Water Quality and Wastewater Planning

Amended Comprehensive Wastewater Management Plan – Preliminary Draft

Prepared For:

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Contents

1.0 Executive Summary

The Town of Orleans is continuing to build on efforts to improve water quality in coastal estuaries as well as freshwater ponds by amending the previous Comprehensive Wastewater Management Plan (CWMP) based on additional wastewater engineering and planning developments that have occurred since publication of the CWMP/SEIR in 2010. Since the CWMP was approved in 2011, the Town has allocated funds each year through the Town meeting process in order to advance the planning and implementation of the Plan. Input gathered from stakeholders over the years has produced a variety of ideas regarding types and quantities of Traditional sewering technologies to use and where they would be most appropriate and effective. In addition, these discussions have identified the potential for using additional Non-Traditional technologies not mentioned in the 2010 Plan including the use of permeable reactive barriers (PRBs), floating constructed wetlands (FCWs), and shellfish aquaculture and coastal habitat restoration (CHR) to reduce nitrogen loads to receiving waters. Several boards, subcommittees and working groups have been formed, and have met over the years with consulting firms to guide the process, in order to achieve consensus on a plan that would be approved by residents. Much progress has been made since 2011, and this document reflects the modifications that have been made to the Plan in 2010.

The Orleans Water Quality Advisory Panel (OWQAP) was formed in 2014 in order to consolidate the information being provided to the Town through the various studies being performed and to assist in reporting to the residents and to achieve consensus for a wastewater treatment plan moving forward. In 2015, this process resulted in a Consensus Plan with a hybrid approach combining both Traditional and Non-Traditional technologies. This Plan was recently revised to reflect the current status of planning and implementing wastewater treatment in the Town.

Facilities Engineering

Conceptual and preliminary design tasks were done that advanced the Traditional engineering tasks pertaining to discharge sites, facilities (wastewater treatment and disposal) preliminary designs, Downtown planning, Tri-Town transitioning, and cost estimates. Two areas were identified for sewering: Downtown ad Meetinghouse Pond.

Downtown planning tasks were undertaken to develop a Town Center (business districts and some residential lots along the Route 6A corridor) plan that would support water quality and wastewater planning on a sub-watershed basis. An updated build-out analysis and land use / market conditions and development constraints was performed, along with future growth scenarios with implications for wastewater load impacts and recommendations for handling Downtown wastewater flows and biosolids.

Several build-out scenarios were developed and evaluated, as well as outcomes of Downtown Planning Workshops to come to a consensus that the future needs of the Town are best met under the future build-out scenario which reflects higher residential density in the Village Center. Recommendations for zoning and regulatory changes required to achieve the strategies and objectives of the scenario were also identified.

Several sites have been identified and were evaluated as potential groundwater discharge sites. The proposed Overland Way WWTF was recommended for construction at the existing Tri-Town septage facility due to the proximity of the location to the Downtown area. Meetinghouse Pond area discharge was proposed at a site on Beach Road.

The collection system was chosen after an evaluation and screening process which included site suitability, as well as environmental, financial, maintenance and other considerations. Preliminary system layouts and costs were developed for both the Downtown and Meetinghouse Areas. Based on these evaluations a "hybrid" wastewater collection system was recommended for both areas.

Wastewater flows and residuals/septage treatments were evaluated based on anticipated volumes for each area. For the Downtown Area, four modular MBR treatment trains were recommended initially with accommodations for a fifth to be added in the future. For Meetinghouse Pond, two MBR treatment trains would be needed. Capital, operational and maintenance, replacement and monitoring costs of the systems are also presented.

Water reuse systems were discussed as advantages/disadvantages as well as potential sites for use in Orleans. Based on this analysis, it was recommended to not include water reclamation in the Program at this time.

Tri-Town Transition Requirements

The existing Tri-Town plant has reached the end of its useful life and the Board of Managers voted not to fund interim improvements and cease receipt of septage on June 1, 2016. AECOM has estimated costs to decommission and demolish the existing facility, and proposed a timeframe to have a bid I hand for demolition by March 1, 2017.

Non-Traditional Technologies

The Non-Traditional technologies under consideration include PRBs, FCWs, and shellfish aquaculture and CHR. All of these Non-Traditional technologies will be implemented initially in relatively small-scale demonstration projects in order to determine specific rates of nitrogen removal. This information will then be utilized in determining engineering details for full-scale implementation meeting Nitrogen removal goals that meet TMDL goals. The information will also be used to compare costs for implementation of Non-Traditional versus Traditional technologies; as well as to assess overall acceptance of these technologies by abutters. Several potential sites were reviewed and ranked for each type of Non-Traditional technology in site selection processes with a goal of demonstration project success, including for the monitoring program to be able to quantify any nitrogen removal.

Floating Constructed Wetlands (FCWs) remove pollutants (Nitrogen, phosphorus, biological oxygen demand, total suspended solids and fecal coliforms) as water passes through the system. The site selection process evaluated and raked five potential sites; with Lonnie's Pond and Quanset Pond ranking first and second, though all five sites were deemed suitable. A preliminary design and monitoring plan were presented along with a cost estimate. During this process it was determined that there is not enough information to determine nitrogen removal rates in estuarine systems compared to cost, therefore more research is needed on the effectiveness of this technology before proceeding with a FCW demonstration project.

Eight potential demonstration sites were evaluated and ranked for shellfish aquaculture and CHR, with the top two locations being Little Pleasant Bay for oyster aquaculture and Quanset Pond for an oyster bed (CHR). Lonnie's Pond was preliminarily evaluated for shellfish, but because it was the preferred site for FCW it was not further ranked in the shellfish process.

Four shellfish demonstration projects have been determined and are now in various states of progress: Lonnie's Pond oyster singles grown in floating bags has been implemented; increased quahog population and propagation in Town Cove is on schedule for implementation in the Fall of 2016; and the Quanset oyster bed installation and increased aquaculture in Little Pleasant Bay projects are in the planning phases.

A total of 200,000 larger oysters (1 and 2-inch) were deployed in floating bags in Lonnie's Pond in June 2016. Baseline water quality monitoring was performed by SMAST prior to deployment, and a monitoring program designed to determine the nitrogen removal rates is currently on-going. The data will be compiled at the end of the growing season and a report will be prepared that will enable the determination of the engineering parameters required for full-scale implementation using oysters to meet TMDL limits.

Prior to implementing any additional quahog propagation efforts in Town Cove, a baseline determination and assessment of the existing quahog population needs to be done by conducting a shellfish survey. Working with the Town Department of Natural Resources (DNR) staff will determine the appropriate areas for survey work, to be performed during FY 17. It is estimated that 10 acres will be surveyed, beginning with the area near the Orleans Yacht Club and to plant an additional 100,000 quahogs.

The Quanset oyster bed installation will begin with growing remote set in trays and/or floating bags for an initial growing period (likely eight weeks) and then bottom planting them in the same area. The plan for FY 17 involves developing a scope of work for baseline water quality monitoring and to begin monitoring within the proposed growing area and preparing a reviewed and implementable engineering design for a 2017 installation.

The Little Pleasant Bay demonstration project includes three components: developing and disseminating a questionnaire to determine whether growers are interested working with the town to expand shellfish propagation for the purpose of water quality improvements; working with growers to establish a total number of shellfish that can be grown and harvested annually for all leases in aggregate; and evaluation of areas in Town Cove for expanding shellfish leases. In FY 17, the survey will be developed and disseminated, with results compiled and discussed with the Shellfish Working Group.

Demonstration projects of PRBs will provide data to assess the effectiveness and applicability of PRBs as a viable alternative technology for the Town to use in the wastewater management implementation. Eight sites were evaluated and ranked to determine potential demonstration project and monitoring success. Results of the evaluation ranking narrowed the list to four potential sites; Main Street and Tonset Road; South Orleans Road at Tonset/Eldredge Parkway; Town Cove Gibson Road; and Town Landfill. A groundwater investigation was completed at all four sites in 2016 to further assist in site selection. The prioritized list of two recommended sites was proposed as Eldredge Park and Town Landfill.

In FY 17, a demonstration PRB will be finalized and implemented at one of these locations, and the monitoring program will be developed and implemented by the AECOM Team. The results of the monitoring will provide the data necessary to detail the full-scale design parameters required to meet TMDL goals for nitrogen remediation in the receiving waters.

Adaptive Management Plan

The Adaptive Management Plan (AMP) was initially described in the 2010 CWMP/SEIR and identified and explained that the Town's approach to managing wastewater and stormwater would be evaluated for effectiveness and would be modified as appropriate based on interim results. Because the Town is now planning to implement a hybrid approach utilizing both Traditional and Non-Traditional technologies, modifications to the AMP are necessary.

The modification process involved assembling existing data into a single database and comparing and contrasting the data to determine data gaps and to recommend additional monitoring required to meet future monitoring goals. Once the data was assembled, trends were identified for each parameter as applicable. Based on data results, the stations were then assigned to one of three action items: confirm system health, determine why inconsistent, or treat as impaired.

The baseline data review concluded with recommendations for improving the long-term monitoring program going forward. Additional studies were recommended in order to fully understand what is causing the anomalies in trends for some parameters. Responsible parties and next steps are identified.

The MEP model and studies were evaluated, and it was determined that due to changes in conditions that the model is based on (updated water usage rate, the 2007 breach at Nauset Beach, etc) it is appropriate to recommend and update to both the model as well as the studies for both Nauset Harbor and Pleasant Bay.

There are several actions underway regarding stormwater and fertilizer management to protect water resources. Several reports and deliverables are due by the end of 2016. AMEC Foster Wheeler will be providing a dynamic planning tool that will provide information needed to design and install stormwater BMPs. The NPDES Phase II Small MS4 General Permit Annual Report to EPA in April 2016 states that the Town is using resources to develop a Stormwater Management Plan (SWMP). Several key activities were listed in the annual report.

The Town continues to implement BMPs to reduce the use of fertilizers and pesticides after passing a Fertilizer Nitrogen Control bylaw at the April 2014 Annual Town Meeting. The Orleans Pod Coalition implemented a public education campaign in Year 13 to inform residents and businesses about the proper use of and alternatives to fertilizers, and provide brochures about fertilizer and pesticide use at Town Hall.

2.0 Acronyms and Abbreviations

µM	micro-Moles
AACE	Association for the Advancement of Cost Estimating
ACEC	Area of Critical Environmental Concern
ADF	Average Daily Flow
AMP	Adaptive Management Plan
BFP	Belt Filter Press
BioN	Bioactive Nitrogen
BOS	Board of Selectmen
CAS	Conventional Activated Sludge
CCC	Cape Cod Commission
CCNS	Cape Cod National Seashore
CDBG	Community Development Block Grants
CEC	Contaminants of Emerging Concern
CFP	Community Food Program
Chl-*a*	Chlorophyll *a*
CHR	Coastal Habitat Restoration
CPR	Coastal Pollutant Remediation
CSC	Center for Coastal Studies
CWMP	Comprehensive Wastewater Management Plan
CWSRF	Clean Water State Revolving Fund
CZM	Coastal Zone Management
DB	Design-Build
DBO	Design-Build-Operate
DIN	Dissolved Inorganic Nitrogen
DMF	Division of Marine Fisheries

DNR	Department of Natural Resources
DO	Dissolved Oxygen
DON	Dissolved Organic Nitrogen
DRI	Development of Regional Impact
EDA	Economic Development Administration
EDU	Equivalent Dwelling Unit
ENR	Engineering News Record
EOEEA	Executive Office of Energy and Environmental Affairs
EVO	Emulsified Vegetable Oil
FCW	Floating Constructed Wetland
FEIR	Final Environmental Impact Report
FY	Fiscal Year
GBT	Gravity Belt Thickener
GIS	Geographic Information Systems
GS	Gravity Sewers
GWDP	Groundwater Discharge Permit
HUD	Department of Housing and Urban Development
HVAC	Heating, Ventilation and Air Conditioning
IFAS	Integrated Fixed Film Activated Sludge
LPS	Low Pressure Sewers
MassDEP	Massachusetts Department of Environmental Protection
MassDOT	Massachusetts Department of Transportation
MBR	Membrane Bioreactor
MEP	Massachusetts Estuaries Project
MEPA	Massachusetts Environmental Policy Act
MET	Massachusetts Environmental Trust

mg/L	milligrams per liter
MM	Million
N	Nitrogen
NH_4	Ammonium
NHESP	Natural Heritage and Endangered Species Program
NO_3	Nitrate
NOAA	National Oceanographic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NT	Non-Traditional
O&M	Operation and Maintenance
ORP	Oxidation Reduction Potential
OWQAP	Orleans Water Quality Advisory Panel
OWQTF	Orleans Marine and Freshwater Quality Task Force
P	Phosphorus
PBA	Pleasant Bay Alliance
PCCS	Provincetown Center for Coastal Studies
PO_4	Phosphate
POC	Particulate Organic Carbon
PON	Particulate Organic Nitrogen
PPP (P3)	Public-private Partnerships
PRB	Permeable Reactive Barrier
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Policy Plan
RBC	Rotating Biological Contractor
RDT	Rotary Drum Thickener
SBR	Sequencing Batch Reactor

SEIR	Single Environmental Impact Report
SMAST	School for Marine Science and Technology
SNEP	Southeast New England Plan
SOP	Standard Operating Procedures
SRP	Soluble Reactive Phosphate
STEG	Septic Tank Effluent Gravity
STEP	Septic Tank Effluent Pumping
TWMP	Targeted Watershed Management Plan
TDN	Total Dissolved Nitrogen
TM	Technical Memorandum
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
UV	Ultra-Violet
VS	Vacuum Sewers
WPA	Wetlands Protection Act
WWTF	Wastewater Treatment Facility
YD	Yarmouth-Dennis

3.0 Glossary and Definitions

In Process of Being Developed.

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4.0 Background and Purpose of Amended Comprehensive Wastewater Management Plan (ACWMP)

4.1 Background

The Town of Orleans (Town) prepared a Comprehensive Wastewater Management Plan (CWMP) and Single Environmental Impact Report (SEIR) in December 2010. The 2010 CWMP/SEIR proposed a new centralized sewer system to reduce nitrogen loads to coastal bays and estuaries in Orleans. The 2010 proposal included 74 miles of new sewer, 63 sewer pump stations, and a new wastewater treatment and groundwater disposal facility at the existing Tri-Town Septage Treatment Facility site, which would have treated up to 64 million gallons per day (MGD) of wastewater and discharged it to groundwater at the Tri-Town site. In addition, the 2010 CWMP/SEIR identified non-structural controls to further reduce nitrogen loading, including fertilizer use controls, stormwater management, land use controls, water conservation, and enhanced embayment flushing.

The Cape Cod Commission (CCC) held a joint hearing with the Massachusetts Environmental Policy Act (MEPA) staff on January 18, 2011 on the S/FEIR, and the CCC voted to submit comments to the Massachusetts Executive Office of Energy and Environmental Affairs (EOEEA) for MEPA review. On January 28, 2011, the EOEEA issued a Certificate on the revised CWMP S/FEIR (Appendix A) stating that the project complied with MEPA, which started the clock for the CCC to hold a public hearing to review the project within 45 days of the certification. Several hearings were held, between March 1, through October 13, 2011 when the full CCC voted unanimously to approve the project and issued an approval for the project as a Development of Regional Impact (DRI) with conditions (Appendix B).

The Orleans CWMP DRI approval included conditions regarding the potential of operating the Orleans WWTF as a shared municipal facility, but also allowed Orleans to proceed with a single town plan if no agreement with the other Towns could be reached. The DRI decision also capped the amount of assimilative capacity in the Nauset Marsh system that Orleans could use through the WWTF discharge.

Since the CWMP was approved in 2011, the Town has allocated funds each year through the Town meeting process in order to advance the planning and implementation included in the document. Input from stakeholders has produced a variety of ideas regarding types and quantities of Traditional sewering technologies to use and where they would be most appropriate and effective. In addition, these discussions have identified the potential for using Non-Traditional technologies to reduce nitrogen loads to receiving waters, and evaluated types and locations of Non-Traditional technologies. Several boards, subcommittees and working groups have met over the years with consulting firms to achieve consensus on a plan that would be approved by residents.

4.2 Cape Cod Commission 208 Plan Update Recommendations

In 2013, MassDEP directed the CCC to develop an update to the Water Quality Management Plan for the region in accordance with Section 208 of the federal Clean Water Act, due to the impairment of water quality in coastal waters as a result of excess nitrogen. The CCC issued the updated plan, and it was approved by MassDEP and US EPA in 2015. The 208 Plan Update identified a number of recommendations to improve water quality in coastal waters surrounding Cape Cod, which are designated into one of four categories: information; regulatory reform; support; or cost.

The 208 Plan Update recommended that the CCC implement the following measures regarding water quality information:

- Implement a regional monitoring program for performance and compliance monitoring;

- Provide a technical guidance document of monitoring protocols for Non-Traditional technologies;
- Create a standing monitoring committee;
- Develop a process for annual updates to the Technologies matrix;
- Seek to sponsor an annual symposium to present and review new research on technologies and approaches coinciding with the regular updates to the Technologies Matrix;
- Create a regional water quality data center;
- Continue cooperation with the Massachusetts Department of Transportation (MassDOT) regarding stormwater contributions as well as opportunities to improve tidal flushing in coastal areas and use rights-of-way for water quality improvement projects; and
- Evaluate the demands for septage processing and treatment.

The regulatory reform recommendations included:

- MEPA and the CCC should jointly develop a streamlined review procedure for review of targeted watershed management plans (TWMPs);
- Identification of requirements for TWMPs based on watershed boundaries;
- Reformation of the Development of Regional Impacts (DRI) process to a simpler, more supportive process;
- Review of local water quality management plans to ensure consistency with the Updated 208 Plan;
- Development of guidance on consistency review to be issued by the CCC;
- The Massachusetts Department of Environmental Protection (MassDEP) should issue guidance outlining the process for watershed permits for nutrient loads;
- MassDEP should designate Nitrogen Sensitive Areas;
- MassDEP should eliminate regulatory language establishing the presumption that Title 5 systems meet state water quality (WQ) standards; and
- The Commonwealth should seek delegated authority under the Clean Water Act to issue and enforce National Pollutant Discharge Elimination System (NPDES) permits.

The 208 Plan Update recognized that additional direct support of local wastewater planning was needed, and recommended that local planning efforts should consult with the CCC early in the process. The Updated 208 Plan recommended that the CCC implement the following measures under support:

- Assign watershed teams to support community planning efforts;

- Advise on the development of watershed scenarios with plans consistent with the 208 Plan Update;
- Provide a detailed evaluation of effluent disposal options;
- Establish criteria for eligible pilot projects, and identify opportunities to implement pilot projects across Cape Cod;
- Evaluate the steps required for a regional or locally based nitrogen impact fee;
- Develop a process or provide guidance to manage disagreement among parties;
- Provide a local public participation process with efforts specifically designed to reach environmental justice communities; and
- Coordination and further discussion with Joint Base Cape Cod and MassDevelopment.

The Updated 208 Plan makes the following recommendations regarding cost:

- The CCC should develop a proposal for a Cape Cod Capital Trust Fund for financing infrastructure design and construction;
- The CCC should develop a proposal for a Septic Trust Fund;
- MassDEP should exercise its discretion in providing principal forgiveness up to 25%;
- The Commonwealth should make available the Environmental Bond Bill money for monitoring programs and pilot projects to Cape Cod for efforts consistent with the Updated 208 Plan;
- The United States Environmental Protection Agency (USEPA) should expand the funding and piloting efforts of the Southeast New England Plan (SNEP); and
- Local watershed management plans that are consistent with the Updated 208 Plan should qualify for existing and potential revenue sources.

Specific recommendations to Orleans from the Plan published in 1978 included: (a) Title 5 enforcement in areas with difficult soils; (b) consideration of a regional septage treatment with Eastham and Brewster; (c) determination of the landfill plume; and (d) a coordinated land use analysis with Brewster to determine watershed protection needs. In the 208 Plan Update, the CCC identified a number of alternative technologies that should be considered to reduce nitrogen loadings from wastewater on the Cape, in addition to the consideration of traditional sewering, treatment, and effluent discharge approaches.

4.3 Purpose of Amended Comprehensive Wastewater Management Plan (ACWMP)

This current document is an amended CWMP, which incorporates by reference relevant aspects of the previous CWMP not modified as a result of the additional planning and engineering effort through the existing scope of work. It is not intended that the ACWMP will represent a re-issuance of the previously published CWMP. Responses to comments on the CWMP are presented in Appendix C.

4.4 Modifications in Response to Comments from Previous CWMP

In response to comments on the CWMP, the Town of Orleans has re-evaluated its previously recommended approach to nitrogen control, which focused on installation of an extensive sewage collection system and new treatment facility and discharge at the Tri-Town septage facility site. Although MEPA, MassDEP, and CCC comments on the 2010 CWMP were generally in favor of the plan, concerns were identified regarding the need for additional monitoring and characterization of the Tri-Town site groundwater plume and the current and future effects on Little Namskaket marsh, as well as the need to further evaluate the Massachusetts Estuaries Program (MEP) reports for Nauset Marsh and Town Cove. The agencies also identified the need to further evaluate water quality issues at Cedar Pond and whether cluster systems to treat wastewater discharges were appropriate for this area.

In addition to agency concerns, a number of residents raised concerns regarding cost of the proposed centralized collection and treatment system and whether this was the most beneficial approach to managing nitrogen loading in the Town of Orleans. As a result of comments on the CWMP/SEIR, as well as recommendations in the 208 Plan, the Town of Orleans has evaluated the potential benefits of Non-Traditional Technologies for lowering nitrogen loading to coastal receiving waters, and considered where these Non-Traditional Technologies might be beneficial as opposed to Traditional collection, treatment, and discharge. In addition, an extensive evaluation of the downtown area current and future wastewater loads was conducted in order to better identify the need for sewers in critical areas where Non-Traditional Technologies would not be appropriate. The initial result was a Hybrid Consensus Plan including both Traditional and Non-Traditional approaches to reducing nitrogen loading in Orleans' subwatersheds, as discussed in greater detail in Section 4.1. The Consensus Plan has been further refined by work in 2015 and 2016, as summarized in Sections 5.0 through 9.0 of this ACWMP.

5.0 Consensus Plan and ACWMP

5.1 Consensus Plan

In 2014, the Orleans Water Quality Advisory Panel (OWQAP) was convened to achieve consensus and build widespread community support for a customized, affordable water quality management plan for the Town. The panel consists of stakeholder representatives (Orleans Selectmen and representatives of engaged citizen constituencies), and liaisons from key town boards and commissions, organizations, neighboring towns, and regional, state, and federal partners. The OWQAP met for twelve half-day meetings, all of which were open to public attendance and comment.

Potential alternative planning scenarios to meet water quality standards were developed for the OWQAP and presented at meetings and workshops. During a day-long OWQAP public workshop on December 17, 2014, the "Hybrid Plan" was presented, screened, and evaluated. This plan described a combination of Traditional and Non-Traditional technologies that meet the MEP load-reduction targets for nitrogen in each impaired waterbody. The OWQAP then formed three subgroups to discuss, evaluate and revise the Hybrid Plan. To assist in this process, the OWQAP received a Technology Evaluation Decision Support Tool that allowed risks and benefits of each technology to be evaluated by subwatershed based on a number of parameters that were ranked for each technology. Preliminary comparative costs were also presented on a relative dollars/kilogram of nitrogen removed basis. The result was a Site Evaluation Matrix that summarized the risks and benefits of each technology. The Matrix is included as Appendix D, and includes the following ranked categories:

- Nutrient removal certainty: nitrogen (saltwater), phosphorus (freshwater);
- Implementation certainty;
- Other benefits: ecosystems, economic, social;
- Adaptability to uncertainty in nutrient-reduction goals and build-out;
- Contaminants of emerging concern (CEC) removal; and
- Overall cost.

