/4" SDR 11 HDPE PIPE

NA0330P02

f.r. mahony & associates, inc.
frma
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273 Weymouth Street • Rockland, MA 02370

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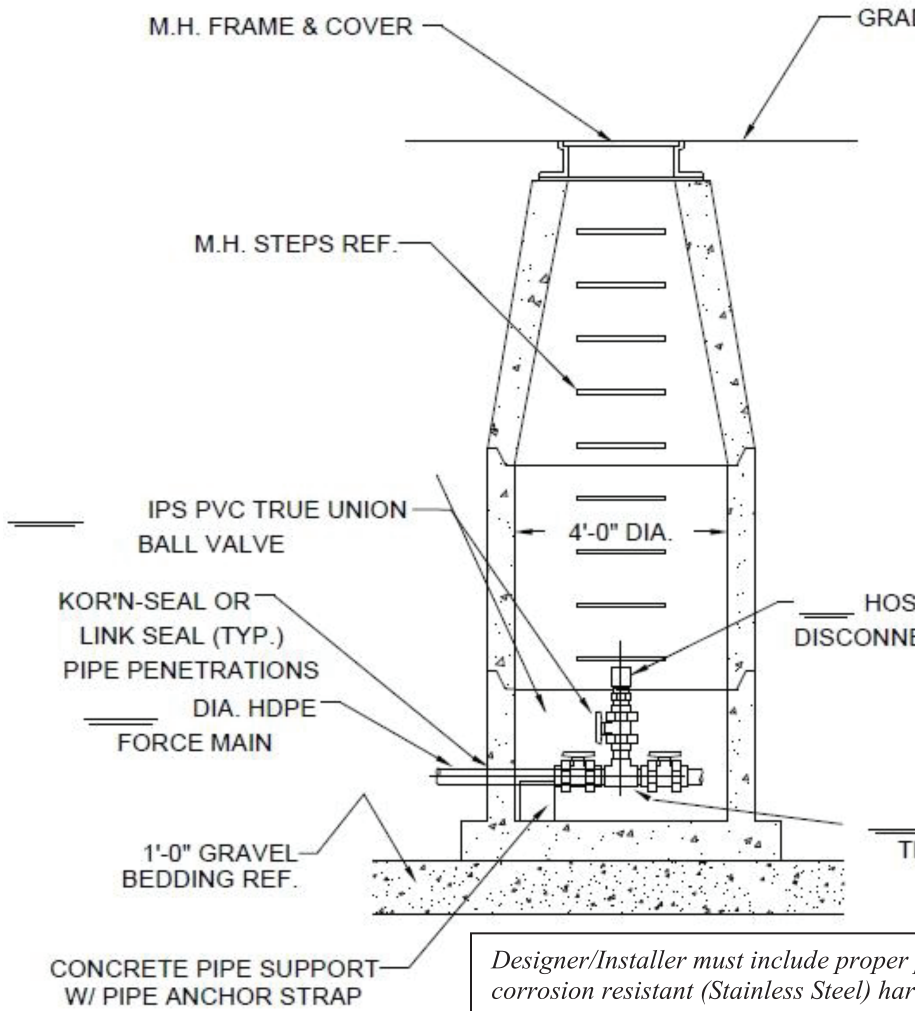
# Example of Typical Cleanout Detail

## (Optional Air/Vacuum Valve shown –right)




*Designer/Installer must include proper pipe supports with corrosion resistant (Stainless Steel) hardware. Supports will vary depending on cleanout configuration.*

Cleanout detail can be modified to match typical installation needs. Inline shut offs may be added to isolate flow direction. Image shown is flow through cleanout. These structures can be terminal end of line cleanouts, or junction cleanouts as may be required. Optional air and vacuum relief valves may be added when required.

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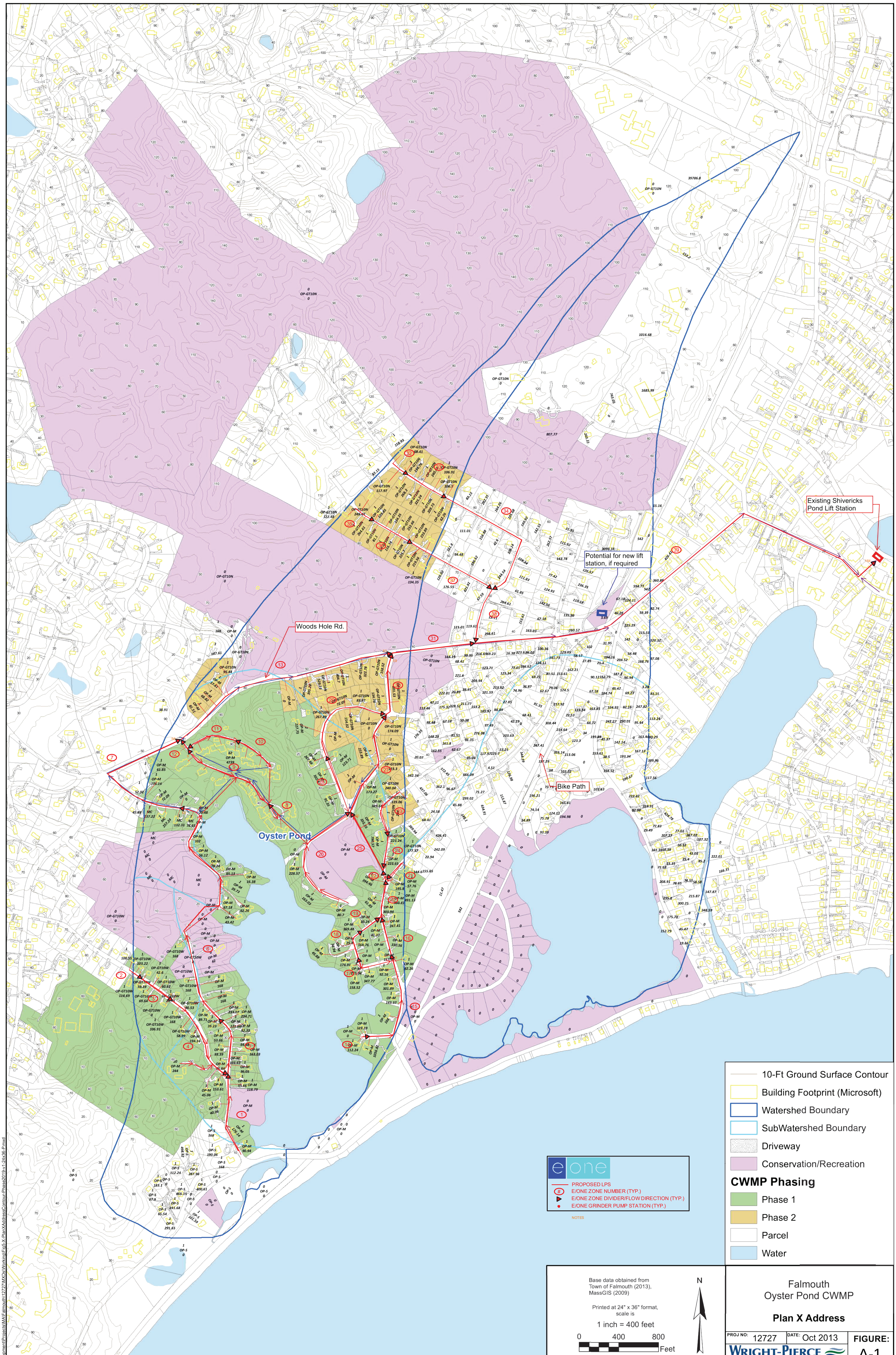
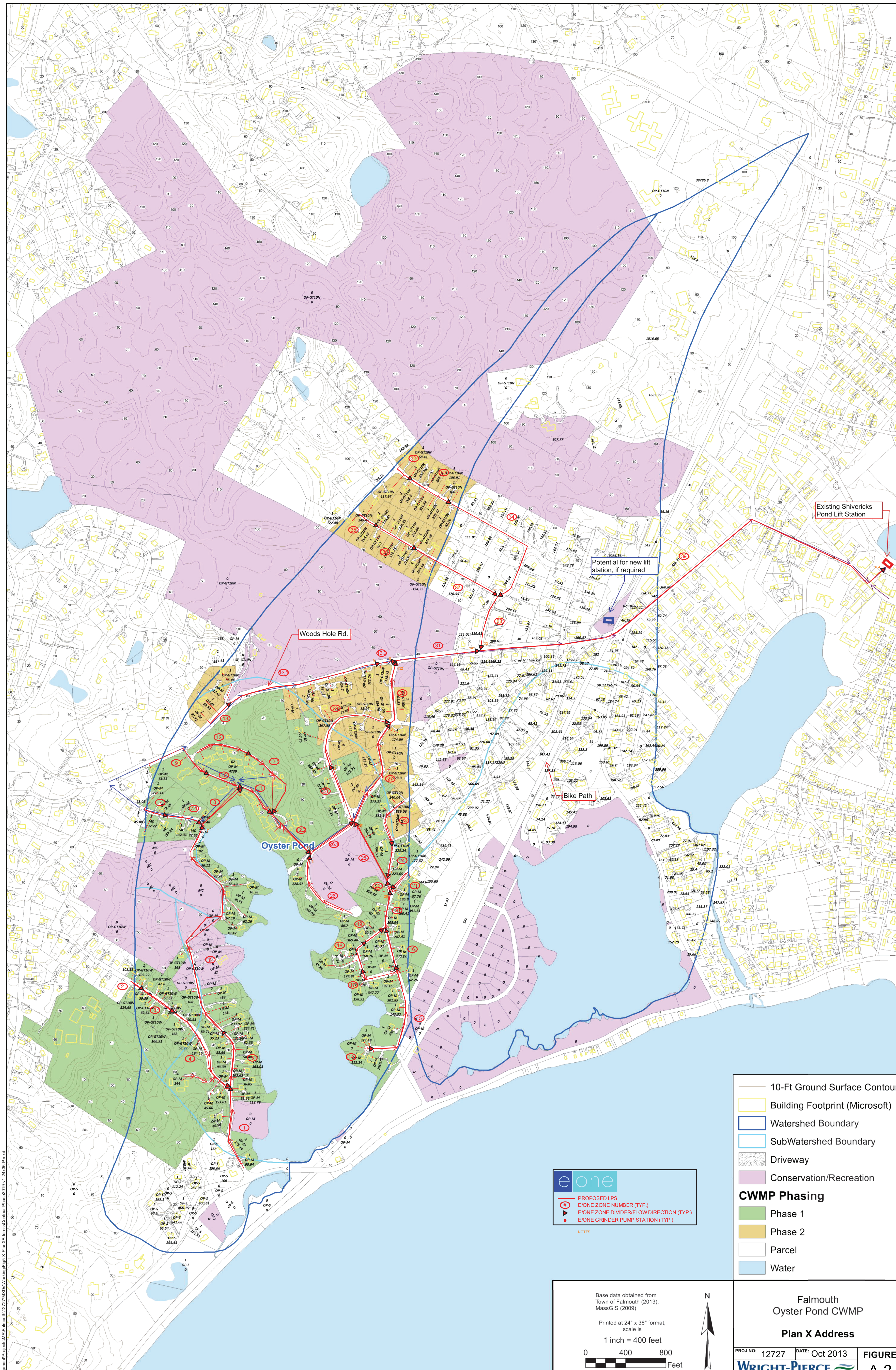
188 Pine Hill Road
South Kingstown, RI 02879
tel. 781-561-6555

V1



Existing Shivericks Pond Lift Station
Potential for new lift station, if required
Woods Hole Rd.
Bike Path
Oyster Pond
PROPOSED LPS
E/ONE ZONE NUMBER (TYP.)
E/ONE ZONE DIVIDER/FLOW DIRECTION (TYP.)
E/ONE GRINDER PUMP STATION (TYP.)
NOTES
10-Ft Ground Surface Contour
Building Footprint (Microsoft)
Watershed Boundary
SubWatershed Boundary
Driveway
Conservation/Recreation
CWMP Phasing
Phase 1
Phase 2
Parcel
Water
Base data obtained from Town of Falmouth (2013), MassGIS (2009)
Printed at 24" x 36" format, scale is
1 inch = 400 feet
0
400
800
Feet
N
Falmouth
Oyster Pond CWMP
Plan X Address
PROJ NO: 12727
DATE: Oct 2013
FIGURE:
A-1
WRIGHT-PIERCE
Engineering a Better Environment

V2
RECOMMENDED



Environment One Corporation

# Pressure Sewer Preliminary

# Cost and Design Analysis

# For

# Oyster Pond Subdevelopment
# Falmouth, MA

VERSION 1

**Prepared For:**
**Wright-Pierce**

**MA** **USA**

**Tel: 207-523-1409**
**Fax:**
**Prepared By: M. Crowley**
**April 17, 2019**

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**Oyster Pond Subdevelopment**
**Falmouth, MA**

**Prepared by :** M. Crowley **On:** April 17, 2019

**Notes :**
Analysis based upon drawings and data provided.  Station recommendations are preliminary.

GPD values impact retention times only, not line sizing or hydraulics.  GP laterals to be 1.25".

General recommendations for valve placement are:  clean out valves at intervals of approximately 1,000 ft and at branch ends and junctions; isolation valves at branch junctions; and air release valves at peaks of 25 ft or more and/or at intervals of 2,000 to 2,500 ft. Lateral kits comprised of a ball and check valve are required to be installed between the pump discharge and street main on all installations.  Laterals should be located as close to the public right of way as possible.

**<<<<< END OF NOTES >>>>>**

PRELIMINARY PRESSURE SEWER - PIPE SIZING AND BRANCH ANALYSIS

Prepared By:
M. Crowley

Oyster Pond Subdevelopment
Falmouth, MA

April 17, 2019

| Zone Number | Connects to Zone | Number of Pumps in Zone | Accum Pumps in Zone | Gals/day per Pump | Max Flow Per Pump (gpm) | Max Sim Ops | Max Flow (GPM) | Pipe Size (inches) | Max Velocity (FPS) | Length of Main this Zone | Friction Loss Factor (ft/100 ft) | Friction Loss This Zone | Accum Fric Loss (feet) | Max Main Elevation | Minimum Pump Elevation | Static Head (feet) | Total Dynamic Head (ft) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| This spreadsheet was calculated using pipe diameters for: | | | | | SDR11HDPE | | | | | | Friction loss calculations were based on a Constant for inside roughness"C" of: | | | | | | 150 |
| 1.00 | 5.00 | 5 | 5 | 200 | 11.00 | 3 | 33.00 | 2.00 | 3.57 | 810.00 | 2.52 | 20.41 | 146.13 | 78.00 | 5.00 | 73.00 | 219.13 |
| 2.00 | 3.00 | 3 | 3 | 200 | 11.00 | 2 | 22.00 | 2.00 | 2.38 | 157.00 | 1.19 | 1.87 | 143.47 | 78.00 | 41.00 | 37.00 | 180.47 |
| 3.00 | 4.00 | 6 | 9 | 200 | 11.00 | 3 | 33.00 | 2.00 | 3.57 | 381.00 | 2.52 | 9.60 | 141.60 | 78.00 | 39.00 | 39.00 | 180.60 |
| 4.00 | 5.00 | 8 | 17 | 200 | 11.00 | 4 | 44.00 | 3.00 | 2.19 | 966.00 | 0.65 | 6.28 | 132.00 | 78.00 | 22.00 | 56.00 | 188.00 |
| 5.00 | 6.00 | 8 | 30 | 200 | 11.00 | 5 | 55.00 | 3.00 | 2.74 | 601.00 | 0.98 | 5.90 | 125.72 | 78.00 | 20.00 | 58.00 | 183.72 |
| 6.00 | 7.00 | 20 | 50 | 200 | 11.00 | 6 | 66.00 | 3.00 | 3.29 | 2,754.00 | 1.38 | 37.92 | 119.82 | 78.00 | 3.00 | 75.00 | 194.82 |
| 7.00 | 13.00 | 6 | 56 | 200 | 11.00 | 7 | 77.00 | 4.00 | 2.32 | 1,657.00 | 0.54 | 8.94 | 81.90 | 78.00 | 41.00 | 37.00 | 118.90 |
| 8.00 | 9.00 | 3 | 3 | 200 | 11.00 | 2 | 22.00 | 2.00 | 2.38 | 171.00 | 1.19 | 2.03 | 101.72 | 78.00 | 36.00 | 42.00 | 143.72 |
| 9.00 | 12.00 | 6 | 9 | 200 | 11.00 | 3 | 33.00 | 2.00 | 3.57 | 1,032.00 | 2.52 | 26.00 | 99.69 | 78.00 | 39.00 | 39.00 | 138.69 |
| 10.00 | 11.00 | 3 | 3 | 200 | 11.00 | 2 | 22.00 | 2.00 | 2.38 | 441.00 | 1.19 | 5.24 | 92.33 | 84.00 | 82.00 | 2.00 | 94.33 |
| 11.00 | 12.00 | 3 | 6 | 200 | 11.00 | 3 | 33.00 | 2.00 | 3.57 | 532.00 | 2.52 | 13.40 | 87.09 | 78.00 | 66.00 | 12.00 | 99.09 |
| 12.00 | 13.00 | 1 | 16 | 200 | 11.00 | 4 | 44.00 | 3.00 | 2.19 | 113.00 | 0.65 | 0.73 | 73.69 | 78.00 | 67.00 | 11.00 | 84.69 |
| 13.00 | 31.00 | 10 | 82 | 200 | 11.00 | 8 | 88.00 | 4.00 | 2.65 | 2,380.00 | 0.69 | 16.45 | 72.96 | 78.00 | 41.00 | 37.00 | 109.96 |
| 14.00 | 15.00 | 3 | 3 | 200 | 11.00 | 2 | 22.00 | 2.00 | 2.38 | 73.00 | 1.19 | 0.87 | 120.25 | 56.00 | 6.00 | 50.00 | 170.25 |
| 15.00 | 16.00 | 6 | 9 | 200 | 11.00 | 3 | 33.00 | 2.00 | 3.57 | 1,073.00 | 2.52 | 27.03 | 119.38 | 56.00 | 6.00 | 50.00 | 169.38 |
| 16.00 | 20.00 | 5 | 14 | 200 | 11.00 | 4 | 44.00 | 3.00 | 2.19 | 392.00 | 0.65 | 2.55 | 92.35 | 56.00 | 10.00 | 46.00 | 138.35 |
| 17.00 | 18.00 | 3 | 3 | 200 | 11.00 | 2 | 22.00 | 2.00 | 2.38 | 189.00 | 1.19 | 2.25 | 101.72 | 56.00 | 7.00 | 49.00 | 150.72 |
| 18.00 | 19.00 | 6 | 9 | 200 | 11.00 | 3 | 33.00 | 2.00 | 3.57 | 321.00 | 2.52 | 8.09 | 99.47 | 56.00 | 9.00 | 47.00 | 146.47 |
| 19.00 | 20.00 | 2 | 11 | 200 | 11.00 | 4 | 44.00 | 3.00 | 2.19 | 243.00 | 0.65 | 1.58 | 91.38 | 56.00 | 15.00 | 41.00 | 132.38 |
| 20.00 | 22.00 | 4 | 29 | 200 | 11.00 | 5 | 55.00 | 3.00 | 2.74 | 379.00 | 0.98 | 3.72 | 89.80 | 56.00 | 14.00 | 42.00 | 131.80 |
| 21.00 | 22.00 | 3 | 3 | 200 | 11.00 | 2 | 22.00 | 2.00 | 2.38 | 236.00 | 1.19 | 2.81 | 88.89 | 56.00 | 24.00 | 32.00 | 120.89 |
| 22.00 | 25.00 | 0 | 32 | 200 | 11.00 | 6 | 66.00 | 3.00 | 3.29 | 92.00 | 1.38 | 1.27 | 86.08 | 56.00 | 33.00 | 23.00 | 109.08 |
| 23.00 | 24.00 | 3 | 3 | 200 | 11.00 | 2 | 22.00 | 2.00 | 2.38 | 549.00 | 1.19 | 6.53 | 100.36 | 83.00 | 65.00 | 18.00 | 118.36 |
| 24.00 | 25.00 | 3 | 6 | 200 | 11.00 | 3 | 33.00 | 2.00 | 3.57 | 358.00 | 2.52 | 9.02 | 93.83 | 56.00 | 55.00 | 1.00 | 94.83 |
| 25.00 | 27.00 | 2 | 40 | 200 | 11.00 | 6 | 66.00 | 3.00 | 3.29 | 696.00 | 1.38 | 9.58 | 84.81 | 56.00 | 12.00 | 44.00 | 128.81 |
| 26.00 | 27.00 | 3 | 3 | 200 | 11.00 | 2 | 22.00 | 2.00 | 2.38 | 1,300.00 | 1.19 | 15.46 | 90.69 | 56.00 | 27.00 | 29.00 | 119.69 |
| 27.00 | 30.00 | 5 | 48 | 200 | 11.00 | 6 | 66.00 | 3.00 | 3.29 | 1,107.00 | 1.38 | 15.24 | 75.23 | 56.00 | 14.00 | 42.00 | 117.23 |
| 28.00 | 29.00 | 3 | 3 | 200 | 11.00 | 2 | 22.00 | 2.00 | 2.38 | 386.00 | 1.19 | 4.59 | 90.93 | 68.00 | 41.00 | 27.00 | 117.93 |
| 29.00 | 30.00 | 6 | 9 | 200 | 11.00 | 3 | 33.00 | 2.00 | 3.57 | 1,046.00 | 2.52 | 26.35 | 86.34 | 68.00 | 20.00 | 48.00 | 134.34 |
| 30.00 | 31.00 | 2 | 59 | 200 | 11.00 | 7 | 77.00 | 4.00 | 2.32 | 645.00 | 0.54 | 3.48 | 59.99 | 56.00 | 48.00 | 8.00 | 67.99 |
| 31.00 | 39.00 | 0 | 141 | 200 | 11.00 | 9 | 99.00 | 4.00 | 2.98 | 844.00 | 0.86 | 7.25 | 56.51 | 56.00 | 56.00 | 0.00 | 56.51 |
| 32.00 | 33.00 | 3 | 3 | 200 | 11.00 | 2 | 22.00 | 2.00 | 2.38 | 192.00 | 1.19 | 2.28 | 78.23 | 89.00 | 80.00 | 9.00 | 87.23 |
| 33.00 | 34.00 | 6 | 9 | 200 | 11.00 | 3 | 33.00 | 2.00 | 3.57 | 454.00 | 2.52 | 11.44 | 75.95 | 71.00 | 71.00 | 0.00 | 75.95 |
| 34.00 | 38.00 | 1 | 10 | 200 | 11.00 | 4 | 44.00 | 3.00 | 2.19 | 1,483.00 | 0.65 | 9.64 | 64.51 | 48.00 | 48.00 | 0.00 | 64.51 |
| 35.00 | 36.00 | 3 | 3 | 200 | 11.00 | 2 | 22.00 | 2.00 | 2.38 | 229.00 | 1.19 | 2.72 | 74.90 | 70.00 | 70.00 | 0.00 | 74.90 |



