Oyster Pond
Comprehensive Wastewater Management Plan

Alternatives Analysis

October 2017

Prepared for the
Town of Falmouth
by

WRIGHT-PIERCE
Engineering a Better Environment

Falmouth, Massachusetts
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TOWN OF FALMOUTH

COMPREHENSIVE WASTEWATER MANAGEMENT PLAN

OYSTER POND

ALTERNATIVES ANALYSIS REPORT

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SECTION 4

IDENTIFICATION AND SCREENING OF ALTERNATIVES

4.1 METHODOLOGY

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 (Figure 3-7 and Table 3-9). 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 the majority of the items from the Cape Cod Commission's recently issued 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 is 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). 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, a number of 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.). Based on discussions with the Working Group, the only growth management provisions that will be incorporated into this plan are the recently promulgated "flow neutral" provisions which are required to obtain 0% interest CWSRF loan funding. These provisions were built into the "aggregated needs" description presented in Section 3.

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 of 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 stream, a source-source organics waste stream 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).

Falmouth currently prohibits garbage grinders 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 with regard to 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.

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 effluent total nitrogen
- I/A System – can routinely meet <19 mg/l effluent total nitrogen
- Enhanced I/A System – anticipated to routinely meet <13 mg/l effluent total nitrogen
- Advanced I/A System – anticipated to routinely meet <10 mg/l effluent total nitrogen

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” (e.g., from toilets) 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 a number of different eco-toilet systems. The WQMC reports that a key finding of this demonstration is that public acceptance of eco-toilets is very low at this time.

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 <u>all</u> toilets to approved eco-toilets will be considered equivalent to Enhanced I/A Systems and Advanced I/A Systems. This assumption will be revisited, as appropriate, when the Falmouth Eco-toilet Working Group provides additional data.

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. The majority of 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 its 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. Larger scale wastewater treatment facilities also require a DEP Groundwater Discharge Permit.

There are two existing WWTFs that could potentially serve part or all of 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. This system is permitted for a flow rate of 450,000 gpd (2002 Modified Groundwater Discharge Permit, 2012 Settlement Agreement) 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 has a design treatment capacity of 1,200,000 gpd and currently receives an annual average flow of 434,000 gpd. The WWTF also receives septage and processes thickened biosolids. Effluent disposal is via 13 rapid infiltration basins. The WWTF also has five abandoned 13-acre seasonal spray irrigation fields and some seasonal wastewater storage ponds. Effluent from the WWTF is 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. 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 (similar to 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 similar to 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. 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.

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.

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

	Flow Range, gpd		Nitrogen, mg/l		Phosphorus, mg/l	
	From	To	Effluent Limit	Expected Performance	Effluent Limit	Expected Performance
Title 5 Systems						
Individual	400	2,000	N/A	35	N/A	10
Cluster	2,000	10,000	N/A	35	N/A	10
I/A Systems						
Individual	400	2,000	N/A	10 to 19	N/A	9
Enhanced I/A System	400	2,000	N/A	<13	N/A	9
Advanced I/A System	400	2,000	N/A	<10	N/A	9
Cluster (Note 1)	2,000	10,000	12	10 to 12	5	5
Decentralized Systems						
Small						
Traditional GWD Permit	10,000	25,000	10	10	N/A	9
High Level N Removal	10,000	25,000	N/A	N/A	N/A	9
P Removal	10,000	25,000	---	---	2	2
Medium						
Traditional GWD Permit	25,000	75,000	10	8	N/A	9
High Level N Removal	25,000	75,000	N/A	N/A	N/A	9
P Removal	25,000	75,000	---	---	1	1
Large						
Traditional GWD Permit	75,000	200,000	10	7	N/A	9
High Level N Removal	75,000	200,000	3 to 5	3 to 5	N/A	4
P Removal	75,000	200,000	---	---	1	0.5
High Level P Removal	75,000	200,000	---	---	0.3	0.3
Centralized Systems						
Traditional GWD Permit	200,000	1,500,000	10	7	---	---
High Level N Removal	200,000	1,500,000	3 to 5	3 to 5	---	---
P Removal	200,000	1,500,000	---	---	1	0.5
High Level P Removal	200,000	1,500,000	---	---	0.3	0.2

Notes:

1) Falmouth has a by-law which requires cluster systems to meet 12 mg/l effluent nitrogen.

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 must include a cost-effective and environmentally sound means to handle these residuals.

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 include 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 similar to 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. Accordingly, a low pressure collection system was used as the basis for the initial screening analysis. Other collection system approaches could be evaluated, if so desired, in the detailed alternatives 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. As an illustrative scenario, **Table 4-4** shows that approximately 24% more homes would need to be managed if effluent disposal was within a nitrogen sensitive watershed.

TABLE 4-4

IMPLICATIONS OF IN-WATERSHED VERSUS OUT-OF-WATERSHED DISPOSAL

Assumptions:

- 100 homes in a watershed on septic systems generating 10 lbs/year of nitrogen per home
- TMDL requires no more than 400 lbs/year of nitrogen remaining in the watershed
- The selected treatment technology has a residual nitrogen level after treatment of 5 mg/l

	Effluent Disposal In-Watershed	**Effluent Disposal Out-of-Watershed**
Starting Load in Watershed	1,000 lbs/yr	1,000 lbs/yr
Target Nitrogen Limit (TMDL)	400 lbs/yr	400 lbs/yr
Amount to be Removed from Watershed	600 lbs/yr	600 lbs/yr
Nitrogen remaining in Watershed after treatment	140 lbs/yr	0 lbs/yr
Amount of Nitrogen to be removed to meet TMDL	740 lbs/yr	600 lbs/yr
Number of Homes Affected	**74**	**60**

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 a number of 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 two locations in Massachusetts – Fairhaven and Hingham. Both installations experienced some problems initially due to high solids loadings to the wicks; however, once the high solids loadings were addressed, both installations have had several 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 of 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. Given that Falmouth has a significant number of watersheds that are known or expected to be nitrogen sensitive, there could be cost savings associated with ocean outfall disposal. Ocean outfalls are now allowed under Massachusetts General Law based on the Marine Ocean Sanctuaries Act. The Cape Cod Commission recently 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. This provides a framework for the Town to consider if this approach is determined to be desirable. The Cape Cod Commission may also review the potential for outfalls into the Cape Cod Canal or Cape Cod Bay as a part of its on-going Regional Wastewater Management Plan/ 208 Plan Update. Falmouth is considering ocean outfall as one approach to be utilized for its central 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 wastewaterderived 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 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, a number of 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.

In order 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 and Falmouth are working on additional studies in this area. This nitrogen control option is attractive because it might actually generate revenue in excess of its costs and its warrants the 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 located in areas with relatively shallow depth to groundwater (say 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 13,600 gal/week/turf acre	0.5 inches/week 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 total nitrogen load to the Oyster Pond watershed of 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, all 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 stratification such that it remains at or 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.

	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. Particular 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 8 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 4-5** and shown on **Figure 4-1**.

Based on regional mapping, the entire study area appears to be located in glacial moraine deposits (USGS Geologic Map of Cape Cod, Mather, et.al.).

4.7.2 Target Effluent Disposal Capacity

The Needs Assessment report identified aggregated wastewater management needs for the Oyster Pond watershed of approximately 29,000 gpd under current annual average conditions and approximately 34,500 gpd at planning horizon annual average conditions. 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 of the Needs Assessment report) 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.

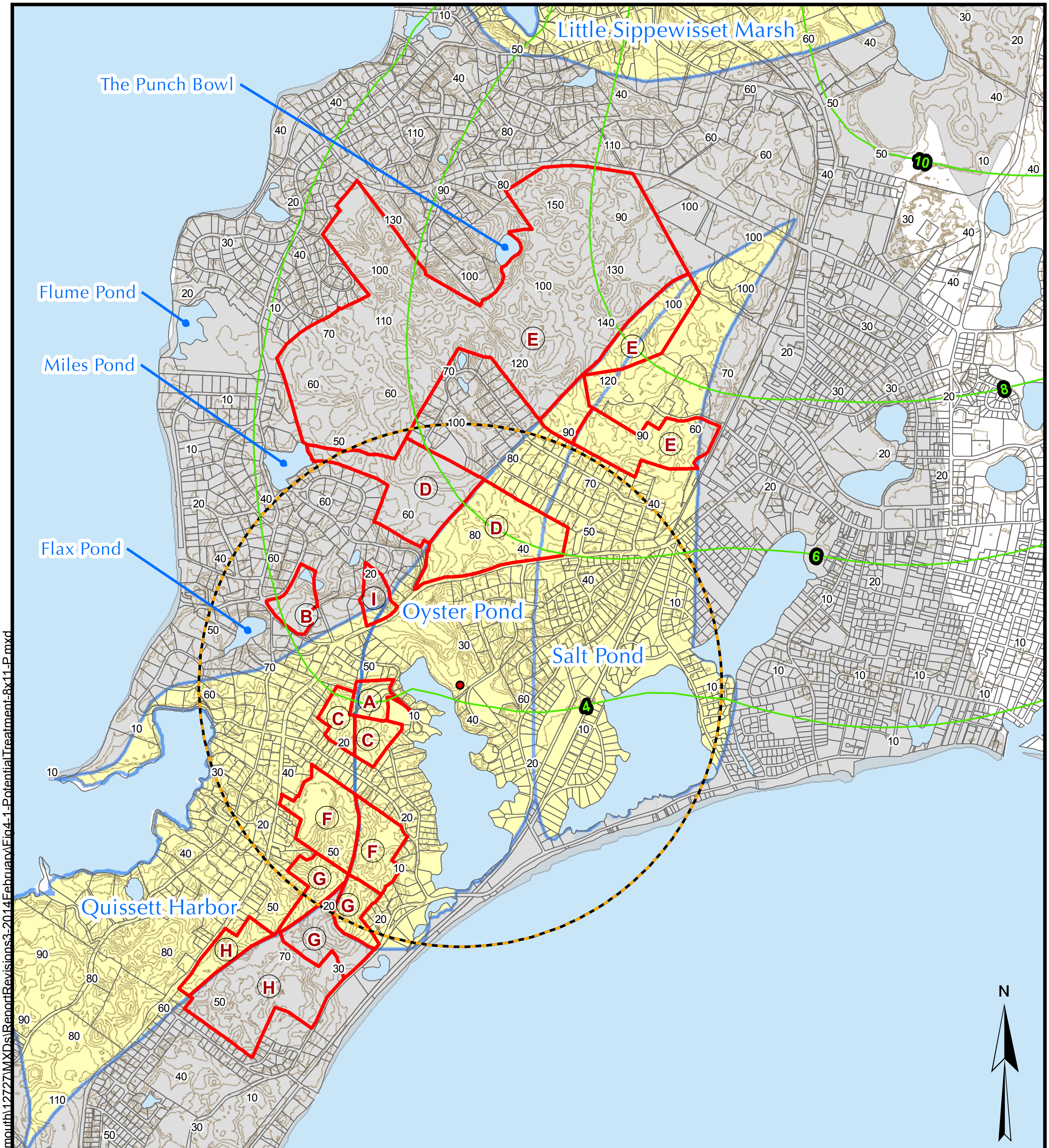
4.7.3 Estimated Size of Site Needed for Off-Site Effluent Disposal

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.

TABLE 4-5: INITIAL SITES FOR WASTEWATER TREATMENT AND DISPOSAL

Map Key	Parcel ID	Owner (a.k.a)	Area (acres)	Watershed	Notes
A	48 11 008 XXX - 254 - 255 - 256 - 257	Oyster Pond Environmental Trust (a.k.a., Zinn Park)	7.5 (total) *1.38 (ind.)* *2.16 (ind.)* *1.83 (ind.)* *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 ***Delete from further consideration***
C	48 10 009 000C	WHOI	17.5	Upper Quissett, Oyster Pond (in OP-GT10W)	Site "RB" from Needs Assessment, 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 ***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 Needs Assessment, Section 3
G	50 06 009 000A	WHOI	40.2	Upper Quissett, Oyster Pond (in OP-S)	Site "RC" from Needs Assessment, 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

WRIGHT-PIERCE
Engineering a Better Environment

W:\GIS_Development\Projects\MA\Falmouth\12727\MXDs\ReportRevisions3-2014February\Fig4-1-PotentialTreatment-8x11-P.mxd

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 4-6 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 4-6: 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 3"	0	10,000	0	0	0	
Subsurface "Area 4"	0	20,000	0	0	0	
Subsurface "Area 5"	0	15,000	0	0	0	
Wick locations	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. Accordingly, we recommend maintaining a "short list" of the best candidate sites for site-specific explorations at this time. This short-list will be developed in consultation with the Town. We recommend the following steps be undertaken by the Town:

- Based on the results of the initial workshop, identify whether Parcels A, B and/or D will be retained for continued evaluation. If so, research whether there are land use restrictions associated with these parcels (i.e., those designated as "conservation" or "recreation and conservation"). 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".

- Document the locations of septic systems and leachfields at Treetops and Woods Hole Research Center based on as-built plans in the Town's records.