The resulting revised Hybrid Plan described two general areas for sewers: the first area included approximately 270 parcels encompassing Downtown Orleans, which were estimated to generate approximately 100,000 gpd of wastewater to be treated at a facility and groundwater effluent disposal area; the second area included approximately 286 parcels within the Meetinghouse Pond subwatershed, which were also estimated to generate 50,000 gpd, to be treated at a new satellite treatment facility and groundwater effluent disposal area. The Hybrid Plan also listed specific sites for potential use for Non-Traditional technologies to remove nitrogen, including aquaculture and coastal habitat restoration (CHR), Permeable Reactive Barriers (PRB) and Floating Constructed Wetlands (FCW). The number of acres of shellfish growing area, linear feet of PRBs and square footage of FCW were quantified to achieve specific nitrogen-removal targets. This exercise was undertaken to confirm that the quantities of all Non-Traditional technologies proposed were feasible to install. These specific locations became the basis for potential demonstration site locations for aquaculture and CHR, FCWs and PRBs moving forward into FY 2016.

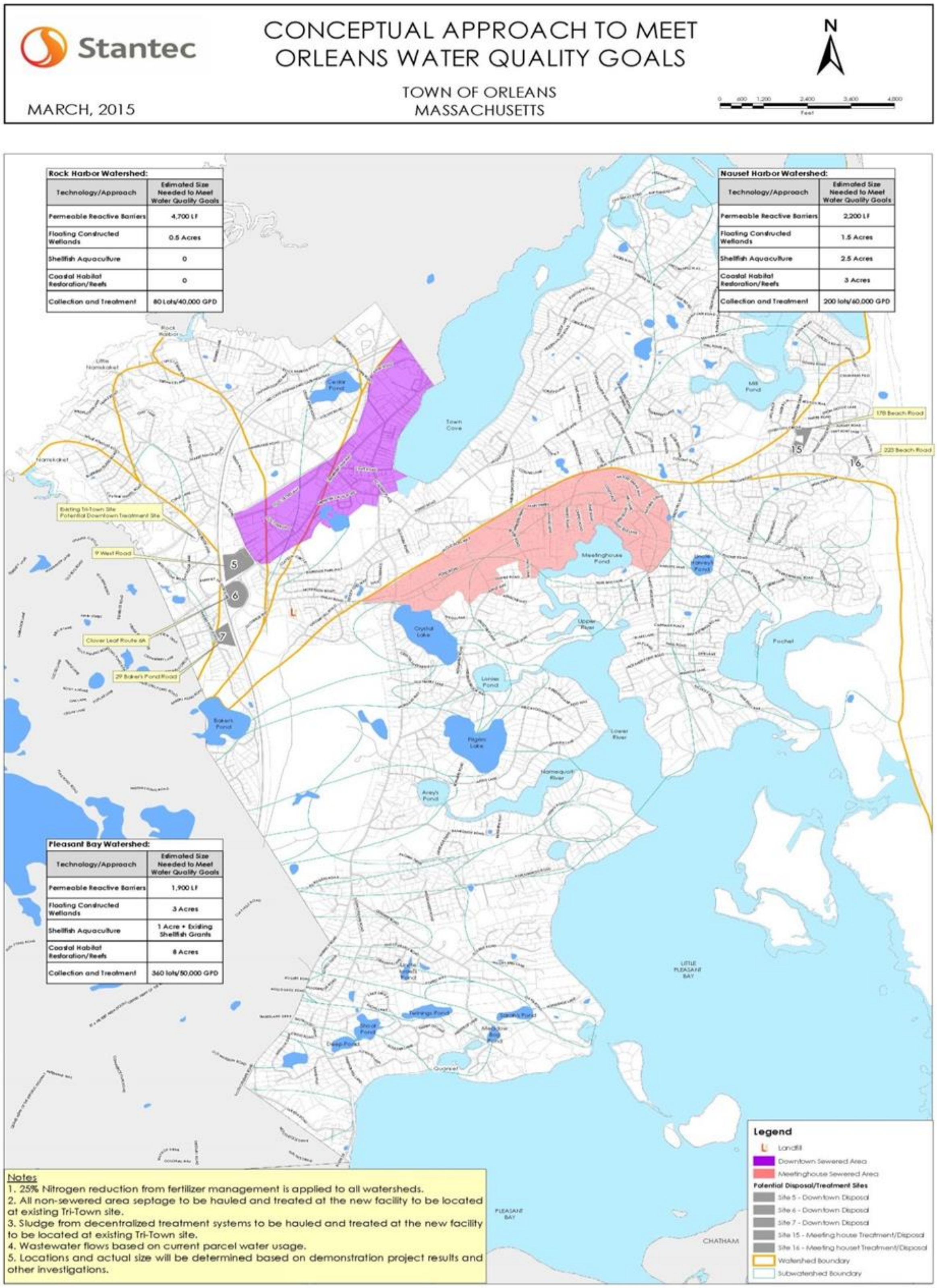
The Hybrid Plan was vetted through the OWQAP during three meetings, including a day-long workshop. This iterative process resulted in a draft Consensus Plan that included a combination of Non-Traditional and Traditional technologies. Once the feasibility of using Non-Traditional technologies as part of the Town's nutrient management strategy was established, the OWQAP decided that the final Consensus Plan would not specify exact locations for these technologies, but instead focused on the overall area needed to remove the appropriate mass of nitrogen at the watershed level. The resulting map (Figure 4-1), entitled Conceptual Approach to Meet Orleans Water Quality Goals (March 2015) shows the agreed upon water quality management plan.

5.2 Summary of Elements of the ACWMP

Since the finalization of the Consensus Plan, the Town of Orleans has been advancing the conceptual approaches outlined therein through a number of tasks aimed at gathering site specific data necessary to advance design of both the Traditional and Non-Traditional elements proposed to achieve the overall goal of nitrogen reduction within the Town's subwatersheds. The work completed to advance the Town's plan for nitrogen loading since the finalization of the Consensus Plan is summarized in this ACWMP. The scope of work contributing to this ACWMP performed from October 2015 through May 2016 included a series of deliverables, in the form of Technical Memoranda (TM), covering the following topics:

- Facilities engineering - the conceptual and preliminary design tasks required to advance the Traditional engineering tasks including Disposal Site Investigations; Facilities (Wastewater Treatment and Disposal) Preliminary Design; Downtown Planning and Cost Estimating;
- Downtown planning - planning goals; current economic conditions and market trend analysis; updated Town center study area build-out analysis; results of build-out scenarios; projections for wastewater flows and loads and projections for biosolids; other potential impacts associated with build-out scenario growth; and proposed zoning and regulatory changes to achieve strategies and objectives;
- Facilities preliminary design - collection systems; wastewater treatment, residuals, septage components, and effluent disposal transmission/pumping; groundwater disposal; water reuse systems; and cost estimating;
- Tri-Town transition requirements - interim use options; potential cost savings for doing demolition of existing facility and construction of new facility together; coordination with the MassDEP; and design criteria for demolition of the facility;
- Demonstration project design and implementation - FCW; aquaculture/shellfish propagation; and PRBs;
- Adaptive management plan (AMP) implementation - identification of tasks necessary to support and refine the program moving forward; development of a long-term water quality monitoring program; development of a water quality monitoring program for demonstration projects to evaluate performance and consideration in light of other system-wide water quality monitoring; and recommendations for Massachusetts Estuaries Project (MEP) study update monitoring;
- Financial evaluation – review and modification to the preliminary financial evaluation completed during Fiscal Year (FY) 15 including evaluation of revenue generating options; financing options; program cost impact assessment and affordability; and public private partnership options; and

Figure 4-1 - A map showing the conceptual approach to meeting Orleans' water quality goals as agreed upon in March 2015.



Rock Harbor Watershed:

Technology/Approach	Estimated Size Needed to Meet Water Quality Goals
Permeable Reactive Barriers	4,700 LF
Floating Constructed Wetlands	0.5 Acres
Shellfish Aquaculture	0
Coastal Habitat Restoration/Reefs	0
Collection and Treatment	80 Lots/40,000 GPD

Nauset Harbor Watershed:

Technology/Approach	Estimated Size Needed to Meet Water Quality Goals
Permeable Reactive Barriers	2,200 LF
Floating Constructed Wetlands	1.5 Acres
Shellfish Aquaculture	2.5 Acres
Coastal Habitat Restoration/Reefs	3 Acres
Collection and Treatment	200 lots/60,000 GPD

Pleasant Bay Watershed:

Technology/Approach	Estimated Size Needed to Meet Water Quality Goals
Permeable Reactive Barriers	1,900 LF
Floating Constructed Wetlands	3 Acres
Shellfish Aquaculture	1 Acre + Existing Shellfish Grants
Coastal Habitat Restoration/Reefs	8 Acres
Collection and Treatment	360 lots/50,000 GPD

- Regulatory review and coordination – No formal MassDEP or MEPA review required for the ACWMP, but coordination efforts with CCC and informal coordination with MassDEP was required during this scope of work.

This ACWMP summarizes each of these TMs, providing an overview of the contents of each. All of the TMs are attached as Appendices (E through ##) which provide full details on each of the topics covered in the current scope of work. In some cases the TMs were prepared simultaneously with ongoing discussions and meetings with the OWQAP and subcommittees as well as with the Board of Selectmen (BOS), Finance Committee and Town Planner. Thus, the TMs in the appendices represent considerations and recommendations at various points along the planning and design process, but the text within the ACWMP represents the final recommendations.

6.0 Facilities Engineering

6.1 General

This section discusses the conceptual and preliminary design tasks undertaken to advance the Traditional engineering tasks including Disposal Site Investigations, Facilities (Wastewater Treatment and Disposal) Preliminary Design, Downtown Planning and Cost Estimating. The Consensus Plan developed by the OWQAP determined that Traditional wastewater collection, treatment, and disposal was appropriate for the Downtown and Meetinghouse Pond sub-watersheds, as shown in Figure 4-1. Since the 2010 CWMP/SEIR, the following activities have occurred to advance the Traditional facilities engineering for these areas, and are described in the subsections that follow:

- Investigations have occurred to characterize a variety of groundwater disposal site alternatives for treated wastewater in terms of hydrogeology, effluent quantity, effluent quality, depth to groundwater, sensitive environmental conditions, etc. The results of these studies as well as recommendations for disposal sites are summarized in Section 5.1.

- An evaluation of build-out conditions in the densely developed Town Center has been conducted both under current conditions relying on septic treatment and zoning controls to limit development, as well as future conditions with a centralized collection system. These evaluations have provided a framework for identifying potential future wastewater flows requiring treatment during initial phases of centralized collection and treatment and are summarized in Section 5.2.

- Based on the projected wastewater flows in the Downtown Area and Meetinghouse Pond subwatersheds, alternatives for wastewater collection, treatment, and disposal technologies were evaluated and recommendations were developed based on cost, feasibility, and effectiveness. The results of these evaluations are summarized in Section 5.3.

The facilities engineering tasks described below have resulted in refinements to the Consensus Plan in regard to boundaries of the Downtown and Meetinghouse Pond areas recommended for centralized collection as well as potential groundwater discharge disposal sites, as shown in Figure 5-1.

6.2 Disposal Site Investigation

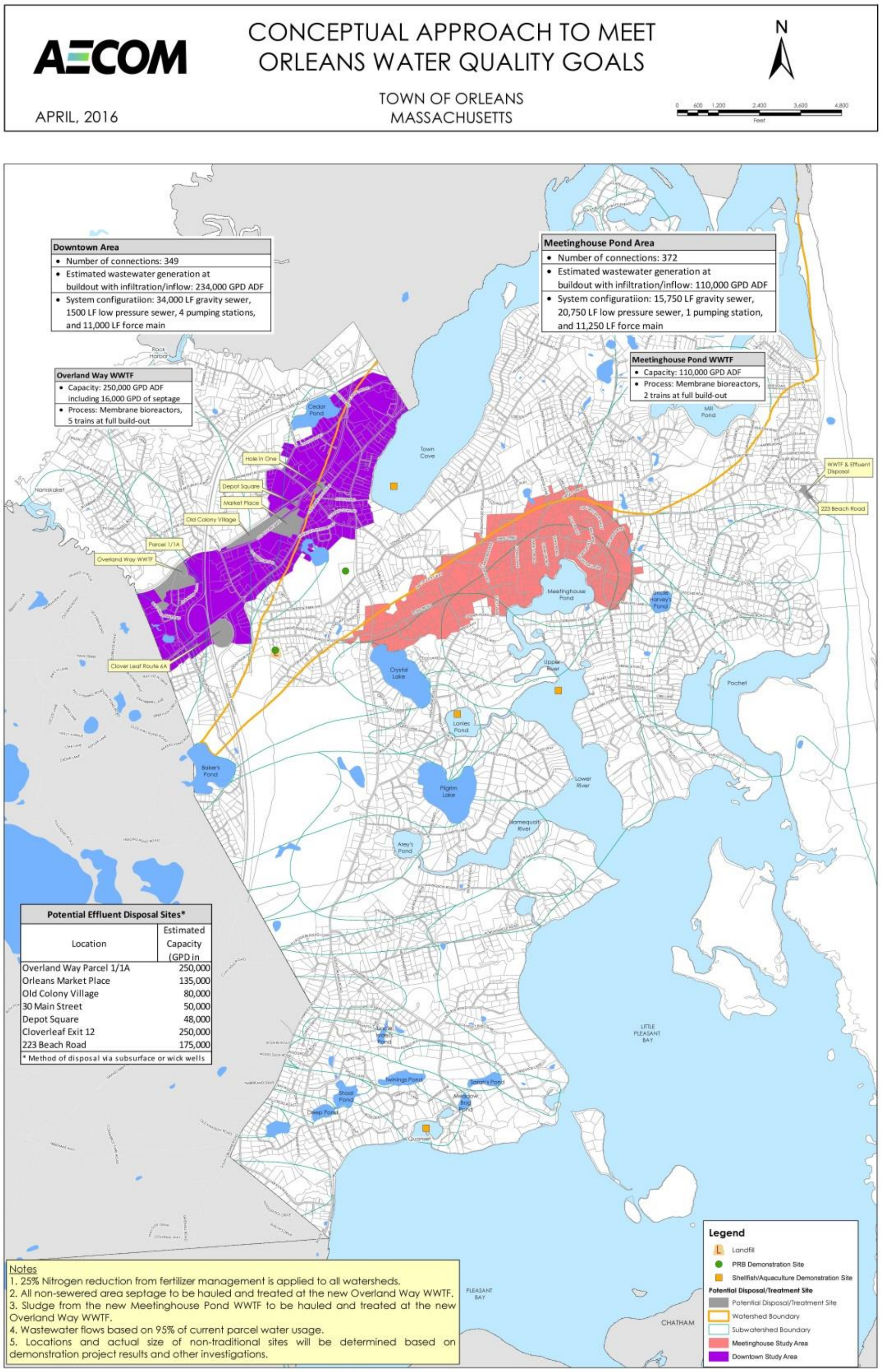
6.2.1 WWTF Groundwater Discharge Site Investigations

As previously discussed, the Consensus Plan proposes two areas for sewering; the Downtown Area and the Meetinghouse Pond area. Each area will require wastewater treatment and a site for the discharge of the WWTF effluent.

The initial groundwater discharge sites, taken from the Hybrid Plan developed during the OWQAP process, were further evaluated by the Town. Two locations were initially shortlisted for hydrogeologic evaluation; Cloverleaf Route 6A and 223 Beach Road. These sites met the goals and objectives of the OWQAP's Consensus Plan.

AECOM was tasked to perform a Hydrogeological Evaluation the Route 6 Interchange and Beach Road sites. The Hydrogeologic Evaluation is part of the MassDEP Groundwater Discharge Permit (GWDP) application process. The purpose of the Hydrogeologic Evaluation is to evaluate each site for the suitability of a groundwater discharge prior to the design and construction of the WWTF and discharge facilities. Details of the evaluation follow.

Figure 5-1. Map showing the proposed Meetinghouse Pond collection area.



6.2.2 Downtown Area - Disposal Site Investigations

The Town of Orleans does not own the parcel within the southeast cloverleaf of the Route 6 Interchange (Exit 12) with Route 6A. In the fall of 2015, the Town approached MassDOT for permission to access the Cloverleaf site to perform a hydrogeologic investigation. When a timely site access agreement could not be obtained, the Cloverleaf Site was removed from consideration in mid-January, 2016. The Town and AECOM began considering alternative groundwater discharge sites. The sites considered were very preliminarily evaluated for a groundwater discharge. The evaluations only included reviewing existing Health Department records and estimating an approximate groundwater discharge area and discharge rate based on existing data. Table 6-1 summarizes the sites investigated including the site address, estimated discharge area and estimated groundwater discharge rate for each site.

Further investigations, including a detailed Hydrogeologic Evaluation, would have to be performed to further evaluate any parcel(s) selected for a groundwater discharge.

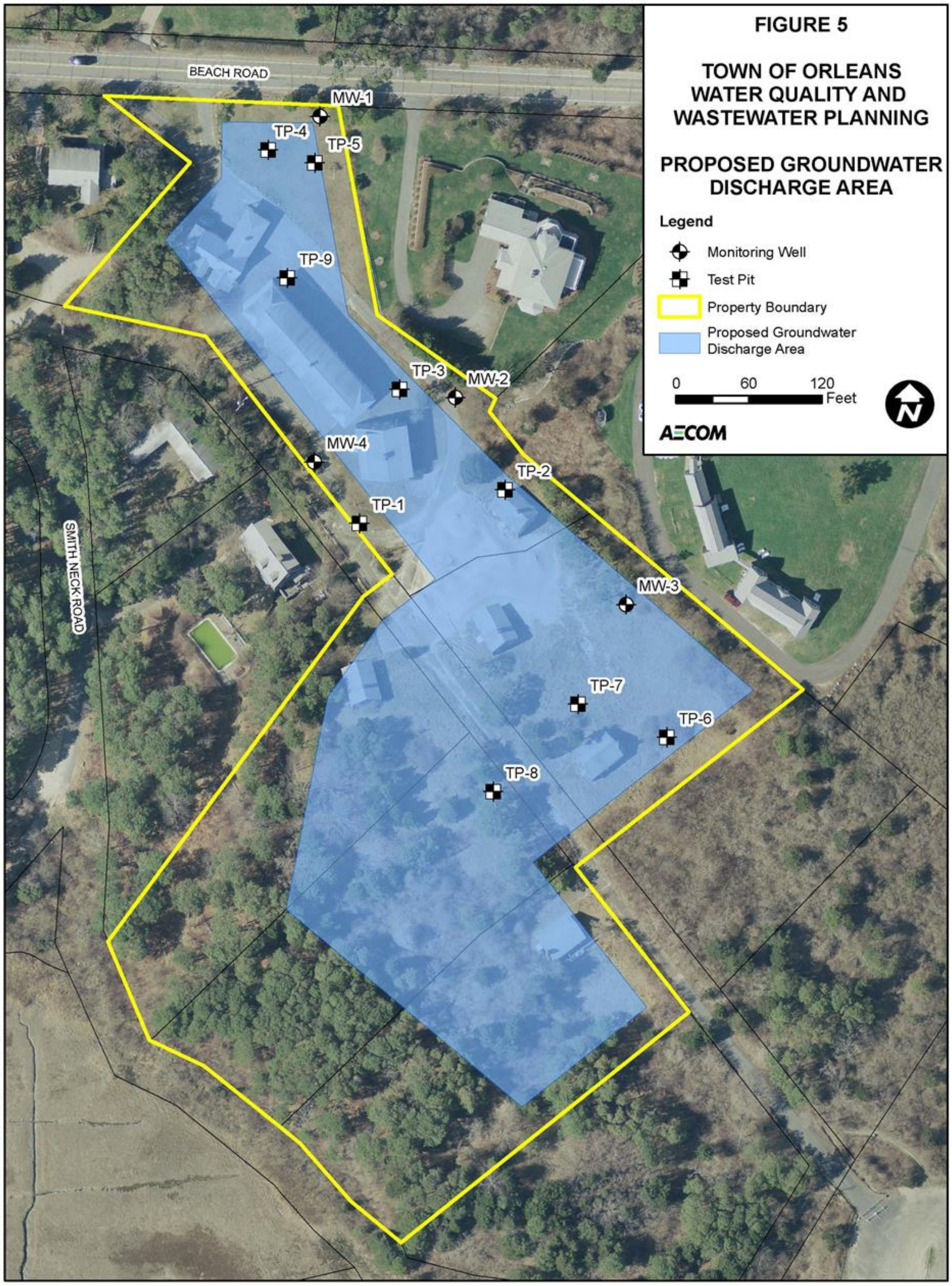
Table 6-1 - Potential Groundwater Discharge Locations

Site	Street Address	Potential Area for Groundwater Discharge (sqft)	Potential Groundwater Discharge Rate (GPD)
Depot Square	8 Old Colony Way	24,000	48,000
Hole in One Restaurant Parking Area	Off Cranberry Highway and Main Street	25,000	50,000
Old Colony Apartments	Old Colony Way	40,000	80,000
Thayer Property Orleans Market Place	130 – 136 Old King Hwy	67,500	135,000
Tri Town Site	29 Overland Way	125,000+	250,000+

6.2.3 Meetinghouse Pond Area - 223 Beach Road

The location of the proposed discharge site for the Meetinghouse Pond collection area is at 223 Beach Road in east Orleans near Nauset Beach, and is shown on Figure 5-2. The Beach Road site was considered for two primary reasons. First, the site is owned by the Town; second, the site is located outside the Meetinghouse Pond Watershed and discharges to the Atlantic Ocean and not to an estuary where the nitrate in the effluent could be a potential issue. The Town also plans to use the site for Nauset Beach parking. Installation of a subsurface discharge at the site would not interfere with these plans.

Figure 5-2. The proposed groundwater discharge site at 223 Beach Road.



G:\Projects\MUNI\60476644ORL\Maps\GWD_Figure5.mxd

On November 30, 2015, a proposed scope of work to conduct a Hydrogeologic Site Evaluation was submitted to MassDEP for review and comment as required by MassDEP (BRP WS 83) for a Groundwater Discharge Permit (GWDP) Application. The Proposed Hydrogeologic Site Evaluation was approved by MassDEP on January 19, 2016 after receiving no public comments. Copies of the proposed Hydrogeologic Evaluation scope of work, Environmental Monitor Notification and MassDEP approval letter are provided in Appendix A of the TM (Appendix E). The investigations included the excavation of test pits, performing Title 5 percolation tests, the installation of soil borings and monitoring wells, grain-size analysis of soil samples, and the performance of slug tests. The data obtained were used to evaluate subsurface conditions, estimate the groundwater flow direction, and calculate aquifer characteristics. Results of the field investigations and data analysis were incorporated into a numerical groundwater flow model to simulate groundwater flow across the site and estimate groundwater mounding under various discharge scenarios.

The potential discharge area at 223 Beach Road is approximately 140,000 square feet (sqft). At this time the projected flow and location of the primary and reserve discharge areas within the 140,000 sqft area has not been determined. However, at a flow of 110,000 gpd, approximately 55,000 sqft would be required for the primary discharge with the reserve located between the laterals of the primary discharge.

Geologic conditions found at the Beach Road site consist of silty sands underlain by relatively clean medium sands with varying amounts of fine and course sand and trace amounts of gravel and silt. The percolation rate of the medium sands was less than 2 minutes per inch indicating that the underlying sands are suitable for a groundwater discharge system. The depth to groundwater under the proposed discharge area is approximately 40 feet. Aquifer characteristic were estimated through laboratory grain-size analysis and analysis of slug test data. A description of each method follows.