Note: This analysis is valid only with the use of progressive cavity type grinder pumps as manufactured by Environment One.

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PRELIMINARY PRESSURE SEWER - PIPE SIZING AND BRANCH ANALYSIS

Prepared By:
M. Crowley

Oyster Pond Subdevelopment
Falmouth, MA

April 17, 2019

| Zone Number | Connects to Zone | Number of Pumps in Zone | Accum Pumps in Zone | Gals/day per Pump | Max Flow Per Pump (gpm) | Max Sim Ops | Max Flow (GPM) | Pipe Size (inches) | Max Velocity (FPS) | Length of Main this Zone | Friction Loss Factor (ft/100 ft) | Friction Loss This Zone | Accum Fric Loss (feet) | Max Main Elevation | Minimum Pump Elevation | Static Head (feet) | Total Dynamic Head (ft) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| This spreadsheet was calculated using pipe diameters for: | | | | | SDR11HDPE | | | | | | Friction loss calculations were based on a Constant for inside roughness"C" of: | | | | | | 150 |
| 36.00 | 37.00 | 6 | 9 | 200 | 11.00 | 3 | 33.00 | 2.00 | 3.57 | 444.00 | 2.52 | 11.19 | 72.18 | 69.00 | 69.00 | 0.00 | 72.18 |
| 37.00 | 38.00 | 4 | 13 | 200 | 11.00 | 4 | 44.00 | 3.00 | 2.19 | 942.00 | 0.65 | 6.12 | 60.99 | 49.00 | 49.00 | 0.00 | 60.99 |
| 38.00 | 39.00 | 0 | 23 | 200 | 11.00 | 5 | 55.00 | 3.00 | 2.74 | 571.00 | 0.98 | 5.61 | 54.87 | 48.00 | 48.00 | 0.00 | 54.87 |
| 39.00 | 39.00 | 0 | 164 | 200 | 11.00 | 10 | 110.00 | 4.00 | 3.31 | 4,716.00 | 1.04 | 49.26 | 49.26 | 44.00 | 44.00 | 0.00 | 49.26 |



Note: This analysis is valid only with the use of progressive cavity type grinder pumps as manufactured by Environment One.

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# PRELIMINARY PRESSURE SEWER - ACCUMULATED RETENTION TIME (HR)

Prepared By:
M. Crowley

Oyster Pond Subdevelopment
Falmouth, MA

April 17, 2019

| Zone Number | Connects to Zone | Accumulated Total of Pumps this Zone | Pipe Size (inches) | Gallons per 100 lineal feet | Length of Zone | Capacity of Zone | Average Daily Flow | Average Fluid Changes per Day | Average Retention Time (Hr) | Accumulated Retention Time (Hr) |
|---|---|---|---|---|---|---|---|---|---|---|
| This spreadsheet was calculated using pipe diameters for: SDR11HDPE | | | | | | | | Gals per Day per Dwelling | | 200 |
| 1.00 | 5.00 | 5 | 2.00 | 15.40 | 810.00 | 124.76 | 1,000 | 8.02 | 2.99 | 12.21 |
| 2.00 | 3.00 | 3 | 2.00 | 15.40 | 157.00 | 24.18 | 600 | 24.81 | 0.97 | 13.24 |
| 3.00 | 4.00 | 9 | 2.00 | 15.40 | 381.00 | 58.68 | 1,800 | 30.67 | 0.78 | 12.28 |
| 4.00 | 5.00 | 17 | 3.00 | 33.47 | 966.00 | 323.29 | 3,400 | 10.52 | 2.28 | 11.50 |
| 5.00 | 6.00 | 30 | 3.00 | 33.47 | 601.00 | 201.13 | 6,000 | 29.83 | 0.80 | 9.21 |
| 6.00 | 7.00 | 50 | 3.00 | 33.47 | 2,754.00 | 921.67 | 10,000 | 10.85 | 2.21 | 8.41 |
| 7.00 | 13.00 | 56 | 4.00 | 55.31 | 1,657.00 | 916.54 | 11,200 | 12.22 | 1.96 | 6.20 |
| 8.00 | 9.00 | 3 | 2.00 | 15.40 | 171.00 | 26.34 | 600 | 22.78 | 1.05 | 7.69 |
| 9.00 | 12.00 | 9 | 2.00 | 15.40 | 1,032.00 | 158.96 | 1,800 | 11.32 | 2.12 | 6.64 |
| 10.00 | 11.00 | 3 | 2.00 | 15.40 | 441.00 | 67.93 | 600 | 8.83 | 2.72 | 8.87 |
| 11.00 | 12.00 | 6 | 2.00 | 15.40 | 532.00 | 81.94 | 1,200 | 14.64 | 1.64 | 6.16 |
| 12.00 | 13.00 | 16 | 3.00 | 33.47 | 113.00 | 37.82 | 3,200 | 84.62 | 0.28 | 4.52 |
| 13.00 | 31.00 | 82 | 4.00 | 55.31 | 2,380.00 | 1,316.45 | 16,400 | 12.46 | 1.93 | 4.23 |
| 14.00 | 15.00 | 3 | 2.00 | 15.40 | 73.00 | 11.24 | 600 | 53.36 | 0.45 | 9.07 |
| 15.00 | 16.00 | 9 | 2.00 | 15.40 | 1,073.00 | 165.27 | 1,800 | 10.89 | 2.20 | 8.63 |
| 16.00 | 20.00 | 14 | 3.00 | 33.47 | 392.00 | 131.19 | 2,800 | 21.34 | 1.12 | 6.42 |
| 17.00 | 18.00 | 3 | 2.00 | 15.40 | 189.00 | 29.11 | 600 | 20.61 | 1.16 | 8.01 |
| 18.00 | 19.00 | 9 | 2.00 | 15.40 | 321.00 | 49.44 | 1,800 | 36.41 | 0.66 | 6.84 |
| 19.00 | 20.00 | 11 | 3.00 | 33.47 | 243.00 | 81.32 | 2,200 | 27.05 | 0.89 | 6.18 |
| 20.00 | 22.00 | 29 | 3.00 | 33.47 | 379.00 | 126.84 | 5,800 | 45.73 | 0.52 | 5.30 |
| 21.00 | 22.00 | 3 | 2.00 | 15.40 | 236.00 | 36.35 | 600 | 16.51 | 1.45 | 6.23 |
| 22.00 | 25.00 | 32 | 3.00 | 33.47 | 92.00 | 30.79 | 6,400 | 207.87 | 0.12 | 4.77 |
| 23.00 | 24.00 | 3 | 2.00 | 15.40 | 549.00 | 84.56 | 600 | 7.10 | 3.38 | 9.14 |
| 24.00 | 25.00 | 6 | 2.00 | 15.40 | 358.00 | 55.14 | 1,200 | 21.76 | 1.10 | 5.76 |
| 25.00 | 27.00 | 40 | 3.00 | 33.47 | 696.00 | 232.93 | 8,000 | 34.35 | 0.70 | 4.66 |
| 26.00 | 27.00 | 3 | 2.00 | 15.40 | 1,300.00 | 200.24 | 600 | 3.00 | 8.01 | 11.97 |
| 27.00 | 30.00 | 48 | 3.00 | 33.47 | 1,107.00 | 370.47 | 9,600 | 25.91 | 0.93 | 3.96 |
| 28.00 | 29.00 | 3 | 2.00 | 15.40 | 386.00 | 59.46 | 600 | 10.09 | 2.38 | 7.56 |
| 29.00 | 30.00 | 9 | 2.00 | 15.40 | 1,046.00 | 161.11 | 1,800 | 11.17 | 2.15 | 5.18 |
| 30.00 | 31.00 | 59 | 4.00 | 55.31 | 645.00 | 356.77 | 11,800 | 33.07 | 0.73 | 3.03 |
| 31.00 | 39.00 | 141 | 4.00 | 55.31 | 844.00 | 466.84 | 28,200 | 60.41 | 0.40 | 2.31 |
| 32.00 | 33.00 | 3 | 2.00 | 15.40 | 192.00 | 29.57 | 600 | 20.29 | 1.18 | 10.98 |
| 33.00 | 34.00 | 9 | 2.00 | 15.40 | 454.00 | 69.93 | 1,800 | 25.74 | 0.93 | 9.79 |
| 34.00 | 38.00 | 10 | 3.00 | 33.47 | 1,483.00 | 496.31 | 2,000 | 4.03 | 5.96 | 8.86 |
| 35.00 | 36.00 | 3 | 2.00 | 15.40 | 229.00 | 35.27 | 600 | 17.01 | 1.41 | 8.14 |



Note: This analysis is valid only with the use of progressive cavity type grinder pumps as manufactured by Environment One

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PRELIMINARY PRESSURE SEWER - ACCUMULATED RETENTION TIME (HR)

Prepared By:
M. Crowley

Oyster Pond Subdevelopment
Falmouth, MA

April 17, 2019

| Zone Number | Connects to Zone | Accumulated Total of Pumps this Zone | Pipe Size (inches) | Gallons per 100 lineal feet | Length of Zone | Capacity of Zone | Average Daily Flow | Average Fluid Changes per Day | Average Retention Time (Hr) | Accumulated Retention Time (Hr) |
|---|---|---|---|---|---|---|---|---|---|---|
| This spreadsheet was calculated using pipe diameters for: SDR11HDPE | | | | | | | | Gals per Day per Dwelling | | 200 |
| 36.00 | 37.00 | 9 | 2.00 | 15.40 | 444.00 | 68.39 | 1,800 | 26.32 | 0.91 | 6.73 |
| 37.00 | 38.00 | 13 | 3.00 | 33.47 | 942.00 | 315.25 | 2,600 | 8.25 | 2.91 | 5.82 |
| 38.00 | 39.00 | 23 | 3.00 | 33.47 | 571.00 | 191.09 | 4,600 | 24.07 | 1.00 | 2.91 |
| 39.00 | 39.00 | 164 | 4.00 | 55.31 | 4,716.00 | 2,608.57 | 32,800 | 12.57 | 1.91 | 1.91 |



Note: This analysis is valid only with the use of progressive cavity type grinder pumps as manufactured by Environment One

April 17, 2019

## Budgetary Low Pressure Sewer System Costs

### Oyster Pond Subdevelopment
### Falmouth, MA

| | Quantity | Description | Unit Cost | Installation | Sub Total |
|---|---|---|---|---|---|
| **Pumps** | 164 | DH071-93 | $0.00 | 0.00 | $0.00 |
| | 164 | Lateral Kits (Includes Ball\Check Valve Assembly) | $0.00 | 0.00 | $0.00 |
| | 164 | Lateral (Boundary) Installation | $0.00 | 0.00 | $0.00 |
| | 164 | Pump/Panel Installation | $0.00 | 0.00 | $0.00 |
| | 8,200 | LF of 1.25" Lateral Pipe | $0.00 | 0.00 | $0.00 |
| | | | | | **$0.00** |
| **Piping** | 10,374 | 2.00" Pipe | $0.00 | 0.00 | $0.00 |
| | 10,339 | 3.00" Pipe | $0.00 | 0.00 | $0.00 |
| | 10,242 | 4.00" Pipe | $0.00 | 0.00 | $0.00 |
| | | | | | **$0.00** |

| | | | | |
|---|---|---|---|---|
| **Number of Connections** | **164** | | | |
| **Total Per Connection** | **$0.00** | **Total (w/o other)** | >>>>>>>>>>>>> | **$0.00** |
| **Grand Total Per Connection** | **$0.00** | **Grand Total (including other)** | >>>>>>>>>>>>> | **$0.00** |

Note: The System Costs above are based on piping sized for, and Grinder Pumps manufactured by Environment One Corporation.

Environment One Corporation

# Pressure Sewer Preliminary

# Cost and Design Analysis

# For

# Oyster Pond Subdevelopment
# Falmouth, MA

VERSION 2
RECOMMENDED

**Prepared For:**
**Wright-Pierce**

**MA** **USA**

**Tel: 207-523-1409**
**Fax:**
**Prepared By: M. Crowley**
**April 17, 2019**

# Oyster Pond Subdevelopment
# Falmouth, MA

**Prepared by :** M. Crowley **On:** April 17, 2019

**Notes :**
Analysis based upon drawings and data provided. Station recommendations are preliminary.

GPD values impact retention times only, not line sizing or hydraulics. GP laterals to be 1.25".

General recommendations for valve placement are: clean out valves at intervals of approximately 1,000 ft and at branch ends and junctions; isolation valves at branch junctions; and air release valves at peaks of 25 ft or more and/or at intervals of 2,000 to 2,500 ft. Lateral kits comprised of a ball and check valve are required to be installed between the pump discharge and street main on all installations. Laterals should be located as close to the public right of way as possible.