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):

- Recently promulgated fertilizer control and flow neutral ordinances.
- 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") 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") 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

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, a number of 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 wastewater treatment facility should be considered.
- The Blacksmith Shop Road WWTF may be an alternative; however, there are several on-going items which may preclude this as a viable alternative for the Oyster Pond watershed. The Town will work to resolve these on-going items prior to the finalization of the Oyster Pond CWMP.
- 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 should be 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. Blacksmith Shop Road WWTF (Table 5-1 and Figure 5-1)
2. New Satellite Plant with Out-of-Watershed Disposal (Table 5-2 and Figure 5-2)
3. New Satellite Plant with In-Watershed Disposal (Table 5-3 and Figure 5-3)
4. Enhanced I/A Systems (I/A<13)[1] plus Pond Mixing (Table 5-4 and Figure 5-4)
5. Advanced I/A Systems (I/A<10)[1] (Table 5-5 and 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 have not yet been incorporated into this analysis; however, a detailed phasing and adaptive management plan will be prepared as a part of a subsequent task.

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 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 provided in Appendix D.

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

The watershed has 211 total parcels with 166 developed parcels. Of these 166 developed parcels, 163 parcels are zoned residential and have 225 existing dwelling units. These residential dwelling units include single family, multi-family and condo units and produce an estimated wastewater flow of 28,780 gpd (Table 2-8, Table 3-7). For future growth in the watershed, the Town elected to set the ‘planning horizon’ for the study to be equal to ‘practical build-out’. This projection resulted in 18 new dwelling units on 12 parcels with an estimated new wastewater flow of 5,600 gpd. Therefore, at planning horizon, the watershed is projected to have 178 developed parcels with 243 dwelling units and an estimated wastewater flow of 34,500 gpd. (Refer to Table 3-7). GIS data used in the analysis was received from the Town of Falmouth in 2013. Water use data was provided by the Town for the period 2007 to 2011. Peaking factors (average to short-term peak) were established in Section 2.9 of the Needs Assessment. Future development which is prevented through the purchase of conservation land will be accounted for in the recommended 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
(VIA SHINING SEA BIKE PATH FORCEMAIN)

Collection
Collection system will include 19,100 feet of low pressure collection sewers, 5,100 feet of low pressure transmission sewers to the existing 18-inch diameter sewer at the intersection of Main Street and Post Office Road. A total of 145 dwelling units from 85 parcels would be served by sewer initially to meet the TMDL and a total of 172 dwelling units from 112 parcels would be served by sewer at the planning horizon. Low pressure pump stations are required for connected dwelling units.

Treatment
Treatment of 26,700 gpd (future annual average) of wastewater at the Blacksmith Shop Road WWTF, including an allowance of 2,500 gpd (annual average) of infiltration/inflow.

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

Land Acquisition
Easements for collection system components within private roads have not been quantified and have been assumed to be conveyed at no cost to the Town.

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

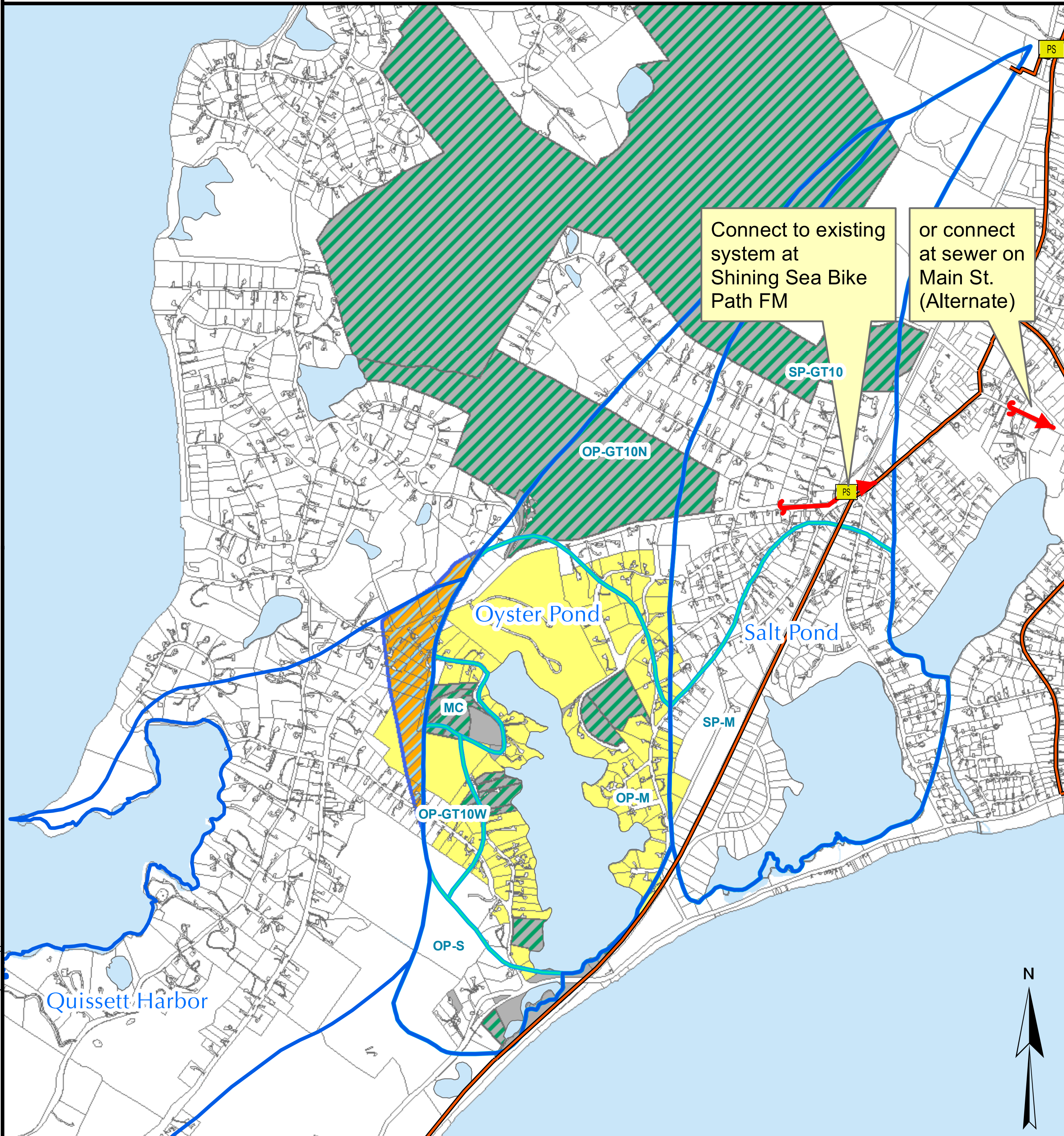
Nitrogen TMDL Compliance
This plan achieves compliance with the removal requirements indicated in the Oyster Pond TMDL. This plan adds an additional 244 lbs/year of Total Nitrogen to the West Falmouth Harbor watershed (assuming 26,700 gpd of wastewater treated to 3 mg/l effluent Total Nitrogen). Note: 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 (assuming 24,200 gpd of septic effluent at 10 mg/l Total Phosphorus).

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 26,700 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



PS Pump Station
Sewer Force Main
OPET Estimated Additional Surface Water Drainage Area
MEP Watershed Boundary
MEP Subwatershed Boundary
Open Water or Pond
Parcel
Properties Served Under Plan
Conservation/Recreation
Vacant/Undeveloped

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

0 1,500 3,000 Feet

Falmouth
Oyster Pond CWMP

Plan 1

PROJ NO: 12727 DATE: Dec 2013

WRIGHT-PIERCE Engineering a Better Environment

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 145 dwelling units from 85 parcels would be served by sewer initially to meet the TMDL and a total of 172 dwelling units from 112 parcels would be served by sewer at the planning horizon.

Treatment
Treatment of 26,700 gpd (future annual average) of wastewater at the expanded and upgraded Woods Hole Oceanographic Institution (WHOI) Quissett Campus, including an allowance of 2,500 gpd (annual average) of infiltration/inflow. The current design flow of the WHOI WWTF is 32,500 gpd (Title 5 basis). It is unlikely that WHOI will be able to accept any additional flow.

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
Permanent easements 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 not been quantified and have been assumed to be conveyed at no cost to the Town.

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

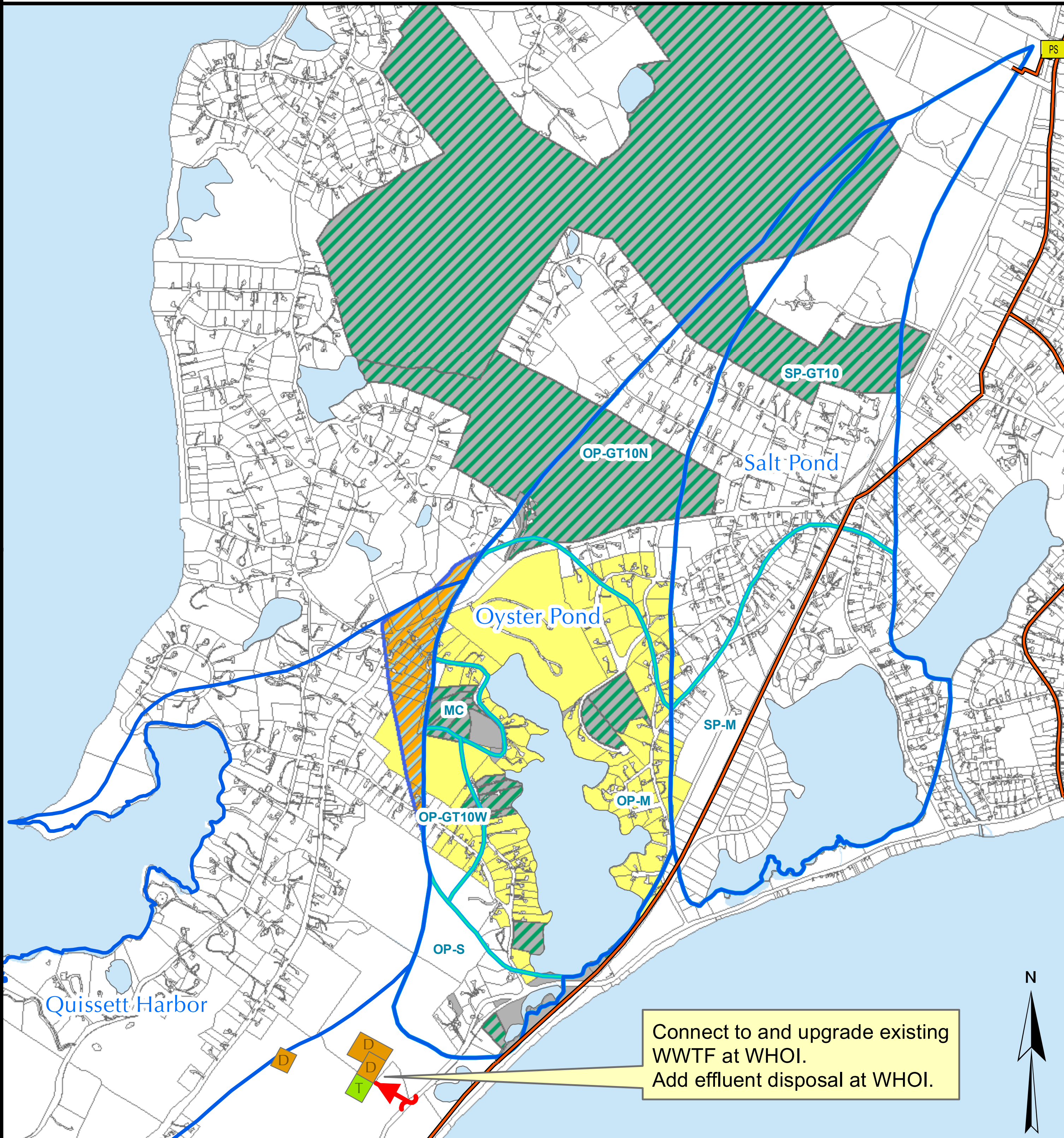
Nitrogen TMDL Compliance
This plan achieves compliance with the removal requirements indicated in the Oyster Pond TMDL. The existing WWTF and disposal system is located in an unnamed watershed which does <u>not</u> flow through a nitrogen sensitive embayment, as determined by DEP and MEP. DEP does not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

Phosphorus Management
This plan removes approximately 740 lbs/year of wastewater-related phosphorus from the watershed (assuming 24,200 gpd of septic effluent at 10 mg/l Total Phosphorus).

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 26,700 gallons per day from the watershed. This represents approximately 4% of the total freshwater recharge to Oyster Pond (MEP Report, Table III-1).

Satellite Plant with Out-Of-Watershed Disposal



- OPET Estimated Additional Surface Water Drainage Area
- Treatment
- Disposal
- MEP Watershed Boundary
- MEP Subwatershed Boundary
- Open Water or Pond
- Parcel
- Properties Served Under Plan
- Conservation/Recreation
- Vacant/Undeveloped
- PS Pump Station
- Sewer Force Main

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

0 1,500 3,000 Feet

Falmouth
Oyster Pond CWMP

Plan 2

PROJ NO: 12727	DATE: Dec 2013	FIGURE: 5-2

WRIGHT-PIERCE
Engineering a Better Environment

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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 176 dwelling units from 116 parcels would be served by sewer initially to meet the TMDL and a total of 213 dwelling units from 153 parcels would be served by sewer at the planning horizon.