A calibrated groundwater flow model was used to simulate a groundwater discharge. Several discharge scenarios were performed to estimate groundwater mounding and flow direction at the Beach Road site. The scenarios simulated discharge rates between 25,000 and 500,000 gpd under high water table conditions. Groundwater mounding at 500,000 gpd was approximately 3.5 feet; approximately 35 feet below ground surface.

According to Town records, there are no public and six potential private water supply wells within 2,500 feet of the discharge. Only one private well is located within the influence of the discharge according to the groundwater model simulations. All of the properties with private wells could connect to the existing Orleans public water supply system located adjacent to their properties.

Based on the groundwater mounding analysis, discharge from the Beach Road site generally flows east and discharges directly to the Atlantic Ocean, a waterbody with no nitrate TMDL. At flows between 200,000 and 500,000 gpd, the model simulations indicate that a portion of the discharge flows to Pochet Neck, a sub-estuary of Pleasant Bay which has a nitrate TMDL. If the discharge at the Beach Road site were to exceed 200,000 gpd, measures to reduce or offset the nitrate load entering Pochet Neck would need to be considered.

A detailed description of the Hydrogeologic Evaluation, groundwater modeling, potential environmental impacts, results, conclusion, and recommendations are summarized in the Hydrogeologic Evaluation Technical Memorandum found as Appendix E. The purpose of the TM is to provide a transparent and objective assessment of the 223 Beach Road Site for the discharge of WWTF effluent. The Hydrogeologic Evaluation will be submitted to the MassDEP as part of the GWDP application process.

6.3 Downtown Planning

This section discusses the Downtown Planning tasks undertaken to develop a Town Center plan that will support water quality and wastewater planning on a sub-watershed basis. The area addressed in this task is the Town Center Study Area, which includes the business districts along the Route 6A corridor as well as some residential use (Figure 5-3). The Downtown Planning task work is summarized in the following Technical Memoranda:

- Updated Downtown Build-Out Analysis and Land Use / Market Conditions and Development Constraints (Appendix F);
- Downtown Future Growth Scenarios, Strategies to Limit Growth, Draft Regulations to Obtain Zero Interest Financing, and Implications for Wastewater Loading Impacts and Other Community Impacts in the Downtown (Appendix G); and
- Management of Future Downtown Wastewater Flows and Biosolids (Appendix H).

Highlights from these Technical Memoranda are provided below, and the complete documents are located as Appendices F-H.

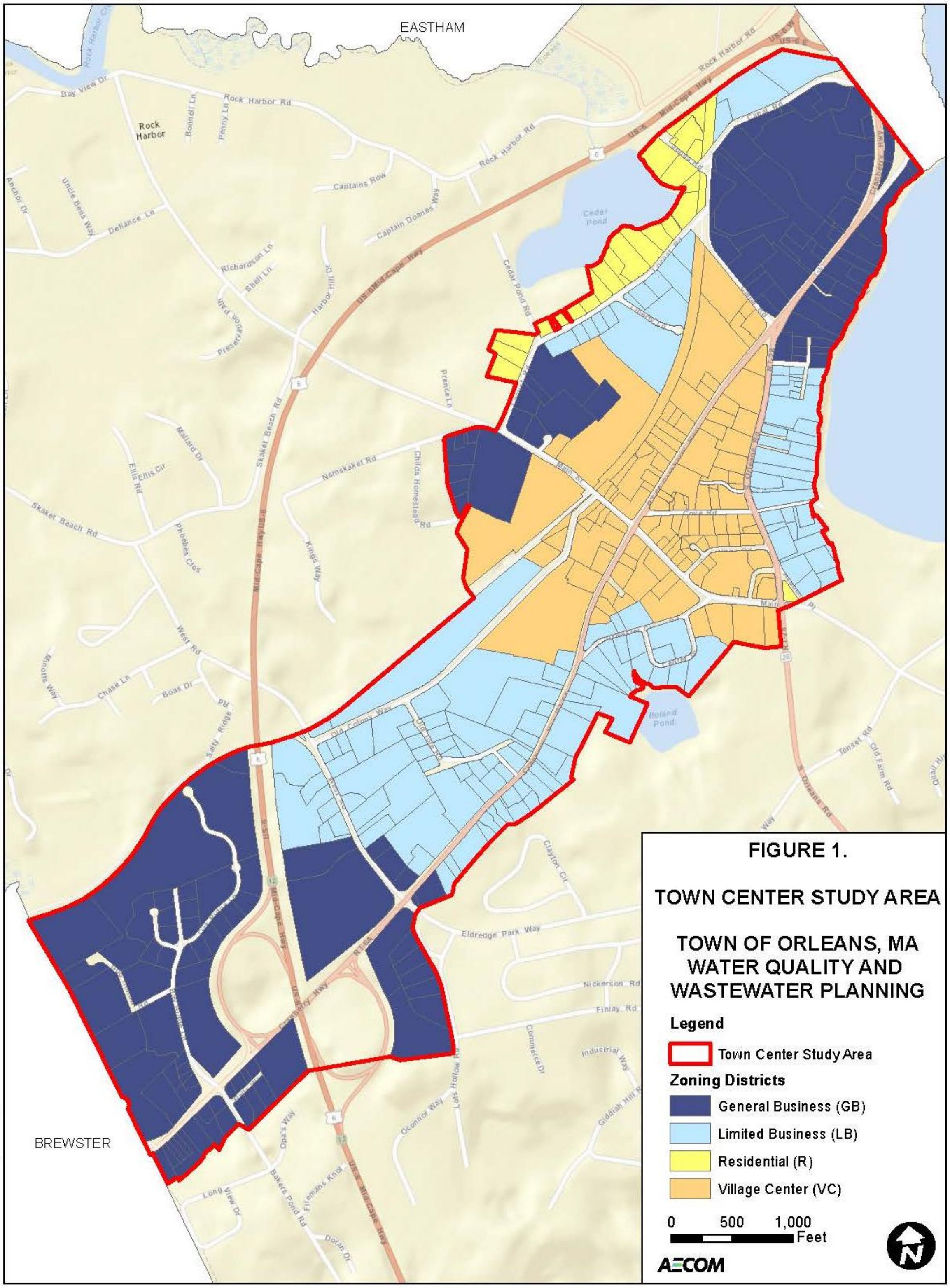
6.3.1 Updated Downtown Build-Out Analysis and Land Use / Market Conditions and Development Constraints

Appendix F provides the TM presenting the results of an updated economic conditions and market trend analysis for the Town Center Study Area, as well as the methodology and results for an updated build-out analysis of the Town Center Study Area based on existing Town regulations and zoning. The information in the TM is summarized below in two sub-sections that address the two components of Updated Economic Conditions and Build-Out Analysis.

6.3.1.1 Updated Economic Conditions and Market Trend Analysis

In 2010, FinePoint Associates conducted an economic analysis of the Orleans Village Center and worked collaboratively with the Planning Department, Planning Board, Chamber of Commerce, and interested citizens to develop a set of 24 strategy recommendations along with potential action steps to consider. Many of these recommendations have since been implemented or are underway. In 2015 FinePoint Associates, as a subcontractor to AECOM, conducted an updated economic analysis for the Town Center Study Area, which incorporates the Village Center. This analysis resulted in the production of an Orleans Town Center Economic Analysis Primer, which provided information and analysis pertaining to economic conditions and other factors that informed the Town and appropriate Boards or Committees as they reassessed/ reconfirmed the vision for the Town Center and the 2010 strategy recommendations, which particular focus on those recommendations that impact future development and therefore wastewater planning.

Figure 5-3. Map showing the town center study area.



The Economic Analysis Primer is comprised of three parts:

- Real Estate and Business Conditions;
- Understanding of the Year Round and Seasonal Retail Market; and
- Other Conditions Pertinent to Town Center Planning.

The Primer is included in its entirety in Appendix F.

6.3.1.2 Updated Town Center Study Area Build-out Analysis

The Town Center Study Area build-out analysis was initiated by reviewing previous relevant planning studies and build-out analyses for the Town. Following review and organization of available information, the Orleans Downtown Planning Workshop No. 1 was convened with the BOS and other invited stakeholders on December 15, 2015. The purpose of this workshop was to: confirm the vision for the Downtown as stated in the 2006 Orleans Comprehensive Plan; confirm the 2009 vision statement for Village Center; and review/revisit the recommendations from the 2010 Economic Analysis of the Village Center prepared by FinePoint Associates and modify as needed based on findings of the updated economic analysis.

After Workshop No. 1, AECOM utilized output from the workshop and coordinated with the Town's Planning Department and subconsultant FinePoint Associates to develop an updated build-out for the Town Center Study Area and a range of future growth / build-out scenarios. Then, the Orleans Downtown Planning Workshop No. 2 was convened with the Board of Selectmen and other invited stakeholders on February 4, 2016. The purpose of this workshop was to: summarize input and key takeaways from Workshop No. 1; present assumptions and results for the Town Center Study Area build-out scenarios; and conduct a group discussion to obtain input on the build-out scenarios.

The Workshop No. 2 participants reconfirmed the Town Vision Statement and the Village Center Vision Statement. The key items discussed related to the vision statements and included: prioritize year-round residents and uses, reverse decline of year-round population and youth, target increased growth and higher density of residential uses, and target lesser increase in non-residential square footage. It was also noted that it is important to maintain continuity of non-residential space in the Town Center Study Area and avoid dead space in between non-residential uses.

2015 Existing Conditions for the Town Center Study Area were initially determined to provide a baseline from which to develop potential growth scenarios. Baseline values for the number of dwelling units, non-residential development (i.e. non-residential square footage), and wastewater generation within the Town Center Study Area were developed.

Following completion of the 2015 Existing Conditions analysis, an updated build-out scenario assuming no change to land use patterns or zoning regulations was developed. The scenario was then evaluated in light of three options:

- **Scenario Option 0a: Full Build-out under Current Zoning with Existing Wastewater Limitations**. This scenario assumes on-site wastewater management continues to be required and a variance would not be issued by the Board of Health to allow construction of new or expanded Title 5 systems under parking areas.

- **Scenario Option 0b: Full Build-out under Current Zoning with Existing Wastewater Limitations and Title 5 Septic Systems Constructed under Parking**. This scenario applies the same approach / assumptions as used for Scenario Option 0a, except it assumes a variance would be issued by the Board of Health to allow construction of new or expanded Title 5 systems under parking areas. This scenario was created as a result of input received at Orleans Downtown Planning Workshop No. 2.

- **Scenario Option 0c: Full Build-out under Current Zoning with Wastewater Limitations, Title 5 Constructed under Parking, and Local Nutrient Management Regulations Removed**. This scenario applies the same approach / assumptions as used for Scenario Option 0b, except it assumes the Town's Nutrient Management Regulations would not be applicable to any parcel in the study area. This scenario was created as a result of input received at Orleans Downtown Planning Workshop No. 2.

The results for all build-out scenario options are presented in Table 5-1 and Table 5-2.

6.3.2 Downtown Future Growth Scenarios, Strategies to Limit Growth, Draft Regulations to Obtain Zero Interest Financing, and Implications for Wastewater Loading Impacts and Other Community Impacts in the Downtown

This TM presents the methodology and results of future build-out scenarios for the Town Center Study Area (see Figure 5-3), as well as strategies to manage growth, draft regulations to obtain zero Interest financing through the MassDEP Clean Water State Revolving Fund (MassDEP CWSRF) program, and implications for wastewater loading impacts and other community impacts in the Town Center Study Area. The sub-sections that follow summarize each of these components of the TM.

6.3.2.1 Future Build-out Scenario Development

A range of future build-out scenarios for the Town Center Study Area was developed based on input received from the two Downtown Planning Workshops held on December 15, 2015 and February 4, 2016; consideration of market demand conditions; and coordination with the Town. Five future build-out scenarios were developed over the course of the project. Ultimately, the following three scenarios were selected for water quality and wastewater planning purposes:

Table 5-1. Orleans Town Center Study Area Updated Build-out Results by Sub-watershed

	2015 Existing Conditions		Scenario Option 0a[1]		Scenario Option 0b[1]		Scenario Option 0c[1]	
Sub-watershed	Residential (dwelling units)	Non-Residential (sf)	Residential (dwelling units)	Non-Residential (sf)	Residential (dwelling units)	Non-Residential (sf)	Residential (dwelling units)	Non-Residential (sf)
Town Cove	181	718,297	196	755,361	196	755,953	196	755,953
Boat Meadow River	5	-	5	-	5	-	5	-
Rock Harbor Stream	1	-	1	-	1	-	1	-
Cedar Pond	98	301,286	107	347,078	107	351,358	110	360,382
Rock Harbor Main	368	78,326	368	78,912	368	79,368	368	79,368
Boland Pond	1	17,121	1	17,121	1	17,121	1	17,121
Little Namskaket	128	218,907	150	464,919	150	545,369	163	670,250
Namskaket Main	10	89,762	22	198,411	22	235,200	22	235,200
Namskaket Stream	8	50,429	26	133,555	26	164,667	26	164,667
Total	*800*	*1,474,128*	*876*	*1,995,357*	*876*	*2,149,037*	*892*	*2,282,941*

Notes:

1. Scenario 0 descriptions:
    - Option 0a: Full Build-out under Current Zoning with Existing Wastewater Limitations
    - Option 0b: Full Build-out under Current Zoning with Existing Wastewater Limitations and Title 5 Septic Systems Constructed under Parking
    - Option 0c: Full Build-out under Current Zoning with Wastewater Limitations, Title 5 Constructed under Parking, and Local Nutrient Management Regulations Removed

Table 5-2. Orleans Town Center Study Area Wastewater Flows by Sub-watershed (gpd)

Sub-watershed	2015 Existing Conditions	Scenario Option 0a[1]	Scenario Option 0b[1]	Scenario Option 0c[1]
Town Cove	61,178	66,268	66,312	66,312
Boat Meadow River	837	837	837	837
Rock Harbor Stream	53	53	53	53
Cedar Pond	26,277	31,086	31,407	32,579
Rock Harbor Main	29,705	29,749	29,783	29,783
Boland Pond	2,603	2,603	2,603	2,603
Little Namskaket	21,699	43,670	49,704	61,050
Namskaket Main	5,252	15,381	18,140	18,140
Namskaket Stream	4,252	13,456	15,790	15,790
Total	*151,855*	*203,102*	*214,628*	*227,146*

Notes:

1. Scenario 0 descriptions:
   - Option 0a: Full Build-out under Current Zoning with Existing Wastewater Limitations
   - Option 0b: Full Build-out under Current Zoning with Existing Wastewater Limitations and Title 5 Septic Systems Constructed under Parking
   - Option 0c: Full Build-out under Current Zoning with Wastewater Limitations, Title 5 Constructed under Parking, and Local Nutrient Management Regulations Removed

- **Scenario 1 – Full Build-out Under Current Zoning without Wastewater Limitation.** This scenario utilizes the same underlying approach and assumptions as used for Scenarios 0a, 0b, and 0c discussed in Section 5.2.1.2, except the on-site wastewater limitation (e.g. Title 5 sizing and setback requirements, Title 5 and the Town's Nutrient Management Regulations wastewater flow limits) that was applied for Scenario 0 is eliminated due to the assumed future provision of sewer to the Town Center Study Area. As a result, additional land area is available for future development and higher densities can be achieved.

- **Scenario 2 – Growth Scenario to Reflect Vision to Increase Residential Density in the Town Center.** This scenario utilizes results from Scenario 1 as a starting point and incorporates changes to increase residential density in the Town Center. In addition to a currently proposed large-scale mixed use development in the Village Center, several trends – low vacancy rates, high housing costs, decreasing household size and aging population – point to the need to expand the variety of housing options in the community. It appears there may be a need for maintenance-free homes in close proximity to services that could serve an older population looking for smaller units, less maintenance, and less driving. There also appears to be a need for lowerpriced homes that could serve a young workforce population. The Downtown Planning Workshops also indicated strong support to expand the variety of housing in the town center.

- **Scenario 3 – 2050 Planning Horizon.** This scenario utilizes the 2015 Existing Conditions results for the Town Center Study Area as a starting point and applies residential and non-residential growth rates for a 2050 planning horizon. The growth rates are applied at the study area-wide level and not by individual parcel. The planning horizon was determined based on an assumed 2020 construction date of a new wastewater facility and a 30 year estimated useful life. This scenario includes two options:

  – Scenario Option 3a: Historical Growth Rate; and

  – Scenario Option 3b: Modified Growth Rate with Consideration of Vision, Market Conditions, and Provision of Sewer.

The residential and non-residential results for all future build-out scenarios are presented in Table 5-3.

The Orleans Planning Board issued a memorandum to the Orleans BOS on February 26, 2016 regarding downtown growth and development. In the memorandum, the Planning Board states that based on the outcome of the Downtown Planning Workshops, it is their opinion that there is general consensus regarding the future of the downtown area as expressed in the Town Center and Village Center Vision Statements that were reviewed. The memorandum also states that the Planning Board agrees that the future needs of the Town are best met under the future build-out Scenario Option 3.b, which reflects higher residential density in the Village Center. This memorandum is included as Appendix G.

Wastewater flows and load associated with the future build-out scenarios were estimated for each scenario using approaches as detailed in the TM. The wastewater flows and loads results for each future scenario are presented in Table 5-4.

6.3.2.2 Coordination of Future Growth with the Orleans Comprehensive Plan

As noted in the 2006 Orleans Comprehensive Plan, growth and development continue to create challenges for the Town, including increased traffic congestion and nitrogen pollution of local waters. Per the Comprehensive Plan, the Town's growth policy is to "ensure that future growth is at a level and in such a manner that will have no or minimal adverse effect upon semi-rural character and environmental integrity of the Town." The Comprehensive Plan also states that future business activities should be oriented primarily in village areas and strip commercial development prevented. This approach is consistent with the growth policy of the 2012 CCC Regional Policy Plan, which is to "guide growth toward areas that are adequately supported by infrastructure and away from areas that must be protected for ecological, historical, or other reasons."

High septic system replacement costs and Title 5 restrictions currently limit the ability of the Town to direct future growth to the Village Center and the two major commercial nodes (Skaket Corners and the Orleans Rotary area). Also, businesses with high sewage volume are significantly constrained from locating in the downtown area, as any business generating in excess of 15,000 gpd of wastewater would require an advanced septic treatment facility, which comes with additional costs and regulatory requirements.

The proposed sewering of the Town Center Study Area will aid in attainment of the Town's growth policy by eliminating current on-site wastewater limitations and enabling denser development and redevelopment within the three commercial nodes targeted to receive future growth. The sewering will also eliminate nitrogen loading from wastewater in the Study Area and aid in restoring the health of local water bodies.

Potential growth must be managed in light of other demands that new growth would place on the Town in terms of other utilities, traffic and transportation, and services (police, fire, etc.). Relevant goals from the Comprehensive Plan related to the additional demands posed by potential future growth were detailed in the TM.

Meeting these demands will need to be coordinated with the goals and policies included in the Town's Comprehensive Plan. The primary infrastructure improvement in the Town Center Study Area required to support the preferred build-out scenario is provision of a wastewater collection system and treatment facility. Without this wastewater infrastructure in place, the desired density and type of development in the Study area as reflected in the preferred build-out scenario (Scenario Option 3b) could not be achieved.

Table 5-3. Orleans Town Center Study Area Future Build-out Scenario Results by Sub-watershed

Sub-watershed	Scenario 1[1]		Scenario 2[1]		Scenario 3[1] Option 3a[1]		Scenario 3[1] Option 3b[1]	
	Residential (dwelling units)	Non-Residential (s.f.)	Residential (dwelling units)	Non-Residential (s.f.)	Residential (dwelling units)	Non-Residential (s.f.)	Residential (dwelling units)	Non-Residential (s.f.)
Town Cove	448	1,328,796	545	820,417	296	768,828	322	781,796
Boat Meadow River	8	-	8	-	6	-	6	-
Rock Harbor Stream	2	-	2	-	1	-	1	-
Cedar Pond	181	987,366	276	431,436	154	365,687	167	382,215
Rock Harbor Main	390	191,769	436	83,439	389	80,856	394	81,505
Boland Pond	5	34,635	24	20,594	8	18,839	10	19,281
Little Namskaket	163	635,984	163	289,074	139	253,627	142	262,538
Namskaket Main	22	217,306	22	113,067	14	101,294	15	104,253
Namskaket Stream	26	169,582	26	91,892	14	70,946	15	76,211
Total	*1,245*	*3,565,437*	*1,502*	*1,849,919*	*1,021*	*1,660,078*	*1,073*	*1,707,800*

Notes:
1. Scenario descriptions:
- Scenario 1: Full Build-out Under Current Zoning without Wastewater Limitation
- Scenario 2: Growth Scenario to Reflect Vision to Increase Residential Density in the Town Center
- Scenario 3: 2050 Planning Horizon
  - Option 3a: Historical Growth Rate
  - Option 3b: Modified Growth Rate with Consideration of Vision, Market Conditions, and Provision of Sewer

Table 5-4. Orleans Town Center Study Area Future Wastewater Flows and Loads

Parameter	Scenario 1[1]	Scenario 2[1]	Scenario 3[1]	
			Option 3a[1]	Option 3b[1]
Wastewater Flow (gpd)	337,013	233,730	183,150	190,815
Septage Flow (gpd)	16,000	16,000	16,000	16,000
I/I Flow (gpd)	22,501	22,501	22,501	22,501
Total Flow (gpd)	375,514	275,231	221,651	229,316
BOD Loading (lbs/d)	1,002	727	592	612
TSS Loading (lbs/d)	940	681	555	574
TN Loading (lbs/d)	188	136	111	115
Effluent BOD Load (lbs/d)	94	68	55	57
Effluent TSS Load (lbs/d)	94	68	55	57
Effluent TN Load (lbs/d)	31	23	18	19
Waste Biosolids (lbs/d)	1,018	863	788	799

Notes:

1. Scenario descriptions:
   - Scenario 1: Full Build-out Under Current Zoning without Wastewater Limitation
   - Scenario 2: Growth Scenario to Reflect Vision to Increase Residential Density in the Town Center
   - Scenario 3: 2050 Planning Horizon
     - Option 3a: Historical Growth Rate
     - Option 3b: Modified Growth Rate with Consideration of Vision, Market Conditions, and Provision of Sewer

6.3.2.3 Zoning and Regulatory Changes Needed to Achieve Strategies and Objectives

Focusing development in the specified nodes in the Town Center Study Area will reduce the potential for undesired strip commercial development and other types of development sprawl. Implementation of the Town's proposed amendment to Section 164-31 Apartment Development of the Zoning By-laws or similar amendment would allow for and encourage the higher residential density that is desired in the Village Center. The Town could also consider implementing a zoning amendment that requires all (or selected types) new housing developments to contribute to the Town's affordable housing stock.

Also, in order for the Town to be eligible to receive zero percent financing through the MassDEP Clean Water State Revolving Fund program (described in detail in Appendix G), the Town must adopt land use controls that would result in no net increase in wastewater flows as a consequence of changed land uses or increased density allowed if sewers are installed.

6.3.3 Management of Future Downtown Wastewater Flows and Biosolids

Appendix H includes the TM that describes the proposed methods to manage future downtown wastewater flows associated with the preferred build-out scenario (i.e. Scenario Option 3b – Modified Growth Rate with Consideration of Vision, Market Conditions, and Provision of Sewer) and allocate sewer capacity, as well as management of future downtown wastewater biosolids. As discussed in greater detail in Section 5.3.2.1, it is recommended that the proposed Overland Way WWTF be constructed at the existing Tri-Town Septage Treatment Facility on a 26-acre parcel to the northwest of the Exit 12 cloverleaf. Because of the planned decommissioning of the facility, and the proximity of this location to the Downtown Area, it is a logical choice for siting a proposed Overland Way WWTF to receive flow from the Downtown Area.