**<<<<< END OF NOTES >>>>>**

# PRELIMINARY PRESSURE SEWER - PIPE SIZING AND BRANCH ANALYSIS

Oyster Pond Subdevelopment

Falmouth, MA

Prepared By:
M. Crowley

April 17, 2019

| Zone Number | Connects to Zone | Number of Pumps in Zone | Accum Pumps in Zone | Gals/day per Pump | Max Flow Per Pump (gpm) | Max Sim Ops | Max Flow (GPM) | Pipe Size (inches) | Max Velocity (FPS) | Length of Main this Zone | Friction Loss Factor (ft/100 ft) | Friction Loss This Zone | Accum Fric Loss (feet) | Max Main Elevation | Minimum Pump Elevation | Static Head (feet) | Total Dynamic Head (ft) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| This spreadsheet was calculated using pipe diameters for: | | | | | SDR11HDPE | | | | | | Friction loss calculations were based on a Constant for inside roughness"C" of: | | | | | | 150 |
| 1.00 | 5.00 | 5 | 5 | 200 | 11.00 | 3 | 33.00 | 2.00 | 3.57 | 810.00 | 2.52 | 20.41 | 144.02 | 56.00 | 5.00 | 51.00 | 195.02 |
| 2.00 | 3.00 | 3 | 3 | 200 | 11.00 | 2 | 22.00 | 2.00 | 2.38 | 157.00 | 1.19 | 1.87 | 141.36 | 56.00 | 41.00 | 15.00 | 156.36 |
| 3.00 | 4.00 | 6 | 9 | 200 | 11.00 | 3 | 33.00 | 2.00 | 3.57 | 381.00 | 2.52 | 9.60 | 139.49 | 56.00 | 39.00 | 17.00 | 156.49 |
| 4.00 | 5.00 | 8 | 17 | 200 | 11.00 | 4 | 44.00 | 3.00 | 2.19 | 966.00 | 0.65 | 6.28 | 129.89 | 56.00 | 22.00 | 34.00 | 163.89 |
| 5.00 | 6.00 | 8 | 30 | 200 | 11.00 | 5 | 55.00 | 3.00 | 2.74 | 601.00 | 0.98 | 5.90 | 123.61 | 56.00 | 20.00 | 36.00 | 159.61 |
| 6.00 | 8.00 | 17 | 47 | 200 | 11.00 | 6 | 66.00 | 3.00 | 3.29 | 2,542.00 | 1.38 | 35.00 | 117.71 | 56.00 | 3.00 | 53.00 | 170.71 |
| 7.00 | 7.10 | 3 | 3 | 200 | 11.00 | 2 | 22.00 | 2.00 | 2.38 | 248.00 | 1.19 | 2.95 | 94.73 | 56.00 | 46.00 | 10.00 | 104.73 |
| 7.10 | 8.00 | 5 | 8 | 200 | 11.00 | 3 | 33.00 | 2.00 | 3.57 | 360.00 | 2.52 | 9.07 | 91.78 | 56.00 | 18.00 | 38.00 | 129.78 |
| 8.00 | 11.00 | 0 | 55 | 200 | 11.00 | 7 | 77.00 | 4.00 | 2.32 | 555.00 | 0.54 | 2.99 | 82.71 | 56.00 | 27.00 | 29.00 | 111.71 |
| 9.00 | 10.00 | 3 | 3 | 200 | 11.00 | 2 | 22.00 | 2.00 | 2.38 | 380.00 | 1.19 | 4.52 | 93.46 | 56.00 | 52.00 | 4.00 | 97.46 |
| 10.00 | 11.00 | 2 | 5 | 200 | 11.00 | 3 | 33.00 | 2.00 | 3.57 | 366.00 | 2.52 | 9.22 | 88.94 | 56.00 | 15.00 | 41.00 | 129.94 |
| 11.00 | 12.20 | 3 | 63 | 200 | 11.00 | 7 | 77.00 | 4.00 | 2.32 | 399.00 | 0.54 | 2.15 | 79.72 | 56.00 | 32.00 | 24.00 | 103.72 |
| 12.00 | 12.10 | 3 | 3 | 200 | 11.00 | 2 | 22.00 | 2.00 | 2.38 | 545.00 | 1.19 | 6.48 | 103.83 | 84.00 | 66.00 | 18.00 | 121.83 |
| 12.10 | 12.20 | 3 | 6 | 200 | 11.00 | 3 | 33.00 | 2.00 | 3.57 | 785.00 | 2.52 | 19.78 | 97.35 | 84.00 | 78.00 | 6.00 | 103.35 |
| 12.20 | 26.10 | 3 | 72 | 200 | 11.00 | 7 | 77.00 | 4.00 | 2.32 | 560.00 | 0.54 | 3.02 | 77.57 | 56.00 | 9.00 | 47.00 | 124.57 |
| 13.00 | 13.10 | 3 | 3 | 200 | 11.00 | 2 | 22.00 | 2.00 | 2.38 | 294.00 | 1.19 | 3.50 | 100.26 | 78.00 | 41.00 | 37.00 | 137.26 |
| 13.10 | 13.20 | 6 | 9 | 200 | 11.00 | 3 | 33.00 | 2.00 | 3.57 | 1,555.00 | 2.52 | 39.18 | 96.76 | 69.00 | 69.00 | 0.00 | 96.76 |
| 13.20 | 31.00 | 1 | 10 | 200 | 11.00 | 4 | 44.00 | 3.00 | 2.19 | 164.00 | 0.65 | 1.07 | 57.58 | 60.00 | 60.00 | 0.00 | 57.58 |
| 14.00 | 15.00 | 3 | 3 | 200 | 11.00 | 2 | 22.00 | 2.00 | 2.38 | 73.00 | 1.19 | 0.87 | 116.58 | 56.00 | 6.00 | 50.00 | 166.58 |
| 15.00 | 16.00 | 6 | 9 | 200 | 11.00 | 3 | 33.00 | 2.00 | 3.57 | 1,073.00 | 2.52 | 27.03 | 115.71 | 56.00 | 6.00 | 50.00 | 165.71 |
| 16.00 | 20.00 | 5 | 14 | 200 | 11.00 | 4 | 44.00 | 3.00 | 2.19 | 392.00 | 0.65 | 2.55 | 88.68 | 56.00 | 10.00 | 46.00 | 134.68 |
| 17.00 | 18.00 | 3 | 3 | 200 | 11.00 | 2 | 22.00 | 2.00 | 2.38 | 189.00 | 1.19 | 2.25 | 98.05 | 56.00 | 7.00 | 49.00 | 147.05 |
| 18.00 | 19.00 | 6 | 9 | 200 | 11.00 | 3 | 33.00 | 2.00 | 3.57 | 321.00 | 2.52 | 8.09 | 95.80 | 56.00 | 9.00 | 47.00 | 142.80 |
| 19.00 | 20.00 | 2 | 11 | 200 | 11.00 | 4 | 44.00 | 3.00 | 2.19 | 243.00 | 0.65 | 1.58 | 87.71 | 56.00 | 15.00 | 41.00 | 128.71 |
| 20.00 | 22.00 | 4 | 29 | 200 | 11.00 | 5 | 55.00 | 3.00 | 2.74 | 379.00 | 0.98 | 3.72 | 86.13 | 56.00 | 14.00 | 42.00 | 128.13 |
| 21.00 | 22.00 | 3 | 3 | 200 | 11.00 | 2 | 22.00 | 2.00 | 2.38 | 236.00 | 1.19 | 2.81 | 85.22 | 56.00 | 24.00 | 32.00 | 117.22 |
| 22.00 | 25.00 | 0 | 32 | 200 | 11.00 | 6 | 66.00 | 3.00 | 3.29 | 92.00 | 1.38 | 1.27 | 82.41 | 56.00 | 33.00 | 23.00 | 105.41 |
| 23.00 | 24.00 | 3 | 3 | 200 | 11.00 | 2 | 22.00 | 2.00 | 2.38 | 549.00 | 1.19 | 6.53 | 96.69 | 83.00 | 65.00 | 18.00 | 114.69 |
| 24.00 | 25.00 | 3 | 6 | 200 | 11.00 | 3 | 33.00 | 2.00 | 3.57 | 358.00 | 2.52 | 9.02 | 90.16 | 56.00 | 55.00 | 1.00 | 91.16 |
| 25.00 | 27.00 | 2 | 40 | 200 | 11.00 | 6 | 66.00 | 3.00 | 3.29 | 696.00 | 1.38 | 9.58 | 81.14 | 56.00 | 12.00 | 44.00 | 125.14 |
| 26.00 | 26.10 | 3 | 3 | 200 | 11.00 | 2 | 22.00 | 2.00 | 2.38 | 745.00 | 1.19 | 8.86 | 83.41 | 56.00 | 26.00 | 30.00 | 113.41 |
| 26.10 | 27.00 | 0 | 75 | 200 | 11.00 | 7 | 77.00 | 4.00 | 2.32 | 555.00 | 0.54 | 2.99 | 74.55 | 56.00 | 10.00 | 46.00 | 120.55 |
| 27.00 | 30.00 | 5 | 120 | 200 | 11.00 | 9 | 99.00 | 4.00 | 2.98 | 1,107.00 | 0.86 | 9.51 | 71.56 | 56.00 | 14.00 | 42.00 | 113.56 |
| 28.00 | 29.00 | 3 | 3 | 200 | 11.00 | 2 | 22.00 | 2.00 | 2.38 | 386.00 | 1.19 | 4.59 | 92.99 | 68.00 | 41.00 | 27.00 | 119.99 |
| 29.00 | 30.00 | 6 | 9 | 200 | 11.00 | 3 | 33.00 | 2.00 | 3.57 | 1,046.00 | 2.52 | 26.35 | 88.40 | 68.00 | 20.00 | 48.00 | 136.40 |



Note: This analysis is valid only with the use of progressive cavity type grinder pumps as manufactured by Environment One.

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PRELIMINARY PRESSURE SEWER - PIPE SIZING AND BRANCH ANALYSIS

Prepared By:
M. Crowley

Oyster Pond Subdevelopment
Falmouth, MA

April 17, 2019

| Zone Number | Connects to Zone | Number of Pumps in Zone | Accum Pumps in Zone | Gals/day per Pump | Max Flow Per Pump (gpm) | Max Sim Ops | Max Flow (GPM) | Pipe Size (inches) | Max Velocity (FPS) | Length of Main this Zone | Friction Loss Factor (ft/100 ft) | Friction Loss This Zone | Accum Fric Loss (feet) | Max Main Elevation | Minimum Pump Elevation | Static Head (feet) | Total Dynamic Head (ft) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| This spreadsheet was calculated using pipe diameters for: | | | | | | SDR11HDPE | | | | Friction loss calculations were based on a Constant for inside roughness"C" of: | | | | | | | 150 |
| 30.00 | 31.00 | 2 | 131 | 200 | 11.00 | 9 | 99.00 | 4.00 | 2.98 | 645.00 | 0.86 | 5.54 | 62.05 | 56.00 | 48.00 | 8.00 | 70.05 |
| 31.00 | 39.00 | 0 | 141 | 200 | 11.00 | 9 | 99.00 | 4.00 | 2.98 | 844.00 | 0.86 | 7.25 | 56.51 | 56.00 | 56.00 | 0.00 | 56.51 |
| 32.00 | 33.00 | 3 | 3 | 200 | 11.00 | 2 | 22.00 | 2.00 | 2.38 | 192.00 | 1.19 | 2.28 | 78.23 | 89.00 | 80.00 | 9.00 | 87.23 |
| 33.00 | 34.00 | 6 | 9 | 200 | 11.00 | 3 | 33.00 | 2.00 | 3.57 | 454.00 | 2.52 | 11.44 | 75.95 | 71.00 | 71.00 | 0.00 | 75.95 |
| 34.00 | 38.00 | 1 | 10 | 200 | 11.00 | 4 | 44.00 | 3.00 | 2.19 | 1,483.00 | 0.65 | 9.64 | 64.51 | 48.00 | 48.00 | 0.00 | 64.51 |
| 35.00 | 36.00 | 3 | 3 | 200 | 11.00 | 2 | 22.00 | 2.00 | 2.38 | 229.00 | 1.19 | 2.72 | 74.90 | 70.00 | 70.00 | 0.00 | 74.90 |
| 36.00 | 37.00 | 6 | 9 | 200 | 11.00 | 3 | 33.00 | 2.00 | 3.57 | 444.00 | 2.52 | 11.19 | 72.18 | 69.00 | 69.00 | 0.00 | 72.18 |
| 37.00 | 38.00 | 4 | 13 | 200 | 11.00 | 4 | 44.00 | 3.00 | 2.19 | 942.00 | 0.65 | 6.12 | 60.99 | 49.00 | 49.00 | 0.00 | 60.99 |
| 38.00 | 39.00 | 0 | 23 | 200 | 11.00 | 5 | 55.00 | 3.00 | 2.74 | 571.00 | 0.98 | 5.61 | 54.87 | 48.00 | 48.00 | 0.00 | 54.87 |
| 39.00 | 39.00 | 0 | 164 | 200 | 11.00 | 10 | 110.00 | 4.00 | 3.31 | 4,716.00 | 1.04 | 49.26 | 49.26 | 44.00 | 44.00 | 0.00 | 49.26 |



Note: This analysis is valid only with the use of progressive cavity type grinder pumps as manufactured by Environment One.

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PRELIMINARY PRESSURE SEWER - ACCUMULATED RETENTION TIME (HR)

Prepared By:
M. Crowley

Oyster Pond Subdevelopment
Falmouth, MA

April 17, 2019

| Zone Number | Connects to Zone | Accumulated Total of Pumps this Zone | Pipe Size (inches) | Gallons per 100 lineal feet | Length of Zone | Capacity of Zone | Average Daily Flow | Average Fluid Changes per Day | Average Retention Time (Hr) | Accumulated Retention Time (Hr) |
|---|---|---|---|---|---|---|---|---|---|---|
| This spreadsheet was calculated using pipe diameters for: SDR11HDPE | | | | | | | | Gals per Day per Dwelling | | 200 |
| 1.00 | 5.00 | 5 | 2.00 | 15.40 | 810.00 | 124.76 | 1,000 | 8.02 | 2.99 | 11.31 |
| 2.00 | 3.00 | 3 | 2.00 | 15.40 | 157.00 | 24.18 | 600 | 24.81 | 0.97 | 12.35 |
| 3.00 | 4.00 | 9 | 2.00 | 15.40 | 381.00 | 58.68 | 1,800 | 30.67 | 0.78 | 11.38 |
| 4.00 | 5.00 | 17 | 3.00 | 33.47 | 966.00 | 323.29 | 3,400 | 10.52 | 2.28 | 10.60 |
| 5.00 | 6.00 | 30 | 3.00 | 33.47 | 601.00 | 201.13 | 6,000 | 29.83 | 0.80 | 8.32 |
| 6.00 | 8.00 | 47 | 3.00 | 33.47 | 2,542.00 | 850.72 | 9,400 | 11.05 | 2.17 | 7.51 |
| 7.00 | 7.10 | 3 | 2.00 | 15.40 | 248.00 | 38.20 | 600 | 15.71 | 1.53 | 7.70 |
| 7.10 | 8.00 | 8 | 2.00 | 15.40 | 360.00 | 55.45 | 1,600 | 28.85 | 0.83 | 6.17 |
| 8.00 | 11.00 | 55 | 4.00 | 55.31 | 555.00 | 306.99 | 11,000 | 35.83 | 0.67 | 5.34 |
| 9.00 | 10.00 | 3 | 2.00 | 15.40 | 380.00 | 58.53 | 600 | 10.25 | 2.34 | 8.37 |
| 10.00 | 11.00 | 5 | 2.00 | 15.40 | 366.00 | 56.37 | 1,000 | 17.74 | 1.35 | 6.03 |
| 11.00 | 12.20 | 63 | 4.00 | 55.31 | 399.00 | 220.70 | 12,600 | 57.09 | 0.42 | 4.67 |
| 12.00 | 12.10 | 3 | 2.00 | 15.40 | 545.00 | 83.95 | 600 | 7.15 | 3.36 | 10.03 |
| 12.10 | 12.20 | 6 | 2.00 | 15.40 | 785.00 | 120.91 | 1,200 | 9.92 | 2.42 | 6.67 |
| 12.20 | 26.10 | 72 | 4.00 | 55.31 | 560.00 | 309.75 | 14,400 | 46.49 | 0.52 | 4.25 |
| 13.00 | 13.10 | 3 | 2.00 | 15.40 | 294.00 | 45.28 | 600 | 13.25 | 1.81 | 7.97 |
| 13.10 | 13.20 | 9 | 2.00 | 15.40 | 1,555.00 | 239.51 | 1,800 | 7.52 | 3.19 | 6.16 |
| 13.20 | 31.00 | 10 | 3.00 | 33.47 | 164.00 | 54.89 | 2,000 | 36.44 | 0.66 | 2.96 |
| 14.00 | 15.00 | 3 | 2.00 | 15.40 | 73.00 | 11.24 | 600 | 53.36 | 0.45 | 8.36 |
| 15.00 | 16.00 | 9 | 2.00 | 15.40 | 1,073.00 | 165.27 | 1,800 | 10.89 | 2.20 | 7.91 |
| 16.00 | 20.00 | 14 | 3.00 | 33.47 | 392.00 | 131.19 | 2,800 | 21.34 | 1.12 | 5.71 |
| 17.00 | 18.00 | 3 | 2.00 | 15.40 | 189.00 | 29.11 | 600 | 20.61 | 1.16 | 7.30 |
| 18.00 | 19.00 | 9 | 2.00 | 15.40 | 321.00 | 49.44 | 1,800 | 36.41 | 0.66 | 6.13 |
| 19.00 | 20.00 | 11 | 3.00 | 33.47 | 243.00 | 81.32 | 2,200 | 27.05 | 0.89 | 5.47 |
| 20.00 | 22.00 | 29 | 3.00 | 33.47 | 379.00 | 126.84 | 5,800 | 45.73 | 0.52 | 4.58 |
| 21.00 | 22.00 | 3 | 2.00 | 15.40 | 236.00 | 36.35 | 600 | 16.51 | 1.45 | 5.51 |
| 22.00 | 25.00 | 32 | 3.00 | 33.47 | 92.00 | 30.79 | 6,400 | 207.87 | 0.12 | 4.06 |
| 23.00 | 24.00 | 3 | 2.00 | 15.40 | 549.00 | 84.56 | 600 | 7.10 | 3.38 | 8.43 |
| 24.00 | 25.00 | 6 | 2.00 | 15.40 | 358.00 | 55.14 | 1,200 | 21.76 | 1.10 | 5.05 |
| 25.00 | 27.00 | 40 | 3.00 | 33.47 | 696.00 | 232.93 | 8,000 | 34.35 | 0.70 | 3.94 |
| 26.00 | 26.10 | 3 | 2.00 | 15.40 | 745.00 | 114.75 | 600 | 5.23 | 4.59 | 8.33 |
| 26.10 | 27.00 | 75 | 4.00 | 55.31 | 555.00 | 306.99 | 15,000 | 48.86 | 0.49 | 3.74 |
| 27.00 | 30.00 | 120 | 4.00 | 55.31 | 1,107.00 | 612.32 | 24,000 | 39.20 | 0.61 | 3.25 |
| 28.00 | 29.00 | 3 | 2.00 | 15.40 | 386.00 | 59.46 | 600 | 10.09 | 2.38 | 7.16 |
| 29.00 | 30.00 | 9 | 2.00 | 15.40 | 1,046.00 | 161.11 | 1,800 | 11.17 | 2.15 | 4.78 |



Note: This analysis is valid only with the use of progressive cavity type grinder pumps as manufactured by Environment One

PRELIMINARY PRESSURE SEWER - ACCUMULATED RETENTION TIME (HR)