Treatment
Treatment of 32,600-gpd (annual average) of wastewater at a new satellite WWTF, including an allowance of 2,500-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
Permanent easements or land purchase will be necessary for one treatment facility location (1.5 acres), and for disposal facility locations (5 acres total). If portions of the WHOI property (Parcel C) are purchased, there is an additional benefit associated with eliminating some of the planned future growth (and the resultant cost that comes from that growth). Easements for collection system components within private roads have not been quantified have been assumed to be conveyed at no cost to the Town.

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

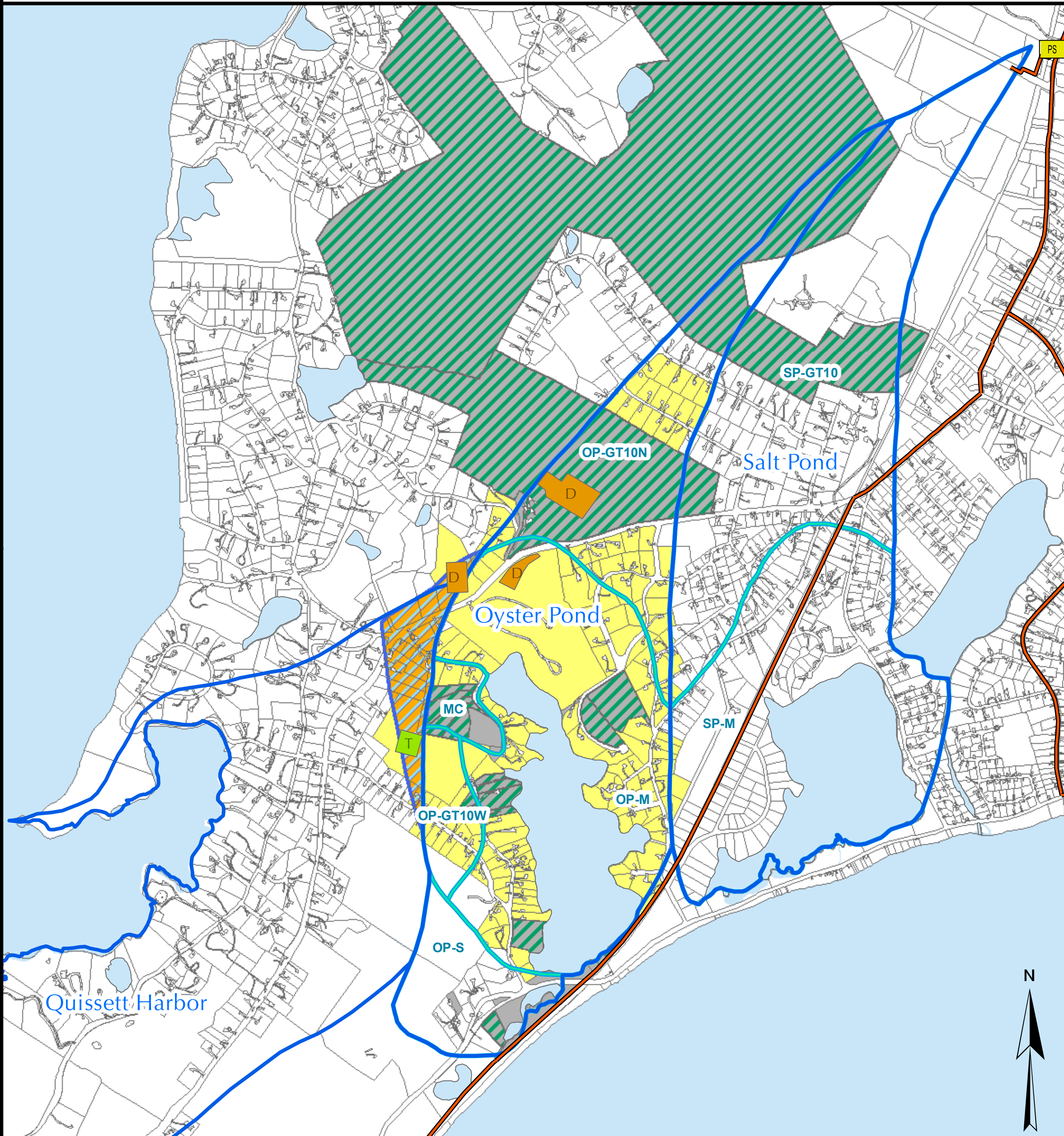
Nitrogen TMDL Compliance
This plan achieves compliance with the removal requirements indicated in the Oyster Pond TMDL.

Phosphorus Management
This plan removes approximately 870 lbs/year of wastewater-related phosphorus from the watershed (assuming 30,100 gpd of septic effluent at 10 mg/l Total Phosphorus and 250 lbs/year for phytoirrigation minus the in-watershed disposal of 32,600 gpd of wastewater at 3 mg/l Total Phosphorus).

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 Plant with In-Watershed Disposal



OPET Estimated Additional Surface Water Drainage Area
Treatment
Disposal
MEP Watershed Boundary
MEP Subwatershed Boundary
Open Water or Pond
Parcel
Properties Served Under Plan
Conservation/Recreation
Vacant/Undeveloped
PS Pump Station
Sewer Force Main

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

0 1,500 3,000 Feet

Falmouth
Oyster Pond CWMP

Plan 3

PROJ NO: 12727 DATE: Dec 2013

WRIGHT-PIERCE
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FIGURE: 5-3

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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 225 dwelling units would be served by "Enhanced I/A systems" (TN<13-mg/l) initially and a total of 243 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).

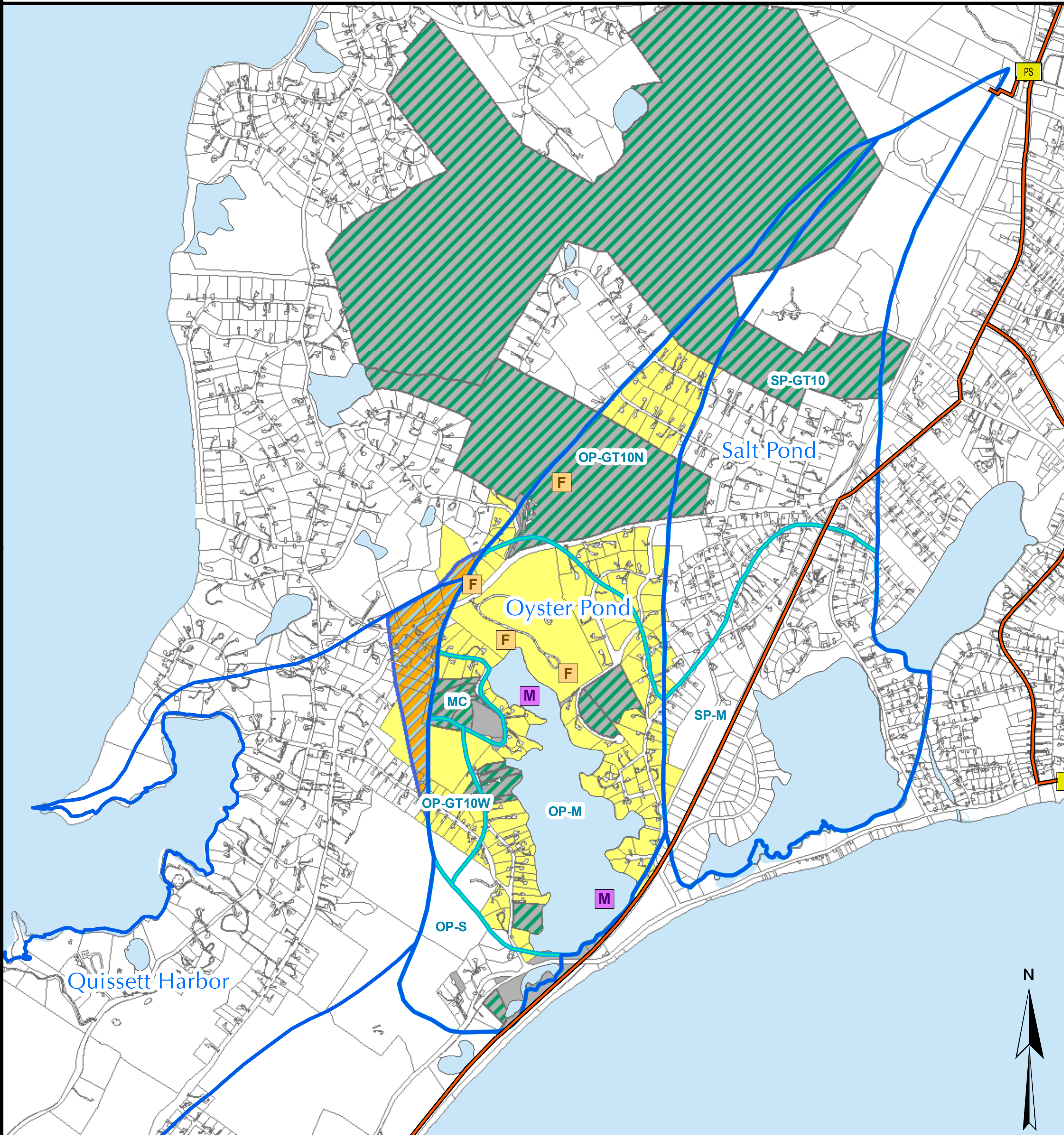
Nitrogen TMDL Compliance
This plan does not achieve compliance with the Oyster Pond TMDL as currently written; however, if DEP and MEP agree that the mixer will raise the minimum observed dissolved oxygen from 2 mg/l (used in the TMDL) to 4 mg/l (based on OPET data above the natural stratification) and 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 160 lbs/year of wastewater-related phosphorus from the watershed (assuming 34,500 gpd of wastewater at 9 mg/l Total Phosphorus, net reduction of 1 mg/l, and 55 lbs/year for fertigation).

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



OPET Estimated Additional Surface Water Drainage Area
Fertigation
Mixer
MEP Watershed Boundary
MEP Subwatershed Boundary
Open Water or Pond
Parcel

Properties Served Under Plan
Conservation/Recreation
Vacant/Undeveloped
Pump Station
Sewer Force Main

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

0 1,500 3,000 Feet

Falmouth
Oyster Pond CWMP

Plan 4

PROJ NO: 12727 DATE: Feb 2014

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FIGURE: 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 204 dwelling units would be served by "Advanced I/A systems" (TN<10-mg/l) initially to meet the TMDL and a total of 242 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.

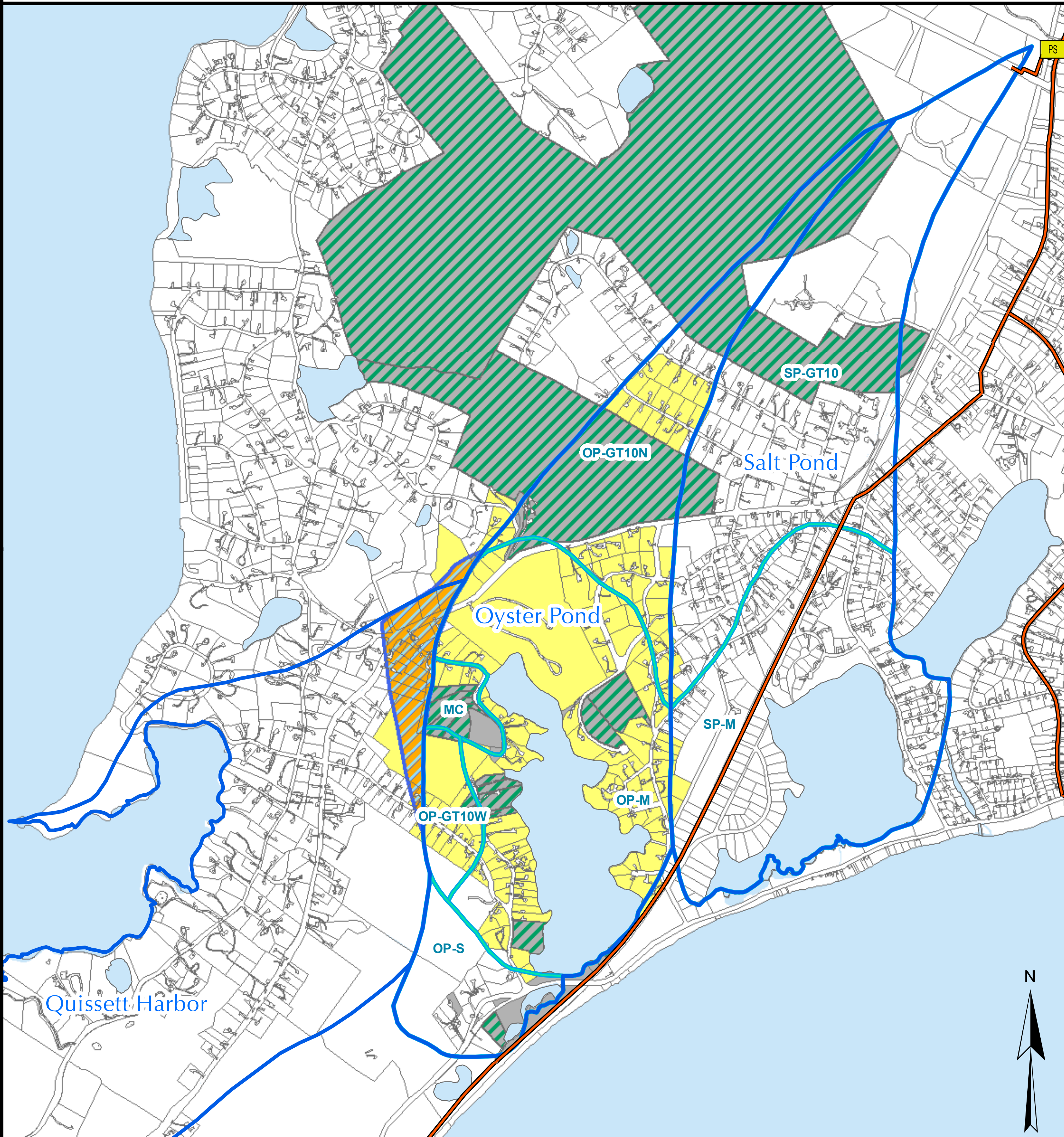
Nitrogen TMDL Compliance
This plan achieves compliance with the removal requirements indicated in the Oyster Pond TMDL.