Phasing of the proposed Overland Way WWTF and Downton Area collection system is a key component of the overall Project Plan. It is proposed that the Overland Way WWTF and Downtown Area collection system be constructed in at least two phases with the first phase occurring within the next five years and the second phase occurring within the next ten years. Additional detail regarding recommendations for treatment of wastewater flows and biosolids is provided in Section 5.3.

6.4 Facilities Preliminary Design

This section discusses the tasks undertaken to advance the preliminary design of the wastewater collection, treatment, and discharge facilities. The Facilities Preliminary Engineering design work is summarized in the following Technical Memoranda:

- Collection System Technologies and Evaluation Technical Memorandum (Appendix I));
- Add name and appendix of whatever tech memo discusses treatment – is this Water Quality and Wastewater Planning Task Number 1.c.10 – Final Technical Memorandum on Wastewater Treatment, Residuals, Septage Management, Effluent Transmission and Pumping Components of the WWTF, which is provided as Appendix H.

Highlights from these Technical Memoranda are provided below.

6.4.1 Collection System

A *Collection System Technologies and Evaluation Technical Memorandum was prepared (*Appendix I) to identify the types of collection system technologies and to evaluate each of the technologies in order to develop a cost-effective alternative for the proposed Downtown Area and Meetinghouse Pond Area wastewater collection areas of Orleans. The Collection System Technologies include: (a) Gravity Sewers (GS); (b) Low Pressure Sewers (LPS); (c) Septic Tank Effluent Gravity (STEG); (d) Septic Tank Effluent Pumping (STEP); and (e) Vacuum Sewers (VS). Design description, considerations and criteria, advantages and disadvantages of each of these collection systems are included in the TM in Appendix I.

6.4.1.1 Collection System Alternatives Evaluation

A technology evaluation and screening criteria for the proposed Collection systems are discussed in detail in the TM (Appendix I), and included the following categories:

- Site Suitability
  - Land Ownership
  - Constructability (Method of Installation)
- Environmental Considerations
  - Permittability
  - Extent of Dewatering
  - Sustainability
- Financial Considerations
  - Construction Costs
  - Operation and Maintenance Costs
- Maintenance Considerations
  - Level of Maintenance, Homeowner
  - Level of Maintenance, Town
- Other Considerations
  - Reliability
  - Ability to Accommodate Expansion
  - Area of Disturbance
  - Duration/Schedule
  - Aesthetics

The evaluation criteria were applied to each of the five technologies. In applying each of the criteria to each of the technologies, a consistent three level rating system was used as follows: Good = 1 point; Neutral = 0 points; and Poor = -1 point.

An overall rating for each technology was completed based on the criteria and weights assigned to each of the individual criteria. It is noted that septic tank effluent pumping (STEP) and low pressure sewer (LPS) are ranked the most favorable with very close criteria points and thus considered essentially equivalent in this analysis. Vacuum sewers were ranked the least favorable for both areas mainly because they are most beneficial in flat terrain. Gravity sewers were ranked at 3 of 5, and septic tank effluent gravity (STEG) systems ranked at 4 of 5. However, the criteria points for gravity were more significantly favorable in the Downtown area due to the emphasis on reliability and minimal maintenance required by the owner at the property level. For both collection system areas, Low Pressure Sewers (LPS) and Septic Tank Effluent Pumping (STEP) systems are ranked essentially equivalent with one point difference in total criteria points.

In this analysis, key differentiators were construction impacts related to cost, environmental considerations and restoration. This focus highlights the benefits of utilizing smaller pipes from LPS and STEP systems to collect and transmit sewage flows at a lower cost of construction per service connection. However, these systems are most suitable to small communities with an established service area and are less able to provide future expansion capacity within the same collection area. For this reason, a hybrid system is recommended that takes advantage of the newer collection system design strategies to provide services to the individual properties, with a limited Traditional gravity sewer system that can collect the flows and provide the capacity for long-term expansion. In this manner, additional phases, or neighborhoods can be added to the system without impacting the existing infrastructure. The gravity sewer would be installed in the public right of ways and designed to eliminate deep excavations and the need for pumping stations as much as possible, by relying on pressure service connections where practical.

While LPS and STEP collection systems were comparable in this analysis, the LPS is determined most favorable for use in the hybrid plan mainly due to the additional cost and maintenance burden on the homeowner related to the septage management requirements of the STEP system. Additional factors include the higher potential for corrosion and odors from the septic conditions of the STEP system at the property as well as increase in difficulty in the biological process of the septic effluent at a wastewater treatment facility. Both systems require nominal cost to the homeowner related to operation and maintenance of the effluent service pumps.

6.4.1.2 Collection System Layout and Cost Estimates

A preliminary system layout (plan and profiles) was developed for both the Downtown Area and Meetinghouse Pond Area. Refer to Appendix A of the TM (Appendix I). The development of the plan and profiles for each area system was based on existing information as follows: (a) Town of Orleans Assessors Records; (b) Town of Orleans topography survey from the stormwater project for part of the Downtown Area; and (c) USGS topographic survey.

The preliminary system layouts were developed in accordance with the New England Interstate Water Pollution Control Commission - TR-16, Guides for the Design of Wastewater Treatment Works, 2016 Edition.

It is anticipated that the final system layouts will be further developed based on various site factors as defined by obtaining detailed topographic survey; performing subsurface investigations (i.e. soil types, and depth to groundwater); acquiring land and/or easements; and investing of existing utilities.

Preliminary cost estimates were developed based on the preliminary system layouts and included Project Costs; Annual Operation and Maintenance Costs; Replacement Costs; and Annual Monitoring Cost, and is included in the following sections. These are summarized in the TM and also described in more detail in Section 5.3.5.

The details for the operation and maintenance, replacement and monitoring costs are included in the TM (Appendix I) and are included in the Life-Cycle Costs. Based on the estimated quantities developed from the preliminary system layouts, estimated Program Costs and Life-Cycle Cost Analysis Assumptions a Life-Cycle Cost was developed for each of the technologies (Gravity Sewers; Low Pressure Sewers; Septic Tank Effluent Gravity; Septic Tank Effluent Pumping; and Vacuum Sewers). The results of the Life-Cycle Cost Analysis are presented in Table 5-5 and Table 5-6 for the Downtown Area and Meetinghouse Pond Area, respectively.

Table 5-5 - Downtown Area Life-Cycle Cost Analysis

Type of Cost	Gravity Sewers	Septic Tank Effluent Gravity	Low Pressure Sewers	Vacuum Sewers	Septic Tank Effluent Pumping	Hybrid (GS and LPS)
Present Value	$38.22	$40.43	$26.96	$41.08	$28.23	$32.81

Note: Costs in Millions of Dollars

Table 5-6 - Meetinghouse Pond Area Life-Cycle Cost Analysis

Type of Cost	Gravity Sewers	Septic Tank Effluent Gravity	Low Pressure Sewers	Vacuum Sewers	Septic Tank Effluent Pumping	Hybrid (GS and LPS)
Present Value	$51.01	$53.37	$30.72	$56.73	$32.08	$27.93

Note: Costs in Millions of Dollars

The "Life-Cycle Cost Analysis" is very cost sensitive to revisions to the system layout, components utilized, changes in unit prices, etc. To understand this sensitivity by the changing system layout the following example is utilized. In the Downtown Area Hybrid (GS and LPS) alternative, once the detailed topographic survey and subsurface investigations are complete, the preliminary system layout will be reviewed and adjusted. If the revised layout results in 3 pump stations, the capital cost, associated O&M, Replacement and Monitoring Costs for a Hybrid System will be reduced and would result in a Present Value of $29.38 million or 10.4 percent reduction over the Present Value shown in Table 5-5.

6.4.1.3 Collection System Recommendation

Based on the technical evaluation and economic evaluation (Life-Cycle Cost Analyses) it is recommended that a “hybrid” wastewater collection system be constructed in both the Downtown Area and Meetinghouse Pond Area. The “hybrid” configuration is recommended because of its ability to accommodate changes in wastewater flows particularly with the Downtown Area caused by zoning changes and business dynamics; ability to phase the design, construction and operations; proven long term reliability; generally a higher public acceptance; and ease of permitting.

The recommendations include the following:

- Utilize similar collection system alternatives in each of the proposed service areas and standardize design details/configurations since this reduces overall project costs;

- Develop 20 to 25 percent planning documents for the Downtown Area and Meetinghouse Pond Area Collection Systems;
- Determine the preferred method of implementation – design-bid-construction; design-build, etc.;
- Utilize the updated information to engage in Public-Private-Partnerships negotiations; and
- Utilize the updated information to prepare funding applications in order to obtain grants and loans.

In addition, as part of the inputs to the Financial Model, the Program Costs need to be inflated to the year anticipated for implementation. The ENR's Cost Index History Tables can be used for estimating inflation on future cost projections that are then used for development of Capital Improvement Plans and Financing Plans.

6.4.2 Wastewater Flows, Septage, Influent Pollutant Concentrations and Treatment

6.4.2.1 Wastewater Flows

Based on wastewater projections developed for both the downtown and Meetinghouse Pond areas of Town and provided projections for the current level of development, as well as a "future build-out" condition. The future build-out condition for the Downtown Area addressed possible re-zoning impacts and different property utilization scenarios. The future build-out condition for the Meetinghouse Pond Area was derived by simply assuming residential properties not currently developed might be so in the future. This analysis yielded the annual average flow projections listed in Table 5-7 below.

Table 5-7 - Initial and Future Build-out Flow Projections for Downtown and Meetinghouse Pond Areas

Downtown Area		Meetinghouse Pond Area	
Initial Design Flow	Future Build-out Condition	Initial Design Flow	Future Build-out Condition
153,000 gpd	250,000 gpd	70,000 gpd	110,000 gpd

Note: Future Build-out Condition for Downtown Area include 16,000 gpd of Septage

<u>Septage</u>

Even after the completion of a sewage collection and transmission system for these two areas, there will still be a significant amount of properties in Town that continue to rely on septic systems. In addition, there will continue to be a need for septage disposal capacity to service Orleans and the surrounding communities in the lower/outer Cape.

Based on a previous study, the existing Tri-Town Septage Treatment Facility has averaged in the order of 9 million gallons of septage annually over the past several years. The sewering of some parts of the Town will decrease septage generation within Orleans. In addition, some permanent loss of market might be expected from some of the communities proximate to the Yarmouth-Dennis facility, as it expands operations to fill the void left by the closure of the existing Tri-Town Septage Treatment Facility. AECOM has conservatively prorated the existing Tri-Town Septage Treatment Facility receiving rates on a town by town basis to what they might be expected to be in the future and has arrived at a projected “high-end” septage loading of 6 million gallons annually, or 16,000 gal/d. While this rate will depend on how the Town chooses to operate the proposed Overland Way WWTF, this is considered a reasonable assumption with which to estimate loadings to the facility.

Influent Pollutant Concentrations

Typical wastewater pollutant concentrations need to be adjusted to account for septage. To address what impact septage receiving would have, actual annual average data from the existing Tri-Town Septage Treatment Facility was used. It was assumed that septage would be received only at the proposed Overland Way WWTF servicing the Downtown Area. Additionally, it is assumed that it will be processed with biosolids from the facility, so that only septage filtrate would be mixed with raw sewage influent to reduce solids loadings on the biological process.

The resulting blended influent, as well as the influent characterization for the proposed Meetinghouse Pond WWTF is as shown in Table 5-8.

Table 5-8 - Assumed WWTF Influent Pollutant Concentrations

Constituent	Downtown Area	Meetinghouse Pond Area
BOD, mg/l	340	270
TKN, mg/l	60	55
TSS, mg/l	300	310

Evaluation

The existing Tri-Town Septage Treatment Facility is located on a 26-acre parcel to the northwest of the Route 6 Exit 12 cloverleaf. Because of the planned decommissioning of the facility, and the proximity of this location to the Downtown Area, it is a logical choice for siting a proposed Overland Way WWTF to receive flow from the Downtown Area. The Meetinghouse Pond Area however would require a force main several miles long to bring flow from the eastern edges of town to either the proposed Overland Way WWTF site or the proposed Downtown Area collection area. For the purpose of this evaluation, it was assumed that a proposed smaller, satellite WWTF would be dedicated to this service area, located on the Town owned property at 223 Beach Road. The higher degree of neighborhood sensitivity associated with the Beach Road site requires as small and unobtrusive a facility as possible. This combined with the economy of scale of providing biosolids/septage processing capacity at one location led to the decision that the Beach Road site would not receive septage, and that any WWTF residuals generated would be trucked to the proposed larger Overland Way WWTF located at the existing Tri-Town Septage Treatment Facility site.

<u>Downtown Area</u>

Liquid Train - With the site selected and flow/loadings to the facility defined, AECOM used its experience with similar projects to define a list of applicable technology options for the proposed Overland Way WWTF. A list of attributes important in the selection of an appropriate liquid train treatment technology was developed, and weighting factors applied to reflect the importance of each attribute to the overall selection process. Lastly, AECOM's wastewater process team ranked each technology selection on how well it met the requirements of each attribute. A weighted ranking was then totaled for each technology.

A technology evaluation and screening criteria for the proposed wastewater treatment facility Liquid Train are discussed in detail in the TM (Appendix J), and included the following categories:

• Project Evaluation	• Energy/GHG Footprint
	• Capital Cost
	• LCC
	• Operational Complexity
	• Degree of Preliminary Treatment Required
	• Expansion Capability (flow/load)
	• Biosolids Production
	• Ability to Achieve Potential Stricter Limits (P, lower N)
	• Ability to Process Septage Filtrate
	• Compatibility with Wick Well for Effluent Disposal
• Site Suitability	• Footprint Required
	• Impact on Neighbors (odors, noise)
• Other/Overriding Considerations	• Proven acceptance by DEP
	• Market Availability (widespread availability vs. proprietary process from limited vendors)

The evaluation criteria were applied to each of the five technologies. In applying each of the criteria to each of the technologies, a consistent three level rating system was used as follows: (1) Good = 1 point; (2) Neutral = 0 points; and (3) Poor = -1 point.

The technologies selected for evaluation were as follows:

- Conventional Activated Sludge (CAS);
- Sequencing Batch Reactor (SBR);
- Integrated Fixed Film Activated Sludge (IFAS);
- Membrane Bioreactor (MBR); and

- Rotating Biological Contractor (RBC).

MBR achieved the highest weighted score by a fairly large margin. In this particular analysis, key differentiators were the low degree of operational complexity, expansion capability, the ability to reach potential lower permit limits in the future, and compatibility with the possible use of a Wick Well for effluent disposal, all of which MBR received higher ratings on.

Residuals/Septage Treatment - For reasons of economy of scale, impact to neighbors, and site constraints, it is anticipated that all treatment plant residuals from the proposed Meetinghouse Pond WWTF will be trucked to the proposed Overland Way WWTF site and co-processed with residuals there. Similarly, it is anticipated that septage receiving will occur only at the proposed Overland Way WWTF. AECOM would recommend that septage be processed directly with WWTF residuals to avoid the solids loading to the biological process that would result if it was introduced directly to the liquid train. An estimate of average solids generation from each source is summarized in Table 5-9.

Table 5-9 - Estimate of Average Solids Production from WWTF and Septage Receiving

Item / Constituent	Meetinghouse Pond WWTF Residuals	Overland Way WWTF Residuals	Septage Receiving at Overland Way WWTF	Combined Totals
Gal/d	1,157	2,625	16,000	19,782
TSS, %	1.80	1.80	0.36	0.64
TSS, lb/d	174	394	480	1,048

A similar process to what was used to evaluate the liquid train options was conducted for residuals/septage treatment.

With the site selected and projected residuals/septage quantities defined, AECOM used its experience with similar projects to define a list of applicable technology options. While dewatering is usually a two-step process requiring thickening first, there are a few technologies available that allow dewatering to acceptable solids levels with one device. Two thickening technologies, two dewatering technologies, and two combined thickening/dewatering technologies were selected for evaluation. A list of attributes important in the selection of an appropriate septage/residuals treatment technology was developed, and weighting factors were applied to reflect the importance of each attribute to the overall selection process. AECOM's wastewater process team ranked each technology selection on how well it met the requirements of each attribute. A weighted ranking was then totaled for each technology. A technology evaluation and screening criteria for the proposed wastewater treatment facility Residuals/Septage Treatment are discussed in detail in the TM (Appendix J), and included the following categories:

• Project Evaluation	• Operating Cost • Capital Cost • LCC • Operational Complexity • Transportation Costs • Solids Quality
• Compatibility with Site	• Footprint Required • Impact on Neighbors (odors, noise)
• Other/Overriding Considerations	• Proven acceptance by MassDEP • Market Availability (widespread availability vs. proprietary process from limited vendors)

The evaluation criteria were applied to each of the five technologies. In applying each of the criteria to each of the technologies, a consistent three level rating system was used as follows: (1) Good = 1 point; (2) Neutral = 0 points; and (3) Poor = -1 point.

The technologies selected for evaluation were as follows:

- Gravity Belt Thickener (GBT);
- Rotary Drum Thickener (RDT);
- Belt Filter Press (BFP);
- Rotary Press;
- Belt Filter Press w/pre-Thickening Zone; and
- Screw Press.

The screw press achieved the highest weighted score by a fairly large margin. A key differentiator in this analysis was the fact that the screw press didn't require a separate thickening step, which reduced the overall capital cost and footprint required for solids processing. Another category that set it apart was that because it is an enclosed system, control of odors and housekeeping are significantly less of an issue than with belt types of processes where the product is open to the ambient.

Overall Site Layout and Costs - AECOM estimates that if some of the existing tankage is utilized to mitigate hourly fluctuations in flow, four modular MBR treatment trains would be needed to satisfy initial design conditions. A fifth treatment train would be needed to accommodate future build-out conditions. Although AECOM would recommend the installation of only four treatment trains is currently recommended, the concrete pad, piping and connections should be designed to accommodate the fifth future train should the full build-out condition materialize.

With the assumption that all of the structures to the project north side of the road adjacent of the Chemical Feed Building are retained at the Tri-Town site, the total estimated project capital cost was estimated at $16.5M as in detail in the TM (Appendix J).

Annual Operation and Maintenance (O&M) Costs were estimated at approximately $972,000/year using the key assumptions detailed in the TM (Appendix J). Septage receiving revenue was estimated at $600,000, leaving the net estimated annual O&M costs $371,900.

<u>Meetinghouse Pond Service Area</u>

Liquid Train - A very similar evaluation of options for technologies was conducted for the proposed Meetinghouse Pond WWTF intended to service the Meetinghouse Pond service area. The same technologies evaluated for the proposed Overland Way WWTF were evaluated, with some minor changes to criteria and weighting. The primary changes were the addition of a selection criterion that favored commonality with the technology choice at the proposed Overland Way WWTF, and a stronger weighting for the impact on surrounding neighbors to reflect the more residential nature around the Beach Road site.

A technology evaluation and screening criteria for the proposed wastewater treatment facility Liquid Train are discussed in detail in the TM (Appendix J), and included the following categories:

- Project Evaluation
  - Energy/GHG Footprint
  - Capital Cost
  - LCC
  - Operational Complexity
  - Degree of Preliminary Treatment Required
  - Expansion Capability (flow/load)
  - Biosolids Production
  - Ability to Achieve Potential Stricter Limits (P, lower N)
  - Ability to Process Septage Filtrate
  - Compatibility with Wick Well for Effluent Disposal
- Site Suitability
  - Footprint Required
  - Impact on Neighbors (odors, noise)
- Other/Overriding Considerations
  - Compatibility with proposed Overland Way WWTF
  - Proven acceptance by DEP
  - Market Availability (widespread availability vs. proprietary process from limited vendors)

The evaluation criteria were applied to each of the five technologies. In applying each of the criteria to each of the technologies, a consistent three level rating system was used as follows: (1) Good = 1 point; (2) Neutral = 0 points; and (3) Poor = -1 point.

The technologies selected for evaluation were as follows:

- Conventional Activated Sludge (CAS);
- Sequencing Batch Reactor (SBR);
- Integrated Fixed Film Activated Sludge (IFAS);
- Membrane Bioreactor (MBR); and
- Rotating Biological Contractor (RBC).

As was the case for the proposed Overland Way WWTF, and for similar reasons, MBR achieved the highest weighted score by a fairly large margin. Again, key differentiators were the low degree of operational complexity, expansion capability, the ability to reach potential lower permit limits in the future, and compatibility with the possible use of a Wick Well for effluent disposal, for all of which MBR received higher ratings. Factors favoring MBR specific to the proposed Meetinghouse Pond WWTF were lower impact on neighbors and compatibility with the technology selection for proposed Overland Way WWTF.

Overall Site Layout and Costs - AECOM estimates that if upstream flow equalization is employed to mitigate hourly fluctuations in flow, two modular MBR treatment trains would be needed to satisfy initial design conditions, but would also have sufficient spare capacity to accommodate future build-out conditions. Flow equalization to mitigate hourly peaks would require a tank in the order of 65,000 gallons in volume. Waste sludge storage capacity is also needed and estimated at approximately 10,000 gals, which would supply about seven days of storage under future build-out conditions.

Because the proposed Meetinghouse Pond WWTF site is in a more residential/recreational area, it is assumed that measures will need to be taken to minimize the impact on the neighborhood from both the standpoint of odors, noise and visual aesthetics. AECOM recommends that the MBR modules and their ancillary equipment be housed in a building designed to match the visual appearance of the surrounding area to the extent possible. Similarly, the storage tanks can be located mostly below grade. AECOM estimates a building with a footprint of 45-feet x 65-feet will be required to house two MBR units and have additional lab and maintenance space. The equalization and storage tanks will be adjacent to the building along one of the 65-foot walls, projecting 15-feet from the wall, and having a total depth of 12-feet (10-below grade).

As previously indicated, capital costs assumed the proposed Meetinghouse Pond WWTF would be housed inside a building to lessen aesthetic and odor impacts on the surrounding neighborhood. Below grade storage tanks were included for both influent flow equalization, as well as waste biosolids storage. All biosolids processing was assumed to take place at the proposed Overland Way WWTF.

The total estimated project capital cost was estimated at $8.1M as in detail in the TM (Appendix J). Annual Operation and Maintenance (O&M) Costs were estimated at approximately $300,000/year using the key assumptions detailed in the TM (Appendix J).

AECOM would recommend that these costs and the pros/cons of modular construction be revisited during the design phases, but believes the concepts developed herein provide a sound strategy and planning level costs for consideration and funding allocation as the Town proceeds with its Water Quality and Wastewater Planning efforts.

6.4.3 Water Reuse Systems

6.4.3.1 General

The use of treated wastewater, also known as reclaimed water, recycled water, or effluent reuse water, is a supply of water for use in non-potable applications, including irrigation, industrial uses, toilet flushing, and aquifer recharge. The use of reclaimed water can satisfy many water demands but in many cases requires an enhanced or higher level of treatment where there is a greater chance of human exposure.

Reclaimed water can provide many advantages, particularly for locations where raw water supplies are limited, water infrastructure does not exist, and water quantity is not available. In addition, in many cases, cost effective water reuse systems allow business and industry to operate and expand at lower cost, and reduced water demand results in healthier rivers, streams, and lakes for recreation and wildlife.

An integral part of any Water Quality and Wastewater Planning program that includes the collection, treatment and disposal of wastewater effluent is the consideration of including effluent reuse. The reuse of treated wastewater requires a higher level of treatment but results in a reduced demand on municipal water supply systems and can enhance recycling of the nutrients remaining after treatment.