Prepared By:
M. Crowley

Oyster Pond Subdevelopment
Falmouth, MA

April 17, 2019

| Zone Number | Connects to Zone | Accumulated Total of Pumps this Zone | Pipe Size (inches) | Gallons per 100 lineal feet | Length of Zone | Capacity of Zone | Average Daily Flow | Average Fluid Changes per Day | Average Retention Time (Hr) | Accumulated Retention Time (Hr) |
|---|---|---|---|---|---|---|---|---|---|---|
| This spreadsheet was calculated using pipe diameters for: SDR11HDPE | | | | | | | | Gals per Day per Dwelling | | 200 |
| 30.00 | 31.00 | 131 | 4.00 | 55.31 | 645.00 | 356.77 | 26,200 | 73.44 | 0.33 | 2.63 |
| 31.00 | 39.00 | 141 | 4.00 | 55.31 | 844.00 | 466.84 | 28,200 | 60.41 | 0.40 | 2.31 |
| 32.00 | 33.00 | 3 | 2.00 | 15.40 | 192.00 | 29.57 | 600 | 20.29 | 1.18 | 10.98 |
| 33.00 | 34.00 | 9 | 2.00 | 15.40 | 454.00 | 69.93 | 1,800 | 25.74 | 0.93 | 9.79 |
| 34.00 | 38.00 | 10 | 3.00 | 33.47 | 1,483.00 | 496.31 | 2,000 | 4.03 | 5.96 | 8.86 |
| 35.00 | 36.00 | 3 | 2.00 | 15.40 | 229.00 | 35.27 | 600 | 17.01 | 1.41 | 8.14 |
| 36.00 | 37.00 | 9 | 2.00 | 15.40 | 444.00 | 68.39 | 1,800 | 26.32 | 0.91 | 6.73 |
| 37.00 | 38.00 | 13 | 3.00 | 33.47 | 942.00 | 315.25 | 2,600 | 8.25 | 2.91 | 5.82 |
| 38.00 | 39.00 | 23 | 3.00 | 33.47 | 571.00 | 191.09 | 4,600 | 24.07 | 1.00 | 2.91 |
| 39.00 | 39.00 | 164 | 4.00 | 55.31 | 4,716.00 | 2,608.57 | 32,800 | 12.57 | 1.91 | 1.91 |



Note: This analysis is valid only with the use of progressive cavity type grinder pumps as manufactured by Environment One

April 17, 2019

## Budgetary Low Pressure Sewer System Costs

### Oyster Pond Subdevelopment
### Falmouth, MA

| | Quantity | Description | Unit Cost | Installation | Sub Total |
|---|---|---|---|---|---|
| **Valves** | 10 | Air/Vacuum Release Valve | $0.00 | 0.00 | $0.00 |
| | 43 | Clean Out | $0.00 | 0.00 | $0.00 |
| | | | | | **$0.00** |
| **Pumps** | 164 | DH071-93 | $0.00 | 0.00 | $0.00 |
| | 164 | Lateral Kits (Includes Ball\Check Valve Assembly) | $0.00 | 0.00 | $0.00 |
| | 164 | Lateral (Boundary) Installation | $0.00 | 0.00 | $0.00 |
| | 164 | Pump/Panel Installation | $0.00 | 0.00 | $0.00 |
| | 8,200 | LF of 1.25" Lateral Pipe | $0.00 | 0.00 | $0.00 |
| | | | | | **$0.00** |
| **Piping** | 12,176 | 2.00" Pipe | $0.00 | 0.00 | $0.00 |
| | 9,071 | 3.00" Pipe | $0.00 | 0.00 | $0.00 |
| | 9,381 | 4.00" Pipe | $0.00 | 0.00 | $0.00 |
| | | | | | **$0.00** |

| | | | | |
|---|---|---|---|---|
| **Number of Connections** | **164** | | | |
| **Total Per Connection** | **$0.00** | **Total (w/o other)** | >>>>>>>>>>>> | **$0.00** |
| **Grand Total Per Connection** | **$0.00** | **Grand Total (including other)** | >>>>>>>>>>>> | **$0.00** |

Note: The System Costs above are based on piping sized for, and Grinder Pumps manufactured by Environment One Corporation.

# APPENDIX E
## Cost Model Back-up
## Science Wares, Inc.

# Cost Basis for Innovative/Alternative (I/A) Septic Systems
# October 1, 2017

## *Based on findings from the West Falmouth Harbor Shoreline Septic System Remediation (WFHSSR) Project*

**Prepared by:**

**Sia Karplus, Technical Coordinator, Science Wares, Inc.**

## 1. Background

The town of Falmouth and the Buzzards Bay Coalition (Coalition), with the help of the West Falmouth Village Association, identified more than 20 homeowners within 300 feet of West Falmouth Harbor (WFH) willing to voluntarily upgrade or replace their existing Title 5 septic systems and cesspools with Innovative/Alternative (I/A) septic systems or eco-toilets (either composting or urine-diverting systems). I/A septic systems are referred to as nitrogen-removing systems in this Final Report. The installed nitrogen-removing systems reduce septic tank effluent to at least 12 mg/L nitrogen (N). This high level of *voluntary* participation by homeowners in a program where they incurred significant costs to install nitrogen-removing septic systems is unprecedented.

Moreover, with modest education and outreach by the Town and the Coalition, the number of homeowners and community leaders willing to invest in a nitrogen reducing septic solution soon surpassed the 20 subsidies provided by this grant. A waiting list has been developed with the hope that further grant funds will become available to continue this effort. It is clear that the West Falmouth community is committed to contributing to clean water in West Falmouth Harbor and quickly agreed to do their part in reducing nitrogen pollution. Homeowners contributed more than $275,000 dollars out-of-pocket over and above the $200,000 provided in the taxable government subsidy. We believe that this commitment and investment in improving water quality can be both continued in West Falmouth and replicated throughout southeastern Massachusetts.

Key program goals included:

- Reduce the amount of nitrogen pollution entering WFH;
- Validate the performance and installed cost of best-off-the-shelf nitrogen-removing septic systems; and
- Demonstrate the benefit of targeting nitrogen-removing septic installations along the shoreline.

WFH fails to meet water quality standards due to nitrogen pollution. WFH is listed as a Category 4a water on the Final Massachusetts Year 2012 Integrated List of Waters. Originally listed as a Category 5 nitrogen impaired waterbody in 2002, a Total Maximum Daily Load, (TMDL) was approved by EPA in 2008 establishing a nitrogen concentration limit of .35mg/L at the sentinel station. Subsequent modeling was done by SMAST for a scenario that included (1) full build-out of the WFH watershed and (2) 0.5 million gallons per day of effluent from the Wastewater Treatment Facility (at the current enhanced level of treatment of 3 mg/L) discharging into this watershed. This scenario modeling found that the nitrogen concentration at the Sentinel Station for WFH would be significantly reduced due to improvements at the Wastewater Treatment Facility (WWTF), going from .464 mg/L to .364 mg/L. Thus, improvements to the WWTF that the Town of Falmouth has *already* implemented almost achieve the TMDL for this watershed, at full build-out. Thus, the actions planned in this Project contribute significantly to achieving the TMDL-compliance goals for WFH.

The best scientific understanding, as documented in the Massachusetts Estuaries Project (MEP) Reports for coastal communities throughout Buzzards Bay, is that wastewater from septic systems is the most significant contributor to nitrogen pollution. Collection systems associated with central sewers in low-density residential areas are costly, making this solution difficult for many towns to afford. Affordable, on-site septic systems and eco-toilets that remove a significant percentage of nitrogen are therefore seen as a critically important technical alternative. The concentration of nitrogen from septic system effluent that has enters a Soil Treatment Area (drainfield) is assumed to be approximately 35 mg/L. Based on water use data from town records as reported in the MEP Report for West Falmouth Harbor, this septic effluent concentration translates into a household contribution of 13.23 lbs N/year to the drainfield or cesspool. These retrofits will meet a nitrogen limit of 12mg/L as opposed to the current 35 mg/L.

Nitrogen-removing septic systems that achieve 66% nutrient removal (to 12 mg/L) should reduce the mass of nitrogen from 6 kg/parcel/year (or 13.23lbs/year) to 2 kg/parcel/year (or about 4lbs/year) in WFH. **This will reduce the overall nitrogen load from 20 homes from ~265lbs/year to ~90lbs/year (removal of 175lbs).**

The removal of approximately 175lbs of nitrogen is equivalent to removing 22% of the fertilizer load from the entire watershed, according to the MEP Report for WFH. It is also equivalent to removing the entire stormwater load from lower Mashapaquit Creek. Coupled with fertilizer reductions that are expected to be realized because of the passage and enforcement of a town-wide Nitrogen Control Bylaw for Fertilizer and the bottom planting of second-year oysters in Snug Harbor, the remediation of these harbor front septic systems may bring West Falmouth Harbor into TMDL-compliance. The ecosystems service that this reduction in nitrogen could accomplish also includes aesthetic improvements (fewer algae blooms), and increased water clarity leading to enhanced eelgrass restoration, which provides invaluable fisheries habitat.

## 2. Project Implementation

A number of steps were required to successfully complete this Project, including:

- Technology Evaluation
- Participant Selection and Enrollment
- Nitrogen-Removing Septic System Design
- Permitting
- Installation
- Monitoring

*2a. Technology Evaluation*

A Working Group was convened to review nitrogen-removing septic technologies that qualified to participate in the WFHSSR Project. Members included: Gerald C. Potamis, Wastewater Superintendent; Sia Karplus, Water Quality Technical Consultant; John Waterbury, Ph.D, member Falmouth Board of Health and Water Quality Management Committee; George Heufelder, Director/Chief Health Officer of Barnstable County Department of Health and Environment (BCDHE); Dr. Rachel Jakuba, Science Director, Buzzards Bay Coalition and Korrin Petersen, Esq. Senior Attorney, Buzzards Bay Coalition. To enable comparisons amongst nitrogen-removing septic systems, a vendor questionnaire was developed by the Working Group and sent to fifteen vendors. The questionnaire (Appendix A) asked for the following information; Cost (equipment and installation), Cost of Operation and Management, Monthly Energy Use, Warranty, Number of Pumps, Ability to Retrofit to Existing Title V System, Components visible above ground.

Review of the vendor responses for single-family nitrogen-removing technologies was based on several criteria:

- Proven ability to achieve a discharge concentration of 12 mg/L N based on data submitted by the vendors; and
- Available third-party data.

Based on vendor responses to this questionnaire, a master list of recommended technologies was developed by the Working Group, and provided to property owners. All eco-toilets currently approved for use in the Town of Falmouth were also eligible for installation. This included both composting systems that have received Product Acceptance from the State Board of Plumbers and Gas Fitters as well as urine-diverting and composting systems that have received Test Site Status for installation in Falmouth.

Nitrogen-Removing Septic System Technology Descriptions

- Fifteen commercially-available systems qualified for the WFHSSR Project, including:
  - AdvanTex AX20RT (Orenco) Joseph Soulia 800-230-9580
    http://www.orenco.com/sales/choose_a_system/advanced_treatment_systems/index.cfm
  - Amphidrome - SBR Mollie Caliri 781-982-9300 x 33
    http://www.amphidrome.com/
  - Biobarrier MBR (Biomicrobics) Lauren Usilton 508-823-9566
    http://www.biomicrobics.com/products/bio-barrier-membrane-bioreactor/
  - Bioclere (Aquapoint) Mark Lubbers 774-930-3900 or 508-985-9050
    http://www.aquapoint.com/bioclere.html
  - BUSSE Green Tech Ingo Schaefer 708-204-3504
    http://www.busse-gt.com/
  - Eliminite +Puraflo Tom Kallenbach 406-581-1613
    http://www.eliminite.com/index-1.html#
  - GPC Mike McGrath 508-548-3564
    http://www.holmesandmcgrath.com/index.html
  - Hoot BNR Ron Suchecki 254-299-0821
    http://hootsystems.com/about-hoot-systems/
  - Nitrex (Lombardo Associates) Lombardo Associates 617-964-2924
    http://www.lombardoassociates.com/
  - NJUN Systems Duncan Corley 404-925-1289
    http://www.njunsystems.com/
  - RUCK Mike McGrath 508-548-3564
    http://www.irucks.com/
  - SepticNET Steve Anderson 406-498-6850
    http://www.septic-net.com/
  - SES Environmental: Hydro-Kinetics Camel McGill 401-785-0130 or 508-406-8381
    http://www.seswastewater.com/hydro-kinetic.html
  - Waterloo Biofilter Greg Corman 519-856-0757
    Chris James 519-830-1490 http://waterloo-biofilter.com/
  - SeptiTech Lauren Usilton 508-823-9566
    http://www.septitech.com/staar-residential/

In addition, two non-proprietary technical solutions were developed as this Project progressed, a blackwater storage tank system and the Layered Soil Treatment Area system (Layer Cake).

*2b. Participant Selection and Enrollment*

To develop a list of priority properties within the WFH watershed, locations were ranked on a scale of 1 to 5 (with higher scores considered most advantageous) based on the following criteria:

- Proximity to Shoreline –Using mapping software, properties directly abutting West Falmouth Harbor and all septic systems within 300 feet landward of mean high tide were identified.  Septic systems very close to shore may contribute more nitrogen than properly functioning systems hundreds of feet from shore because there are some nitrogen losses in the septic plume near the leach field.  In addition, the short travel time of the plumes from these systems to reach the bay makes their replacement desirable because nitrogen reductions to the bay will occur in weeks or months and not years.
- Proximity to Sentinel Station – A primary goal of this project is to help achieve water quality standards in WFH and meet the TMDL nitrogen concentration limit of .35mg/L at the sentinel station, which is in the Snug Harbor subwatershed.  Properties which abut the shoreline within the Snug Harbor subwatershed were ranked highest.
- Type and Age of Septic System – It is presumed that Title 5 septic systems and cesspools discharge approximately the same amount of nitrogen.  However, cesspools located in saturated soils close to water bodies will discharge more nitrogen due to the lack of soil attenuation.  For this reason, cesspools will receive a slightly higher priority ranking than Title V septic systems for this project.  Furthermore, upgrading cesspools has the additional benefit of reducing bacteria and pathogen contamination with positive water quality and public health benefits.   The type and age of system will be determined by reviewing Board of Health records for selected properties and through interviews with property owners.
- Annual Occupancy – In order to optimize the reduction of nitrogen currently discharged from properties within the WFH watershed, homes that are occupied year round received a higher rank than homes that are used on a seasonal basis.  However, seasonally occupied homes were also selected in order to assess the performance of nitrogen-removing septic systems that are used on an intermittent basis.
- Willing Property Owners – As long as the property fell within 300 feet landward of mean high tide, a property owner’s willingness to participate in the project became the ultimate determining factor.

To identify interested households, the Coalition, together with the leaders from the West Falmouth Village Association sent personalized letters and Fact Sheets (Appendix B) to the top sixty priority candidates.  This first round of letters yielded 9 commitments to participate.  A subsequent letter was sent to the entire list of 170 qualifying properties within 300 feet landward of mean high tide.  Follow-up included numerous emails and phone calls as well as site meetings.  In addition, the Coalition presented the project at the West Falmouth Village Association’s annual meeting in July 2015.

A significant factor in enrolling participants was gaining the support of community leaders. West Falmouth is a close-knit community and once community leaders supported the project, many others residents agreed to participate.  In this case it was critical to win the endorsement of a local property management company that many homeowners along WFH rely on for handling technical issues related to their property and to whom homeowners defer to with respect to septic system upgrades.  Working in partnership with this property management company we were able to sign up many homeowners for upgrades.

*2c. Site Specific Technology Selection*

It was not practical to present 15 different I/A systems and 10 different ecotoilet options without a way for the property owner to objectively evaluate each option.  For those candidates committed to exploring an upgrade, the Town's Technical Coordinator and the Coalition created a Decision Support Tool (Appendix C) to help homeowners rank systems based on their preferences for such attributes as aesthetics, complexity, energy use, and cost.  The town's Technical Coordinator and the Coalition then reviewed the top technologies for installation feasibility and reviewed the top qualified nitrogen-removing septic systems and ecotoilets with property owners.  Each property had a unique set of site constraints such as space limitation, proximity to resource areas, depth to groundwater, and existing landscaping features.  Therefore, not all of the qualifying systems were feasible to install.

To help property owners gain familiarity with different nitrogen-removing septic systems and their vendors, the Town and the Coalition held a workshop at the home of a WFH resident interested in participating in the project.  Based on approximately 15 different homeowner interviews and the results of the Decision Support Tool, six different types of systems were the most popular and those vendors were invited to present their systems.  Representatives of the Bioclere, Eliminite, Hoot, Nitrex, and NJUN systems attended.  Over ten property owners attended this workshop, along with BCDHE, the Town's technical Consultant, staff from the Coalition and members of the Falmouth Water Quality Management Committee.  Most of the homeowners who attended this workshop participated in the Project and those who did not participate are very committed to participating in a future phase.  Homeowners top priorities for choosing a system were aesthetics (minimize visual impacts of components above grade), cost, and complexity (number of pumps required).  Ultimately, four system types were selected by property owners for installation, and are described in the paragraphs below.

- Blackwater storage as part of a Title 5 system (for seasonal homes)
- Eliminite
- HOOT
- Layered Soil Treatment Area (STA)

Table 1 lists the twenty systems that were installed as part of this Project.

Table 1.  System Types Installed and Replaced with Location by Case Study Number

| Case Study # | System Type | System Replaced |
|---|---|---|
| BW1 | Blackwater Holding Tank | Cesspool |
| BW2 | Blackwater Holding Tank | Title 5 |
| BW3 | Blackwater Holding Tank | Cesspool |
| BW4 | Blackwater Holding Tank | Title 5 |
| BW5 | Blackwater Holding Tank | Cesspool |
| BW6 | Blackwater Holding Tank | Cesspool |
| BW7 | Blackwater Holding Tank | Cesspool |
| BW8 | Blackwater Holding Tank | Title 5 |
| BW9 | Blackwater Holding Tank | Title 5 |
| BW10 | Blackwater Holding Tank | Cesspool |
| EL1 | Eliminite | Title 5 |
| EL2 | Eliminite | Title 5 |
| EL3 | Eliminite | Title 5 |
| HO1 | HOOT | Cesspool |
| HO2 | HOOT | Cesspool |
| HO3 | HOOT | Cesspool |
| HO4 | HOOT | Title 5 |
| HO5 | HOOT | Cesspool |
| HO6 | HOOT | Title 5 |
| LSAS1 | Layered SAS | Cesspool |

**Blackwater Storage**

2,000 Gallon Blackwater Tank installed in parallel with an existing Title V systems at the location of Case Study BW9.

In WFH there are many homes that are only occupied eight to ten weeks out of the year.  These homes are typically uninsulated and located on small lots in close proximity to wetlands.  An innovative, non-proprietary, cost effective solution was developed to enable nitrogen-removing septic systems to be installed in these homes.  This system adds a 1500 to 2000-gallon storage tank to a standard Title 5 septic system.  Interior toilets are re-plumbed to divert into this holding tank.  Thus greywater from sinks, showers, dishwashers and washing machines does not need to be stored.  Sizing of the blackwater holding tank is calculated to require only one or two pump-outs per season.  An alarmed float meter is installed to alert homeowners and property managers when the blackwater tank is 2/3 full and a counter is also installed to track the number of times the alarm is triggered. Figure 1 shows one of many possible configurations of this system.  A total of 10 Blackwater tanks were installed.