Phosphorus Management
This plan removes approximately 105 lbs/year of wastewater-related phosphorus from the watershed (assuming 34,500 gpd of wastewater at 9 mg/l Total Phosphorus, net reduction of 1 mg/l).

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



OPET Estimated Additional Surface Water Drainage Area
MEP Watershed Boundary
MEP Subwatershed Boundary
Open Water or Pond
Parcel
Properties Served Under Plan
Conservation/Recreation
Vacant/Undeveloped
PS Pump Station
Sewer Force Main

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

0 1,500 3,000 Feet

Falmouth
Oyster Pond CWMP

Plan 5

PROJ NO:	DATE:	FIGURE:
12727	Feb 2014	5-5

WRIGHT-PIERCE
Engineering a Better Environment

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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 freshwater recharge to Oyster Pond. Plans 4, 5 and 6 do not remove wastewater from the watershed.
- Plans 1, 2 and 3 utilize existing or new wastewater treatment facilities. Plans 4, 5 and 6 utilize 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 through the use of approved Eco-toilets, to the extent Eco-toilets and/or on-site nutrient recovery are approved by the Town.

A comparison of key technical data for each plan is summarized in **Table 5-7**.

TABLE 5-7: COMPARISON OF VARIOUS PLANS (revised June 2017)

	Plan 1		Plan 2		Plan 3		Plan 4		Plan 5		Plan 6	
	Initial	Design	Initial	Design	Initial	Design	Initial	Design	Initial	Design	Initial	Design
Description	Sewer to BSR WWTF (out-of-watershed)		Sewer to WHOI WWTF (out-of-watershed)		Sewer to Local WWTF (in-watershed)		Enhan. I/A plus Mixing (in-watershed)		Advanced I/A (in-watershed)		No action (in-watershed)	
Dwelling Units in Watershed	225	243	225	243	225	243	225	243	225	243	225	243
Dwelling Units Served - Sewer	145	172	145	172	176	213	0	0	0	0	0	0
Dwelling Units Served - I/A System	0	0	0	0	0	0	225	243	204	242	0	0
Dwelling Units - Title 5 Systems	80	31	80	31	49	30	0	0	21	1	225	243
Parcels Served in Plan	85	112	85	112	116	153	166	178	166	178	0	0
Wastewater flow, gpd annual average												
Septic elimination	18,600	24,200	18,600	24,200	22,600	30,100	0	0	0	0	0	0
Infiltration/inflow	1,900	2,500	1,900	2,500	1,900	2,500	0	0	0	0	0	0
Total	20,500	26,700	20,500	26,700	24,500	32,600	0	0	0	0	0	0
Winter, average daily	*10,300*	*13,400*	*10,300*	*13,400*	*12,300*	*16,300*						
Summer, peak daily	*51,300*	*66,800*	*51,300*	*66,800*	*61,300*	*81,500*						
Length of Collector LPS, ft		19,100		18,200		21,300	n/a	n/a	n/a	n/a	n/a	n/a
Length of Transmission LPS, ft		5,100		3,000		1,500	n/a	n/a	n/a	n/a	n/a	n/a
Effluent Concentrations & Loads												
I/A effluent N conc., mg/l	17	17	17	17	17	17	13	13	10	10	26.25	26.25
N load removed per Sewer, lb/yr/DU	13.3	14.7	13.3	14.7	13.3	14.7	13.3	14.7	13.3	14.7	0	0
N load removed per I/A, lb/yr/DU	6.7	7.4	6.7	7.4	6.7	7.4	8.2	9.1	9.4	10.4	0	0
Nitrogen Removed from Watershed, lb/yr												
Septic system elimination	1,929	2,528	1,929	2,528	2,341	3,131	-	-	-	-	-	-
I/A sytem installation	0	0	0	0	0	0	1855	2214	1920	2517	0	0
Fertilization reduction	86	86	86	86	86	86	86	86	86	86	86	86
Stormwater management	46	46	46	46	46	46	46	46	46	46	46	46
Phytoirrigation/Fertigation	0	0	0	0	213	213	42	42	0	0	0	0
New WWTF effluent	0	0	0	0	(597)	(794)	0	0	0	0	0	0
Total	2,061	2,660	2,061	2,660	2,090	2,683	2,029	2,388	2,052	2,649	132	132
Watershed N removal target, lb/yr												
TMDL Met/**Not Met**	2,064	2,647	2,064	2,647	2,064	2,647	**2,064**	**2,647**	2,064	2,647	**2,064**	**2,647**
Alternate criteria Met/**Not Met**	763	1,346	763	1,346	763	1,346	763	1,346	763	1,346	**763**	**1,346**
Phosphorus Removed from Watershed, lb/yr												
Septic system elimination	566	737	566	737	688	916	-	-	0	0	0	0
I/A sytem installation	0	0	0	0	0	0	88	105	88	105	0	0
Fertilization reduction	tbd	tbd	tbd	tbd	tbd	tbd	tbd	tbd	tbd	tbd	tbd	tbd
Stormwater management	tbd	tbd	tbd	tbd	tbd	tbd	tbd	tbd	tbd	tbd	tbd	tbd
Phytoirrigation/Fertigation	0	0	0	0	253	253	55	55	0	0	0	0
New WWTF effluent	0	0	0	0	(224)	(298)	0	0	0	0	0	0
Total	566	737	566	737	717	872	143	160	88	105	0	0
Ultimate Discharge Watershed	West Falmouth Harbor		Un-named		Oyster Pond		Oyster Pond		Oyster Pond		Oyster Pond	

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, or dollars per pump 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.

The Eco-toilet Working Group is developing a cost database for eco-toilet local installations. To date there are five installations. Given this limited dataset, we have treated the capital cost of approved eco-toilet systems and Enhanced I/A systems as equivalent but have provided different annual costs for each type of approach for the purposes of this screening analysis. This assumption will be updated with local information when more information is available.

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 40% for public project components and at 25% 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 the pods for wastewater solutions (e.g., group LPS pumping station or group I/A system). The cost analysis treats these as 62 dwelling units, which can be refined based on the selected plan.
- Costs associated with the first-year operations, maintenance and performance monitoring of low pressure pump stations and Advanced I/A system were assumed to be included in the capital costs.
- Costs for private property work (e.g., trenching, redirecting drain, abandoning septic system, etc.) and do not include landscaping costs.
- Costs for sewer connection fees included, where applicable, based on Town policy as of Dec 2013.
- Septic systems that aren’t 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 cost in Barnstable County Cost Report.

Table 5-8 summarizes the capital costs for each plan. Appendix 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. No cost has been included for “nitrogen offsets” for Plan 1.

Table 5-8 summarizes the annual O&M costs for each plan. Key O&M unit cost information is provided in Appendix E.

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

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 present worth 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 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 of the three town-wide alternatives is summarized in **Table 5-8**.

5.4 WORKSHOP RESULTS

A workshop was held with the Oyster Pond Working Group and members of the interested public on July 30, 2014. 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. A summary of questions and comments from the public is included in Appendix G.

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 their limited land and wastewater facilities to fulfill the WHOI mission.

Based on the comments noted above, the Oyster Pond Working Group incorporated the comments received into a focused follow-on analysis for Plan 1 and Plan 5, described below.

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TABLE 5-8: SUMMARY OF PLANNING-LEVEL COST ESTIMATES (revised June 2017)

Meet TMDL at Planning Horizon

	Plan 1 Sewer to BSR WWTF	Plan 2 Sewer to WHOI WWTF	Plan 3 Sewer to Local WWTF	Plan 4 Enhanced I/A plus Pond Mixing	Plan 5 Advanced I/A	Plan 6 No Action
Capital Cost						
Construction - Collection and Transport	$4,880,000	$4,450,000	$5,020,000	$770,000	$0	$0
Construction - Treatment (including I/A systems)	$0	$2,260,000	$2,940,000	$6,730,000	$6,730,000	$0
Construction - Disposal (Note 7)	$370,000	$1,030,000	$1,550,000	in above	in above	$0
Contingency, Admin, Legal & Technical Services	$2,100,000	$3,100,000	$3,800,000	$2,630,000	$1,680,000	$0
Land Acquisition	$0	$1,250,000	$1,750,000	$0	$0	$0
Other (Note 1)	$700,000	$700,000	$860,000	$0	$0	$0
Total Capital Cost	**$8,050,000**	**$12,790,000**	**$15,920,000**	**$10,130,000**	**$8,410,000**	**$0**
Total Annual O&M Cost						
Collection, Treatment & Disposal, Off-Site System	$132,000	$331,000	$424,000	$0	$0	$0
On-Site Systems (pumping and replacement)	$57,000	$57,000	$24,000	$391,000	$391,000	$194,000
Total Annual O&M Cost	**$189,000**	**$388,000**	**$448,000**	**$391,000**	**$391,000**	**$194,000**
Total Annual Debt Service on Capital Cost (Note 2)	$403,000	$640,000	$796,000	$708,000	$587,000	$0
Total Equivalent Annual Cost (Note 3)	**$592,000**	**$1,028,000**	**$1,244,000**	**$1,099,000**	**$978,000**	**$194,000**
Metrics						
No. of Dwelling Units Served	172	172	213	242	242	0
Capital Cost per Dwelling Unit Served	$46,800	$74,400	$74,700	$41,900	$34,800	$0
EAC per Dwelling Unit Served	$3,440	$5,980	$5,840	$4,540	$4,040	n/a
Meets Nitrogen TMDL? (Note 4)	Yes	Yes	Yes	Yes	Yes	No
Nitrogen Removed from Watershed (lbs/year)	2,660	2,660	2,680	2,390	2,650	0
$$ Equivalent Annual Cost/ lbN removed	$223	$386	$464	$460	$369	n/a
Phosphorus Removal?	Significant	Significant	Significant	Minor	Minor	None
Phosphorus from Watershed (lbs/year)	740	740	870	160	105	0
$$ Equivalent Annual Cost/ lbP removed	$800	$1,389	$1,430	$6,869	$9,314	n/a

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% at 20 years for public costs and at 4% for 20 for private costs.
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 9700 (December 2013).
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 discharge capacity at the Blacksmith Shop Road WWTF.

5.5 FOCUSED REVIEW OF PLAN 1 AND PLAN 5

The Oyster Pond Working Group requested a focused follow-on analysis which includes only Plan 1 and Plan 5 and which shows the costs for meeting the TMDL under current conditions only. This information is presented in **Table 5-9**, which presents four scenarios:

- Plan 1 – Sewer
- Plan 5 – Advanced I/A with "Conservative O&M" assumptions
- Plan 5 – Advanced I/A System with "Optimistic A" O&M assumption; and
- Plan 5 – Advanced I/A System with "Optimistic B" O&M assumptions.

The assumptions used for the "conservative" O&M scenario represent a situation where DEP requires a more conservative watershed management framework than proposed by the Oyster Pond Working Group; whereas, the assumptions used for the "optimistic" O&M scenario represent a situation where DEP allows the framework proposed by the Oyster Pond Working Group. The difference between the two "optimistic" scenarios is the interest rate which is used for the public costs associated with Plan 5. Specifically, 2% interest was used for "Optimistic A" and 0% interest was used for "Optimistic B". The watershed management framework was described earlier in this section and in Appendix F.