A Technical Memorandum (Appendix K) was prepared to discuss the current MassDEP Reuse Regulations; Advantages and Disadvantages of effluent reuse; Examples of Reclaimed Water in Massachusetts; Potential of Reclaimed Water Use in Orleans; and Conclusions and Recommendations.

6.4.3.2 Regulations

The MassDEP regulates the use of reclaimed water under 314 CMR 20.00: Reclaimed Water Permit Program and Standards. The regulations were established to regulate and permit reclaimed water systems and include requirements for the use, sale, and distribution of reclaimed water. In general, the regulations allow for reclaimed water reuse for the following uses:

- Irrigation as a source of water for recreational use;
- Industrial or commercial cooling, air conditioning, or boiler feed;
- Toilet and urinal flushing;

- Agricultural use;
- Creation of wetlands;
- Commercial (i.e. laundries, carwashes, snowmaking);
- Miscellaneous (i.e. fire protection, dust control, soil compaction, street cleaning); and
- Aquifer recharge.

The regulations do not allow for reclaimed water to be used as follows:

- Used or distributed in a manner within the Zone I of a public water supply well, the Zone A of a surface water source for a public water system, or within 100 feet of a private water supply well.
- Used or distributed in a manner that will cause or contribute to violations of the Massachusetts Surface Water Quality Standards, or impair the use of the ground water as an actual or potential source of potable water.
- Used or distributed in a manner that affects the water quality of any public source of potable water or private source of water used for drinking, domestic or culinary purposes.

MassDEP reclaimed water regulations state that in order to meet the EPA Class I Reliability Standards (EPA-430-99-74-001 – Design Criteria for Mechanical, Electrical, and Fluid System and Component Reliability), the wastewater treatment facilities have to be designed to include the following components:

- Two independent and separate sources of power, with the backup source sufficient to operate all vital components during peak flow conditions, together with critical lighting and ventilation;
- Unit redundancy;
- Additional storage or bypass to a discharge site; and
- Sufficient inventory of spare equipment and parts to minimize the time period that treatment facility operations are off-line.

The regulations establish three classes of reclaimed water reuse identified as Class A, Class B and Class C and are described in the TM (Appendix K).

6.4.3.3 Advantages and Disadvantages

The following summarizes some advantages and disadvantages of reclaimed water use.

Advantages

- Reduces demand on the municipal water supply system;
- Provides an increment of supply for growing communities in stressed basins;
- Provides an option for wastewater disposal;
- Provides a cost-effective supply for industrial users with large-scale demand for non-potable water, for industrial uses, cooling water, or toilet flushing;
- Reduces the impact of large developments;
- Decreases the diversion of freshwater from sensitive ecosystems;
- Reduces or eliminates treated wastewater discharges into sensitive water bodies;
- Creates or enhances wetlands and stream habitats; and
- Reduces reliance on commercial fertilizers to the extent that nitrogen and phosphorus in the reclaimed water can offset current uses on irrigated surfaces.

It should be noted that Item 3, Item 7 and Item 9 are the most relevant to the Town of Orleans.

Disadvantages

- Increased public education required;
- Increases capital costs since additional equipment (i.e. pumps, tanks, analyzers, etc.) as well as distribution piping are required for the reuse system and therefore increase capital costs above and beyond the typical WWTF;
- Increases operation and maintenance costs since additional equipment (i.e. pumps, tanks, analyzers, etc.) for the reuse facilities will increase O&M;
- Increases monitoring costs since MassDEP requires additional monitoring for reuse facilities above and beyond the normal WWTF monitoring and reporting process;
- Increases level of oversight to ensure that reclaimed water is not used for inappropriate purposes (MassDEP requires the monitoring occur so that the reuse that is permitted for a specific purpose is not used for another purpose without an increase in treatment {i.e. Class C – Boiler Feed and then used for Class A Snowmaking}); and

- Adds legal and administrative costs related to customer agreements.

6.4.3.4 Examples of Reclaimed Water in Massachusetts

Examples of Reclaimed Water in Massachusetts were summarized in the TM (Appendix K) and included the following locations:

- Yarmouth-Dennis Septage Treatment Facility, Yarmouth, MA
- Wrentham Premium Outlet Mall, Wrentham, MA;
- New Seabury Properties, LLC, Mashpee, MA;
- EMC Corporation, Hopkinton, MA;
- Gillette Stadium, Foxborough, MA; and
- Linden Ponds Retirement Community, Hingham, MA.

6.4.3.5 Potential of Reclaimed Water Use in Orleans

Previous reports have been developed for the Town and have indicated that the use of reclaimed water should be considered as a viable enhancement to the Town's Water Quality and Wastewater Program for many of the reasons outlined above.

The most recent document (Conceptual Reclaim Water System Memorandum by Stantec dated October 17, 2014) indicates that the theoretical demand of reclaimed water for irrigation approaches 460,000 gpd (69 MG / 150 irrigation days). These potential irrigation sites included:

- Ocean Edge Golf Course – 15 MG annual demand;
- Captain Golf Courses (Port Course and Starboard Course) – 30 MG annual demand;
- Wequassett Resort and Golf Club - 15 MG annual demand;
- Orleans Cemetery - 3 MG annual demand;
- Orleans Athletic Fields on Eldredge Park Way – 3 MG annual demand; and
- Brewster Athletic Fields on Freemans Way (4 fields) – 3 MG annual demand.

The document indicted that a reclaimed water system would include a pumping system, storage tank and distribution network and has an “order of magnitude” cost of about $12,000,000 as shown below.

Reclaim Water Pumping system	$100,000
Reclaim Water Storage Tank	$500,000
Reclaim Water Distribution Network (12 miles X 5,280 feet/mile = 64,000 lf at $180/lf)	$11,500,000

6.4.3.6 Conclusions and Recommendations

Recent discussions with the Town of Brewster on March 24, 2016 indicated that the use of reclaimed water would be limited since the sites are located in nitrogen sensitive areas.

The incorporation of a reclaimed water system increases the capital, operation and maintenance, replacement and monitoring costs of the proposed WWTF. While the costs within the limits of the proposed WWTF are modest, the cost of the distribution system necessary to bring the treated wastewater to the various points of use would be substantial, as indicated by the $12 million estimate previously developed. AECOM has reviewed this estimate, and concurs that it is in the right order of magnitude.

The incorporation of a reclaimed water system does not result in a reduction of effluent disposal capacity since the current state rules and regulations require that an effluent disposal system be incorporated into the project plan in case effluent quality degrades to a level that is not acceptable for reuse.

Preliminary communications with the Town of Brewster and Brewster golf courses did not identify useful options, but that there are other private and public sites in Brewster that will be investigated during the next phase of planning/design, such as the Brewster Day Camp, Ocean Edge and Nickerson State Park, and the stone/concrete company.

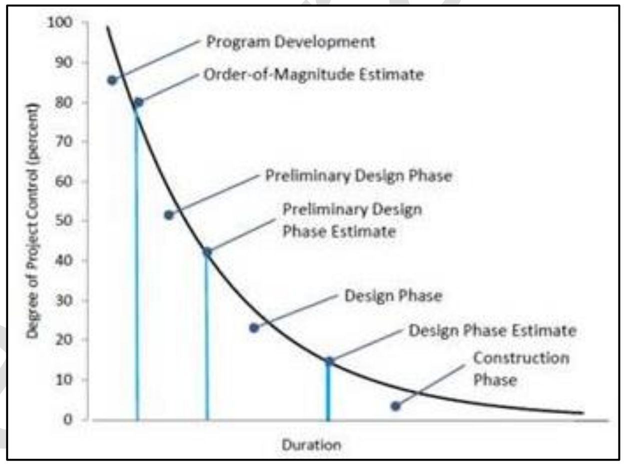
In conclusion, the incorporation of a reclaimed water system at the proposed WWTF site would increase the capital, operation and maintenance, replacement and monitoring costs at the WWTF. Additionally, because there are no large scale users of irrigation water in immediate proximity to the proposed WWTF site, there is considerable capital expense associated with a distribution system to bring reclaimed water to potential points of use. Lastly, there is some uncertainty on whether or not some of the identified points of use would be viable due to watershed concerns and/or public perception issues. At a time when implementation of different elements of the Town’s Water Quality and Wastewater Program is subject to limited revenues, AECOM recommends that water reclamation not be included in the Program at this time. The currently recommended treatment process for the proposed Overland Way WWTF lends itself well to being modified for water reclamation in the future should water reclamation prove to be more viable at a later date, but items such as storage, color treatment, and most importantly a distribution system are not recommended at this time.

6.4.4 Project Cost Estimates

A Project Cost estimate was prepared for each of the Traditional and Non-Traditional technologies. The details of these estimates are included in the various Technical Memorandums included in Appendices. This included estimates for the Non-Traditional Demonstration Projects, as well as best estimates for the full-scale implementation projects, assuming the technologies are cost-effective

6.4.4.1 Development of Program Costs

Cost estimating is a critical component of project evaluation in the early stages of planning and concept design, before selection of a definitive plan and commitment of any funds. The Program Costs were developed with AECOM in-house specialists who provide cost estimates for construction and operation using industry standards for materials and labor as well as actual bid tabs from a library of projects. Supplemented with information obtained from the Project's interactive workshops and a collaborative process to fully understand the cost implications of the various alternatives, these comprehensive costs allow for informed decision making.



The Program Costs include Capital Costs, Annual Operation and Maintenance Costs, Replacement Costs and Monitoring Costs. These costs obviously vary with the specific design considerations and layout configurations, etc.

The Program Costs presented are planning level costs and should be refined as additional informational details are identified and/or determined. This refinement to the project scope includes topographic survey, subsurface exploration, types of equipment, redundancy, and types of control systems. In addition, project constraints, project schedule, and overall project complexity will impact Program Costs. It is recommended that planning level Program Costs be updated just prior to appropriation of funding for design and construction.

The Program Costs are preliminary in nature and contain construction cost, construction contingencies, administrative, legal, construction engineering, environmental and regulatory permitting. The Class 3 opinion of probable construction costs were developed in accordance with "AACE International Recommended Practice No. 18R-97 - Cost Estimate Classification System – As Applied in Engineering, Procurement, and Construction for the Process Industries" as prepared by the Association for the Advancement of Cost Estimating (AACE) International (www.aacei.org) dated February 2, 2005. Refer to Table 5-11 for the AACE International Cost Estimating classification system.

Table 5-11 - AACE International Cost Estimating Classification System

Estimate Class	Primary Classification	Secondary Classification			
	Level of Project Definition[1]	**End Usage[2]**	**Methodology[3]**	**Expected Accuracy Range[4]**	**Preparation Effort[5]**
5	0 to 2 percent	Concept Screening	Capacity Factored, Parametric Models, Judgment or Analogy	L: -20 to -50 percent H: +30 to +100 percent	1
4	1 to 15 percent	Study or Feasibility	Equipment Factored or Parametric Models	L: -15 to -30 percent H: +20 to +50 percent	2 to 4
3	10 to 40 percent	Budget Authorization or Control	Semi-Detailed Unit Costs with Assembly Level Line Items	L: -10 to -20 percent H: +10 to +30 percent	3 to 10
2	30 to 70 percent	Control or Bid Tender	Detailed Unit Cost with Forced Detailed Take-off	L: -5 to -15 percent H: +50 to +20 percent	4 to 20
1	50 to 100 percent	Check Estimate or Bid Tender	Detailed Unit Cost with Detailed Take-off	L: -3 to -10 percent H: +3 to +5 percent	5 to 100

Notes:

1 Expressed as percent of Complete Definition

2 Typical Purpose of Estimate

3 Typical Estimating Method

4 Variation of Low and High Ranges. The state of process technology and availability of applicable reference costs data affect the range market. The +/- value represents percentage variation of actual costs from the cost estimate after application of contingency (typically at a 50 percent level of confidence) for given scope.

5 Typical Degree of Effort Relative to Least Cost Index of 1. If the range index value of “1” represents 0.005 percent of project costs, then an index value of “100” represents 0.5 percent. Estimate preparation effort is highly dependent upon the size of the project and the quality of estimating data and tools.

AECOM has no control over costs of labor, materials, competitive bidding environments and procedures, unidentified field conditions, financial and/or market conditions or other factors likely to affect the opinion of probable project costs all of which are and will unavoidably remain in a state of change. It is further understood that the probable project costs are a "snapshot in time" and that the reliability of this opinion of probable project costs will inherently degrade over time. The probable project costs need to be indexed on a common "baseline". The construction industry uses the Engineering News Record (ENR) Construction Cost Index (www.enr.com) that is based on construction and materials costs throughout the United States. Therefore, the probable project costs contained herein are based on an ENR Construction Cost Index of 10182 for February 2016.

6.4.4.2 Capital Costs

Capital Costs are those to construct any type of wastewater treatment system including Non-Traditional and Traditional technologies. Capital Costs are generally financed through a loan or bond program. This provides up front funding for construction, with principal and interest payments spread out over time. Estimates have been developed to show Capital Costs by each type of system component. Defining costs by individual system component is essential given the eligibility requirements of different financing programs and revenue sources. Included in the Capital Costs were land purchases, at $200,000 per acre, required for locations of pumping stations that are not proposed on existing municipally owned land.

6.4.4.3 Operation and Maintenance Costs

Operations and Maintenance (O&M) Costs relate to the day-to-day running and upkeep of the Non-Traditional and Traditional technologies. O&M Costs include items such as labor, utilities, chemicals, etc. In order to achieve maximum asset life and reduce O&M costs, the establishment of standardized O&M procedures is critical. Standardized procedures help personnel operate all assets within acceptable operational levels and ensure that each person is following the same routines. Lack of regular maintenance may result in the deterioration of the system components and result in rapid failure and reduced nitrogen removal from the environment as well as the ability to meet operating permits. O&M Costs are an annual cost generally paid through fee or tax revenues as costs accrue. O&M Costs will vary greatly by technology solution and have been estimated on a technology-by-technology basis.

6.4.4.4 Replacement Costs

In addition to O&M Costs, components will malfunction or fail and therefore Replacement Costs, including Repair Costs, become a necessary part of the overall costs of the wastewater system. Replacement Costs are used to replace various pieces and parts of the Non-Traditional and Traditional technologies that have failed or malfunctioned such as the injection of liquid organic carbon (i.e. emulsified vegetable oil) for PRBs or to replace a broken pump bearing. As part of an Asset Management Program, a schedule of assets with their useful life should be developed since understanding the costs for partial replacement and full replacement of an asset will become necessary for sound financial planning. If more funding is spent on a repair to an asset, there will be a decreased need for the replacement of the asset. However, if greater funding is spent to replace the asset, therefore will be a decreased need for repairs to an asset. Overall there is a balance between how much to fund in each category in order to achieve the most efficient system. Like Capital Costs, Replacement Costs are generally financed through a loan or bond program. This provides up front funding for construction, with principal and interest payments spread out over time. Estimates have been developed to show Replacement Costs by each type of system component. Defining costs by individual system component is essential given the eligibility requirements of different financing programs and revenue sources.

6.4.4.5 Monitoring Costs

Monitoring of the Non-Traditional and Traditional technologies is an essential component of adaptive management. Monitoring will assess the effectiveness of the different technologies to remove nitrogen from the environment. The results of monitoring will indicate which technologies are working and which are less successful. This allows adjustments in the phased approach to improve overall performance of the solution. Like O&M Costs, Monitoring Costs are an annual cost generally paid through fee or tax revenues as costs accrue. Monitoring Costs will vary greatly by technology solution and have been estimated on a technology-by-technology basis.

The Project Cost estimates for Traditional and Non-Traditional technologies are shown in Table 5-12.

Table 5-12 - Project Cost Estimates

Components	Capital Cost	Annual O&M Cost	Replacement Cost	Annual Monitoring Cost
Traditional Technologies				
Downtown Area				
Collection System - Downtown Area	$ 24,180,400	$ 261,400	$ 41,700	$ 11,900
Wastewater Treatment Facility - Downtown Area (Overland Way)	$ 16,539,300	$ 952,600	$ 256,300	$ 16,900
Effluent Disposal - Downtown Area (Overland Way - Parcel 1/1A)	$ 2,902,200	$ 11,300	$ -	$ 10,800
	$ 43,621,900	$ 1,225,300	$ 298,000	$ 39,600
Meetinghouse Pond Area				
Collection System - Meetinghouse Pond	$ 21,203,300	$ 166,800	$ 34,600	$ 3,000
Wastewater Treatment Facility - Meetinghouse Pond (223 Beach Road)	$ 8,003,100	$ 284,300	$ 112,700	$ 16,900
Effluent Disposal - Meetinghouse Pond (223 Beach Road)	$ 1,189,000	$ 11,300	$ -	$ 10,800
	$ 30,395,400	$ 462,400	$ 147,300	$ 30,700
Non-Traditional Technologies				
Floating Constructed Wetlands				
Floating Constructed Wetlands - Demonstration 1 - Data Refinement	$ 50,000	$ -	$ -	$ -
Floating Constructed Wetlands - Demonstration 2 - Lonnie's Pond	$ 1,821,900	$ 13,600	$ 24,500	$ 127,100
Floating Constructed Wetlands - Site 1 - Cost Effectiveness to Be Validated	$ 12,338,800	$ 68,000	$ 128,000	$ 367,500
Floating Constructed Wetlands - Site 2	$ -	$ -	$ -	$ -
Floating Constructed Wetlands - Site 3	$ -	$ -	$ -	$ -
Floating Constructed Wetlands - Site 4	$ -	$ -	$ -	$ -
Floating Constructed Wetlands - Site 5	$ -	$ -	$ -	$ -
Aquaculture/Shellfish Propagation				
Aquaculture/Shellfish Propagation - Demonstration 1 - Terminal Pond Oyster Bed	$ 126,900	$ 143,800	$ -	$ -
Aquaculture/Shellfish Propagation - Demonstration 2 - Quanset Pond Oyster Bed	$ 49,900	$ 216,400	$ -	$ 54,700
Aquaculture/Shellfish Propagation - Demonstration 3 - Shellfish Extension Program	$ 76,900	$ -	$ 512,500	$ 58,900
Aquaculture/Shellfish Propagation - Demonstration 4 - Quahog Inventory	$ 50,800	$ -	$ -	$ -
Aquaculture/Shellfish Propagation - Site 1 - Shellfish Extension Program	$ 432,300	$ 283,300	$ 409,900	$ 58,900
Aquaculture/Shellfish Propagation - Demonstration 2 - Quanset Pond Oyster Bed (2nd Year)	$ 756,700	$ -	$ -	$ 59,500
Aquaculture/Shellfish Propagation - Full Scale Location TBD	$ 1,080,800	$ 56,700	$ 153,700	$ 59,500
Permeable Reactive Barriers				
Permeable Reactive Barriers - Demonstration 1 - Landfill Focused Injection Test	$ 164,100	$ -	$ 8,700	$ 110,300
Permeable Reactive Barriers - Demonstration 2 (Eldredge Park South Main St. Area)	$ 593,800	$ -	$ 17,100	$ 244,300
Permeable Reactive Barriers - Site 1 - Landfill (550 L.F.)	$ 526,000	$ -	$ 350,200	$ 117,500
Permeable Reactive Barriers - Site 2 Eldredge Park (3,500 L.F.)	$ 2,934,800	$ -	$ 359,480	$ 433,700
Permeable Reactive Barriers - Site 3	$ -	$ -	$ -	$ -
Permeable Reactive Barriers - Site 4	$ -	$ -	$ -	$ -
Permeable Reactive Barriers - Site 5	$ -	$ -	$ -	$ -
	$ 21,003,700	$ 781,800	$ 1,964,080	$ 1,691,900
Other Program Components				
Adaptive Management Implementation	$ 6,217,000	$ -	$ -	$ -
Program Management	$ 4,217,900	$ -	$ -	$ -
Miscellaneous	$ 212,500	$ -	$ -	$ -
	$ 10,647,400	$ -	$ -	$ -
Totals	**$ 105,668,400**	**$ 2,469,500**	**$ 2,409,380**	**$ 1,762,200**
Septic Impact Fee	$ 200	per On-Site System		

Engineering News Record (ENR) = 10182 (Feb. 2016)

7.0 Tri-Town Transition Requirements

7.1 Background

The Orleans-Brewster-Eastham Groundwater Protection District (Tri-Town District) owns and operates the Tri-Town Septage Treatment Facility, located on Overland Road in Orleans, MA. The Facility was constructed over 30 years ago and is designed to treat up to 45,000 gallons per day of septage and grease. A document entitled "Tri-Town Septage Treatment Facility Decommissioning Action Plan", dated October 18, 2013 was prepared by Stantec Consulting Services Inc. for the Tri-Town District. The purpose of the report was to develop an action plan to decommission and demolish the Tri-Town Septage Treatment Facility prior to May 30, 2015 (expiration date of the agreement). Following the preparation of the report, the Tri-Town District agreement and the Facility's MassDEP Groundwater Discharge Permit were both extended until December 2016.

The Tri-Town Septage Treatment Facility has reached the end of its useful life and the Tri-Town Septage Treatment Facility Board of Managers voted not to fund interim improvements estimated at approximately $1,000,000 for a 5-year extended life and ultimately to cease receipt of septage on June 1, 2016.

7.2 Estimated Costs

AECOM's estimated cost to decommission and demolish the Tri-Town Septage Treatment Facility including demolition, site restoration, engineering and contingencies is estimated at $2,025,000. The results are shown in the attachment following the TM (Appendix L). AECOM estimates that a savings of 10 to 20 percent ($200,000 to $400,000) can be realized if the decommissioning and demolition of the Tri-Town Septage Treatment Facility is included as part of the construction of a new Wastewater Treatment Facility at the site. The potential cost savings does not include the potential additional cost savings that might be achieved through repurposing some of the existing facility (e.g. – administration building) as part of the new Wastewater Treatment Facility. These potential cost savings were considered as the concept for the proposed new Wastewater Treatment Facility developed as part of Task No. 1 – Facilities Engineering, subtask C Facilities Preliminary Design.

7.3 Schedule

- Plant decommissioning will take about 3-months;
- Towns voted to extend 3-month salary retention offer to employees to stay at the plant to conduct plant decommissioning process;
- Design of demolition was procured and contracted on June 8, 2016 Town Meeting and take about 5 months;
- Bid in hand for demolition by March 1, 2017 to allow Town Meeting Appropriations (Brewster, Eastham, and Orleans); and
- Demolition to expect to start in September 2017 and be completed March 2018.

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8.0 Demonstration Project Design and Implementation

The Consensus Plan (Figure 4-1) recommended three Non-Traditional (NT) technologies for use in key locations in Orleans' sub-watersheds in order to reduce nitrogen loading in the Town's coastal estuaries: Floating Constructed Wetlands (FCW), aquaculture/shellfish propagation, and permeable reactive barriers (PRBs). This section describes each of these NT tools, discusses site selection for demonstration projects for each NT, and describes the work plan associated with the demonstration projects.

8.1 Floating Constructed Wetlands

Floating Constructed Wetlands (FCW) are one of the Non-Traditional (NT) tools being tested by the Town of Orleans to determine the efficacy in managing nitrogen within the Town's water resources. The intent of including the FCWs as part of the Nitrogen management solution is to use the constructed ecosystems to mimic natural floating wetlands to aid in nutrient removal and potentially provide other potential ecosystem services such as wave attenuation, habitat and food structure and refuge for fish and other marine life.

The Site Characterization and Evaluation Technical Memorandum (Appendix M) documents the process used to identify, evaluate, rate, rank and ultimately recommend specific demonstration sites to test the efficacy of FCW to remove nitrogen from the estuarine waters located within the Town of Orleans, and the Work Plan Technical Memorandum (Appendix N) sets forth the preliminary design of the FCW, including the project components, sequencing of subtasks, the equipment, labor and other resources required to construct the FCW, and a preliminary cost estimate. The FCW Work Plan also sets forth a draft monitoring and maintenance plan, along with potential regulatory requirements and funding sources.