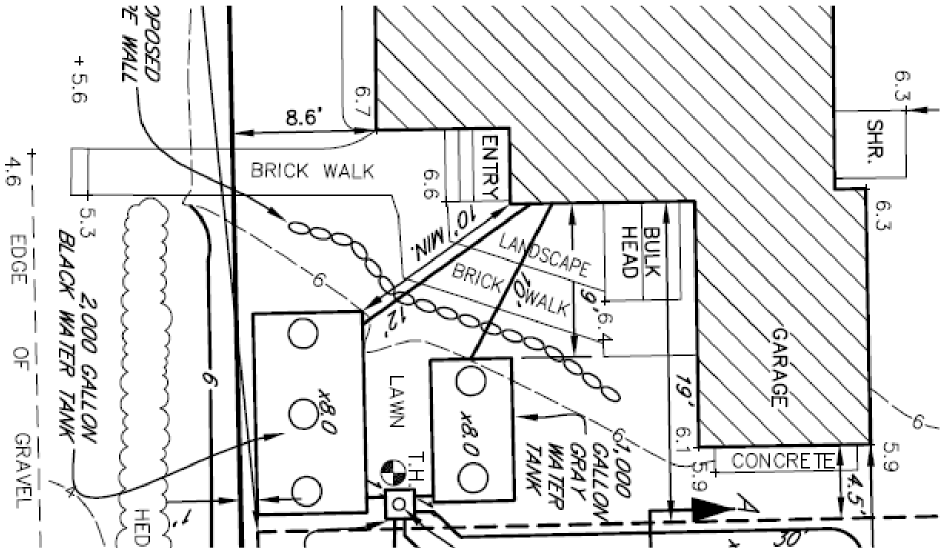



Figure 1. Blackwater Storage Tank Configuration

**Eliminite**

Eliminite is a fixed-film biological reactor with recirculation and alternating aerobic/anoxic treatment processes. While many models and configurations targeting a variety of wastewater constituents are available, the most basic configuration consists of a single primary settling tank (septic tank) and a single Eliminite treatment tank. The treatment tank houses the fixed-film bioreactor, recirculation/storage volume, level control and effluent pump(s).

Eliminite systems utilize patented, proprietary treatment media called MetaRocks. MetaRocks media represents a significant improvement over other types of trickling filter media common to the industry. Long-term use has proven that MetaRocks possess superior treatment characteristics which are absent from other types of fixed-film systems, including the following:

- High specific surface area in excess of 60 ft2/ft3 provides ample surface for microbial attachment and biofilm development.
- Large void volume exceeding 70% ensures low headloss for efficient air transfer through entire media bed.
- Large average void space diameter of 0.5 to 1.5 inch translates to nearly zero clog potential.
- Rough surface reduces time to maturation and enhances water holding characteristics.
- High hydraulic loading capacity, 250 gal/(min* ft2).
- Polar surface is hydrophilic and wets completely with water.
- Thin liquid surface film allows oxygen to penetrate into the full depth of the developed biofilm.
- Light weight at 7 lb/ft3 allows for deep media bed with no additional structural requirements imposed on the tank manufacturer.
- MetaRocks are free-flowing and take the shape of the vessel they occupy while retaining superior hydraulic and biological properties. This allows for their use in virtually any type of tank.

Eliminite Tank installed in parallel with an existing Title V systems at the location of Case Study EL3.

Eliminite was developed in Bozeman, Montana in 1994 in response to evolving water quality regulations developed by Montana Department of Environmental Quality (MDEQ). The new regulations identified nitrogen, due to its potential mobility in the saturated zone, as the contaminant of primary concern. Between 1994 and 2004, no formal classification for nutrient removal systems existed in Montana. However, early results from the Eliminite technology were so promising that MDEQ allowed them to be installed on a case-by-case basis until the formal rules were prepared. By the time MDEQ finalized the regulations, Eliminite systems had been in use in residential, commercial and community applications throughout Montana for 10 years. Eliminite are now used in hundreds of homes, businesses and government facilities in Montana, Colorado, New Mexico and California. Figure 2 is a technical drawing of the Eliminite System and Figure 3shows the Eliminite process. A total of 3 Eliminite Tanks were installed.

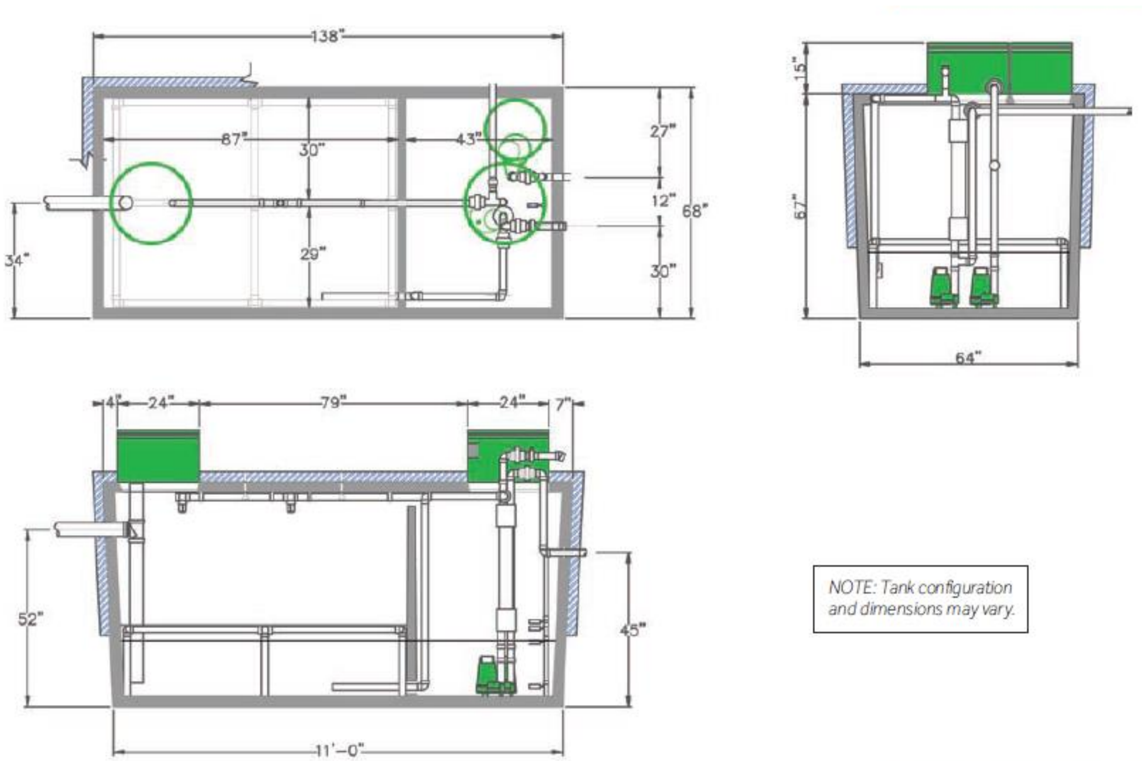



Figure 2.  Eliminite Schematic

## The Eliminite Process

### 1. Collection

Sewage flows from the home or facility into a watertight primary tank or chamber. The solids settle and the liquid effluent flows by gravity through an effluent filter to the Eliminte system.

### 2. Treatment

The recirculating biofilter provides passive biological treatment through an active biofilm matrix. MetaRocks, suspended in the tank, provide large surface area for microorganisms to attach and grow. The Lung supplies additional oxygen to the biofilm through the action of the recirculation pump.

### 3. Dispersal

Treated effluent is pump dosed from the Eliminite recirculation chamber into gravel trenches, chambers, LPP, drip irrigation or other dispersal methods. Effluent is suitable for reuse. Chemical or UV disinfection may be required.

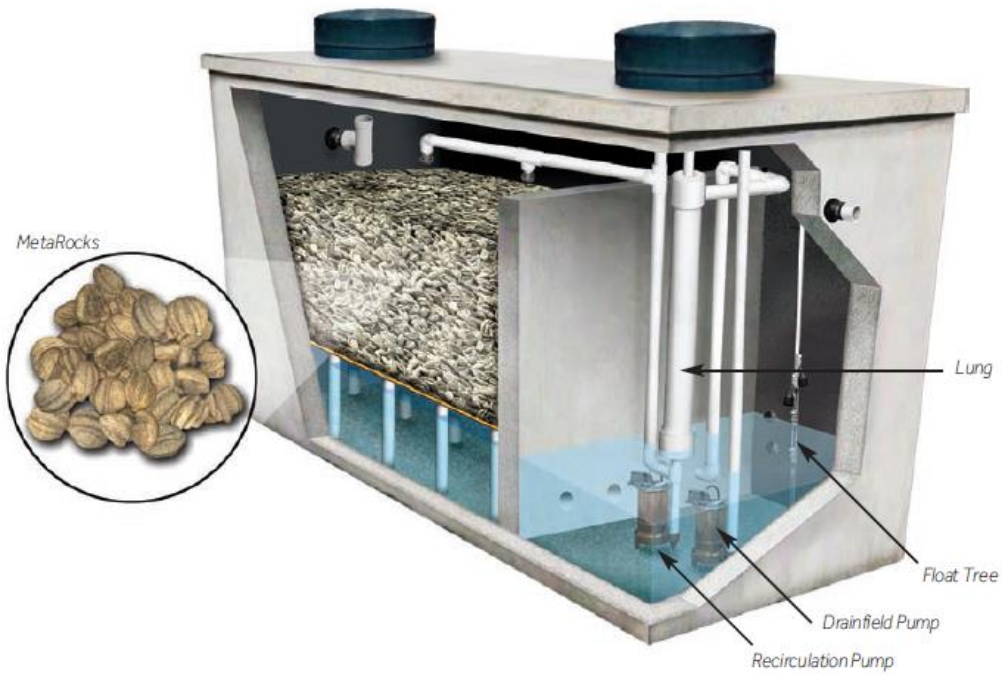



Figure 3. Eliminite Process

**Hoot**

The Hoot ANR Treatment System is comprised of five components, namely a pretreatment tank, aeration chamber, clarifier, media tank and final clarifier/pump tank.

The pre-treatment tank or trash trap contains the volume of approximately 1 day's system flow. The pre-treatment tank, aids in the anaerobic decomposition of the influent by providing a storage area for non-biodegradables which are inadvertently added to the system. This tank functions like a septic tank, providing a space for components that are lighter than water to float (e.g. fats oils and grease - which should not be added to the system in the first place) and a place for other solids (e.g. hair, dirt and other non-biodegradable solids) to settle A reduction of up to 50% of the Total Suspended Solids (TSS) and approximately 25% of the Biochemical Oxygen Demand (BOD) occurs within this tank. This tank also contains a mid-level, baffled crossover by which the liquid waste enters into the aeration chamber.

The aeration chamber is the heart of the activated sewage treatment of the plant, using a Troy air blower to incorporate oxygen into the sewage. This introduction of oxygen is done to intimately mix the organics of the sewage with the bacterial populations in the aeration chamber. Reduction of the organics is accomplished by these organisms. Excess oxygen not needed for the organic decomposition is utilized by nitrifying bacteria to convert ammonia into the more stable form on nitrogen known as nitrate. Movement of sewage in the aeration chamber also causes the activated sludge that settled in the final clarifier to be re-introduced into the aeration chamber.

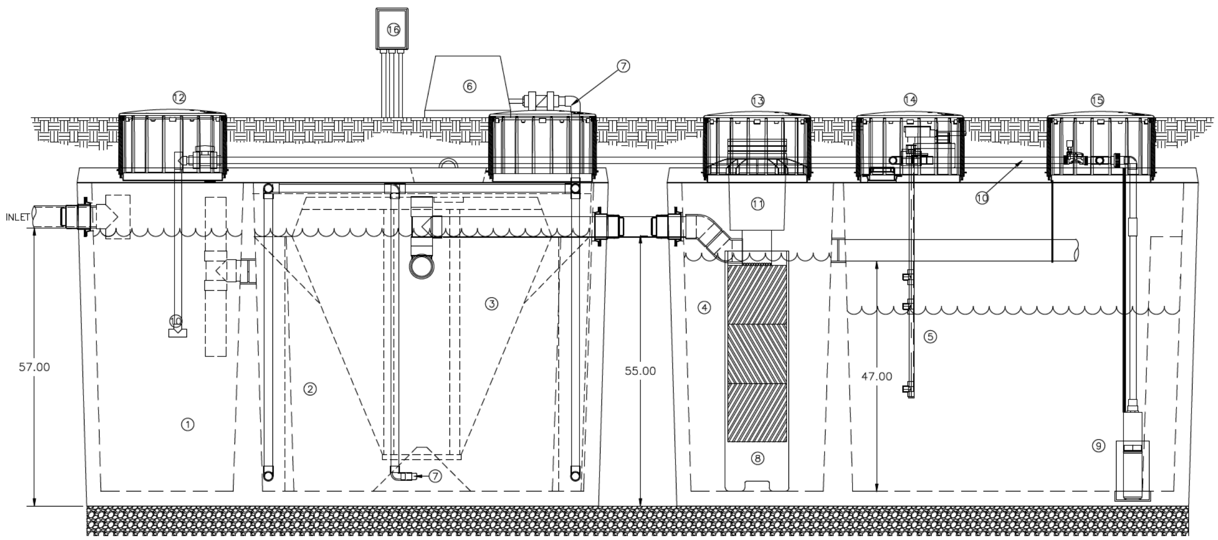
The clarifier is a still chamber located within the aeration chamber and provides a quiescent zone where the clear odorless effluent rises through the outlet, located 6 inches below the surface of the clarifier. This chamber holds approximately ½ day's capacity of effluent which passes from the clarifier into the media tank.

The media tank contains a fixed media surface. This fixed media is an environment optimized for the growth of denitrifying bacteria. A proprietary carbon source, HOOT-CS is added via a peristaltic pump to the wastewater in this chamber, providing the energy needed for *Nitrosomas* and *Nitrobacter* to convert nitrate into $N_2$, harmless airborne Nitrogen gas. Approximately 78% of the air we breathe is made up of odorless, colorless, Nitrogen gas. The chamber that holds the fixed media cell contains approximately a day's worth of flow volumetrically. From this media chamber, the effluent leaves and passes into an optional final clarifier/pump or directly to the SAS.

Hoot system installed as part of a full upgrade from cesspools at the location of Case Study HO2.

The final clarifier/pump tank is the last treatment component before release to the soil treatment area. This chamber contains a screening device that provides for storage of settled solids to be stored before the final discharge. This storage prevents the solids from reaching the pump so that pump will run cool and last longer. A calculated portion of the daily flow of the system is recirculated from this chamber back to the pre-treatment tank. The pump tank also serves as a storage chamber for holding the treated effluent for disposal at a later time.

All HOOT systems are designed to have a minimum of 12 hours of flow after the alarm to give ample time for service personnel to arrive and correct any problem which may have occurred. Additional storage volume above the chambers in the air space provides approximately 2 days of additional emergency storage. ANSI/NSF Standard 40 and 245 requires a minimum removal of various constituents for wastewater treatment systems. For a system to be certified as a Standard 40 Class I Treatment unit, the arithmetic mean of all effluent samples for Biological Oxygen Demand (BOD) collected in a seven-day period must be less than 45 mg/L. The HOOT ANR System has an average BOD of 6 mg/L with an average influent of 250 mg/L BOD and a Total Suspended Solids (TSS) average of 4 mg/L with an average influent of 300 mg/L, both averaging over a 98% removal efficiency.  In Addition to the Class I performance for BOD and TSS, for the Standard 245, the System was sampled 3 times per week for Total Kjeldahl Nitrogen (TKN), nitrate and nitrite to determine Total Nitrogen (TN). The influent in TKN averaged 37.2 mg/L and effluent averaged 5.8, producing a nitrogen removal efficiency of 82%.  If the HOOT ANR is properly installed, used and maintained, it is capable of producing similar effluent quality in actual use conditions. Figure 4 shows a schematic of the HOOT system.  A total of 6 Hoot Systems were installed.




1) PRETREATMENT TANK– WHERE ANAEROBIC DIGESTION OCCURS AND STORAGE FOR NON–BIODEGRADEABLE MATERIALS.

2) AERATION CHAMBER– WHERE AIR IS INTRODUCED INTO SEWAGE FOR DIGESTION.

3) CLARIFIER– A STILL CHAMBER WHERE SOLIDS SETTLE OUT AND THE CLEAR EFFLUENT RISES.

4) MEDIA TANK – CARBON LOADED MEDIA CHAMBER.

5) PUMP TANK – CONTAINS RECIRC PUMP, CAN PROVIDE PUMPED OR GRAVITY DISCHARGE.

6) TROY AIR LINEAR AIR BLOWER– LONG LIFE, EFFICIENT LINEAR BLOWER WHICH COMPRESSES ATMOSPHERIC AIR AND UNDER PRESSURE DELIVERS IT TO THE TANK. MUST BE LOCATED NO GREATER THAN 6 FEET FROM THE PANEL AND NO GREATER THAN 50 FROM THE TANK.

7) AERATION LINE– DELIVERS THE AIR FROM THE BLOWER TO THE MANIFOLD. CHECK VALVE INCLUDED, TERMINATED AT DIFFUSER INTO TANK.

8) MEDIA BLOCK – FIXED SURFACE AREA FOR FOR ANOXIC DENITRIFICATION TO OCCUR ON.

9) SUBMERSIBLE RECIRC/DISCHARGE PUMP – A SINGLE PUMP (OR MULTIPLE PUMPS) ARE USED FOR RECIRC. & EFFLUENT DISCHARGE.

10) RECIRC. LINE – A PORTION OF THE DAILY FLOW IS REPROCESSED THROUGH THE SYSTEM FOR ADDITIONAL TREATMENT (MIN. 50%)

11) HOOT CS CONTAINER – STORAGE CONTAINER PROVIDES CARBON SOURCE AND A LOW LEVEL INDICATOR.

12) PRE–TREAT/AERATION RISER – ACCESS THROUGH THIS RISER ALLOWS FOR OBSERVATION OF PRE–TREATMENT TANK, RECIRC. LINE, TRANSFER BAFFLE, AERATION CHAMBER & CLARIFIER. ALSO USED TO PUMP SYSTEM.

13) MEDIA CHAMBER RISER – ALLOWS ACCESS TO MEDIA BLOCK, REFILL OF CARBON SOURCE AND LOCATION OF PERISTALTIC PUMP.

14) MEDIA EQUIPMENT ACCESS – PROVIDES ACCESS TO PROBE, PERISTALTIC PUMP, WATER METER AND OPTIONAL UV DISINFECTION (IF EQUIPPED)

15) PUMP TANK/ SAMPLE PORT ACCESS – PROVIDES ACCESS TO PUMP TANK, RECIRCULATION & DISCHARGE LINES OR OPTIONAL GRAVITY FLOW OUTLET. ACCESS TO DISCHARGE EFFLUENT IN TANK OR FROM SAMPLE VALVE.

16) SYSTEM CONTROLLER – OPERATES BLOWER, PUMPS (DISCHARGE, RECIRC. AND PERISTALTIC) AND PROVIDES ALARM NOTIFICATION BY TRIGGERING AUDIBLE/VISUAL ALARM. MUST BE LOCATED NO GREATER THAN 6 FEET FROM THE BLOWER, AND 50 FEET FROM THE TANK.

Figure 4.  HOOT systems configuration and component description

**Layered Soil Treatment Area (Layered STA)**

Layered STA installed as part of a full upgrade from cesspools at the location of Case Study #6.