TABLE 5-9: SUMMARY OF PLANNING-LEVEL COST ESTIMATES (June 2017)

Meet TMDL Under Current Conditions for Plan 1 and Plan 5

	Plan 1 - Sewer to BSR Meet TMDL at Current Conditions	Plan 5 - Advanced I/A Meet TMDL at Current Conditions (Conservative O&M)	Plan 5 - Advanced I/A Meet TMDL at Current Conditions (Optimistic A O&M)	Plan 5 - Advanced I/A Meet TMDL at Current Conditions (Optimistic B O&M)
Capital Cost				
Construction - Collection and Transport	$4,270,000	$0	$0	$0
Construction - Treatment (including I/A systems)	$0	$5,670,000	$5,670,000	$5,670,000
Construction - Disposal (Note 7)	$290,000	in above	in above	in above
Contingency, Admin, Legal & Technical Services	$1,820,000	$1,420,000	$1,420,000	$1,420,000
Land Acquisition	$0	$0	$0	$0
Other (Note 1)	$590,000	$0	$0	$0
Total Capital Cost	**$6,970,000**	**$7,090,000**	**$7,090,000**	**$7,090,000**
Total Annual O&M Cost				
Collection, Treatment & Disposal, Off-Site System	$108,000	$0	$0	$0
On-Site Systems (pumping and replacement)	$64,000	$360,000	$216,000	$216,000
Total Annual O&M Cost	**$172,000**	**$360,000**	**$216,000**	**$216,000**
Total Annual Debt Service on Capital Cost (Note 2)		$495,000	$495,000	$472,000
Total Equivalent Annual Cost (Note 3)	**$521,000**	**$855,000**	**$711,000**	**$688,000**
Metrics				
No. of Dwelling Units Served	145	204	204	204
Capital Cost per Dwelling Unit Served	$48,100	$34,800	$34,800	$34,800
EAC per Dwelling Unit Served	$3,590	$4,190	$3,490	$3,370
Meets Nitrogen TMDL? (Note 4)	Yes	Yes	Yes	Yes
Nitrogen Removed from Watershed (lbs/year)	2,660	2,660	2,660	2,660
$$ Equivalent Annual Cost/ lbN removed	$196	$321	$267	$259
Phosphorus Removal?	Significant	Minor	Minor	Minor
Phosphorus from Watershed (lbs/year)	740	105	105	105
$$ Equivalent Annual Cost/ lbP removed	$704	$8,143	$6,771	$6,552

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% at 20 years.
   For Plan 5 "Conservative" and "Optimistic A", debt service is based on 2% at 20 years for public costs and at 4% for 20 for private costs.
   For Plan 5 "Optimistic B", debt service is based on 0% at 20 years for public costs and at 4% for 20 for private costs.
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 9700 (December 2013).
6) Costs for Plan 1 Sewer are contingent on the availability of discharge capacity at the Blacksmith Shop Road WWTF.

SECTION 6

NEXT STEPS

With the completion of the Alternatives Analysis phase, the "next steps" include moving forward with the development of the recommended plan. As a part of that effort, updated monitoring results from the West Falmouth Harbor Shoreline Septic System Remediation Project will be reviewed in Spring 2018 in order to update the list of systems that can reliably meet the effluent total nitrogen requirements of Plan 5.

In addition, there were several "next steps" that were identified in the Needs Assessment which may be considered by the Town, as noted below.

1. Decide whether to proceed with establishing "alternate criteria". This approach would involve first developing documentation for review by DEP and then subsequently meeting with DEP. This process could likely be a difficult technical and legal endeavor.

2. Quantify the nutrient reduction effectiveness of the measures which have been implemented since the MEP Report was completed when MEP data is made available. The purpose of this step is to quantify any nitrogen-removal that can be credited to the target nitrogen reduction load. Specific examples include:
   a. 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).
   b. 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.
   c. How much credit can be accrued for water quality improvements based on the OPET monitoring data collected since 2005.
   d. Land acquisitions that remove parcels from buildout.

3. Request MEP baseline analytical data. Consider requesting additional MEP model runs to update the MEP model based on current water quality data, implemented measures and a

non-linear relationship between nitrogen and dissolved oxygen and to update to inputs for Mosquito Creek watershed based on new data. The purpose of this step is to better understand both the current controllable nitrogen load entering Oyster Pond as well as the target nitrogen reduction load.

4. Determine whether and how to control for phosphorus.

APPENDIX D
TMDL Compliance Calculations

FALMOUTH OYSTER POND CWMP

Wright-Pierce, 6 Dec 2013
Rev 20 Feb 2014, 7 July 2014, 14 Mar 2017

TMDL Compliance

	EPA-Approved TMDL		Alternate Criteria*	
	kg/yr	lb/yr	kg/yr	lb/yr
Current watershed loads				
Septic	1,364	3,008	1,364	3,008
Fertilizer	78	172	78	172
Stormwater	107	236	107	236
Natural areas	60	132	60	132
Total	1,609	3,548	1,609	3,548
Target watershed loads--Scenario 3 (Table 3-3)				
Septic	488	1,076	1,078	2,377
Fertilizer	39	86	39	86
Stormwater	86	190	86	190
Natural areas	60	132	60	132
Total	673	1,484	1,263	2,785
Target load removals--Scenario 3 (Current Loads minus Target Loads)				
Septic	876	1,932	286	631
Fertilizer	39	86	39	86
Stormwater	21	46	21	46
Natural areas	-	-	-	-
Total	936	2,064	346	763
Target removals, % of current				
Septic		64.2%		21.0%
Watershed		58.2%		21.5%

* Min DO = 4 mg/l

Target Removal of Existing Load to Meet TMDL 1,932 lbs/yr

FALMOUTH OYSTER POND CWMP

Wright-Pierce, 6 Dec 2013
Rev 20 Feb 2014, 7 July 2014, 14 Mar 2017

**Dwelling Unit = DU		Current	Growth	Plan. Hor.	% incr.
Wastewater flows, gpd			5,600		
Current		28,893			
Increase--vacant lots			2,720		
Increase--redevelopment			2,880		
Future				34,493	19.4%
Developed parcels	Parcels	166	12	178	7.2%
Treetops = 60 Dwelling Units >>	DU	225	18	243	8.0%
Number of septic systems					
Treetops		15		15	
Remainder		165		174	
Total		180		189	
Flow per Dwelling Unit, gpd					
Currently developed		128.4		141.2	10.0%
Future				160.0	
Overall				141.9	10.5%
Septic N load per Unit, lb/yr		13.37		14.70	10.0%
Equivalent N concentration, mg/l		34.20		34.20	
Septic load, lb/yr					
Total (based on future flow)		3,008	583	3,591	19.4%
Target		1,076		1,076	
To be removed		1,932	583	2,515	30.2%
Parcels to be served for out-of-watershed disposal		PLAN 1 AND PLAN 2			
EPA TMDL					
Load to be removed		1,932	583	2,515	30.2%
Load per DU		13.37		14.70	10.0%
Dwelling Units to be served		145	27	171	18.4%
Parcels to be served	Treetops-60	85		111	
% of devel parcels		51%		62%	
Septic flow eliminated, gpd		18,556		24,156	30.2%
Alternate criteria					
Load to be removed		631	583	1,214	92.4%
Load per DU		13.37		14.70	10.0%
Dwelling Units to be served		47	35	83	75.0%
Parcels to be served		0		23	
% of devel parcels		0%		13%	
Septic flow eliminated, gpd		6,058		11,658	92.4%

FALMOUTH OYSTER POND CWMP

Wright-Pierce, 6 Dec 2013
Rev 20 Feb 2014, 7 July 2014, 14 Mar 2017

	Current	Growth	Plan. Hor.	% incr.
Parcels to be served for in-watershed disposal (without reuse irrigation)				PLAN 3
EPA TMDL				
Base load to be removed	1,932	583	2,515	30.2%
Tentative effluent discharge				
gpd	25,000		33,030	
mg/l	8		8	
lb/yr	609		804	
Extra load from in-watershed disp.	609		804	
Total load to be removed	2,540		3,319	
Load per DU	13.37		14.70	10.0%
Dwelling Units to be served	190	36	226	18.8%
Parcels to be served	130		166	
% of devel parcels	78%		93%	
Septic flow eliminated, gpd	24,405		31,883	
Alternate criteria				
Base load to be removed	631	583	1,214	92.4%
Tentative effluent discharge				
gpd	8,560		16,400	
mg/l	10		10	
lb/yr	261		499	
Extra load from in-watershed disp.	261		499	
Total load to be removed	891		1,713	
Load per DU	13.37		14.70	10.0%
Dwelling Units to be served	67	50	117	74.8%
Parcels to be served	7		57	
% of devel parcels	4%		32%	
Septic flow eliminated, gpd	8,561		16,454	
Parcels to be served for in-watershed disposal (WITH reuse irrigation)				PLAN 4
EPA TMDL				
Base load to be removed	1,932	583	2,515	30.2%
Tentative effluent discharge				
gpd	25,000		33,030	
mg/l	8		8	
lb/yr	609		804	
Extra load from in-watershed disp.	609		804	
Benefit of reuse irrigation	185		185	
Total load to be removed	2,356		3,134	
Load per DU	13.37		14.70	10.0%
Dwelling Units to be served	176	37	213	21.0%
Parcels to be served	116		153	
% of devel parcels	70%		86%	
Septic flow eliminated, gpd	22,629		30,108	

FALMOUTH OYSTER POND CWMP

Wright-Pierce, 6 Dec 2013
Rev 20 Feb 2014, 7 July 2014, 14 Mar 2017

	Current	Growth	Plan. Hor.	% incr.
Parcels to be served with Enhanced I/A systems				
Title 5 effluent, mg/l	34.20		34.20	
Enhanced I/A effluent, mg/l	13.00		13.00	
Difference, mg/l	21.20		21.20	
% N removal	62%		62%	
Average flow per DU, gpd	128.4		141.9	
N load removed per DU, lb/yr	8.29		9.16	
N load remaining per DU, lb/yr	5.08		5.62	
Title 5 N load per DU (sum), lb/yr	13.37		14.78	
Required removal--TMDL, lb/yr	1,932		2,515	
Number of DU to be served	233		275	
Number of developed DU	225		243	
% of DU served	104%		113%	
Number of parcels served	173		215	
Required removal--altern criteria, lb/yr	631		1,214	
Number of DU to be served	76		133	
Number of developed DU	225		243	
% of DU served	34%		55%	
Number of parcels served	16		73	
Parcels to be served with Advanced I/A systems		PLAN 5		
Title 5 effluent, mg/l	34.20		34.20	
Advanced I/A effluent, mg/l	10.00		10.00	
Difference, mg/l	24.20		24.20	
% N removal	71%		71%	
Average flow per DU, gpd	128.4		141.2	
N load removed per DU, lb/yr	9.46		10.40	
N load remaining per DU, lb/yr	3.91		4.30	
Title 5 N load per DU (sum), lb/yr	13.37		14.70	
Required removal--TMDL, lb/yr	1,932		2,515	
Number of DU to be served	204		242	
Number of developed DU	225		243	
% of DU served	91%		99%	
Number of parcels served	144		182	
Required removal--altern criteria., lb/yr	631		1,214	
Number of DU to be served	67		117	
Number of developed DU	225		243	
% of DU served	30%		48%	
Number of parcels served	7		57	

FALMOUTH OYSTER POND CWMP

Wright-Pierce, 6 Dec 2013
Rev 20 Feb 2014, 7 July 2014, 14 Mar 2017

	Current	Growth	Plan. Hor.	% incr.
Plan 4A - Partial Sewer (OOW) & Partial I/A				
Parcels to be served with Enhanced I/A systems				
Title 5 effluent, mg/l	34.20		34.20	
Enhanced I/A effluent, mg/l	17.00		17.00	
Difference, mg/l	17.20		17.20	
% N removal	50%		50%	
Average flow per DU, gpd	128.4		141.2	
N load removed per DU, lb/yr	6.72		7.39	
N load remaining per DU, lb/yr	6.65		7.31	
Title 5 N load per DU (sum), lb/yr	13.37		14.70	
Required removal--TMDL, lb/yr	1,932		2,515	
Sewer				
Number of DU to be served	84 <<		112 <<	
N load removed, lb/yr	1,123		1,646	
I/A				
Number of DU to be served	117 <<		117 <<	
N load removed, lb/yr	786		865	
TOTAL, N load removed, lb/yr	1909		2511	