8.1.1 Description of Floating Constructed Wetlands

FCWs are man-made rafts that float on the water's surface and are planted with native plants. The FCWs provide habitat and surface-area for a wide range of naturally-occurring attached growth microorganisms and invertebrates. As water passes through the system, nitrogen, phosphorus, biological oxygen demand, total suspended solids and fecal coliforms can be reduced.

The key feature of FCWs is their high surface area-to-footprint ratio, which enables them to perform functions similar to a natural wetland treatment system but in a fraction of the space. The FCW can be designed into any shape or size, but a typical section is rectangular. Any number of sections can then be connected together by cable to create a unit. The FCWs will be anchored to stay in one area of the surface water body, but rise and fall naturally with the tide. FCWs have a draft of about 6 inches, and would likely be located in water depths of approximately 5 - 6 feet. This would minimize disturbances to the benthic environment.

FCWs remove pollutants from the water column by four main processes: physical, biogeochemical, microbial and plants. The larger surface area created by the plant roots increases sedimentation, microbial decomposition, nitrification and denitrification, and alters water chemistry.

Denitrification by FCWs occurs by producing anoxic conditions through the restriction of oxygen diffusion into the water column. Also, roots and plant litter act as sorption sites, with biofilms developing which increase denitrification rates and thus nitrate removal rates (Vymazal, 2007). Plant uptake accounts for a small percentage of nutrient (N and P) removal in FCWs (Dodkins and Mendzil 2014).

8.1.2 2015 Site Reconnaissance

The initial FCW sites identified in the Hybrid Plan developed during the OWQAP process were reviewed by the AECOM team on maps and in the field through reconnaissance surveys in the fall of 2015. This reconnaissance review served to determine the final list of sites to be further evaluated as potential demonstration project locations.

Prior to the field visit, it was determined by the AECOM team that freshwater water bodies did not meet one of the criteria of the FCW demonstration projects since the results would not be replicable in the estuarine water bodies of Orleans. As a result, Boland Pond, Crystal Lake and Pilgrim Lake were removed from the list of potential sites. Rock Harbor was also determined to not be feasible for purposes of the FCW demonstration project due to its narrow harbor and heavy boat traffic through the harbor. These factors would not allow for a large square footage of FCW in Rock Harbor, and would also decrease the likelihood of successful establishment and survival of a FCW system due to the high potential for disturbance.

Therefore, the final list of sites reviewed as part of the 2015 reconnaissance field surveys were: Lonnie's Pond, Mill Pond, Namequoit River, Paw Wah Pond, Pleasant Bay, Pochet Neck, Quanset Pond, Town Cove, and Upper River.

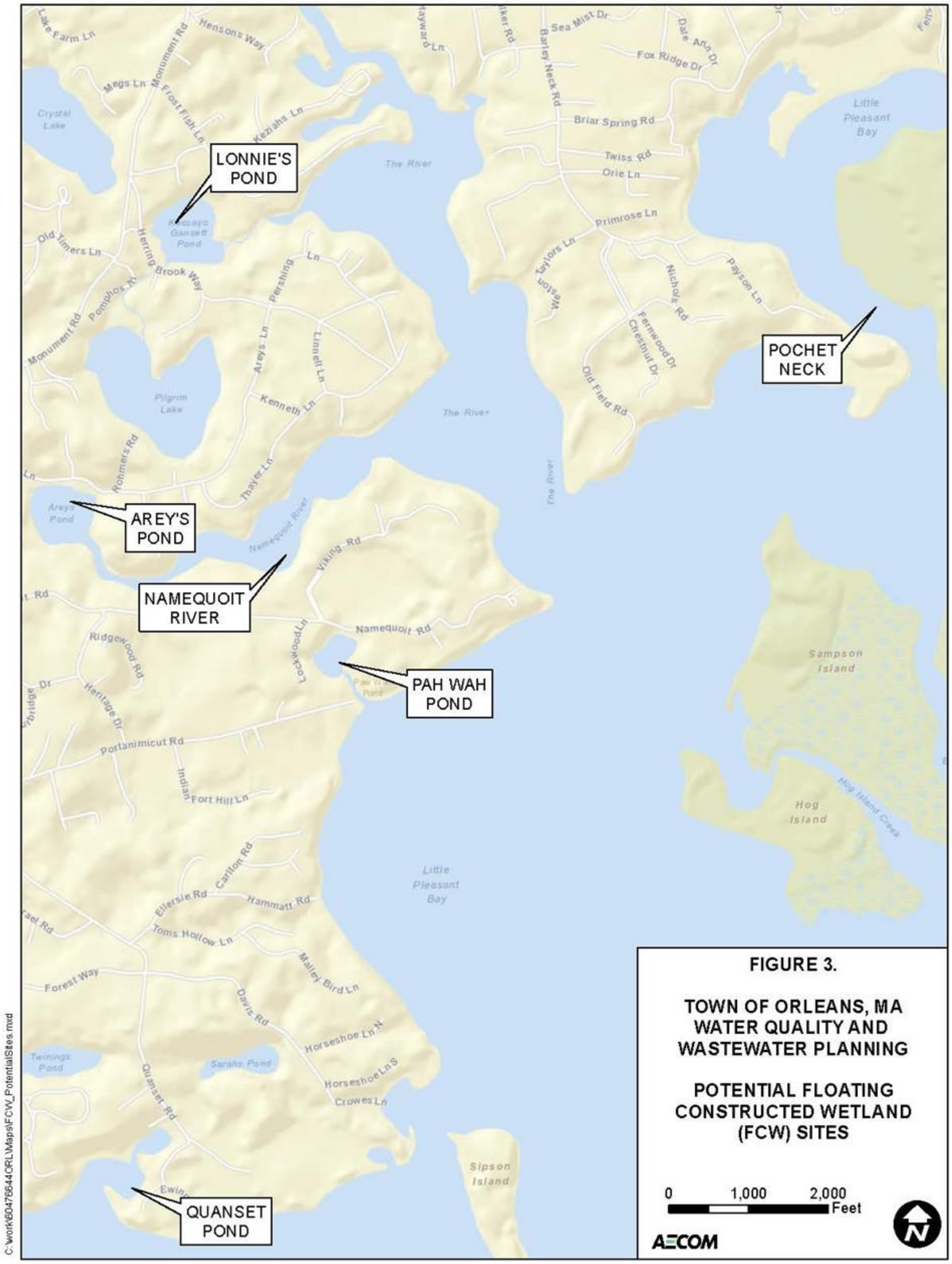
Based on the reconnaissance field survey, the list was further narrowed. Large water bodies with complex hydrological systems were removed from the list, as these features would make it difficult to measure nitrogen changes due to the installation of FCW. These two large waterbodies were Pleasant Bay and Town Cove. In addition, Mill Pond and Upper River were removed from the list due to the relatively small amount of available surface water space relative to the large number of boat moorings and boating activity in the area.

As a result of the previous efforts, and the reconnaissance field review of potential sites, the list of potential sites available for a FCW demonstration project were narrowed down to five sites, as listed below and shown on Figure 7-1 – Potential Floating Constructed Wetland Sites:

- Lonnie's Pond;
- Namequoit River (with access through Arey's Pond);
- Paw Wah Pond;
- Pochet Neck; and
- Quanset Pond;

Because of the similarities in the five sites, the parameters reviewed for comparative purposes were targeted to differentiating features rather than common characteristics. Sites were reviewed to better understand site conditions and allow for comparison between sites centered on information about site hydrology (i.e. water flow), size of available surface water, and general surrounding water and land use conditions.

Figure 7-1. Potential sites for floating constructed wetland demonstration projects



8.1.1 Enumerate Site Evaluation and Screening Criteria

To facilitate a systematic and objective evaluation of each of the potential demonstration sites, a site selection matrix was developed. The matrix includes a number of criteria obtained from the site conditions and observations to determine the overall site suitability for hosting a FCW demonstration project. The site selection criteria used were: use conflicts, utility infrastructure conflicts and benefits, ease of access, land ownership, depth of water, overall likelihood of monitoring plan to yield quantifiable results, and regulatory criteria/permittability.

Additional considerations include the aesthetics of the FCW on the local surroundings and overall community buy-in of the demonstration project. At this point in the review process, the information about the project and the potential site is not developed enough to include this criterion within the matrix. However, once a potential site is recommended, it will be fully vetted and aesthetic and community buy-in must be considered.

8.1.2 Analysis: Evaluate and Rate Each Site based on Criteria

To rate each criterion in the Site Selection Matrix, the AECOM team collected available data, reviewed past reports and site maps, and conducted a site visit by land and by water. A rating system was then developed to quantify how well each site met a specific criterion. The point-based system is as follows:

- Good = 1 point: A good rating (1) was assigned if the criterion could be met fully.
- Neutral = 0 points: A neutral rating (0) was assigned if the criterion could be met in part, but there were some potential issues and/or difficulties
- Poor = -1 point: A poor rating (-1) was assigned if the criterion could not be met.

It was determined by the team that no one criterion was most important than another, and therefore, each criterion was assigned equal weight. After the sites were rated for each criterion, an overall rating for each site was developed and sites were ranked in order of favorability. Results are presented in the following section.

8.1.3 Findings/Recommendations

The total rating and ranking of the sites is as follows:

- Recommended Site – Lonnie's Pond, 5 points;
- Quanset Pond, 3 points;
- Paw Wah Pond, 1 point;
- Namequoit River, -1 point; and
- Pochet Neck, -1 point.

These results were consistent with the overall assessment of the team after the field visits were completed, but before the site suitability matrix was developed and completed. The main reasons for Lonnie's Pond being ranked the highest potential site is due to the site's configuration including the narrow channel that outlets to the River, the existing stormwater pipe that discharges into the site, shallow depths in the area near the stormwater pipe, overall shallow depth of the pond, the ease of access to the site, and the lack of potential user conflict. The four other final sites were found to be suitable for purposes of siting a FCW system; however, their site properties were found to be more difficult to monitor and measure changes in water quality. Specifically, although Quanset Pond and Paw Wah Pond are similar to Lonnie's Pond in many ways, in general these two sites have a relatively smaller surface area available for use for the FCW project and in general are deeper. Namequoit River and Pochet Neck are much more open systems, hydrologically, and would present additional challenges when trying to measure water quality differences due to the placement of the FCW.

8.1.4 Preliminary Design

The preliminary design includes two floating modules**,** each approximately 16,250 square feet in size, which will cover 5 percent of the surface waters at Lonnie's Pond. The modules will be made from a polymer material made from plants, and will include an internal connection system using 3/16 stainless steel cable. The design layout is illustrated in the TM Appendix N. The floating modules will be anchored utilizing helical anchors and a combination of galvanized steel cable and elastic mooring units and will be planted with *Spartina alterniflora. W*aterfowl fencing will be placed around each unit to deter waterfowl and shorebirds. Project components, sequencing of tasks and labor resources needed are detailed in Appendix N.

8.1.5 Monitoring and Maintenance

The objective of this study is to evaluate the effectiveness of an array of FCW deployed in Lonnie's Pond to reduce nitrogen. For this evaluation, the focus of the monitoring will include in situ water quality sampling as well as assessments of standing macrophyte dry weight biomass and biofilm analysis. The data collected for the Lonnie's Pond FCW will be compared to other performance data on estuarine FCW in Baltimore Harbor (National Aquarium and Waterfront Partnership of Baltimore, Inc. 2011) and from other natural marshes that can provide reference conditions and an understanding of relative performance.

Small round samples of FCW material "pucks" will be attached to the undersides of the FCW. Each puck is approximately 100 mm in diameter and 15 mm thick, weighing on average 3.5 – 4.0 grams. A subset will be removed seasonally to collect data on epiphyte biofilm establishment and colonization by macro/micro invertebrates. Seasonal measurements of redoximorphic conditions (i.e. temperature, oxygen, acidity, iron, manganese) will be made of each island to determine if the conditions exist for nitrification or denitrification. A calculation of the combination of the macrophyte biomass and epiphyte biofilm nutrient absorption and uptake will be made.

Maintenance requirements include visual inspections of the FCWs on a monthly basis. The main purpose of the maintenance inspections will be to confirm that project integrity is maintained and to document any changes to the units or the surrounding area. Maintenance activities will include: inspection to confirm integrity of all submerged hardware and anchoring, and above water tethering and waterfowl fencing; health of plants, and replanting where necessary; removal of man-made and natural debris; and periodic inspection for signs of vandalism, natural degradation of base material, mechanical (tearing), waterfowl use, or ultra-violet (UV) damage (discoloration).

8.1.6 Project Cost Estimate

A cost estimate for the FCWs was estimated and is provided in Appendix B of the TM (Appendix N). The cost estimate is based on the conceptual design, and will be refined after additional engineering analyses are conducted. The cost estimate includes the following elements: mobilization and demobilization; fabrication (base material, anchoring, cabling); plant and planting medium; installation; maintenance; monitoring – lab and in-situ; contingency; and town administration and engineering.

The FCW demonstration project would be located in a resource area subject to jurisdiction by MassDEP under the Massachusetts Wetlands Protection Act (WPA) regulations (310 CMR 10.00), Chapter 91 regulations, (310 CMR 9.00), and 401 Water Quality Certification regulations (310 CMR 4.00), while the US Army Corps of Engineers has jurisdiction over the pond under the federal Clean Water Act. In addition, the Town of Orleans Conservation Commission has jurisdiction over Lonnie's Pond under both the Orleans Wetland By-law and the MA WPA regulations. Lonnie's pond is located in an Area of Critical Environmental Concern (ACEC), which triggers the need for MEPA review. Based on available on-line mapping tools available from the MA Natural Heritage and Endangered Species Program (NHESP), the pond appears to be located just outside of an area of Estimated Habitat of Rare Wildlife that includes most of Pleasant Bay.

Many of the general funding mechanisms for the overall wastewater management program, as discussed in Section 10, would also be potential funding mechanisms for the FCW Demonstration or Full Scale Implementation Project. In addition, potential funding sources available specifically for constructed wetlands were researched and websites with additional information on each funding opportunity are listed in Table 7-1.

8.1.7 Next Steps

The next step recommended before implementation of the FCW Demonstration Project is to conduct additional research regarding potential nitrogen removal rates that can be achieved by FCWs in estuarine water bodies. Although data regarding FCW nitrogen removal rates for non-saline (freshwater) stormwater ponds have been reviewed, no measurements of nitrogen removal rates by FCWs in estuarine embayments have been undertaken. Additional literature research on nitrogen removal rates in biofilms in estuarine habitats such as rocky intertidal zones is recommended to ascertain whether or not this data would aid in further refining the range of nitrogen removal rates anticipated by FCWs in estuarine waters, and therefore the optimal size of the FCW Demonstration Project.

In addition, Biohabitats has FCWs installed in Baltimore Harbor, Maryland and Jamaica Bay, New York. While nitrogen removal rates from these installations are not being actively measured, additional research could be undertaken to retrofit these installations to attempt to measure nitrogen removal rates using laboratory analysis.

Table 7-1. Potential Funding Sources for Floating Constructed Wetland Demonstration Project

Grant Title	Website
US EPA Wetlands Program Development Grants	https://ofmpub.epa.gov/apex/watershedfunding/f?p=109:2:::NO::P2_X_PROG_NUM,P2_X_YEAR:65,2015
North American Wetlands Conservation Fund	https://www.cfda.gov/index?s=program&mode=form&tab=core&id=97dc7d8a3d12b63a01dec93e3a73c1c9
U.S. Fish and Wildlife Service, Wildlife and Sport Fish Restoration: National Coastal Wetlands Conservation Grant Program	http://www.fws.gov/coastal/CoastalGrants/index.html.
5 Star Wetland and Urban Waters Restoration Grants	http://www.nfwf.org/fivestar/Pages/home.aspx
MA CZM Coastal Pollutant Remediation (CPR) Grant Program	http://www.mass.gov/eea/agencies/czm/program-areas/coastal-water-quality/cpr/.
North American Wetlands Conservation Act Grants	http://www.fws.gov/birds/grants/north-american-wetland-conservation-act.php
Massachusetts Environmental Trust (MET) General Grants	http://www.mass.gov/eea/grants-and-tech-assistance/grants-and-loans/mass-enviro-trust/met-grants.html.

8.2 Aquaculture/Shellfish Propagation

The purpose of the Orleans shellfish demonstration is to both locally measure the nitrogen-removal benefits of shellfish cultivation, as well as demonstrate the practical applications of shellfish propagation and aquaculture expansion within the Town of Orleans. The AECOM Shellfish Team has taken a two-step approach to plan and design demonstration projects for Orleans. The first step is to review existing data and evaluate a number of potential sites for overall suitability using a variety of criteria. This siting evaluation provides a transparent and objective assessment of possible locations in Orleans for the installation of shellfish based Non-Traditional technology demonstration projects. Comments received on the draft memo, and the team's responses were also part of the evaluation process used to identify locations for shellfish demonstration projects.

In Orleans, the most suitable shellfish species for aquaculture include American (or Eastern) oyster (*Crassostrea virginica*), hard clam (or northern quahog) (*Mercenaria mercenaria*), and blue mussel (*Mytilus edulis*). Shellfish aquaculture for Orleans involves growing single oysters and/or quahogs in gear such as bags, trays or cages until these shellfish reach a suitable size for bottom planting or harvest. Aquaculture systems that require supplemental feeding to support growth are not under consideration. Blue mussels were evaluated and rejected for a demonstration project due to the difficulty of growing this species at this time. Nitrogen-removal calculations are based on average shellfish uptake as demonstrated in published literature as well as through personal experience by the assembled Team.

The Final Site Characterization and Evaluation TM (Appendix O) presents the process used to identify, evaluate, rank and ultimately recommend specific shellfish demonstration sites. The Memorandum details: a description of the initial process that was employed to develop the Orleans Consensus Plan and associated potential demonstration sites; next steps that have been taken in the process of evaluating demonstration sites; data that is available to help evaluate potential demonstration sites; evaluation and ranking of sites based on the site selection matrix and criteria; recommended demonstration sites paired with specific shellfish propagation approaches (such as bottom planting hard shell clams, oyster beds or oyster aquaculture), and rationale for selection. Comments received during review of the draft of this memo and the AECOM Shellfish Team responses can be found as Appendix A to the TM (Appendix O). Once the specific locations for demonstrations were selected, the next step was to define the specific design parameters for each demonstration project site, including numerical targets for shellfish and nitrogen-removal. This detailed design and engineering including schedules of implementation is presented in the Preliminary Engineering Design and Work Plan Technical Memorandum (Appendix P) and contains a detailed monitoring plan for water quality as well as shellfish biomass, predators and diseases.

8.2.1 Site Review and Validation

The specific methodology used for in-depth site evaluations included the following steps: review Nauset Harbor and Pleasant Bay watersheds to identify potential demonstration locations that may not have been identified during development of the Consensus Plan; study available data (water quality and other data); conduct land-based and water-based field investigations of potential sites; discuss potential demonstration sites with Orleans Shellfish Constable/Harbormaster and Assistant Harbormaster; refine criteria to be used in the Site Selection Matrix; rank sites based on criteria using Site Selection Matrix; assess the relative importance of each criteria to establish a weighting of criteria if appropriate; perform Quality Assurance/Quality Control (QA/QC) of initial ranking and criteria weighting; review preferred demonstration sites that resulted from the Site Selection Matrix process; submit Site Selection Matrix to Town of Orleans for review; and recommend demonstration site locations.

8.2.2 Site Evaluation and Screening Criteria

To facilitate a systematic and objective evaluation of each of the potential demonstration sites, a Site Selection Matrix was developed. This Site Selection Matrix includes a number of criteria for Site Suitability, Permitting, and Project Evaluation. Site Suitability criteria address the environmental, land use and implementation characteristics of each proposed demonstration location. Permitting criteria assess the regulatory issues related to each proposed demonstration location. Project evaluation criteria estimate the likelihood of obtaining meaningful results from a proposed demonstration site. Other/Overriding Considerations refer to any threshold issue that precludes a demonstration at a given site.

These criteria were first presented as part of the process of developing the Orleans Consensus Plan. The Shellfish Technical Team refined the criteria after reviewing the Site Ecology and Surrounding Environment data as described above. The Site Selection Matrix now includes the following criteria, which are described in detail in the TM (Appendix O):

Site Suitability: available growing area/adequacy of acreage; water quality indicators; disease/predation; ease of access; aesthetic impacts; representativeness of the site (transferability); use conflicts; ability to co-locate with other Non-Traditional technologies.

Permitting: abutter compatibility; wild harvest conflicts (Massachusetts Department of Marine Fisheries [DMF]); grow-out to harvest size allowed (DMF); and permittability.

Project Evaluation: expected survival; and overall likelihood of monitoring plan to yield quantifiable results

8.2.2.1 Analysis: Evaluate and Rate Each Site Based on Criteria

To rank each criterion in the Site Selection Matrix, the Shellfish Technical Team assembled available data, and conducted a site visit. A ranking system was then developed to quantify how well each site met a specific criterion. The point-based system is as follows:

- Good = 1 point: A good ranking (1) was assigned if the criterion could be met fully.
- Neutral = 0 points: A neutral ranking (0) was assigned if the criterion could be met in part, but there were some potential issues and/or difficulties
- Poor = -1 point: A poor ranking (-1) was assigned if the criterion could not be met.

To apply this tool to each potential shellfish demonstration site, the Shellfish Technical Team held a day-long working session. At this session, the Team first reviewed and discussed all of the available information for each site: water quality data from the MEP Reports, Pleasant Bay Alliance data and reports, shellfish suitability and other Geographic Information Systems (GIS) maps from the DMF, preliminary grain size maps from Center for Coastal Studies (CSC) and notes from site visits with the Assistant Harbormaster and Shellfish Constable/Harbormaster. The Team then evaluated each demonstration site and ranked the criteria for each site based on this available information.

Once each site was ranked, the Team reviewed the numerical values assigned to each criterion across sites to achieve consistency. The Team also discussed whether any criterion was more important than another and determined that each criterion should be weighted equally.

The final step in site evaluations is to assign an overall rating to each site based on evaluation findings and criteria rankings. Before total criteria points were calculated and site rating assigned, the team deliberated over which sites seemed preferred for demonstrations from a qualitative and common sense perspective. Then, quantitative rankings were tabulated in the Site Selection Matrix.

8.2.2.2 Findings/Recommendations: Summary of Site Selection Matrix/Site Screening Results

The results of the Site Suitability ratings are as follows:

- Little Pleasant Bay Existing Grants (12 points);
- Quanset Oyster Bed (12 points);
- Pochet Oyster Bed (10 points);
- Arey's Pond Oyster Singles in Floating Bags (9 points);

- Town Cove quahog propagation (9 points);
- Mill Pond quahog propagation (9 points); and
- Lower River Oyster Singles in Floating Bags (7 points).

A maximum of fourteen (14) points is possible. Because the Team determined that all of the criteria were equally important to site selection, no one criterion impacted the overall ratings more than any other. Furthermore, this overall rating was consistent with the assessments made after deliberations but before numerical tabulations were completed.

The top two sites derived from both the Site Selection Matrix as well as Team deliberations were Little Pleasant Bay for shellfish aquaculture and Quanset Pond for an oyster bed (CHR). These two sites were also recommended by the Shellfish Constable/Harbormaster and Assistant Harbormaster during the site visits. To demonstrate the water quality benefits as well as implementation logistics and practical densities of oyster aquaculture, working with current shellfish grant-holders seems ideal. The expertise, gear and interest already exist. The plan for this option generally includes working with growers to optimize shellfish harvest numbers, identify the needs of this group, and design a monitoring plan that can capture water quality impacts. To demonstrate an oyster bed, Quanset Pond has several advantages, including ease of access and patrol, suitable bottom and nutrients, and a reasonable expectation of monitoring yielding quantifiable results. Pochet is also a favorable location for an oyster bed demonstration but access and patrol is more difficult, and therefore this site did not rank as highly as Little Pleasant Bay and Quanset.