With funding from various sources, staff at the Massachusetts Alternative Septic System Test Center (MASSTC), which is operated by BCDHE, have been experimenting with a simple, non-proprietary technique of layering soil mixed with wood byproduct (sawdust, woodchips) beneath a standard soil treatment area (STA; alternately known as soil absorption system or leaching field) in order to reduce nitrogen loading. The principle is fairly simple. Components of a standard STA generally convert the ammonia-nitrogen in septic tank effluent into nitrate, which is then leached into the groundwater where it contributes to the over-production of algae and consequent eutrophication of our bays and estuaries. If the percolating nitrate-laden effluent can be first directed through a layer of sawdust matrix and certain conditions are maintained before it reaches the groundwater, the nitrate can be reduced to harmless nitrogen gas (denitrification) and vented to the atmosphere. MASSTC has been studying simple and inexpensive ways to produce the sequential conditions necessary to complete the above-described process. Figure 5 shows the main components of this layered STA concept, which includes a septic tank, pump chamber, pressure dosing system, and 18-inch layer of sand and, 18-inch layer of sawdust matrix. Figure 6 shows the conceptual model that invites the name Layer Cake as well as results from one installation at MASSTC. One Layered STA was installed.

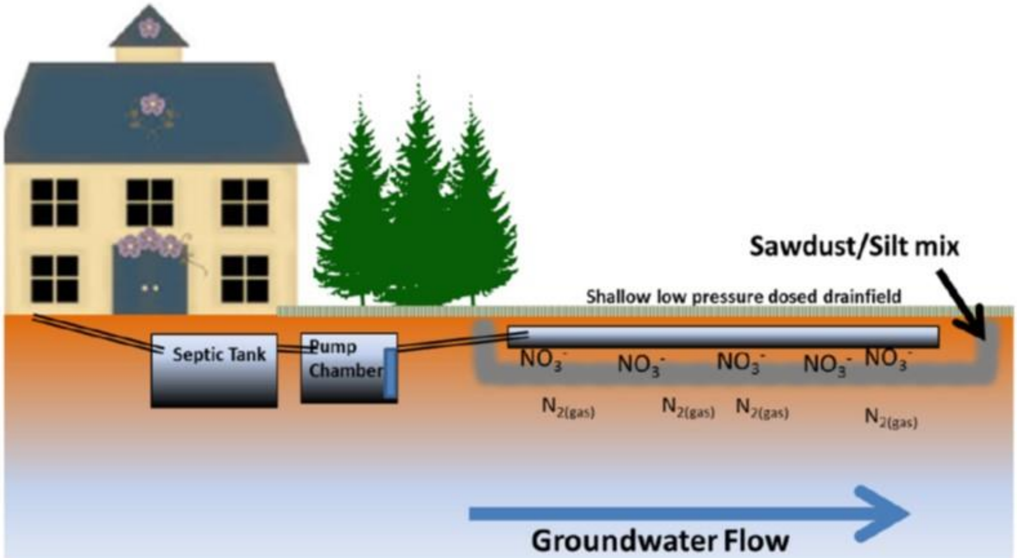
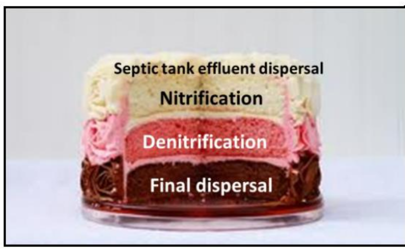
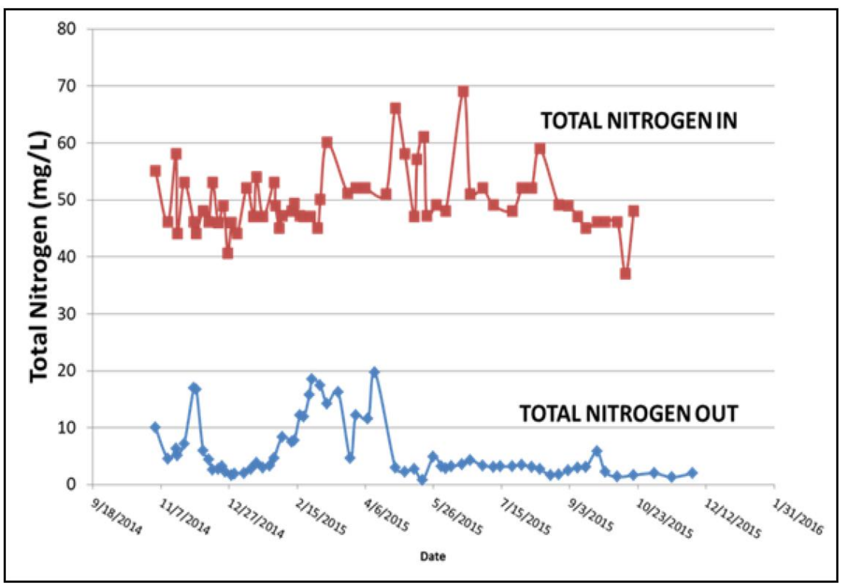



Figure 5. Layered STA Schematic




*The concepts detailed here could be described as a* ***layer cake,*** *where septic tank effluent passes sequentially through a layer for nitrification, denitrification and then final dispersal.*




*Results from one of the three designs being tested at the Massachusetts Alternative Septic System Test Center*

Figure 6. Layered STA Test Results

*2d. Design, Permitting and Installation*

These systems were not only new to the homeowners but relatively new to the engineers and installers and therefore a steep learning curve existed for all stakeholders. It became evident early in the process that the Town Technical Coordinator and the Coalition would have to manage and ensure follow-through of the various steps required to design, permit and install a nitrogen-removing septic system.  While property owners were willing to participate, given the timeframe of the grant, none were able to take on the responsibility of project management, which consisted of the following critical activities:

- Technology Selection
- Engineer of Record Selection
  - Coordinating engineering quotes for services
- System Design
  - Coordinating plan preparation with vendors
  - Coordinating location of system components with Conservation and Board of Health agent as well as property owners
- Permitting
  - Meeting with Board of Health and Conservation agents
  - Preparing permit applications
  - Attending hearings
- Installer selection
  - Coordinating installation quotes for services
  - Coordinate timing of installations
- Site management of installations

Once a technology was selected, an engineer of record was hired to prepare plans for the system for Board of Health approval and solicit quotes from qualified septic system installers. The Technical Coordinator and the Coalition worked with these engineers of record and coordinated with vendors and local regulators to ensure plans were prepared correctly.  In several cases, percolation tests and site surveys were needed prior to plan preparation.  Depth to groundwater, soil types, distance from wetlands and other siting information was specified on all engineered plans.

Town of Falmouth Technical Coordinator and the Coalition interfaced with the Town Health Agent and Conservation Agent to identify and apply for all required permits.  Review of draft engineering plans with these agents was often required.  The Applications were prepared by Technical Coordinator in collaboration with the property owner and engineer of record, with the selected vendor providing technical information.  The approval hearings with the Board of Health and Conservation Commission were attended by the Town's Technical Coordinator, who presented these plans, and the Coalition's Senior Attorney.  Four installations required site-specific pilot approvals for technologies not yet approved for use in Massachusetts, the Eliminite system and the Layer Cake.  The Town Technical Coordinator worked closely with MADEP to obtain these site specific pilot approvals.

The following list of permits were required for installations. Not all locations required all of these permits.

- Local Board of Health Approval for nitrogen-removing septic systems
- Local Conservation Commission RDA filing
- Massachusetts Department of Environmental Protection (DEP) Site Specific Pilot Approvals for system not already approved for use in Massachusetts

Once plans were prepared and approved, the Technical Coordinator and Coalition worked with participants to identify certified installers from which to request quotes and made these inquiries on behalf of participants. Once selected by participants, scheduling of installations was also coordinated for them.

*2e. Site Management of Installations*

Participating homeowners relied on the Town's Technical Coordinator and the Coalition as the project manager. In most circumstances, the homeowners were not on-site for the installation and deferred to the Town's Technical Coordinator and the Coalition to be present on site during installation to ensure that the impacts to existing landscaping, and components are located in a way that is acceptable to property owners. Many decisions related to installing septic systems are made in the field. Engineering plans do not typically specify final locations of a number of components, and field conditions often require modifications to engineered plans. Installing the concrete tanks, blowers, pipes, and control panels associated with septic systems often present siting challenges on properties with mature landscaping. Installation requires digging large holes to accommodate tanks that are over six feet wide and ten feet long and digging long lengths of trenches for the piping that brings effluent from the home to these tanks. Delivering concrete tanks on trailers with booms large enough to move them can require moving smaller trees or even cutting larger ones. The disruption to existing landscaping and restoration thereof can increase total installation costs significantly.

Other details of installations require careful management. Coordinating equipment purchase and delivery, as well as electrical and plumbing modifications were all necessary. Another important detail is whether septic tank covers are exposed at grade to enable access to pumps and other system components for maintenance. These covers are twelve to thirty-six inches in diameter and can present aesthetic challenges. In addition, control panels and blowers for aeration must also be carefully located to minimize both noise as well as aesthetic impacts. The importance of a knowledgeable person to oversee installations is critical.

## 3. Total Project Cost

The total project cost of different nitrogen-removing septic systems is shown in Table 2. Total project costs includes engineering, equipment, installation and restoring landscaping. While the range for the Eliminite and HOOT systems are modest, approximately $1,000 and $6,000 respectively, the range for the blackwater storage tank option is significant (approximately $15,000). This large range for costs can be explained by the difference in installation requirements. In some cases, existing Title 5 systems were in place and the addition of a blackwater tank and plumbing modifications were all that was required. In other cases, full Title 5 upgrades, including a soil absorption system (leachfield) were needed. The cost range for the HOOT system illustrates the significance of site conditions on installation costs. The low end of the installed costs was a case where there were minimal site constraints. The high end case had significant landscaping constraints, adding to the time required for installation and the extent of landscaping to return the property to existing conditions. For the Layered STA system, the costs associated with a deep excavation and fill were the cost drivers. A standard drainfield would have similar costs.

Table 2. Installation Costs by System Type

| System Type | Average Total Installed Cost by System Type ($) | HIGH Total Installed Cost by System Type ($) | LOW Total Installed Cost by System Type ($) |
|---|---|---|---|
| Blackwater Holding Tank | $ 18,274 | $ 32,327 | $ 13,353 |
| Eliminite | $ 20,760 | $ 21,458 | $ 19,523 |
| HOOT | $ 34,581 | $ 40,425 | $ 28,158 |
| Layered STA | $ 42,530 (please see note) | only one installation | only one installation |
| Layered STA NOTE: | The cost of this installation was dominated by the required 15-foot strip-out of the STA area. | | |
| | The cost for a standard STA (drainfield) would have been comparable. | | |

Source reduction via nitrogen-removing septic systems will, by and large, require installing these systems on existing properties where there are numerous constraints that limit the area available for tanks and STA (drainfield) siting, including:

- Lot size;
- Location of existing structures on the property;
- Proximity to wetlands;
- Soil types;
- Depth to groundwater; and
- Mature landscaping, including trees.

Installation costs will be significantly affected by these site-specific constraints. To enable comparison of capital cost for I/A systems with other traditional as well as alternative wastewater management technologies, a benchmark installed cost of $26,000 was calculated. This cost was determined by obtaining estimates from three local septic installers for a three-bedroom, Title 5 system on a hypothetical lot. Key parameters for these cost estimates include:

- The system including a tank and a SAS (drainfield);
- Access on to install the Title 5 system on the hypothetical lot is direct and easy (for example in the front of the house); and
- The hypothetical lot did not have any existing landscaping.

Based on these parameters, the cost to install a Title 5 system for a three-bedroom home, including equipment, was $12,800. The vendor-provided cost of the equipment that is specific to the I/A functionality for HOOT, Eliminite, Layer Cakes and Nitrex systems was then averaged and added to this baseline cost for a Title 5 system. An allowance of $3,300 for preparing engineering plans and Board of Health permitting was included in the benchmark cost.

## 4. Performance

Preliminary monitoring results presented by the Buzzards Bay Coalition in their May 2017 Status Report indicate that the HOOT, Eliminite and Blackwater I/A systems remove at least 62 percent of the influent total nitrogen that enters these systems from a residence. In terms of final effluent concentrations, two systems are currently meeting the program target of 12 mg/L or less. The HOOT system reliably achieves an average final effluent concentration of no more than 12 mg/L total nitrogen. The blackwater system reliably achieves an average final effluent concentration 8 mg/L total nitrogen. Sampling of all 20 systems continues through 2017 and monitoring results will be reported in the first quarter of 2018.

APPENDIX A: Vendor Questionnaire

NAME OF I/A SYSTEM VENDOR:________________________________________

**Innovative/Alternative (I/A) Septic System Questions - Single Family**

**Technical and Performance Questions:**

- **Please provide a brief overview of the treatment technology and provide a schematic showing the placement of the system in context of a standard septic tank/leachfield (please provide approximate dimensions of components on the diagram and list all components necessary to achieve 12 mg/l at the discharge)**

- **Can the I/A system be retrofit to an existing septic tank-soil absorption system?**

- **List general requirements for installation, such as:**
  - **Must the installer be certified by the company?**
  - **Are there any site limitations?**
  - **Other general requirements?**

- **How long has the Company been in business?**

- **How many systems are installed in the ground (please specify how many in New England and how many in other states)?**

- **What is the expected system longevity?**

- **Are there data to support a claim that this system will achieve total nitrogen removal to 12 mg/L as measured prior discharging to drainfield? (Please supply data and source of data information):**

**Permitting and Approval Questions**

- **Does the system manufacturer hold proprietary patents or are there patents pending? Please list USPTO numbers:**

- **List state or provincial approvals held by the technology:**

NAME OF I/A SYSTEM VENDOR:______________________________________

- **If not approved in the Commonwealth of Massachusetts, is your company willing to file an application for a Site-Specific Pilot?**
- **List installation sites on Cape Cod (if any):**
- **Do you partner with specific engineering firms? If so, whom?**
- **What type of warranty do you offer?**
- **Please list three references that can be contacted (including 1 regulatory official) for their familiarity with your system performance and operation.**

**Cost-Related Questions:**

- **Equipment Cost:**
- **Estimated Single Family Installation Cost (average and range):**
- **Estimated monthly energy usage (kWh) including required pretreatment components:**
- **Typical long-term Maintenance Cost:**
- **Typical inspection and sampling cost (excluding analyses).**

APPENDIX B: Letter to Potential Participants and Fact Sheet

BUZZARDS BAY COALITION
WEST FALMOUTH VILLAGE ASSOCIATION

July 20, 2015

Dear ,

**We hope you'll join us to help clean up West Falmouth Harbor.**

Because you are someone who loves West Falmouth Harbor, the West Falmouth Village Association and the Buzzards Bay Coalition thought you might be interested in a **voluntary program** that will reduce nitrogen pollution, help improve the harbor's natural beauty, and protect the water for generations to come.

Nitrogen pollution is the greatest long-term threat to the health of West Falmouth Harbor. The town of Falmouth is reducing the amount of nitrogen coming from the wastewater treatment plant and great progress has been made in the past few years. More pollution reduction will restore our Harbor's health quicker. As a homeowner, there is something you can do to give the harbor a hand.

In the fall of 2014, the Buzzards Bay Coalition pursued a $200,000 grant to subsidize the **voluntary** replacement of 20 individual on-site septic systems around West Falmouth Harbor with a nitrogen-reducing solution. Homeowners who want to take advantage of this opportunity would **receive up to $10,000** to replace their septic systems and cesspools with a solution that can reduce nitrogen pollution to West Falmouth. (Please see the attached fact sheet for more detail about this program.)

**How can you get involved?**

As a West Falmouth Harbor property owner near the water with a septic system which causes nitrogen to flow into the Harbor, you have the opportunity to receive this subsidy and upgrade your system. Your property is among 170 homes that qualify for this subsidy. However, there are only 20 subsidies available. If you are interested in this opportunity, please contact Korrin Petersen at the Buzzards Bay Coalition as soon as possible at (508) 999-6363 ext. 206 or petersen@savebuzzardsbay.org. **There is no upfront commitment required.** Simply contact the Buzzards Bay Coalition to find out more and receive a no-cost evaluation. If you choose to take part in the program, the Coalition will assist you in selecting a solution, hiring an engineer, and completing the permitting process.

Thank you for making a difference to protect West Falmouth Harbor.

Sincerely,

John Weyand, President
West Falmouth Village Association

Mark Rasmussen, President
Buzzards Bay Coalition

buzzards BAY COALITION

FACT SHEET

## Upgrade Your Septic System to Help Save West Falmouth Harbor

### The Problem: Septic Systems and Nitrogen Pollution

Septic systems are the largest source of nitrogen pollution to Buzzards Bay. Even properly functioning Title 5 septic systems cause pollution problems.

When you add up all the homes on septic systems around places like West Falmouth Harbor, this amounts to a major source of pollution.

If nitrogen pollution is not treated, it travels into the groundwater and reaches West Falmouth Harbor.

When too much nitrogen pollution gets in the water, it fuels the growth of algae that makes the harbor cloudy and murky. Eelgrass dies, fish and shellfish disappear, and beaches and boats can become covered with green algae.

Nitrogen pollution is the greatest long-term threat to West Falmouth Harbor. For 20 years, West Falmouth residents like you have watched the harbor's health decline due to nitrogen pollution from the wastewater treatment plant.

The good news is that recent upgrades and new pollution limits are reducing the amount of nitrogen from the wastewater treatment plant.

We can reduce even more nitrogen and speed up the harbor's recovery. By upgrading your home's on-site septic system to a nitrogen-reducing system or eco-toilets. **There is funding available for you to do this.**

### What are nitrogen-reducing septic systems and eco-toilets?

Cesspools and Title 5 septic systems do not treat for nitrogen – which means that the majority of homes around the harbor contribute pollution.

There are two technologies that can help reduce nitrogen pollution:

- **Nitrogen-reducing septic systems** remove approximately 66% of the nitrogen from a Title 5 system or cesspool by treating the wastewater on-site and discharging it through a leach field.
- **Eco-toilets** collect human waste by composting or separating urine, which is then disposed of or used as fertilizer off your property.

### Why should I upgrade my current system?

By participating in this program, you can make a difference to reduce nitrogen pollution to West Falmouth Harbor. A healthy harbor means better fishing and shellfishing, swimming, and boating. In addition, clean water can protect real estate values. Installing a new septic system is a significant positive investment in the value of your home.