APPENDIX E

Cost Model Back-up

FALMOUTH - OYSTER POND CWMP		*Wright-Pierce, 20 Dec 2013*				ENR CCI	8600				Apr-10
ALTERNATIVES ANALYSIS		*Revised 18 Feb 2014, 7 July 2014*				ENR CCI	9700				Dec-13
		Revised 2 June 2017									
COSTS FOR VARIOUS WASTEWATER MANAGEMENT ALTERNATIVES, BY WATERSHED											
Model developed based on Barnstable County Cost Report, April 2010						**Projected to Dec 2013 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-PS	BSR-MS	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-PS/FM	LPS-Sewer					CON	OPT	OPT	
Number of Dwelling Units, Total		243	225	243	243	243	243	225	225	225	243
Number of Dwelling Units involved in plan:											
Off-Site Management// Connections		172	145	172	213	112	0	0	0	0	0
On-Site (I/A or Alt Toilets)// Systems		0	0	0	0	117	242	204	204	204	0
Total - involved in plan		172	145	172	213	229	242	204	204	204	0
Total - stay with Title 5		71	80	71	30	14	1	21	21	21	243
Gallons for:											
Off-Site Management		24,200	18,600	24,200	30,100	14,000	0	0	0	0	0
Infiltration/Inflow		2,500	2,500	2,500	2,500	1,000	0	0	0	0	0
Total Gallons - Average flow (gpd)		26,700	21,100	26,700	32,600	15,000	0	0	0	0	0
Avg flow per connection, gpd		155	146	155	153	134	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		0.067	0.053	0.067	0.082	0.038	0.000	0.000	0.000	0.000	0.000
Capital Costs for Collection, Treatment and Disposal											
Sewers											
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		175	175	175	175	175	175	175	175	175	175
Construction cost		0	0	0	0	0	0	0	0	0	0
Low Pressure Sewers											
Distance, 1000 ft		19.10	16.40	18.20	21.30	6.00	0.00	0.00	0.00	0.00	0.00
Cost per foot		125	125	125	125	125	125	125	125	125	125
Construction cost		2,390,000	2,050,000	2,280,000	2,660,000	750,000	0	0	0	0	0
Pump Stations											
Grinder PS (Private)	100%	172	145	172	213	112	0	0	0	0	0
Unit Cost		10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Small PS (100-200 gpm)		0	0	0	0	0	0	0	0	0	0
Unit Cost		400,000	400,000	0	0	400,000	0	0	0	0	0
Construction cost, pump stations		1,720,000	1,450,000	1,720,000	2,130,000	1,120,000	0	0	0	0	0
Transport to Treatment											
Distance, 1000 ft		5.10	5.10	3.00	1.50	5.10	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		770,000	770,000	450,000	230,000	770,000	0	0	0	0	0
Treatment// On-Site (Title 5, I/A or Eco-Toilets)											
Cost per connection (Current $$)		14,000	14,000	14,000	14,000	27,810	27,810	27,810	27,810	27,810	14,000
Construction cost		0	0	0	0	3,250,000	6,730,000	5,670,000	5,670,000	5,670,000	0
Treatment// Off-Site											
"Basis" flow rate (mgd)		1.75	1.75	0.099	0.082	1.75					
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	33.84	36.09	0.00	0.00	0.00	0.00	0.00	0.00
Flow, mgd		0.067	0.053	0.067	0.082	0.038	0.000	0.000	0.000	0.000	0.000
Construction cost		0	0	2,260,000	2,940,000	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	5.50	0.00	0.00	0.00	0.00	0.00
Flow, gpd (Short-Term Peak Flow)		66,750	52,750	66,750	81,500	37,500	0	0	0	0	0
Subtotal, Disposal construction cost		370,000	290,000	730,000	650,000	210,000	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	150,000	0	0	0	0	0	0

FALMOUTH - OYSTER POND CWMP		*Wright-Pierce, 20 Dec 2013*				ENR CCI	8600				Apr-10
ALTERNATIVES ANALYSIS		*Revised 18 Feb 2014, 7 July 2014*				ENR CCI	9700				Dec-13
		Revised 2 June 2017									
COSTS FOR VARIOUS WASTEWATER MANAGEMENT ALTERNATIVES, BY WATERSHED											
Model developed based on Barnstable County Cost Report, April 2010						**Projected to Dec 2013 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-PS	BSR-MS	WHOI	OPET	ENH I/A	ADV I/A	ADV I/A	ADV I/A	ADV I/A	No Action
Construction Cost		370,000	290,000	730,000	800,000	210,000	0	0	0	0	0
Total Construction Cost		5,250,000	4,560,000	7,740,000	9,510,000	6,100,000	6,730,000	5,670,000	5,670,000	5,670,000	0
Contingencies, Admin., Legal, & Technical		40	40	40	40	35	25	25	25	25	0
Cost		2,100,000	1,820,000	3,100,000	3,800,000	2,140,000	1,680,000	1,420,000	1,420,000	1,420,000	0
Land											
Total area, acres		0.0	0.0	5.0	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		0	0	1,250,000	1,750,000	0	0	0	0	0	0
Costs on Private Property											
Allowance for on-site plumbing and service work		4,000	4,000	4,000	4,000	3,000	2,000	2,000	2,000	2,000	0
Connection fee		50	50	50	50	50	0	0	0	0	0
Cost		700,000	590,000	700,000	860,000	340,000	0	0	0	0	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		8,050,000	6,970,000	12,790,000	15,920,000	8,580,000	8,410,000	7,090,000	7,090,000	7,090,000	0
Cost reduction for future technology		0	0	0	0	0	0	0	0	0	0
CAPITAL COST SUMMARY		8,050,000	6,970,000	12,790,000	15,920,000	8,580,000	8,410,000	7,090,000	7,090,000	7,090,000	0
O&M Costs from Cost Curves											
Wastewater Collection, Treatment & Disposal											
"Basis" flow rate (gpd)		400,000	400,000	40,000	32,600	400,000					
Unit cost, $/yr per gpd (BCCR, Apr 2010)		2.39	2.39	9.00	9.50	2.39	-	-	-	-	-
Unit cost, $/yr per gpd (Current $$)		2.70	2.70	10.15	10.72	2.70	-	-	-	-	-
Annual average flow, gpd		26,700	21,100	26,700	32,600	15,000	0	0	0	0	0
O&M cost for Public C/T/D, $/yr		72,000	57,000	271,000	349,000	40,000	0	0	0	0	0
Unit cost for Private LPS PS, $/yr		350	350	350	350	350	0				
O&M cost for Private LPS PS, $/yr		60,200	50,750	60,200	74,550	39,200	0	0	0	0	0
O&M cost for Overall C/T/D, $/yr		132,000	108,000	331,000	424,000	79,000	0	0	0	0	0
I/A System and Eco-Toilet Households											
Number, Total		0	0	0	0	117	242	204	204	204	0
Number, I/A System households	98%	0	0	0	0	115	237	200	200	200	0
Unit cost, $/yr per unit (BCCR, Apr 2010)		0	0	0	0	1,450	1,450	1,450	810	810	0
Unit cost, $/yr per gpd (Current $$)		-	-	-	-	1,635	1,635	1,635	914	914	-
O&M cost, $/yr		0	0	0	0	188,000	388,000	327,000	183,000	183,000	0
Number, Eco-toilet households	2%	0	0	0	0	2	5	4	4	4	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 $$)		395	395	395	395	395	395	395	395	395	395
O&M cost, $/yr		0	0	0	0	900	1,900	1,600	1,600	1,600	0
Septic System Pumping (for Title 5; I/A and Ecotoilet including in above)											
Number		71	80	71	30	14	1	21	21	21	243
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)		7,100	8,000	7,100	3,000	1,400	100	2,100	2,100	2,100	24,300
Septic System Future Replacement - Annualized (for those system NOT replaced in Capital Costs above)											
Number		71	80	71	30	14	1	21	21	21	243
Frequency (every XX years)		20	20	20	20	20	20	20	20	20	20
Unit cost, $/replacement		14,000	14,000	14,000	14,000	27,810	27,810	27,810	27,810	27,810	14,000
Annualized Cost (simple)		50,000	56,000	50,000	21,000	19,000	1,000	29,000	29,000	29,000	170,000
Irrigation with Potable Water											
Number of Parcels											
Volume per Irrigation Season (ccf)		15	15	15	15	15	15	15	15	15	15
Unit cost, $/ccf		6	6	6	6	6	6	6	6	6	6
Cost		0	0	0	0	0	0	0	0	0	0

FALMOUTH - OYSTER POND CWMP	*Wright-Pierce, 20 Dec 2013*				ENR CCI	8600				Apr-10
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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-PS	BSR-MS	WHOI	OPET	ENH I/A	ADV I/A	ADV I/A	ADV I/A	ADV I/A	No Action
O&M Cost summary	**189,100**	**172,000**	**388,100**	**448,000**	**288,300**	**391,000**	**359,700**	**215,700**	**215,700**	**194,300**
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	2	2	2	2	0	2
PW Factor - Loan Town	20.00	20.00	20.00	20.00	16.35	16.35	16.35	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	13.59	13.59	13.59	13.59	13.59	13.59	13.59	13.59	13.59	13.59
Capital cost - Loan Town	8,050,000	6,970,000	12,790,000	15,920,000	2,574,000	2,523,000	2,127,000	2,127,000	2,127,000	0
Capital cost - Loan Private	0	0	0	0	6,006,000	5,887,000	4,963,000	4,963,000	4,963,000	0
O&M cost	189,000	172,000	388,000	448,000	288,000	391,000	360,000	216,000	216,000	194,000
Equivalent Annual Cost of Capital	403,000	349,000	640,000	796,000	599,000	587,000	495,000	495,000	472,000	0
Total Equivalent Annual Cost	**592,000**	**521,000**	**1,028,000**	**1,244,000**	**887,000**	**978,000**	**855,000**	**711,000**	**688,000**	**194,000**
Metric - Cost Per Dwelling in Plan (Sewer & I/A)										
Number of Connections/Systems	172	145	172	213	229	242	204	204	204	0
Capital Cost	**46,800**	**48,100**	**74,400**	**74,700**	**37,500**	**34,800**	**34,800**	**34,800**	**34,800**	**#DIV/0!**
Equivalent Annual Cost	**3,440**	**3,590**	**5,980**	**5,840**	**3,870**	**4,040**	**4,190**	**3,490**	**3,370**	**#DIV/0!**

COMPARISON OF ESTIMATES FOR ANNUAL O&M COSTS
BARNSTABLE COUNTY COST REPORTS - 2010 AND 2014
Wright-Pierce, June 2017

APPROXIMATE BREAKDOWN OF COSTS FROM BARNSTABLE COUNTY COST REPORT (2010)

Items (ENR CCI 8700, 2010)	Title 5	N Removing Current Practice	N Removing Enhanced Practice	N Removing Enhanced Practice for TMDL Compliance
Pumping Frequency	4 yrs	3 yrs	3 yrs	3 yrs
Septage	$110	$125	$125	$125
Electricity	$0	$300	$350	$350
Maintenance/ Inspections	$0	$200	$400	$400
Chemicals	$0	$0	$0	$0
Repairs and Supplies	$0	$100	$200	$200
Monitoring	$0	$425	$700	$700
Engineering	$0	$0	$125	$125
Admin (Insurance, etc.)	$0	$100	$100	$100
Return Visits/Monitoring & Fine Tuning				$1,200
Total	$110	$1,250	$2,000	$3,200
BCCR-2010	$110	$1,250	$2,000	$3,200
BCCR-2014	$165	$1,375	not incl.	$3,850

BREAKDOWN OF COSTS FOR OYSTER POND CWMP

Items (ENR CCI 9700, 2013)	Title 5 (Annual)	LPS Pump Station to Sewer (Annual)	Advanced I/A TMDL Compliance (First Yr)	Advanced I/A TMDL Compliance (Remaining Yr) Conservative	Advanced I/A TMDL Compliance (Remaining Yr) Optimistic
Pumping Frequency	5 yrs	n/a	5 yrs	3 yrs	5 yrs
Septage	$60	n/a	$60	$100	$60
Electricity		$50	$100	$100	$100
County - Annual Fee/ Records		n/a	$50	$50	$50
Maintenance/Parts		$300	warranty	$200	$200
Inspections		n/a	$700	$350	$175
Monitoring/ Sampling/ Lab		n/a	$900	$450	$150
Return Visits/Monitoring & Fine Tuning		n/a	n/a	$200	$0
Total	$60	$350	$1,810	$1,450	$735
			Notes 1,2	Notes 1,4,6	Notes 1,3,5

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 1% of systems fail to meet TN (value shown is 1% of inspection and monitoring/sampling/lab).
6) Assumes that 25% of systems fail to meet TN (value shown is 1% of inspection and monitoring/sampling/lab).

APPENDIX F

Technical Memoranda – Science Wares, Inc. & Water Quality Management Committee

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.

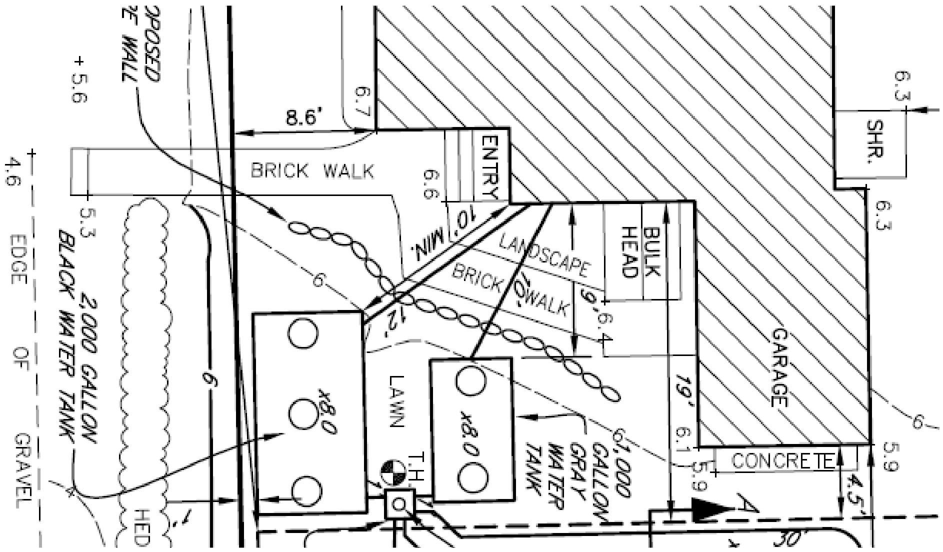


Figure 1. Blackwater Storage Tank Configuration

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.