Pursuing a shellfish demonstration in Town Cove or Mill Pond was not recommended in the site selection process because (1) oyster propagation is precluded due to excessive oyster drill population (Massachusetts Shellfish Officers Association advises against oyster propagation where drills are prevalent as a Best Management Practice) and; (2) a population study for quahogs is necessary to establish a baseline before any new propagation can be quantified.

The Technical Memorandum on Shellfish Cultivation - Preliminary Engineering Design and Work Plan for Preferred Sites (Appendix P) presents detailed preliminary designs for four different shellfish demonstration projects. To identify the sites included in this Technical Memorandum, an in-depth critique of the above Site Characterization Technical Memorandum was conducted, involving review and comments from several outside experts as well as several meetings with a Town of Orleans working group that consisted of the Shellfish Constable/Harbormaster and representatives from the Shellfish and Waterways Advisory Committee, Orleans Marine and Freshwater Quality Task Force, Orleans Pond Coalition, Citizens Peer Review Committee, and Orleans Water Alliance. After this detailed review, four demonstration programs were selected for preliminary engineering: increased production of quahogs in Town Cove through additional seed planting; propagation of oysters in Kescayo-Gansett (Lonnie's) Pond; formation of an oyster bed in outer Quanset (Quanset); and enhancing oyster aquaculture in Pleasant Bay and Town Cove by either working with existing growers to increase production and/or through the Town offering additional lease areas. Lonnie's Pond had not been evaluated initially by the Shellfish Team during site selection due to it having been selected by the FCW team as the best alternative for FCW implementation. Once the Town put implementation of the

FCW temporarily on-hold until further refinement of nitrogen removal and costs were evaluated, Lonnie's Pond became available for a shellfish demonstration. The choice of Lonnie's Pond as the preferred location for the town's first shellfish demonstration project was made based on two key factors: the town's strong desire to improve the environmental conditions in the town's terminal ponds, and the expected ability to monitor water quality and other impacts caused by shellfish in this semi-closed subembayment.

8.2.3 Discussion of Selected Shellfish Demonstration Projects

The four selected demonstration projects are further refined below, but for complete details including proposed schedules for each of the four projects please refer to the TM (Appendix P).

8.2.3.1 Lonnie's Pond Oyster Singles Installation

The first year plan for Lonnie's Pond is to grow between 170,000 – 340,000 oyster singles, starting at a size of at least ½ inch, in floating bags. This demonstration design mitigates against the known issues with predation and siltation by maintaining the oysters in floating gear. Most of an oyster's nitrogen uptake occurs during the second year of growth. Therefore, to maximize the impact of this demonstration project on water quality parameters, oysters should be grown starting with the largest size seed available, with a minimum starting size of ½ inch. Based on the timing of decision making related to this demonstration, availability of seed is one critical factor that will determine the final number of oysters and initial size that will be grown during this demonstration project.

Monitoring of water quality, sediment and benthic impacts, and oyster growth and nitrogen content will provide critical evidence regarding the environmental aspects of shellfish cultivation. This information will help define future shellfish programming. In addition, operation and maintenance, actual costs and neighborhood responses will be documented to inform future decision making.

Based on the timing of decision making related to this demonstration, availability of seed is one critical factor that will determine the final number of oysters and initial size that will be grown during this demonstration project. In addition, the number of floating bags and acres required for different quantities of oysters is presented in Table 7-2. An important caveat to the estimates for the kilogram removal rates provided in Table 7-2 is that the final amount of nitrogen taken up by the oysters installed in this demonstration will depend on the actual size of the oysters at the end of the 2016 growing season. The time available to procure and build gear is also limited. Given these factors, the first year plan is to grow between 170,000 and 340,000 oyster singles, starting at a size of at least ½ inch, in floating bags. It does not seem feasible to the AECOM Shellfish Team to grow more than the upper limit of 340,000 oysters in 2016.

Table 7-2. Oyster Demonstration Sizing Factors

Area of Water Surface Utilized (Acres)	Number of Floating Bags at 1700 per Acre	Number of Oysters at 200 per Bag	Kilograms of Nitrogen Removal at .26 grams N per 3 inch (76 mm) oyster
0.5	850	170,000	44
1	1700	340,000	88
2	3400	680,000	177
3	5100	1,020,000	265

8.2.3.2 Increased Quahog Population and Propagation Planning

In Town Cove and parts of Pleasant Bay, expansion of municipal quahog propagation is recommended to establish maximum practical densities that can be grown and harvested in these areas, and to allow water quality changes to be correlated to numbers of new quahogs added to these systems. Quahogs have been grown successfully through the Town's propagation program, and there is suitable bottom in both Town Cove and Pleasant Bay for increased quahog planting. Based on site reviews, it was found that there are existing populations of quahogs throughout Town Cove and Pleasant Bay. Therefore, a quahog demonstration should only be pursued after a baseline quahog population has been established. This will provide an estimate of current quahog densities in specific areas where additional quahogs would be planted as part of a demonstration project.

Determining current populations before additional quahogs are added to these waterbodies is an important first step in evaluating survival, growth, and the impacts of additional quahogs on water and sediment quality. This survey is also critical to determining how many additional quahogs should be planted. In FY 17 this demonstration project will begin in Town Cove. The specific areas in Town Cove to be surveyed, quantity of quahogs purchased, as well as the precise location where quahogs will be planted will be determined in close coordination with the Town Department of Natural Resources (DNR) staff. The acreage that will be surveyed and the number of quahogs that are purchased for bottom-planting will be limited by available funding, final cost per acre for the survey, and the price of quahogs of field-plantable size (approximately 21 – 25mm).

Once the baseline population is established, the specific quantities and sizes of additional quahogs will be recommended as part of an expanded quahog propagation program for certain areas in Town Cove and Pleasant Bay. For planning purposes, the goal for FY 17 is to survey at least ten acres, beginning with the area near the Orleans Yacht Club and plant at least 100,000 quahogs in this area.

8.2.3.3 Quanset Oyster Bed Installation

The Orleans oyster bed demonstration projects involve growing remote sets and planting them in suitable areas, resulting in bed-like grow-out under the diverse environmental conditions experienced over the course of a typical Pleasant Bay growing season. The waters of Pleasant Bay do not have a naturally-occurring oyster population that could spawn. To establish an oyster bed in areas where there is no natural set, remote set can be used to introduce oysters into the growing environment.

The technique for establishing an oyster bed in the Quanset area is similar to techniques used throughout Cape Cod, and recently implemented successfully in West Falmouth Harbor, MA. This technique begins with installing remote set in trays and/or floating bags for an initial growing period. In the Quanset area, remote set will likely be able to be bottom planted after approximately eight weeks. The remote set will likely be planted under the bags and trays in which they were initially grown. The significant benefit of planting remote set after a maturation period is that it allows the oyster spat to mature in a protected environment, thus reducing predation and mortality. Planting remote set when oysters have reached over 1.5 inches (38 mm) in size also reduces mortality caused by siltation. Harvest occurs by opening this area to recreational harvest.

Growing out remote set in both trays as well as floating bags with bottom-planting will enable an evaluation of the growth and survival rates of each technique. Moreover, evaluating the potential for bottom-planting oyster remote set at Quanset will help determine the feasibility of expanding oyster beds in other parts of Pleasant Bay where there is suitable substrate, such as areas along the Upper and Lower River, Namequoit, and Pochet.

The plan for this demonstration project in FY 17 involves developing a scope of work for baseline water quality monitoring and to begin monitoring within the proposed growing area; prepare a draft engineering design for a 2017 installation; review the plan with the Shellfish Working Group; and finalize the engineering design for 2017 installation.

8.2.3.4 Shellfish Aquaculture

The demonstration methodology proposed for Little Pleasant Bay involves working with the growers on the town's existing private shellfish leases. There are currently 12 leases with an average size of 1.75 acres. Typically, single oysters are raised from seed to harvest size in trays, bags and cages. In total, growers are harvesting approximately 1,000,000 oysters annually from these leases in Pleasant Bay. Working with growers can create opportunities to demonstrate the water quality benefits as well as implementation logistics and practical densities of oyster aquaculture.

The expansion of private leases for oyster aquaculture in certain areas of Town Cove is also an important option to pursue. Oyster aquaculture in gear, off the bottom would be the only method of growing oysters in this area due to the oyster drill population. The expansion of private grants requires several permitting steps beginning with a recommendation from the Board of Selectmen to the MA DMF. A study of the feasibility of expanding private aquaculture leases is needed to assess the Town's interest in this approach for shellfish propagation in Town Cove.

This demonstration will build on these established growing methods, and includes three components: developing and disseminating a questionnaire to determine whether growers are interested working with the town to expand shellfish propagation for the purpose of water quality improvements; working with growers to establish a total number of shellfish that can be grown and harvested annually for all leases in aggregate; and evaluation of areas in Town Cove for expanding shellfish leases.

Activities proposed in FY 17 include: developing a survey to gauge interest from Pleasant Bay growers in exploring an expanded production program in Pleasant Bay; disseminating the survey through the Shellfish Constable; aggregating and understanding the survey results; and discussing survey findings and grower interest in pursuing an enhanced aquaculture demonstration in Pleasant Bay with the Shellfish Working Group.

8.2.4 Grant Funding for Demonstration Projects

A phased budget for these demonstrations was provided to the town as part of preparing for both the annual and special Town Meetings. The following list of potential external funding sources is based on solicitations that have been published historically:

- Cape Cod Economic Development Council (any organization or individual may apply): Annual, pre-proposals typically solicited in November/December;
- Cape Cod Water Protection Collaborative: Applications from Cape Cod towns are accepted on an ongoing basis;
- USEPA Southeast New England Estuaries Project grants (limited to municipal entities, state government and non-profit organizations): Solicited on an irregular basis, recently pre-proposals due in July and January;
- NOAA Fisheries Saltinstall-Kennedy grant (any organization or individual may apply): Annual, typically early October announcement for full proposal due in November; and
- USDA Community Food Project (CFP) grant (Only food provider organization may apply): Annual, typically early October announcement for full proposal due in November.

8.2.5 Detailed Assessment of Lonnie's Pond Monitoring Program

The purpose of implementing shellfish demonstrations in Orleans is to determine the extent to which shellfish can be grown to achieve water quality improvement goals as well as compliance with regulatory standards. Monitoring of both ecological parameters as well as implementation success will provide information that is needed to incorporate shellfish into the town's full-scale water quality improvement program. Both the UMASS Dartmouth's School for Marine Science and Technology (SMAST) and the Center for Coastal Studies (CCS) have a QAPP for water quality and benthic denitrification and infauna sampling. Either QAPP could be followed. As part of implementing a comprehensive performance monitoring program for this demonstration, a project-specific Quality Assurance Policy Plan (QAPP) may be required.

8.2.5.1 Water Quality Monitoring

To quantify any water quality changes that result from this demonstration project, twice monthly sampling from May – September should include the following parameters at both water surface and bottom locations (where depth is greater than 5 feet) at the sampling stations: Total Nitrogen (TN), nitrate + nitrite, ammonia, dissolved organic nitrogen (DON), dissolved inorganic nitrogen (DIN), particulate organic nitrogen (PON), Temperature, Chlorophyll *a*, Pheophytin *a*, PO_4 (SRP), Salinity, Dissolved oxygen (DO), and Transparency (Secchi depth). Continuous monitoring of Chlorophyll *a*, DO and turbidity is recommended at one location within the demonstration site and one location outside the growing area. Figure 7-2 shows the two potential demonstration sites in Lonnie's Pond, with proposed monitoring stations.

Figure 7-2. Aerial view of the two potential sites for the Lonnie's Pond demonstration project and the respective proposed monitoring stations.

8.2.5.2 Measuring Changes in Sediment and Benthic Flux Associated with Oyster Aquaculture

Analysis of enhanced sediment denitrification that can be attributed to oyster aquaculture is critical to determining the impact of oysters on the estuary in which they are grown. This analysis includes collecting sediment core samples and incubating them under in situ conditions during the period of maximum denitrification rates in summer (July–September); and collecting time series measurements of total dissolved nitrogen, nitrate + nitrite and ammonium. The rate of oxygen uptake is also necessary in order to: (1) evaluate sediments relative to organic matter deposition rates; and (2) develop a general nitrogen model for oyster impacts to the nitrogen cycle in the sediments.

8.2.5.3 Monitoring Shellfish Growth and Survival at Lonnie's Pond

In addition to water quality sampling and sediment analysis, tracking the size of the shellfish population, as well as growth and survival rates is also recommended. Single oysters should be randomly sampled from floating bags in different rafts, and measured every two weeks to establish a growth rate. Survival within the floating bags should be quantified monthly. Observations regarding predation and other stressors should be recorded. Survival at the beginning of the second growing season should then be measured.

Additionally, observations regarding increased biodiversity should be made and documented. A basic assessment of species (e.g., shrimp, crabs and fish) in the vicinity of the growing area should be made prior to installing the demonstration. This can be accomplished by observing and recording organisms in the water column as well as sorting and identifying benthic infauna in the laboratory. Weekly observations of any species that were not initially present in the water column but have been attracted to the area because of oysters due to the structure created by the floating gear should be recorded.

8.2.6 Cost Estimates

Based on the evaluation contained within the TM (Appendix P), cost estimates were prepared for demonstration projects and full scale aquaculture implementation. Cost estimates are summarized in Section 5.4.7, and additional cost details can be found in the TM in Appendix P.

8.3 Permeable Reactive Barriers

The TM *Site Characterization and Evaluation for Permeable Reactive Barriers (evaluation criteria and ranking)* (Appendix Q) describes in detail the process involved in identifying and evaluating potential sites for PRBs in order to select sites for PRB demonstration testing. The selected locations will be used to develop a Preliminary Engineering Work Plan TM (Appendix R), which will detail designs, schedules, and costs for PRB demonstrations. Strategies for performance verification through groundwater monitoring will be included in the Work Plan.

Nitrogen loading from point and non-point sources in the watersheds is impacting surface water quality. PRBs can intercept and remove part of this nitrogen load from the groundwater system by enhancing the activity of naturally occurring denitrifying bacteria in the aquifer that consume nitrate in their respiration. This process of bacterial metabolism results in the conversion of nitrate to inert nitrogen gas (denitrification) and requires both anoxic conditions (dissolved oxygen less than 1 mg/L in groundwater) and sufficient food substrate for bacterial growth. PRBs provide the food substrate to deplete oxygen levels, resulting in conditions that favor denitrifying bacteria, and food substrate to promote their growth. The PRB treatment zone is located in groundwater below the water table. Nitrate is removed in place in the ground (in-situ) as groundwater flows through the thickness of the permeable barrier.

The Demonstration Tests will provide data to assess the effectiveness and applicability of PRBs as a treatment alternative for the Town. It is expected that the tests will demonstrate the level of nitrate removal that can be achieved with PRBs and provide data to prepare a full scale design. The Demonstration Tests will be evaluated by the following performance objectives:

(1) Achieve satisfactory distribution of the carbon substrate solution into the subsurface;

(2) Establish and maintain necessary anaerobic (reducing) and groundwater flow conditions in the subsurface throughout the targeted treatment area;

(3) Demonstrate reduced nitrate concentrations and flux in groundwater through monitoring to extrapolate to reduction targets for full scale (total maximum daily load [TMDL]);

(4) Demonstrate performance, compliance monitoring, and assessment of treated water quality, including potential secondary water quality affects, through groundwater monitoring program;

(5) Evaluate time frame for technology performance;;

(6) Evaluate potential impacts to sensitive receptors (surface water, private wells, etc.); and

(7) Obtain data for engineering evaluations and to optimize full scale design and implementation.

8.3.1 Site Selection

Potential PRB locations identified on the Consensus Plan Hybrid Map and additional locations were evaluated by the AECOM PRB Technical Team (AECOM and MT Environmental Restoration) as potential demonstration sites. The specific methodology used for detailed site evaluations included reviewing potential PRB locations developed through the Consensus Planning process, review of other locations within the Town of Orleans to identify potential demonstration locations that may not have been previously identified, assess potential PRB nitrogen reductions with the online Multi-variant Planning tool developed by the CCC (WatershedMVP), field visits to potential sites; review of existing soil and groundwater quality data, discussion of potential demonstration sites with Town of Orleans, officials; ranking of sites based on criteria using Site Selection Matrix; and recommending site locations for additional field investigation and Work Plan cost estimates.

Eight (8) potential locations for PRB demonstration were considered in detail including:

- Main Street and Tonset Road (Main Street);
- South Orleans Road at Tonset/Eldredge Parkway (Route 28 site);

- Town Cove Gibson Road;
- Namequoit Road;
- Town Landfill;
- Paw Wah Pond;
- Rock Harbor Road Area; and
- Kescayo Gansett Pond (Lonnie's Pond).

Based on the eight (8) locations identified above, preliminary full scale PRB scenarios were evaluated for nitrogen reduction with WatershedMVP to evaluate estimated nitrogen mass removal for various theoretical PRBs at full length based on land use in the watershed and hydraulic capture zone of a theoretical PRB at each site.

A Site Selection Matrix was developed for objective evaluation of selected PRB sites. The Matrix includes criteria for Site Suitability, Permitting, Project Evaluation and Other/Overriding Considerations. These criteria address environmental, land use and implementation features of the proposed demonstration locations. Permitting criteria assess regulatory requirements and potential conflicts related to the proposed demonstration locations. Project evaluation criteria evaluate the benefits gained from a proposed demonstration site. Other/Overriding Considerations refers to other superseding issues that support or prevent a demonstration at a given site.

The PRB Technical Team collected site specific information, conducted site visits, and evaluated the potential performance effectiveness of selected PRB locations with the WatershedMVP tool. A ranking system was then developed to quantify how well each site met a specific criterion. The point-based system used is as follows:

- Good = 1 point
- Neutral = 0 points
- Poor = -1 point

A good ranking (1) was assigned if the criterion could be met fully.

A neutral ranking (0) was assigned if the criterion could be met in part, but there were some potential issues and/or difficulties.

A poor ranking (-1) was assigned if the criterion could not be met.

Results of the evaluation ranking are presented in Table 2 of the TM (Appendix Q). The site suitability evaluation process narrowed the list of potential Demonstration Test sites to the following four locations:

- Main Street and Tonset Road (Site A);
- South Orleans Road at Tonset/Eldredge Parkway (Site B);
- Town Cove Gibson Road (Site C); and

- Town Landfill (Site E).

8.3.2 Hydrogeological Investigations

To support further evaluation of these sites and the preparation of a Preliminary Engineering Work Plan for PRBs, a groundwater investigation was completed by AECOM in 2016. The investigation included the installation of several groundwater monitoring wells, groundwater sampling, and data analysis on these four sites. Based on the 2016 investigation, a preferred Demonstration Test site at Eldridge Park (Site B) was selected. The Eldridge Park site (Site B) has sufficient groundwater nitrogen data (from AECOM in 2016 and data collected at existing monitoring wells within the areas of interest identified through records search) to support a demonstration project, and the results will be representative of other potential PRB locations in Orleans. The Town-owned Eldredge Park Demonstration Test site is located in the parking lot area between the playing fields off Eldredge Parkway. This demonstration location supports full scale PRBs that may be located in Eldredge Park, along South Orleans Road, Tonset Road, and Main Street or some combination of these options. PRBs at one or more of these locations would be designed to reduce nitrogen loading to Town Cove. One additional potential demonstration site, the Town Landfill (Site E) was identified as a test site option that may also be implemented with the preferred site, given sufficient funding. The landfill demonstration location is seen as highly advantageous, close in preference to the Eldredge Park location, and ideally would be implemented along with Eldredge Park. The locations of the recommended Demonstration Test sites are shown on Figure 7-3.

AECOM completed hydrogeological investigations at selected sites in the Town (four locations that scored highest from the site suitability evaluation) to support the design of the demonstration tests. Demonstration tests and groundwater nitrate treatment in general would be most cost effective where the mass flux of nitrate in groundwater is high based on groundwater nitrate concentrations and groundwater flow velocity. The understanding of environmental conditions (the conceptual site model) developed for each of the potential sites was updated with the additional data from site specific investigations, including:

- Depth to groundwater;
- Groundwater flow direction;
- Soil type and groundwater flow velocity;
- Vertical nitrogen concentration profile; and
- General groundwater chemistry.

The potential Demonstration Test sites investigated included

- 1. Main Street and Tonset Road (Main Street);
- 2. South Orleans Road at Tonset/Eldredge Parkway (Route 28 site);
- 3. Gibson Road at Asa's Landing; and
- 4. Orleans Town Landfill.

A summary of field and laboratory groundwater data is presented in Table 3 and Section 4.b.5) of the TM (Appendix R).

8.3.3 Demonstration Test

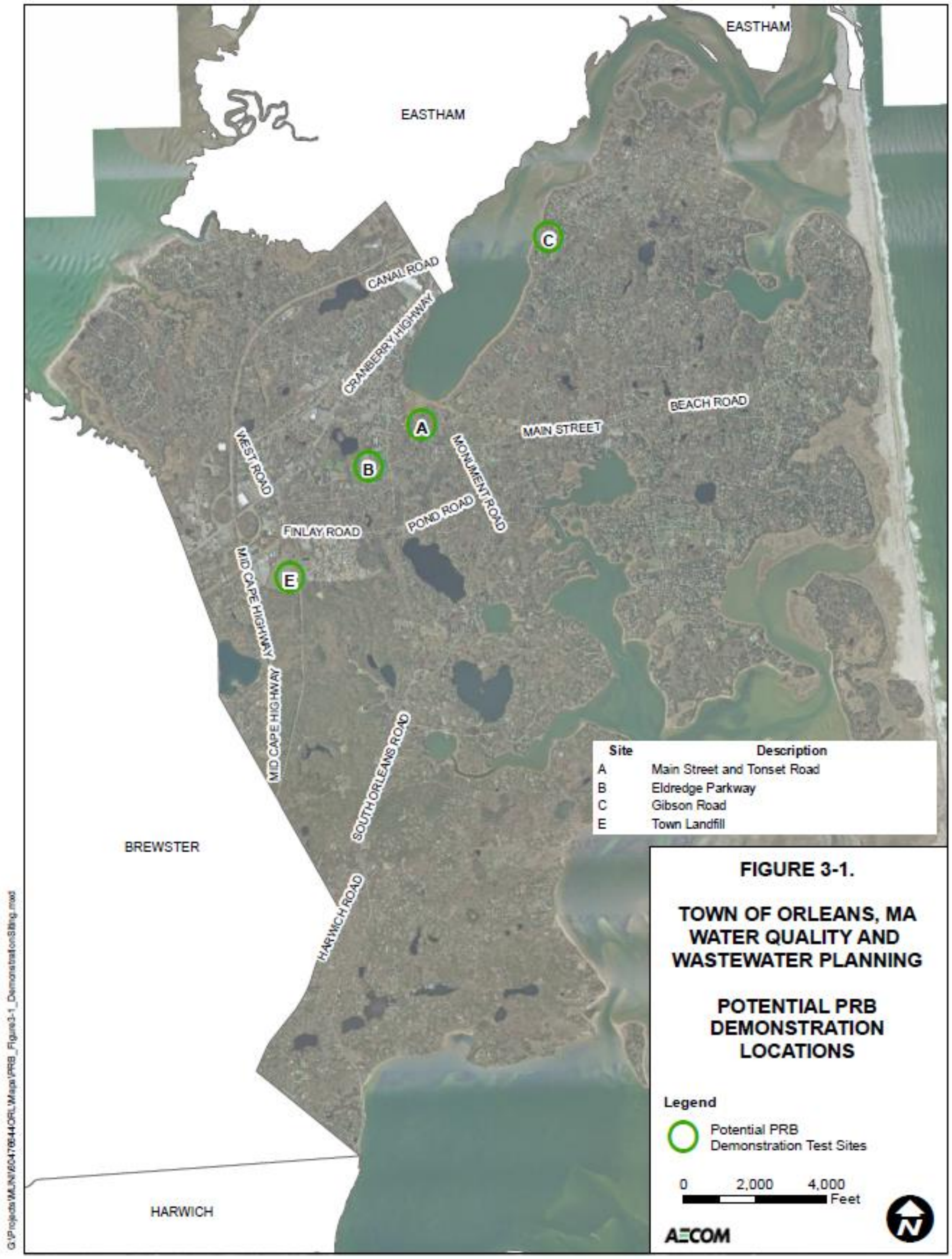
A prioritized list of two recommended PRB demonstration tests has been proposed – Eldredge Park and the Landfill. The proposed PRB demonstration at the preferred locations will generally each include one line of injection points spaced 10 feet apart. The approximate locations of the proposed PRBs are shown on Figure 7-3. Proposed demonstration test PRB lengths are 200 feet for Eldredge Park 200 feet and 50 feet for Landfill.