Turn over to learn about funding to upgrade your home's on-site septic system. →

## APPENDIX C: Decision Support Tool Screen Shot

NAME:
WEST FALMOUTH PROPERTY ADDRESS:
DATE:

**Please tell us how important the follow characteristics are to you based on the following scale:**

| Characteristic | Rating | Scale |
|---|---|---|
| **First Cost (equipment and installation)** | | **1 = very important** |
| **20 Year Present Worth (including O&M)** | | **2 = important** |
| **Energy Use** | | **3 = somewhat important** |
| **Aesthetics** | | **4 = not very important** |
| **Complexity** | | **5 = not a concern** |

**Is there another criteria not listed here that is important to you?**

**Summary of top 7 systems to consider based on your weighting of the above criteria:**

| System Name Contact Website | Decision Tool Total Score | Average Estimated Installed System Cost | Annual Cost for Quarterly Inspections | Lab Costs after 1st year | Monthly Energy Use (kWh)* | 20 year Present Worth for O&M** | Company Warrantee on System | Special Considerations | Number of Pumps |
|---|---|---|---|---|---|---|---|---|---|

# APPENDIX F
## Watershed Management Documentation - WQMC Oyster Pond Working Group

The following materials are supplied to support DEP approval of a watershed permit to meet TMDL compliance for the Oyster Pond Watershed in Falmouth, Massachusetts using advanced innovative /alternative septic systems:

I. A detailed watershed Implementation Plan using advanced I/A systems achieving total nitrogen removal to 10mg/l or 75% removal (Exhibit A).

II. Falmouth Home Rule supplements to CMR 15.000 (Title 5) that augment the monitoring requirements and define failure criteria for advanced I/A septic systems (Exhibit B).

III. Data from local piloting projects in West Falmouth Harbor and at the Barnstable County Test Center that demonstrate that some advanced I/A septic systems can routinely achieve 10mg total nitrogen per liter or 75% TN removal (Exhibit C).

The Oyster Pond Implementation Plan envisions approving a few systems that meet the standards described in the Management Plan. Phase One of the project will install approximately 189 advanced I/As in the watershed. By the time the watershed permit is issued these systems should be supported by a number of years of test data adequate to permit them for Provisional Use Approval. Once installed in the watershed the advanced I/A systems will be monitored for 14 years during phase One of the project and will yield data sufficient for DEP to issue General Use Approvals for these systems and thus allow their use throughout the Commonwealth.

Implementation Plan to meet TMDL Compliance for the Oyster Pond Watershed, Falmouth, MA. using Advanced Innovative/Alternative Septic Systems

## 1.0 Definitions

BOD Biological Oxygen Demand
DEP Department of Environmental Protection
I/A Innovative/Alternative
RME Responsible Management Entity
TMDL Total Maximum Daily Load of Nitrogen in mg/l
TN Total Nitrogen [nitrite, nitrate and Total Kjeldahl Nitrogen [TKN]]
TSS Total Suspended Solids
TWMP Targeted Watershed Management Plan

## 2.0 Watershed Boundaries

The boundaries of the TWMP watershed will be those defined in the Massachusetts Estuaries Project Linked Watershed/Embayment Model for Oyster Pond, as adopted by Massachusetts DEP and by the Falmouth Town Meeting. The TWMP will designate which properties within the watershed will be required to install an Advanced I/A System.

3.0 Plan: The Town of Falmouth proposes to meet the TMDL for Oyster Pond through a two-phase program using Advanced I/A Systems to remove 2280 lbs/yr of Total Nitrogen from the watershed.

3.1 Advanced Innovative/Alternative Septic Systems: I/A systems meeting less than 10 mg/l TN or at least 75% removal of TN will be used for all the systems required to be installed in the watershed. To calculate % removal of TN refer to local Board of Health Regulation FHR 15.0 Approval of Alternative Onsite Septic Systems, 15.3.9 Compliance Using Mass Loading Calculations. A conceptual model and specifications of systems that might meet these requirements are provided in Appendix I.

3.1.1 Candidate vendors are referred to the State of Florida Onsite Sewage Nitrogen Reduction Strategies Study(www.floridahealth.gov/environmental-health/onsitesewage/research/b15report.pdf andwww.floridahealth.gov/environmentalhealth/onsitesewage/research/_documents/rrac/hazensawyervol0iireportrappend.pdf ) for examples.

## 3.2 Phased Implementation

3.2.1 Phase 1: This phase will include (189) dwelling units (Wright Pierce, Draft CWMP, July 2019, Section 6.5.3) and will have a duration of 14 years from the start date to evaluate the impact on watershed compliance.

3.2.2 Phase 2: This phase (Wright Pierce, as above) will be initiated after 14 years if compliance has not been achieved in Phase 1.

## 4.0 Management

### 4.1 Property Owner Requirements

Owners of designated properties within a watershed who are required to install an Advanced I/A System must obtain a Disposal System Construction Permit (DSCP) from the municipality within one year of the Start Date (see section 4.3 below). Owners must have completed installation of an Advanced I/A System within three years of the issuance of the DSCP and must grant a right of access to the municipality and its designee to periodically inspect, monitor total nitrogen and other constituents as necessary, maintain and pump the Advanced I/A Systems.

### 4.2 Municipal Participation

The Town of Falmouth will purchase and supply the designated property owners with the physical components of the Advanced I/A systems, at no charge. The designated property owners will be responsible for the site engineering plans, permitting from town agencies, components of a normal Title 5 System and the installation of the system including landscaping.

### 4.3 Responsible Management Entity (RME)

The Executive branch of the Town of Falmouth will designate an appropriate town department as the Responsible Management Entity (RME). The RME will be responsible for record keeping, inspecting, nitrogen and other monitoring, pumping and other maintenance, enforcement, and reporting to DEP on watershed nitrogen TMDL compliance. The RME may engage public or private contractors to perform some or all of these duties. The RME will designate the Start Date for installation of the Advanced I/A Systems within the watershed.

### 4.4 Advanced I/A Systems Approval

The RME will issue a Request for Proposals (RFP) to vendors of Advanced I/A Systems who wish to have their systems installed in the Town of Falmouth. Responsive vendors must meet the qualifying requirements of the RME, provide bonded warranties and train local technicians in the operation and maintenance of their systems. The RME will designate which vendors' Advanced I/A Systems will be approved for installation in the Town of Falmouth's watersheds.

## 4.5 Performance Monitoring

4.5.1 Probation Period: Monitoring for TN, BOD and TSS will be conducted by the RME or its designee. There shall be no ownership, management or employee connection between any monitoring contractor and any system or maintenance vendor. Upon installation, all systems will be considered under probation and sampled every other month for one year. However, if a system is not in use for any months during probation (as determined by water meter readings) then the RME at its discretion may alter the schedule to obtain the six required readings during occupied months that may be contiguous. If there are fewer than six occupied months in the year, the probation period may extend up to three years.

4.5.2 After Probation Period: If after the probation period the mean or equivalent nitrogen load reduction has not reached the required standard of 10 mg TN/L or 75% TN removal, the owner shall be responsible for the cost of bringing the system into compliance within one year of notification of this exceedance and shall resume probation period sampling.

## 4.6 Compliant System Monitoring

Following the Probation Period, 1/12 of the I/A systems in the watershed will be monitored for effluent total nitrogen each month. Properties chosen for sampling that month will be picked with a random number generator that excludes properties already sampled since the previous September 1 (start of the monitoring calendar year) and unoccupied seasonal homes. Each property will be sampled at least once per year at an unpredictable time. If at any future time a system is found to exceed the 10 mg TN/L standard or equivalent nitrogen load (75% removal), it must be resampled within 60 days. If that result still exceeds the standard, then it reverts to probation status.[see Section 4.5.1 above].

## 4.7 Operation and Maintenance (O&M)

Advanced I/A Systems must be maintained by the RME in accordance with Mass. DEP standards. In addition to the annual nitrogen monitoring described in section 4.6, the RME will inspect the control panel and other above ground components of the system twice yearly, either by means of remote sensing or onsite examination. An annual system inspection that includes operation and maintenance of the system shall be performed by vendor-trained and certified technicians under contract to the RME within a reasonable time following said annual nitrogen monitoring.

## 4.8 Pump-Outs

Septic systems will be pumped every five years by RME -approved contractors or as determined by inspection in compliance with 310 CMR 15.35, with cost assumed by RME semi-annual fee.

## 4.9 Record Keeping

Records will be kept by the RME for each property within the watershed and will be tied to the municipal geographic information system. Records shall include:

4.9.1 Engineered and “as built” plans submitted electronically;
4.9.2 Water readings (from transponder equipped water meters at each property);
4.9.3 Monitoring results;
4.9.4 Operation and Maintenance [O&M] records; and
4.9.5 Pumping records

## 4.10 Reporting

The RME will report watershed compliance to DEP on an annual basis. Compliance may be demonstrated by any of the following:

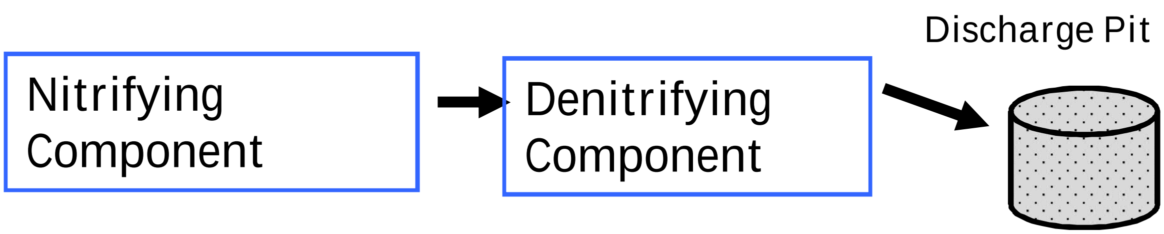
4.10.1 All systems meet the effluent standard of 10 mg TN/L or 75% removal of TN; or
4.10.2 Systems that fail to meet the standard are balanced by systems that exceed the standard; or
4.10.3 The TMDL-mandated water column nitrogen concentration for Oyster Pond is met at the sentinel station; or
4.10.4 The watershed load meets the target load needed to achieve TMDL compliance. The watershed load is calculated quarterly, based on water usage and the twelve month rolling average of accumulated nitrogen documented in the annual sampling data for total nitrogen.

## 5.0 Fees

Each dwelling unit with an Advanced I/A System will be assessed a fee semi-annually that will cover appropriate RME costs.

# Appendix I

## Conceptual Model for Nitrogen Removal using Advanced Innovative Alternative Septic Systems to: Achieve < 10mg/L TN or >75% removal of TN




### System Performance Requirements:

1. Effluent Total Nitrogen (TKN + nitrate + nitrite) < 10 mg/L or >75% TN removal
2. Effluent BOD, TSS < 30 after 4 months of operation
3. Systems shall be configured such that no more than one pump for the conveyance of fluid is necessary and the total power usage for entire system shall not exceed 2.5 kWh/day
4. Denitrifying medium must have a replacement requirement of not less than five years and be easily replaced without system excavation .

### Nitrifying Component:

There are a number of candidate technologies that might meet the requirements for nitrification. Refer to DEP web site: www.mass.gov/guides/title-5-innovativealternative-technology-approval-letters

### Denitrifying Component:

Technologies that might meet the criteria for denitrification would have enclosed chambers with a cellulosic medium such as used in the Nitrex™ and NitROE™ systems.

### Discharge Component:

Discharge is proposed with variously sized pits using loading and design criteria from the pre-1995 Code. Tests* indicate that these pits when receiving effluents with a treatment level of TN< 10mg/L and BOD and TSS levels <30mg/L after 4 months of operation will be as effective as currently required field configurations and do so at considerable cost savings.

*Component evaluated at the Massachusetts Alternative Septic System Test Center, a Division of the Barnstable County Department of Health and Environment (Viral Travel Time Studies are funded and will be tested on pits as described above)

# FHR-15.0 SUPPLEMENTS TO 310 CMR 15.000: THE STATE ENVIRONMENTAL CODE TITLE 5

## 15.1 PURPOSE AND AUTHORITY:

The Falmouth Board of Health adopts these regulations in accordance with Massachusetts General Laws, Chapter 111 Section 31, Chapter 21A Section 13, and the regulations contained within 310 CMR 15.000 et seq. (as amended in 1995) to provide for the protection of public health and the environment. The supplements to 310 CMR 15.000 are adopted due to the unique conditions in Falmouth including, among others, nitrogen in the Town's embayments rapidly percolating soils, the abundance of recreational and shellfish harvesting resources, extensive fresh water and salt water wetlands, public drinking water supply wells, and the occasional presence of private drinking water wells.

## 15.2 CONDITIONS THAT SHALL APPLY TO THE INSTALLATION OF ALL SEPTIC SYSTEMS:

1. **Septic Systems on Lot Served.**
   All septic systems and septic system components designed to dispose of sanitary wastes shall be constructed on the same lot as the structure or structures that they serve except that shared systems pursuant to 310 CMR 15.290-291 shall be allowed. No easements or right-of-way for the installation, maintenance or service of any septic system on a different lot than the lot to be served shall suspend, diminish or invalidate this regulation.

2. **Manhole Covers and Risers.**
   a. All septic tanks, cesspools, pump chambers, and leaching pit covers on existing and new individual sewage disposal systems shall be of sound and durable materials. Cement covers used below grade shall be a minimum of twenty (20) inches in diameter and free of all cracks and chips and in good repair.
   **b.** Septic system covers at grade level shall be of material capable of supporting a minimum of H-10 loading. Covers shall be set flush to the ground and not tilt when stepped on. The rim of a manhole cover shall be firmly attached to the component or riser, and the cover be removable only with the use of some type of implement.
   **c.** If portions of a septic system are not replaced during an upgrade, such as reusing a septic tank, that component must also have risers installed.
   **d.** H-20 load rated covers not at grade must have a "special" ring and cover to allow for easier removal of the covers during servicing and inspection while maintaining sufficient strength for H-20 loading.
   **e.** All covers for all septic tanks, distribution boxes and inspection ports must have magnetic tape or suitable substitute firmly secured to each riser/cover to allow for locating them in the future.

3. **Distribution Boxes.**
   All distribution boxes must have an H-20 load rating.

4. **Observation Ports Required on Leaching Facilities.**

A minimum of two (2) observation ports, enabling the inspection of effluent ponding levels, shall be installed in each leaching facility. The observation port shall have a minimum two-inch diameter and shall extend from the bottom of the leaching facility to within three (3) inches of final grade. All observation ports shall have securely sealed caps. If installed below grade, a metal object that will allow detection with a metal detector shall be placed immediately on top of the end cap. The location of all observation ports shall be noted on the septic plan and accurately indicated on an as-built illustration. Any structure, such as a gallery or chamber, having an observation port extended to within six (6) inches of surface grade may substitute for a separately installed observation port, provided that at least two (2) ports are present and are evenly spaced in the soil absorption area. All observation ports shall be labeled or otherwise marked to provide identification and prevent misuse.

5. **Engineered Plans.**
   **a.** The locus of the property on which a septic system is proposed shall be provided on the septic system site plan. The locus shall identify the nearest intersection and nearest three (3) streets to the locus. A separate sheet containing the locus shall not satisfy the requirement of this regulation.
   **b.** An electronic copy of the approved plan, in a format specified by the Health Department, shall be submitted to the Board of Health prior to the issuance of a certificate of compliance.

6. **As-Built Illustrations.**
   a. At the time of final inspection, a legible as-built illustration that shows the location of all components of a septic system shall be signed by the installer and submitted to the Health Department. Each reference on the illustration shall contain, at a minimum, the distance from two (2) points on permanent structures for each of the following: all observation ports, the center of two (2) manholes for all tanks or watertight structures, the four (4) corners of the leaching facility or the beginning and end of each trench if applicable. The as-built illustration shall be submitted to the Health Department on a 5"x7" card, and a copy of the as-built illustration shall also be supplied to the homeowner.
   b. In situations where the vertical separation distance of the bottom of the stone beneath the soil absorption system is within six feet of high groundwater in soils with a percolation rate of more than two minutes per inch and within seven feet of high groundwater in soils with a percolation rate of two minutes or less per inch, the system's final elevations must be certified by the septic engineer/designer and submitted to the Health Department. In these cases, the elevations shall be determined using the North American Vertical Datum of 1988, or any datum that supersedes this system.

## 15.3 APPROVAL OF ALTERNATIVE ONSITE SEPTIC SYSTEMS:

1. **Purpose.**
   In certain situations, alternative septic systems, when properly designed, constructed, operated, and maintained, may provide enhanced protection of the public health and the environment. Notwithstanding the sound technical basis of many alternative technologies, the Falmouth Board of Health seeks, through these regulations, to ensure that those alternative on-site septic systems installed within its jurisdiction are operated in compliance with the appropriate Commonwealth of Massachusetts approvals for these technologies. In addition, by ensuring the completion of all required monitoring, the Board of health

seeks to gain information on the efficacy of such technologies and modify its approval process accordingly.

**2. Definitions.**

**Alternative Onsite Septic Systems (I/A's) / Enhanced Nitrogen Removal Systems.**
Systems designed to provide or enhance on-site sewage disposal which either do not contain all of the components of an on-site disposal system constructed in accordance with 310 CMR 15.100 through 15.255 or which contain components in addition to those specified in 310 CMR 15.100 through 15.255 and which are proposed to the Falmouth Board of Health and/or the Massachusetts Department of Environmental Protection (MADEP), or an agent authorized by the MADEP, for Remedial, Pilot, Provisional, or General use approval pursuant to 310 CMR 15.280 through 15.289.

**Corrective Actions specific to Alternative Onsite Septic Systems.**
Corrective action shall include, at minimum the following:

- A review of previous maintenance records and notes including the maintenance checklist;
- A review of water records for the home and all facilities serving the system identified as nonfunctioning;
- A verification that all water fixtures in the residence are sound and without leaks;
- A review with the homeowner and record of water use patterns, cleaning products, etc.;
- In the case of inadequate denitrification, a measure of alkalinity at the discharge point shall be taken and recorded;
- A review with the homeowner of the proper use of the system including practices recommended by the manufacturer;
- A consultation with the manufacturer of the treatment technology and a completion of any manufacturer recommendations;
- A report to the Board of Health on the actions and findings;

Should these corrective actions not result in findings that needed to be corrected and result in satisfactory system performance in accordance with the Board of Health Requirements, the maintenance provider's Corrective Action shall additionally include the performance of further diagnostic investigations that shall include, at minimum:

- Dissolved oxygen measurements at appropriate locations in the treatment train;
- Further in-depth listing of cleaning products used in the residence;
- Other actions that may be prescribed by the manufacturer of the treatment technology.
- A detailed report to the Board of Health on all consultations, actions and measurements taken.

**Seasonal Dwelling**
A dwelling unoccupied for three or more consecutive months in any one-year period.

**3. Application Requirement.**

**a.** All applications for disposal system construction permits involving the use of alternative septic system components purporting enhanced treatment shall be submitted to the Board of Health which shall hold a hearing to consider their approval. No abutter notification shall be required for this approval except as otherwise required. The Board of Health may deny the use of an alternative septic system if in its opinion the installation of said system is not in the interest of public health.