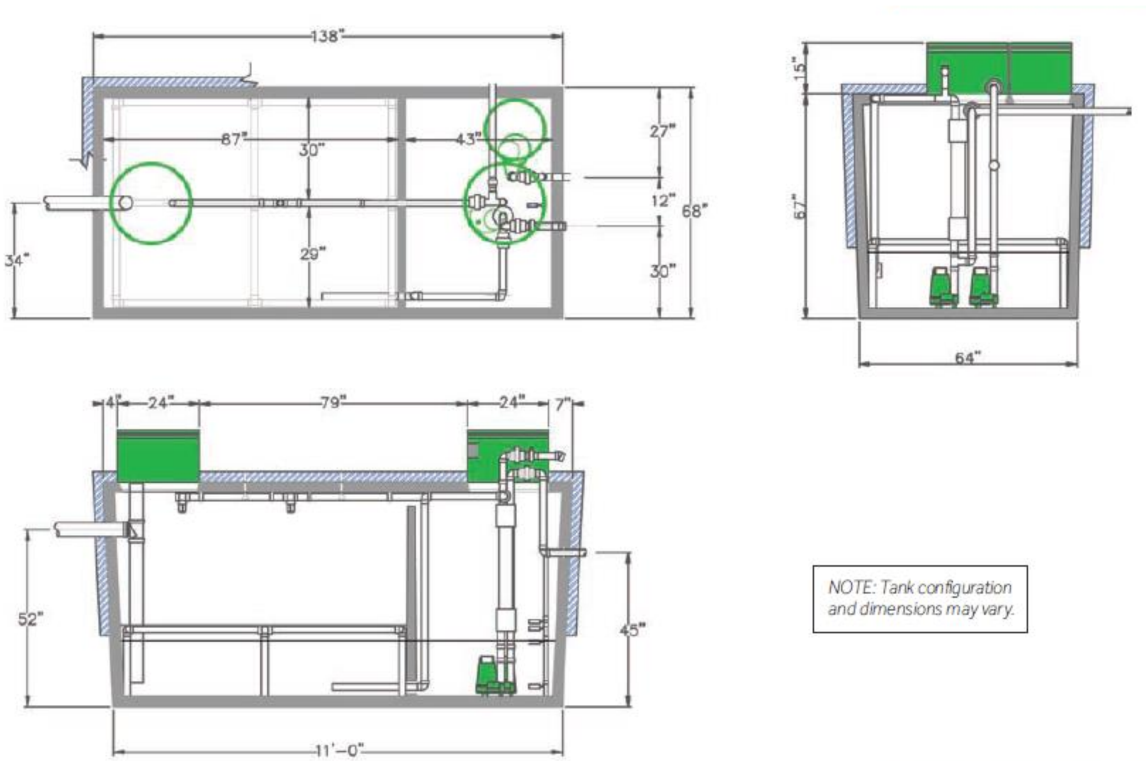


Figure 2. Eliminite Schematic

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 Elimiinte 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.

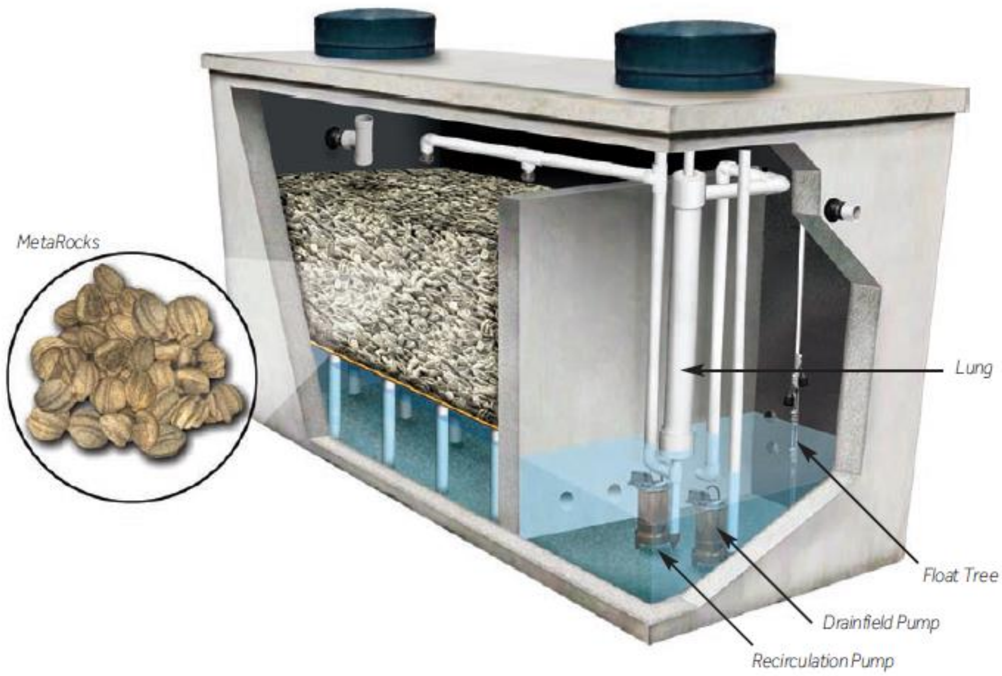


Figure 3. Eliminite Process

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.

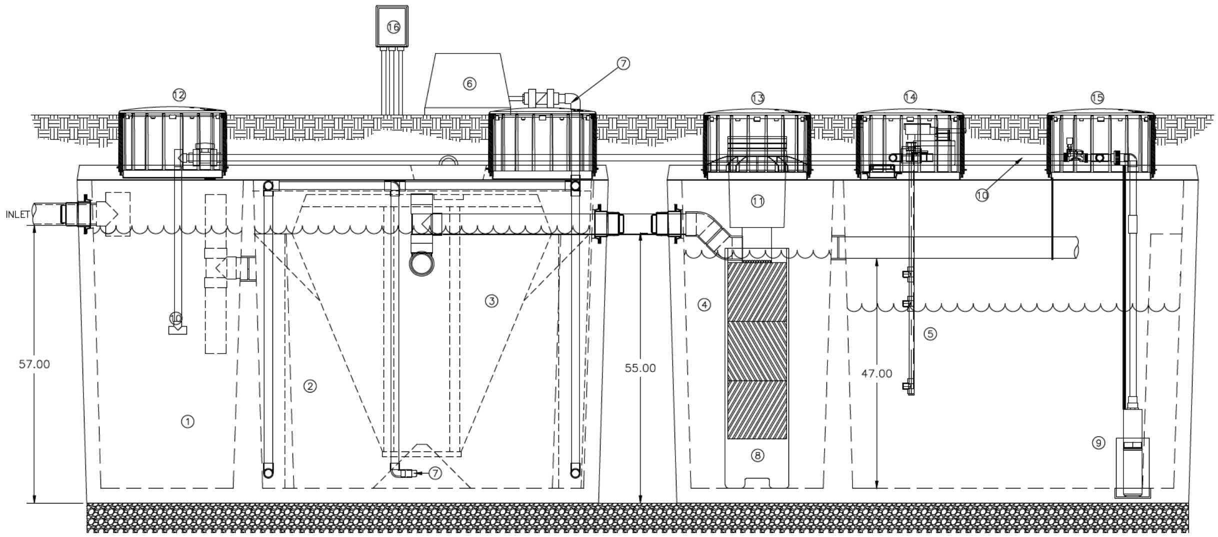
The clarifier is a still chamber located within the aeration chamber and provides a quiescent zone where the clear odorless effluent rises through the outlet, located 6 inches below the surface of the clarifier. This chamber holds approximately ½ day's capacity of effluent which passes from the clarifier 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.

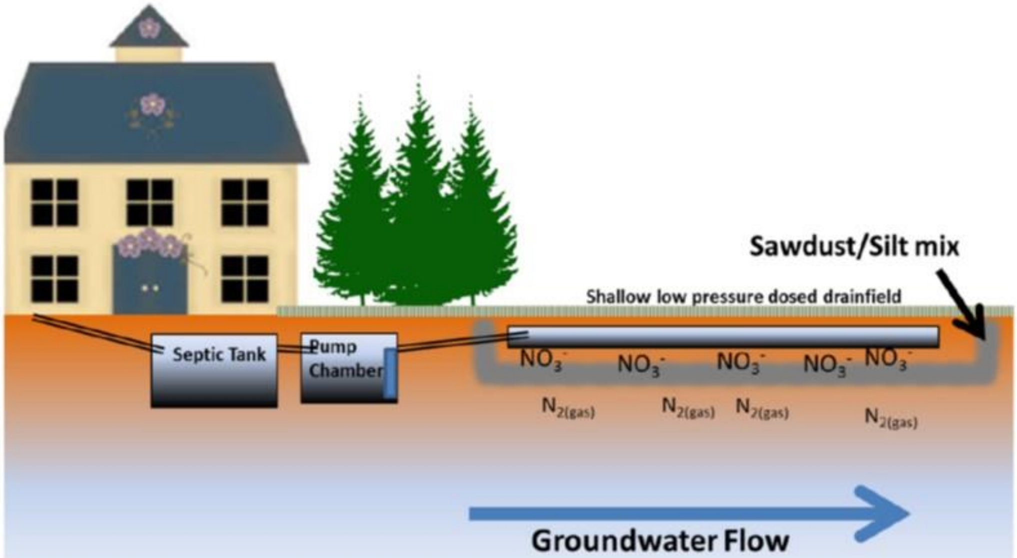
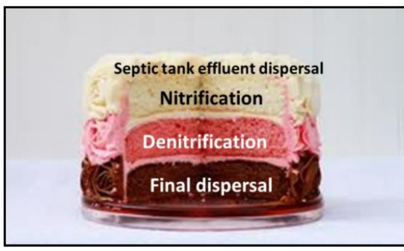
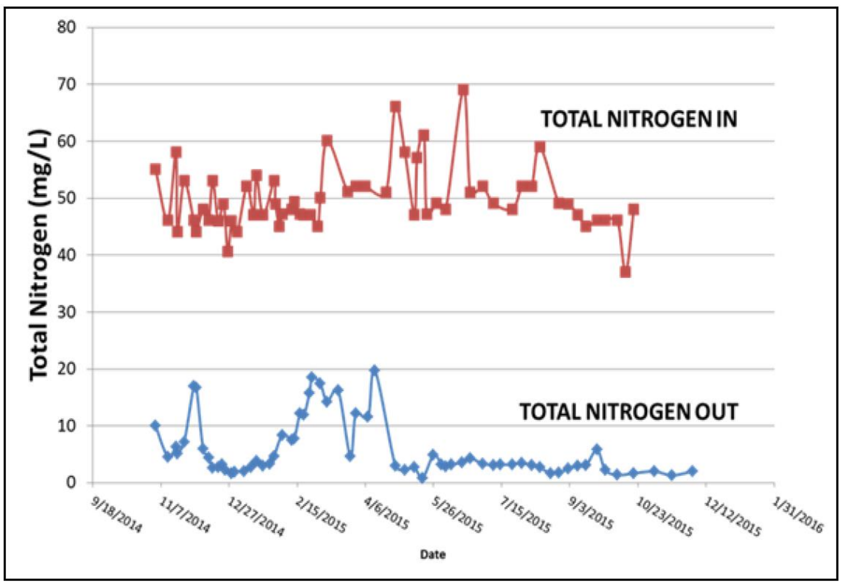


Figure 5. Layered STA Schematic



*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:

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

DRAFT (10/24/17)

PROPOSED WATERSHED MANAGEMENT AND MONITORING PLAN FOR ENHANCED INNOVATIVE/ALTERNATIVE NITROGEN REDUCING SEPTIC SYSTEMS

1.0 Use of Enhanced Innovative/Alternative Septic Systems (Enhanced I/A Systems)

A municipality may use Enhanced I/A Systems meeting a standard of 10 milligrams total nitrogen per liter (mg TN/L) to reduce the nitrogen load entering an estuary from a watershed as part of a Comprehensive Wastewater Management Plan (CWMP) approved by the Massachusetts Department of Environmental Protection (MassDEP).

2.0 Watershed Boundaries

The boundaries of the CWMP watershed will be those defined in the Massachusetts Estuaries Project Linked Watershed/Embayment Model for that estuary, as adopted by MassDEP and by the municipality's legislative body. The CWMP will designate which properties within that watershed will be required to install Enhanced I/A Systems.

3.0 Property Owner Requirements

Owners of designated properties within a watershed who are required to install Enhanced I/A Systems must obtain a Disposal System Construction Permit (DSCP) from the municipality within one year of the Start Date (see section 4.0 below) and must have completed installation of the Enhanced 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 Enhanced I/A System.

3.1 Municipal Incentive Grant

All owners of designated properties will be eligible for an incentive grant, in an amount to be determined by the municipality, subject to appropriation. Failure to comply with the requirements of section 3.0 will disqualify the property owner from receiving the incentive grant.

4.0 Responsible Municipal Management Entity (RMME)

The Executive branch of the municipality will designate an appropriate agency as the Responsible Municipal Management Entity (RMME). The RMME 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 RMME may engage public or private contractors to perform some or all of these duties. The RMME will designate the Start Date for installation of Enhanced I/A Systems within each watershed.

4.1 Enhanced I/A Systems Approval

The RMME will issue a Request for Proposals (RFP) to vendors of Enhanced I/A Systems who wish to install their systems in the municipality. Responsive vendors must agree to meet the qualifying requirements of the RMME, to provide bonded warranties and to train local technicians in the operation and maintenance of their systems. The RMME will designate which vendors' Enhanced I/A Systems will be approved for installation in the municipality's watersheds.

4.2 Performance Monitoring

Nitrogen monitoring will be conducted by the RMME 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 RMME at its discretion may alter the schedule to obtain the six required readings during occupied months which may be contiguous. If there are fewer than six occupied months in the year, the probation period may extend up to three years. If after the probation period the mean or equivalent nitrogen load reduction has not reached the required standard 10 mg TN/L, the owner shall be responsible for the cost of bringing the system into compliance within one year of notification of this exceedance.

4.3 Compliant System Monitoring

Following the first year, 1/12 of the 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, it will revert to probation status and be treated as above.

4.4 Operation and Maintenance (O&M)

Enhanced I/A Systems must be maintained by the RMME in accordance with vendors' current written requirements. In addition to the annual nitrogen monitoring described in section 4.2, the RMME 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 below ground inspection that includes operation and maintenance of the system shall be performed by vendor-trained and certified technicians under contract to the RMME within a reasonable time following said annual nitrogen monitoring.

4.5 Pump-Outs

Septic systems will be pumped every five years by RMME-approved contractors or as determined by inspection in compliance with 310 CMR 15.35.

4.6 Record Keeping

Records will be kept by the RMME for each property within the watershed and will be tied to the municipal geographic information system. Records may include:

a. Engineered and "as built" plans submitted electronically;
b. Water readings (from transponder equipped water meters at each property);
c. Monitoring results for total nitrogen;
d. O&M records; and
e. Pumping record

4.7 Reporting

The RMME will report watershed compliance to DEP on an annual basis. Compliance may be demonstrated by any of the following:

a. All systems meeting the effluent standard of 10 mg TN/L;
b. Some failures balanced against those systems bettering the standard and some properties being occupied seasonally;
c. Maintaining the TMDL-mandated water column nitrogen concentration for municipal waters, such as the sentinel station for estuaries; or
d. The watershed load, reported quarterly, based on water usage and the moving average of accumulated nitrogen sampling test data for total nitrogen.

4.8 Fees

Homeowners with Enhanced I/A Systems will be assessed a fee semi-annually for each Enhanced I/A System that will cover appropriate RMME costs.

APPENDIX G
Comments from Public Meetings

Scope item 2.3.2 includes summarizing the results of the watershed workshop. My understanding of the questions posed and comments made is listed below. Answers provided during meetings are identified in *italics*. Notes to the Working Group are provided in [*italic CAPS*]. Please identify whether there are additional comments worth adding or additional response worth adding.

Watershed Meeting – July 30, 2014

1. Describe how the weir works? *In simplistic terms, the weir is intended to keep ocean water from flowing in to the pond under typical tidal conditions. The weir is intended to keep the pond salinity in the range of 2 to 7 ppt, providing a consistent ecosystem for adapted species.*
2. Why not include inlet widening as one of the plans? What are the costs, advantages and disadvantages? *Inlet widening could be included. MEP would need to be contacted to discuss a potential model run. [NOTE: THE MEP REPORT PROVIDES BACKGROUND INFORMATION ON WHY THE POND IS MANAGED TO A BRACKISH SALINITY AND THE PRACTICAL MATTERS ASSOCIATED WITH MAINTAINING UNRESTRICTED WATER FLOW (P. II, 13, 18-19, 57-66, 74-81). THE MEP REPORT DOES NOT CONSIDER ANY ALTERNATIVE SCENARIOS REGARDING INLET WIDENING.] Ultimately, there is a regulatory requirement to manage the pond as a low salinity brackish pond; therefore, inlet widening is not feasible. See Section 4.6.3 for additional details.*
3. Who determined that inlet widening would not be an alternative? *The Working Group and WP discussed and decided this early in the project. The Working Group and WP will discuss this further. [NOTE: THE ORIGINAL RFP AND THE TOWN-WP CONTRACT STATE THAT INLET WIDENING, AQUACULTURE AND NON-COMPLIANT ECOTOILETS AND ONSITE SYSTEMS WILL BE EXCLUDED.]*
4. Have we considered the fact that some homes are full-time and some are seasonal/ part-time? *Yes, both the MEP work and the WP work look at water use and nitrogen loadings on an annual basis, so full-time/part-time/seasonal occupancy is accounted for.*
5. Weir does not appear to be functioning correctly right now. Lagoon water level is higher than the weir. The pond is maintained a low salinity to allow for anadromous fish habitat. *Comment noted.* [*NOTE: THE TMDL ASSUMES THAT THE WEIR IS FUNCTIONING CORRECTLY. I'M NOT CERTAIN I AGREE WITH THE ASSERTION THAT THE WEIR NOT OPERATING CORRECTLY; HIGHER TAILWATER ELEVATION DOES NOT NECESSARILY MEAN IT IS NOT FUNCTIONING. LIKELY THE TRUNK RIVER SILL HAS BUILT UP AND WARRANTS DREDGING BY EXCAVATOR OR HIGH PRESSURE WATER. THE TRUE TEST OF WHETHER IT IS WORKING IS TO CONFIRM IF SALINITY IS VARYING OUTSIDE THE TARGET RANGE.*]
6. Can grape vines be removed from trees along the shore? *This is a question for the Conservation Commission.*
7. If a homeowner elects to use ecotoilets can they avoid betterments? *No. A similar question was asked for the Maravista area during the lead-up to Town Meeting. This topic involved a significant amount of discussion and analysis and special legislation. The Town will be monitoring how many residents elect to take this approach before considering it for any other watersheds. To date, none of the homeowners into the Little Pond sewer service area has elected to take this approach.*
8. Plan 4 was modified to a hybrid plan which focuses early effort at the north end of Oyster Pond. Will the Town evaluate methods to address cost equity and fairness between property owners that need to modify their ww management system and those who benefit from the expenditure? *Yes, addressing cost equity and fairness will be included in Task 3 (Development of the Recommended Plan).*

9. Mr. Kerfoot stated that he is working on developing a cost estimate for Treetops system. Wants to submit “Plan 7” for consideration, which will include a credit for conservation easement on a 22-acre parcel that will likely be purchase. Noted that the cost to “upgrade” a Title 5 system to an I/A system is less than that for a “new” system. Noted that there were discussions with MA Water Resources in the late 1990s regarding pond salinity and maintaining habitat for anadromous fish habitat. Stated that “the town has a responsibility to do so”. *Additional information will be considered. Conservation easements will be considered after they are secured. While there may be a cost differential between upgrading and new construction for I/A systems, it is not appropriate to account that information at this level of planning.*
10. Buessler stated that “OPET does not have a plan”. Kerfoot has been working on plans and OPET has been discussing plan, but OPET has not adopted any positions on the matter. Buessler has the records/data from the resident survey conducted regarding “salt vs brackish” – can provide the data. Could re-do the survey.
11. Could a hurricane wipe out Surf Drive? *Potentially, but this is more a question of coastal resiliency versus wastewater management (e.g., would Surf Drive restored or abandoned?) [NOTE IF THIS HAPPENED, IT COULD POTENTIALLY DAMAGE THE WASTEWATER FORCEMAIN FROM WOODS HOLE TO BLACKSMITH SHOP ROAD WWTF WHICH COULD RESULT IN A SIGNIFICANT SEWAGE RELEASE.]*
12. What are the cost implications per dwelling unit? Having this information posted on the internet could impact a homeowners ability to sell their home. In the very near term, the Town should clearly identify the maximum cost to a homeowner or eliminate plans that have excessive costs. Is the Town considering incentives for homeowners to put I/A systems in? *Town will review and follow-up. [NOTE: S. LEIGHTON/ J. POTAMIS – “WE NEED TO SHOW THE ROUGH ESTIMATES OF COSTS PER HOMEOWNER WITH 70% ASSUMPTIONS AND SEWER FEES, ETC“.]*

Questions from Steve Leighton’s July 13, 2014 Treetops Meeting

1. What about the question from the earlier meeting about OP as a “disturbed site”? [*NO WORK DONE ON THIS. IT IS A MANAGED ECOSYSTEM RESULTING FROM HUMAN DISTURBENCE. IT SHOULD GIVE US FLEXIBILITY IN IMPLEMENTATION, BUT MAY OR MAY NOT. DEP CONSIDERS IT “SA”. THIS AREA WILL NEED TO BE MANAGED AS AN ESTUARY AS DEFINED BY THE DEP IN THE TOTAL MAXIMUM DAILY LOAD (TMDL) REPORT AND THE MEP REPORT FOR THE OYSTER POND SYSTEM.*]
2. Barry Norris noted that the upper watershed is in plan 1 and asked how accurately do we know the exact boundaries of the watershed up there. *[THE BOUNDARIES ARE ESTABLISHED BY MEP. THEY DO VARY TO A LIMITED EXTENT BASED ON ANNUAL PRECIPITATION.]*
3. In Plan 1, why is the force main connection on WH Rd and not the much closer bikeway? *[DPW STATED THEY WANTED A LIFT STATION. I WOULD DISCOURAGE CONSTRUCTING A NEW LIFT STATION ON SHORE ROAD GIVEN FLOOD MAPPING AND VELOCITY ZONE.]*
4. How sure are we that the various schemes will meet the TMDL? Is there a safety factor? *[TMDL PREPARED BY MEP, APPROVED BY DEP AND EPA. SAFETY FACTOR BUILT INTO TMDL. NO ADDITIONAL SAFETY FACTOR APPLIED.]*
5. “Has anyone asked Treetops if they would object to PRB’s?” – Obviously not but is it moot for price and/or technical reasons or are we risking wrongly assuming that they wouldn’t want it? *[PERMEABLE REACTIVE BARRIERS ARE NOT YET DEP APPROVED. THE TOWN IS ALREAADY CONDUCTING DEMONSTRATION PROJECTS ON WHETHER THIS IS A VIABLE APPROACH. WQMC COULD ASK CDM-SMITH TO RUN ITS SELECTION MATRIX FOR “OYSTER POND NORTHEAST”?]*

6. "WQMC should do an opinion re-survey for inlet widening unless the herring habitat constraints etc. rule that out anyway." Someone does not want our assumptions based on OPET's assertion that this survey was done long ago and that the results were highly negative. However note that Treetops is on high ground far from the Sound compared to most of the single family residences. *[THERE LOTS OF ISSUES TIED UP IN THIS ONE. THERE IS NO INLET WIDENING SCENARIO IN THE MEP REPORT, SO WE DON'T HOW EFFECTIVE IT WOULD BE. WQMC COULD REQUEST A MODEL RUN FROM MEP. WHETHER OR NOT THIS POND SHOULD BE MANAGED TO A BRACKISH CONDITION IS A POLITICAL QUESTION. REFER TO SECTION 4.6.3 FOR ADDITIONAL INFORMATION ON THIS TOPIC.]*
7. "WQMC should prioritize options, not rule them out entirely." (Perhaps I did not give good enough reasons for why we ruled out some options.) *[WE WILL GO THRU REASONS AT THE MEETING; HOWEVER, THE PURPOSE OF THE STUDY IS TO PUT THINGS ON THE TABLE, DISCUSS THEM, PRIORITIZE THEM AND THEN SELECT A MULTI-FACETED PLAN TO MOVE FORWARD WITH OVER TIME.]*

WQMC – June 19, 2014

1. Mr. Kerfoot – Purchasing 22 acres, would like nitrogen credit for this. Would like the mixer removed from consideration. Agree with LPS; however, homeowners should know that "no power = no pumping" (unless there is a generator for the home). Agree with maintenance of Trunk River sill. Agree with management of TP. Claimed that there is a "rapid groundwater flow regime" at the north end of Oyster Pond and that Treetops need to remove its wastewater from the watershed. Have water use data for Treetops that can be submitted. Noted that CECs have been detected in the pond. Provided written comments including Treetops water flow data. *Comments noted.*
2. Mr. Follet – I/A systems in seasonal residences may not work consistently. Have served on ConsCom in another MA town and considers Oyster Pond to be a "disturbed site". Claimed that this gives the Town degrees of freedom in developing solutions. Asked that tidal flushing/ inlet widening be considered. *Comments noted.*
3. Ms. Buessler – Asked that mixer be removed from consideration. Asked if MEP data had been requested. Asked if the Town be contacting WHOI to see if their WWTF is available? *Concern noted regarding the pond mixer. Yes, Town has requested MEP data but has not yet received it. Yes, Town will be contacting WHOI.*

WRIGHT-PIERCE

Engineering a Better Environment