**b.** All applications for alternative septic systems shall be accompanied by a copy of the MA DEP Approval Letter appropriate for the technology indicating the level of approval (General Use, Remedial Use, Provisional Use, Piloting Use, or Site-Specific Pilot Approval).

**c.** All applications submitted under Piloting Approval shall be accompanied by performance data from all piloting sites where the alternative system has been similarly configured.

**4. Requirements on Plans**

All alternative septic systems shall have sampling ports appropriate for obtaining a representative sample and that are easily accessible and secured from unauthorized tampering. The design plans incorporating the use of alternative septic systems shall contain a clear illustration of all sampling ports, accompanied by an illustration and explanation for their use.

**5. Monitoring Requirements.**

The following monitoring requirements shall apply to the Town of Falmouth except that areas designated under an approved Targeted Wastewater Management Plan OR A Comprehensive Waste Water Plan shall follow all the requirements set forth by Mass DEP and the Responsible Management Entity of the Town of Falmouth. Also the following requirements are in addition to those stated in the Mass DEP Approval Letter for specific technologies.

**a.** The system effluent of all Innovative/Alternative (I/A) septic systems installed for the purpose of nitrogen reduction must undergo an initial probationary period of two years, during which the system shall be sampled and analyzed quarterly for parameters indicated by the Board of Health. Seasonally occupied homes shall be sampled two or three times during periods of occupancy with a minimum of six weeks between samples until eight measurements have been made.

**b.** Excluding the first quarter, if at any time thereafter during this initial sampling period a value exceeds the permitted level of any contaminant by greater than 25%, the maintenance contractor must notify the property owner, the Board of Health, and the Barnstable County Department of Health and Environment within 48 hours of receipt of the laboratory results, determine a plan for additional sampling, and initiate corrective actions referenced in FHR 15.3.2 within 30 days. Should these corrective actions not result in findings that needed to be corrected and result in satisfactory system performance in accordance with the Board of Health requirements, the maintenance provider’s corrective action shall additionally include the performance of further diagnostic investigations that shall include at the minimum:

- Dissolved oxygen measurements at appropriate locations in the treatment train
- Further in-depth listing of cleaning products used in the residence
- Other actions that may be prescribed by the manufacturer of the treatment technology
- A detailed report to the Board of Health on all consultations, actions and measurements taken

**c.** Reported results of corrective actions must include the results of all follow-up samples taken, and must be submitted within 60 days from the initial non-compliant value.

6. **Probationary Period.**
The probationary period shall conclude after two years of consecutive quarterly measurements, or in the case of seasonal homes after eight samples taken during periods when the home is occupied, if the following requirements are met:
   - **a.** No more than two measurements of the primary parameter, as defined by the Board of Health approval letter, exceed the permitted value by more than 25% **and**
   - **b.** The average of the eight measurements is equal to or less than the value permitted for the use of the technology.

Samples taken in conjunction with the corrective actions referenced in FHR 15.3.2 shall not count toward the eight consecutive quarterly samples except that a sample resolving the deficient performance sample may be substituted for the failed sample from that quarter.

7. **Reduction of Testing Schedule.**
Following successful completion of the probationary period, the applicant may petition to the Board of Health for a reduction of the testing schedule, provided that all of the permitted requirements have been satisfied, except in cases superseded by Mass DEP requirements.

8. **System Failure.**
If the Board of Health determines that a system is in failure it may at its discretion mandate corrective actions as defined in FHR 15.3.2 and may additionally include system upgrades or replacement. The system will be considered in failure if at the end of the probationary period or following a reduced schedule of testing the concentrations of the permitted parameters repeatedly fail to meet the system requirements through either standard sampling results or through the use of mass loading calculations as defined in FHR 15.3.9.

9. **Calculating Compliance Using Mass Loading Calculations.**
   - **a.** If the I/A system is considered to be failed using standard sample results, compliance may still be achieved if it can be demonstrated by use of influent concentration of total nitrogen (TN) and/or concurrent documented reduced water use that the system meets or exceeds the permitted reduction in nitrogen loading. For example, in a system permitted at 19 mg/l TN, the system would need to meet or exceed a 50% reduction in TN, a system permitted at 12 mg/l TN would need to meet or exceed a 70% reduction in TN, and a system permitted at 10 mg/l TN would need to meet or exceed a 75% reduction in TN.
   - **b.** Information required for use in this alternate means for determining system performance shall include:
     - Influent TN concentration and the means by which this value was determined;
     - Concurrent water use records in the form of a statement from the Falmouth Water Department;
     - The number of occupants during the period of consideration;
     - Any additional information the applicant considers relevant to the explanation of system performance.
   - **c.** When it is not feasible to obtain a system influent TN concentration, a qualified wastewater professional may submit information for consideration for alternate means of determining system performance, which shall be considered by the Board of Health.

10. **Reporting Requirements.**
Any person or entity that owns an alternative on-site septic system or septic system with pressure distribution in Falmouth shall cause the results of all monitoring and inspections to be submitted to the Barnstable County Department of Health and Environment in a format designated by that department. All reports regarding maintenance, monitoring, or inspections of alternative septic systems or systems with pressure distribution shall be submitted within thirty (30) days of the time when the maintenance, inspection, or monitoring was performed.

11. **Notification with Registry of Deeds.**
No certificate of compliance for a septic system that incorporates an alternative septic system that has any regular inspection or service requirement under the MA DEP Approval Letter shall be issued until the applicant has filed with the deed for the property a notice indicating the presence of an alternative septic system and the requirement for a service contract for the life of the system.

12. **Requirement for Use of Shared Systems.**
All subdivisions subject to the requirement of denitrification by any Board or Commission in the Town of Falmouth, shall be required to construct a shared septic system as defined in 310 CMR 15.002 and shall meet a limit of twelve (12) mg/l TN at the point where the treatment unit discharges to the soil absorption system. Individual on-site denitrifying septic systems shall be prohibited in subdivisions subject to denitrifying requirements.

13. **Requirement for Accessory Apartments.**
If an I/A system is required to meet the Falmouth Accessory Apartment Bylaw, that I/A system shall achieve a limit of 12 mg/L Total Nitrogen (TN) or achieve 70% TN removal.

## 15.4 CONDITIONS THAT SHALL APPLY TO PRESSURE DISTIBUTION SYSTEMS:

All systems with pressure distribution shall be designed in accordance with the most recent guidelines for the design and construction of pressure-dosed systems as available through the Massachusetts Department of Environmental Protection.

1. The calculations for the sizing of pumps, diameter of discharge orifices, diameter of all wastewater conveyance lines, and the spacing of orifices shall be provided at the time of application for a disposal works permit. The permit application shall be considered incomplete until this information is submitted.
2. The report from the mandatory annual inspection (required under 310 CMR 15.254) of all systems with pressure distribution shall be submitted to the Barnstable County of Health and Environment in a format designated by that Department.

## 15.5 VARIANCES:

1. **General Requirements.**
   - **a.** Variances may be granted only as follows: The Board of Health may vary the application of any provisions of this regulation with respect to any particular case when, in its opinion, the applicant has demonstrated that:

- The enforcement thereof would do manifest injustice after considering all the relevant facts and circumstances of the individual case; and
- A level of public health and environmental protection, that is at least equivalent to that provided under these regulations, can be achieved without strict enforcement of the provision of the regulation from which a variance is being sought.

**b.** Every request for a variance shall be made in writing and shall state the specific variance requested and the reasons therefore. All variances required shall be noted on the plan and specify which requirement of in 310 CMR 15.000 or Falmouth Board of Health regulation(s) cannot be met. Any variance granted by the Board of Health shall be in writing. Any denial of a variance shall also be in writing and contain a brief statement of the reasons for the denial. A copy of any variance granted shall be available to the public at all reasonable hours in the office of the Town Clerk or the Health Department while it is in effect.

**c.** Any variance or other modification authorized to be made by these regulations may be subject to such qualification, condition, revocation, suspension or expiration as the Board of Health expresses in its grant. A variance or modification authorized to be made by these regulations may otherwise be revoked, modified, or suspended, in whole or in part, only after the holder thereof has been notified in writing and has been given an opportunity to be heard in conformity with the requirements of 310 CMR 11.00 for orders and hearings.

**d.** All variances to Title 5 granted by the Board of Health shall be recorded at the Barnstable Registry of Deeds in the chain of title of the subject property. The cost of recording shall be paid by the applicant. A copy of the recorded variance shall be returned to the Health Department. Variances shall be valid for two (2) years unless a certificate of compliance for the associated construction works permit application has been obtained.

**2. Abutter Notification.**

For the purpose of notifying property abutters required by an action of the Board of Health as provided by Massachusetts General Laws or a Commonwealth of Massachusetts Regulation, abutters to a property shall include all owners of property falling entirely or in part within a one hundred (100) foot radius taken from any point on the property line of the subject lot. Abutters shall be identified through a certified list of abutters obtained from the Falmouth Board of Assessor's and said list shall be presented at the Board of Health hearing as evidence that the abutters have all been properly identified.

**3. Standard Conditions.**

The following conditions may be applied to variances granted from the requirements of Title 5 and these regulations. The Board of Health shall have the discretion to apply the conditions as they deem appropriate. The purpose of these conditions is to obtain the same degree of environmental protection as would have been provided if the system conformed to Title 5 or this local regulation. The Board may add other conditions which it deems necessary to mitigate environmental damage considering all the relevant facts and circumstances of the individual case. For any variances, the Board of Health may require:

**a.** The installation of flow-restrictor devices on all faucets and shower fixtures in the house.

**b.** A retrofitting of the toilets in the house to low-volume flush toilets in addition to the placement of flow-restrictor devices on all faucets and shower fixtures in the house.

**c.** Design changes to the proposed plan which reduce the application rate of the septic effluent.

- **d.** That there shall be no increase in the number of bedrooms or rooms that could be adapted for use as an additional bedroom. A bedroom is defined in DEQE (now DEP) correspondence 935-2160, dated 22 October 1985, which states "Bedroom" means any portion of a dwelling which is so designed as to furnish the minimum isolation necessary for use as a sleeping area and includes, but is not limited to, bedroom, den, study, sewing room, but does not include kitchen, bathroom, dining room, halls or unfinished cellar.
- **e.** That the existing system must be pumped dry and filled with clean soil before the new system is in service, or the system removed and the resulting void filled.
- **f.** That the excavation area must be adequately shored during construction so as to prevent the roadway or abutting property from caving in or being undermined.
- **g.** That the septic tank must be pumped at least every five years or as determined by inspection in compliance with 310 CMR 15.351.
- **h.** That no garbage grinder shall be allowed.
- **i.** That the leaching area must be redesigned to provide a distribution line to each leaching component.
- **j.** That wells near the property must be moved to meet the one hundred (100) foot lateral separation.
- **k.** That irrigation wells located within fifty (50) feet must be decommissioned and their use discontinued.

**4. Penalties.**
Penalty for failure to comply with any provision of this regulation shall be governed by Massachusetts General Laws, Chapter 111, Section 31. Each day's failure to comply with an order shall constitute a separate violation. Further, the Board of Health, after notice to and after a hearing thereon, may suspend, revoke, or modify any permit issued hereunder for cause shown.

## 15.6 SEPTIC SYSTEM LOCATION AND CONSTRUCTION – SEPTIC SYSTEMS NEAR SURFACE WATERS AND WETLANDS:

**Purpose:** On-site sewage disposal systems designed to meet 310 CMR 15.000 have not proven to be adequate protection from viruses, pathogens, and other contaminants of groundwater and surface water, particularly in areas where there is a lack of filtration due to rapidly percolating soils. Scientists have observed virus entrainment in groundwater to distances of greater than two hundred (200) feet from where they were introduced to the subsurface through a conventional on-site sewage disposal system. In saturated groundwater flow, viruses can travel unattenuated in medium-to-coarse sands for distances exceeding the minimum requirements set forth in 310 CMR 15.211. Human consumption of viruses, pathogens and other contaminants which enter shellfish resource areas, swimming areas, and/or within zones of contribution to public water supply wells can place the public at risk to disease.

**1. Prohibition of Systems Within One Hundred (100) Feet of Resource Areas That Serve New Construction.**
No septic system leaching facility serving new construction (as defined in 310 CMR 15.002) shall be constructed within one hundred (100) feet of a surface water or wetlands (as defined in 310 CMR 15.002) or within one hundred (100) feet of a water body or a bordering vegetated wetland (as defined in 310 CMR 10.000). Further, no system shall be located on a coastal beach, barrier beach, or dune (as defined

in 310 CMR 10.000). The minimum distance of a completely sealed septic tank shall be fifty (50) feet from a surface water or wetland as defined above.

2. **Conditions That Shall Apply to Repair of Septic Systems Within One Hundred (100) Feet of Surface Waters or Wetlands.**

The following conditions shall be required for the repair of those septic systems proposed within one hundred (100) feet of surface waters or wetlands. These regulations proceed on the principle that localized hydraulic loading resulting from gravity fed soil absorption systems results in decreased hydraulic retention, decreased wastewater treatment, and removal of pathogens. This situation compromises the public health near sensitive receptor sites such as surface waters, including wetlands. This regulation incorporates the principle that increased vertical separation between the bottom of the soil absorption system, afforded by pressure distribution networks, or alternative technologies, may compensate for horizontal setback deficiencies. Accordingly, where the health agent has determined that all feasible means have been taken to minimize the incursions toward the resource area, the following design features shall be incorporated. Notwithstanding the incorporation of the following design features, the health agent may, at his/her discretion refer any plan to the Board of Health for a hearing when, in their opinion, the applicant has not adequately demonstrated that all feasible means have been taken to minimize excursions toward resource areas.

**a.** Where no increased design flow is proposed and where the bottom elevation of the soil absorption system (SAS) is greater than ten (10) feet from the adjusted seasonal high groundwater and where the maximum achievable horizontal separation between the SAS and a surface water or wetland is at least fifty (50) feet, but less than one hundred (100) feet, the applicant shall demonstrate that they have achieved the maximum separation between the SAS and the resource area, and the approval shall be subject to the conditions of FHR 15.5.3 a, d, g, h, i, j, and k.

**b.** Where no increased flow is proposed and the bottom elevation of the SAS is less than ten (10) feet but at least five (5) feet from the adjusted seasonal high groundwater (but is otherwise in compliance with 310 CMR 15.242) and where the maximum achievable horizontal separation between the SAS and a wetland or surface water is at least seventy-five (75) feet but less than one hundred (100) feet, the applicant shall demonstrate that they have achieved the maximum separation between the SAS and the resource area and the approval shall be subject to the conditions of FHR 15.5.3 a, b d, g, h, i, j, and k.

**c.** Where no increased flow is proposed and the bottom elevation of the SAS is less than ten (10) feet but at least five (5) feet from the adjusted seasonal high groundwater (but otherwise in compliance with 310 CMR 15.202), and where the maximum achievable horizontal separation between the SAS and a wetland or surface water is at least fifty (50) feet but less than seventy-five (75) feet, a pressure distribution system shall be required that conforms to guidelines issued by the MA DEP. The approval shall be subject to the conditions of FHR 15.5.3 a, b, d, g, h, i, j, and k.

**d.** Where no increased design flow is proposed and where the bottom elevation of the SAS is greater than ten (10) feet from the adjusted seasonal high groundwater and where the maximum achievable horizontal separation between the SAS and a wetland or surface water is less than fifty (50) feet but at least forty (40) feet, a pressure distribution system shall be required that conforms to guidelines issued by the MA DEP. The approval shall be subject to the conditions of FHR 15.5.3 a, b, d, g, h, i, j, and k.

**e.** Where no increased design flow is proposed and where the bottom elevation of the SAS is less than ten (10) feet from the adjusted seasonal high groundwater (but is otherwise in compliance with 310 CMR 15.202) and where the maximum achievable horizontal separation between the SAS and a wetland or surface water is less than fifty (50) feet but at least forty (40) feet, an alternative on-site septic system in conjunction with a disinfection unit having no chemical residual and a system with pressure distribution shall be required that conforms to guidelines issued by the MA DEP. The approval shall be subject to the conditions of FHR 15.5.3 a, b, d, g, h, i, j, and k.

## 15.7 CRITERIA FOR DETERMINING A SEPTIC SYSTEM REPAIR OR REPLACEMENT:

To protect the public health against potential sources of contamination of the ground and surface waters in the Town of Falmouth, the Board of Health adopts the following regulation. The Board of Health may require the repair or replacement of a septic system if any of the following apply:

1. The results of an inspection of the septic system pursuant to 310 CMR 15.300 – 310 CMR 15.304 reveal that the system is failed.
2. Any of the following observations is made independent of a complete inspection pursuant to 310 CMR 15.300 – 310 CMR 15.304:
   - There is evidence of sewage flow to the surface of the ground, there is structural damage to the components of the system which prevent it from functioning as required
   - The system was pumped more than two (2) times in a ninety (90) day period (excluding maintenance pumping of grease traps),
   - There is evidence of breakout, there was sewage back-up into the house resulting from a non-functioning leaching area
   - The system is damaged or destroyed by storm or flood.
3. In the case where the septic system serving a facility is comprised of a cesspool(s), and where the seasonal high groundwater is less than two (2) feet from the bottom elevation of any cesspool, the system shall be considered failed and shall be replaced with a system in compliance with 310 CMR 15.000. Observations of these conditions in the course of an inspection pursuant to 310 CMR 15.300-15.305 shall be referenced on the certification statement part of the inspection form in the words “Needs Further Evaluation by Approving Authority”.
4. If the septic system being inspected is found not to be on the same lot it serves the system is considered failed unless a previous existing easement can be provided.

## 15.8 SEPTIC SYSTEM INSPECTION REQUIREMENTS:

1. A certified septic inspector who has failed a soil absorption system shall not conduct an installation, upgrade, repairs, or emergency repairs without the Board of Health or its agents certifying the system is in failure.
2. All domestic potable wells shall be located from two (2) points on permanent structures and included on the “As-Built” section of the inspection report.
3. Upon transfer of a property, if the dwelling is serviced by a domestic potable water well the septic system and has not been tested in the previous twelve (12) months, the inspector shall report the system as “needs further evaluation”. The well water shall be tested for total coliform, nitrate, pH, sodium, copper, iron,

conductance at a minimum. The Board of Health may also require additional testing for Volatile Organic Compounds. A new water quality analysis report shall be submitted to the Board of Health with the inspection report. In order for the system to be elevated to a "pass", the drinking water results must meet drinking water standards. Any septic system found within 50' of a drinking water well will be considered a failure. Refer to the MassDEP's Private Well Guidelines for further information.

**4.** Covers shall be brought to within 6" of grade for access to primary cesspools and septic tanks. Should the distribution boxes and/or soil absorption system be exposed during the process of the inspection, the risers shall be brought to within 6" of grade, 3" for inspection ports. If a system or component fails the inspection, then installation of risers is no longer required, as this will be corrected when the system is replaced or repaired.

**5.** When H-20 risers are needed, those covers must meet 15.2.2

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