Future full-scale PRBs or sections or PRBs are anticipated to be longer (500 to 3000 feet, depending on the location); however, demonstration test locations are proposed to be shorter distances to assess construction/implementation and allow adequate monitoring of groundwater conditions in the vicinity of the PRBs for initial demonstration. For the demonstration test PRBs, a vertical treatment interval is anticipated from the top of the groundwater table to approximately 40 feet into the saturated soils. The total depth below land surface will also depend on the depth to groundwater at the location. Multi-level groundwater sampling events conducted on Cape Cod have identified bands of groundwater containing nitrate concentrations 25 to 40 feet thick (MT Environmental, 2015). The field groundwater investigation completed by AECOM in 2016 indicated that nitrate is present 30 feet below the water at concentrations similar to shallower groundwater supporting a vertical treatment interval of 40 feet for demonstration testing for the two proposed PRB locations.

Based on numerous disadvantages and potentially unacceptable environmental impacts, trench installation was considered and ruled out for PRB demonstrations in Orleans due to limited feasibility and prohibitive siting requirements. Due to shallow installation depth, trench-based PRBs would need to be located very close to surface water in resource areas, causing potential damage to natural resources and increasing permitting requirements and cost. Installation of trenches may cause significant disruption, and abutter concerns may be significant. In addition, trench locations would not provide sufficient downgradient travel time for stabilization of groundwater chemistry before groundwater discharge to the surface water. The most likely design will use soil borings for injection of slow-release organic carbon electron donor substrates, such as food-grade emulsified vegetable oil (EVO) as carbon food source, to create a PRB capable of stimulating denitrifying bacteria to remove nitrate. These soil boring PRB installations would be located upgradient away from resource areas and could be installed with minimal impacts. For the PRB demonstration test, EVO is the recommended amendment based on the need to optimize PRB longevity. EVO contains only non-toxic, food grade materials, primarily soybeans, and is widely used in enhanced bioremediation applications for groundwater. After injection, EVO is relatively immobile in the subsurface and relies on the slow release of soluble compounds that are distributed by advection, dispersion, and diffusion in groundwater. Injection of carbon substrates is proposed to be completed using direct-push tooling (i.e., GeoProbe®).

The demonstration test will evaluate field implementation and observations, including range of observed injection flow rates, observed injection pressures and EVO dilution rates and associated handling. Monitoring wells in proximity to the preliminary injection test points will be observed to measure how far EVO emulsion travels downgradient and cross-gradient as a result of injection. A description of how the field injection activities are anticipated to be conducted is detailed in the TM (Appendix R).

Figure 7-3. Map showing the potential locations for PRB demonstration projects.



8.3.4 Demonstration Test Monitoring

Performance monitoring of the PRB demonstration test will be performed to assess nitrate transformation, concentrations of other key indicators, and the distribution of the injected reagents. Groundwater samples will be collected from both existing monitoring wells and additional monitoring wells to be installed prior to commencing the PRB demonstration test. The monitoring well network for demonstration test performance monitoring is presented on Figure 7-4 and Figure 7-5 for the Eldredge Park and landfill PRBs, respectively. The monitoring well network for demonstration test sites includes monitoring wells upgradient, downgradient, and cross-gradient of the PRB to evaluate changes to nitrate and groundwater quality or to aquifer permeability as a result of the injection of EVO. Groundwater quality parameters will be measured in the field (pH, oxidation reduction potential (ORP), dissolved oxygen (DO), specific conductivity, temperature, turbidity), with particular attention to ORP (mV) and DO (mg/L) which will be used to evaluate the generation and distribution of reducing conditions. Groundwater samples will be collected prior to initiation of in-situ treatment to provide a comparative baseline to evaluate performance of the demonstration test. Following completion of injections for the full demonstration tests, it is anticipated that groundwater sampling would be performed quarterly for a period of three years. Primary objectives of the post-injection sampling will be to:

- Demonstrate reduction in nitrate concentrations in groundwater in monitoring wells compared to baseline samples and/or wells upgradient of the PRB;
- Identify distance traveled by EVO emulsion;
- Identify extent of generated reducing conditions;
- Evaluate potential for reduction in aquifer permeability as a result of EVO application;
- Evaluate persistence of EVO emulsion and anaerobic conditions favorable for denitrifying bacteria after PRB installation; and
- Assess changes in groundwater monitoring parameters as a result of the PRB

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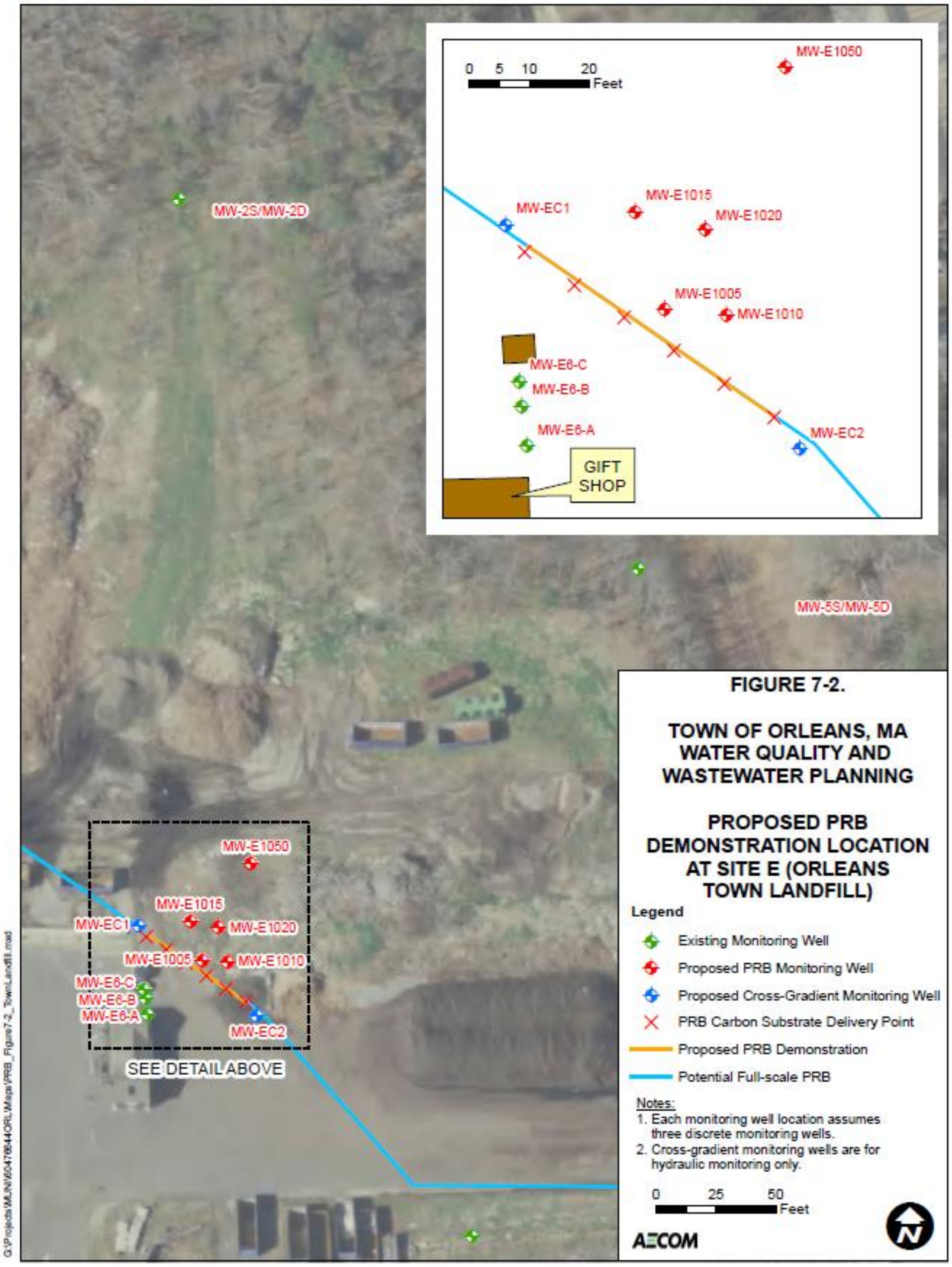
Figure 7-4 – Proposed PRB demonstration project at Eldredge Park showing locations of Monitoring Wells

Figure 7-5 – Proposed PRB Demonstration Project at the Orleans Town Landfill



8.3.5 Cost Estimates

Based on the evaluation contained within the TM (Appendix R), cost estimates were prepared for demonstration tests and potential full-scale PRBs at the two preferred locations: Eldredge Park and Town Landfill. Cost estimates are summarized in Section 5.4.7, and additional cost details can be found in the TM in Appendix R.

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9.0 Adaptive Management Plan Implementation

The 2010 CWMP included an Adaptive Management Plan (AMP) that outlined the process by which initial phases of the Town's proposed approach to managing wastewater and stormwater would be evaluated for effectiveness and modified as appropriate based on interim results. The 2010 AMP included a Groundwater and Surface Water Quality Monitoring Plan and identified that the Town would prepare an annual TMDL Compliance Report. Since the Town has modified its approach to meeting nitrogen load reductions through a hybrid approach of Traditional and Non-Traditional technologies, modifications to the AMP water quality program are needed. This section describes the baseline water quality data available, identifies data gaps, and identifies additional water quality monitoring needed in order to document the status of compliance with the TMDL.

9.1 Baseline Monitoring Data

The purpose of TM *Final Water Quality Monitoring and Modeling: Consolidation and Comparison of Baseline Monitoring Data Sets* (Appendix S) is to evaluate the adequacy of sampling locations and sampling methodology (protocols and parameters) in order to accomplish the following monitoring objectives:

- Establish current baseline conditions for evaluating water quality improvements as the town's overall nutrient management program is implemented;
- Establish baseline conditions for evaluating specific demonstration projects;
- Allow Massachusetts Estuaries Project (MEP) model revisions where physical conditions and nutrient loads have changed;
- Verify MEP model runs made as part of CWMP updates; and
- Determine data gaps and recommend additional monitoring to meet the above monitoring goals.

To make this assessment, existing water quality data collected from 2000 to 2015 were consolidated and reviewed, and missing data have been identified. These water quality samples were collected by citizen volunteers and were analyzed for Orleans by the Massachusetts Estuaries Project (MEP) laboratory. In addition, this water quality information is compared to baseline monitoring data from the MEP reports for Pleasant Bay and Nauset Harbor and trends have been documented.

Recorded water quality parameters contained in the data sets for Pleasant Bay and Nauset Harbor include: weather, wind force, wind direction, water condition, secchi depth, DI salinity, field corrected salinity, sample time, sample depth, in situ dissolved oxygen (DO), in situ DO (as percent saturation), in situ water temperature, laboratory salinities, laboratory conductivity, soluble reactive phosphate (SRP), ammonium (NH_4), nitrate (NO_3), dissolved inorganic nitrogen (DIN), dissolved organic nitrogen (DON), total dissolved nitrogen (TDN), particulate organic nitrogen (PON), total organic nitrogen (TON), total nitrogen (TN), particulate organic carbon (POC), chlorophyll a and pheophytin. Several of these terms, including weather, wind force, wind direction, water condition, sample depth, and field temperature are recorded to characterize the conditions under which the water quality sample is taken.

In terms of establishing baseline conditions, The MEP report for Nauset Harbor watershed includes fifteen monitoring stations, WMO-25 to WMO-40. The only stations that have a complete set of data from 2003-2014 are WMO- 27 (the Sentinel Station for the Nauset Harbor in Town Cove), WMO-34 (Mill Pond), and WMO-38 (Salt Pond). The remaining monitoring stations only have consistent data for 2003-2004, with sporadic data collected in 2005. These three stations do not provide sufficient spatial resolution within the sub-embayments of this estuary to establish a baseline to compare against demonstration monitoring data. Although Pleasant Bay is sampled at twenty-four stations, there are long distances between stations. Moreover, the standard deviation for annual average values in both Pleasant Bay and Nauset Harbor ranges from 10% to over 50%. This indicates that there is a large range of values in the approximately five data points collected within a season. Averaging these data points to establish an annual value for a given parameter is the accepted practice of the MEP for overall water quality determination. This data set is valuable for long term study and gross comparisons within the watershed, however, in order to quantify a small change in nitrogen that is removed from a shellfish or floating wetland installation, pre installation samples taken in close proximity to the demonstration sites are needed to establish reference values at a given demonstration location.

9.1.1 Nauset Harbor Data Assessment

Currently, there are only three stations being sampled as part of the annual monitoring done by SMAST, representing the Town Cove, Mill Pond and Salt Pond (Eastham) systems within Nauset Harbor, which are shown in figures in the TM – Appendix S. To establish robust baseline conditions for Nauset Harbor, additional stations are recommended so that trends and values shown at the single stations in these sub-embayments can be compared to data from additional locations in the same system. Comparison of water quality parameters at these stations over the monitoring period of record is as follows:

- **Total Nitrogen (TN):** Since 2011, Town Cove has been consistently higher than the MEP baseline values; Mill Pond has been consistently higher than the MEP baseline values since 2010; and since 2011, Salt Pond has been consistently lower than the MEP baseline values, but has been rising towards the baseline since 2012.
- **Salinity**: Town Cove has been consistently lower than the MEP baseline value since 2009; Mill Pond has been consistently lower than the MEP baseline value since 2009, but in 2011 began approaching that baseline; and Salt Pond has been above and below the MEP baseline value since 2003, and in 2014 was essentially at that baseline.
- **DO**: Town Cove and Mill Pond have been consistently lower than the MEP data from the data sets from 2003; and Salt Pond has been higher than the MEP data from 2004.
- **Chlorophyll-a (Chl-a**): Town Cove has been consistently higher than the MEP data from the data sets for 2003 but is declining; Mill Pond has been oscillating above and below the MEP data for 2003 but was lower in 2014; and Salt Pond has been higher than the MEP data for 2004 since 2009, but in 2010 began to decrease and in 2014 was slightly lower relative to 2004. There is significant variation in the data, as shown by the standard deviation bars.

While the Total Maximum Daily Load (TMDL) for TN has not yet been established by MassDEP/US EPA for Town Cove and Mill Pond, neither Town Cove nor Mill Pond meet the target load for nitrogen that is prescribed in the MEP Report, which is 58.718 kg/day and 9.219 kg/day respectively. In addition, TN concentrations are higher than the MEP recommended threshold of 0.45 mg/L at the Sentinel Station in Town Cove. Nitrogen concentrations are also higher relative to the 2003 reference point. Increasing DO and Chl-a echo this TN trend. Lower salinity may indicate an occluded inlet and shoaling relative to the 2003 value.

An analysis of the available data also highlights the importance of surface and bottom measurements to understanding water quality trends, as seen in Figures 5 and 6 in the TM (Appendix S). Differences in data values for surface and bottom sampling locations are apparent for all four parameters at both stations where data was available for comparison.

Another notable feature of the data was discovered when examining Chl-a for Mill Pond (WMO-34B) and Salt Pond (WMO-38B). Figures 4d and 5d in the TM (Appendix S) show very large standard deviation for the 2001 bottom Chl-a data. Plotting each measurement as a function of time suggests an exponential decline over the course of years. Note the logarithmic vertical scale of the graph. This may have been caused by an algal bloom occurring during the sampling time at Salt Pond (WMO-38B) in 2011, with the values in subsequent years showing a continuous declining trend. By 2014, values in Salt Pond had returned to typical pre-2011 levels. However, values in Mill Pond had decreased to near zero by 2014, possibly indicating a permanent change in this ecosystem. However, a change in the water depth from which the sample is taken can also impact results.

A brief review of the data sets provided to Orleans shows large anomalies in some of the data. These may be the result of sampling errors, an atypical event or natural temporal and spatial variations within a particular sub-embayment.

9.1.2 Pleasant Bay Data Assessment

The Pleasant Bay Alliance was formed in 1998 to oversee resource management planning for Pleasant Bay. For the past fifteen years, the Alliance has organized and trained volunteers to collect water quality data from sampling stations bay-wide, which are sampled two times per month during July and August and once in early September. Fourteen of these stations are in Orleans's waters, although volunteers from Orleans coordinate with Chatham to sample two additional stations. In 2015, the Alliance contracted Cadmus Group to analyze the monitoring data for statistical changes over time.

In 2015, the Alliance contracted the Cadmus Group to analyze the monitoring data for statistical changes over time. In order to evaluate trends within all of Pleasant Bay, the Cadmus Report pooled water quality data from samples from all 34 monitoring stations (Cadmus 2015). The number and frequency of samples were considered adequate for establishing trends in overall data parameters.

Water between Pleasant Bay and the Atlantic Ocean is currently exchanged through two tidal inlets. South Inlet was formed in 1987, and North Inlet was formed in 2007 when a breach occurred at the southern end of an unbroken, ten-mile stretch of barrier system known as "North Beach". Geographically the breach is located in North Chatham in the vicinity of Strong Island and Ministers Point. The formation of this new inlet was expected to bring increased tides and flushing to the bay. Both before and after the 2007 breach, several bay-wide trends are evident.

The post-breach trends include:

- Increasing DIN, Bioactive Nitrogen (BioN);
- Decreasing Pigments;
- Increasing DO;
- Trends in TN, PO4 not considered statistically significant; and
- Increased salinity.

A Bay-wide analysis of the data shows several unexpected trends:

- DIN is increasing at a slower rate after the break, but PON and DON are not changing in ways that are consistent with this trend;
- BioN (DIN +PON) is increasing but pigments are decreasing;
- While Bay-wide trends show an increase in BioN, individual sampling station values increase at only two locations while eight show a decrease. Nine locations show no statistically significant difference;
- DO is higher at the bottom of the water column; and
- Temperatures are higher at the bottom of the water column

After the breach, DIN continued to increase, but at a significantly slower rate. A steady decline in PON was occurring before the breach. If increased flushing due to the breach was responsible for improving water quality, the expected drop in PON would be more pronounced after the break. Instead, PON started to climb slightly.

DON was also decreasing before the breach. This drop in DON would also have been expected to accelerate after the breach, but the data show it is decreasing more slowly. Atmospheric trends should be expected to continue unaffected by the breach, but DON from biological activity should be lower if there were increased flushing. Instead the rate of DON decrease lessened. If this change in BioN were due to increased flushing, accelerated decreases in PON and DON should be observed, but this is not the case.

There are several potential explanations for the seemingly contradictory bay-wide trend that BioN (DIN and PON) is increasing and pigments are decreasing. Pigment reductions may be explained by lower populations of phytoplankton and other microalgae, but BioN may also be stimulating the growth of macroalgae. Macroalgae populations can be promoted by nitrogen levels that are lower than optimal for phytoplankton, yet still elevated (Hein, 1995). Sampling during the summer may not measure DIN and PON accurately because DIN is consumed and PON is produced as part of macroalgae cycling. Summer sampling may be underestimating actual DIN inputs, and may not capture PON. Increased grazing by zooplankton may also be reducing phytoplankton populations. Pigments are the sum of Chl-a and pheophytin. It may be more accurate to track Chl-a alone for a more representative measure of microalgae.

9.1.3 Evaluation of Baseline Data to Establish Demonstration Project Monitoring Needs

Long term data sets from Pleasant Bay were investigated to determine whether current water quality data are sufficient to establish baseline conditions for evaluating Non-Traditional demonstrations in Orleans. The Cadmus report presents trend lines that were fitted to sampling data for each of 20 stations, including trends before and after the 2007 breach at Nauset Beach. The specific parameters include: dissolved inorganic nitrogen (DIN), bioactive nitrogen (BioN), total nitrogen (TN), phosphate (PO4), total phytopigments (pigments), dissolved oxygen (DO) and salinity. This trend analysis for Pleasant Bay monitoring stations includes the following stations in Orleans (Cadmus 2015):

- Meetinghouse Pond (PBA-16);
- The River at Rattles Dock (WMO-10);
- Namequoit South (PBA-12);
- Namequoit North (PBA-13);
- Namequoit Mid (WMO-6);
- Arey's Pond (PBA-14);
- Kescayo Gansett Pond (Lonnie's, PBA-15);
- Paw Wah Pond (PBA-11);
- Little Pleasant Bay near Quanset (PBA-8);
- Pochet Mouth (WMO-3);
- Pochet Upper (WMO-5);
- Quanset Pond (PBA-10); and
- Little Quanset Pond (WMO-12).

Stations in Orleans that were not included in this evaluation because of significant gaps in data include the following:

- Pochet (mid): WMO-4 which has not been sampled since 2004;
- The River (mid): WMO-8 which does not have data from 2005-2013;
- Namequoit River (mouth) WMO-7 which has not been sampled since 2004;
- Round Cove: WMO- 9 which does not have data from 2006 to 2013; and
- Pleasant Bay north of Round Cove: PBA-7 which does not have data after 2005.

For each of the Pleasant Bay sites in Orleans, the analysis shows no statistically significant results (at 95% confidence) were found for the following parameters shown in Table 8-1:

Table 8-1: Water Quality Parameters with no statistically significant results at the 95% confidence interval are indicated by an X. Boxes with a dash indicate statistically significant trends (based on Cadmus 2015).

		DIN	BioN	TN	SRP (PO_4)	pigment	DO	salinity
Meetinghouse Pond	(PBA-16)	X	-	X	X	-	X	X
Namequoit South	(PBA-12)	X	-	-	-	-	-	-
Namequoit North	(PBA-13)	-	X	X	X	-	X	X
Namequoit Mid	(WMO-6)	X	-	-	X	-	X	X
Pochet Upper	(WMO-5)	X	X	X	-	-	-	X
Kescayogansett Pond (Lonnie's)	(PBA-15)	X	-	-	-	-	X	X
Paw Wah Pond	(PBA-11)	X	-	-	X	-	X	-
Pochet Mouth	(WMO-3)	X	-	-	X	-	X	X
Little Quanset Pond	(WMO-12)	-	-	-	X	X	-	-
Arey's Pond	(PBA-14)	X	X	X	X	-	-	X
Quanset Pond	(PBA-10)	-	-	-	-	-	X	X

Appendix F of the Cadmus Report presents graphed data for DIN, BioN, TN, SRP (PO4), Pigments, DO and salinity for all monitoring locations (Cadmus 2015). These data were also evaluated and are presented in Table 8-2. Black text, a black "X" or arrow "↑" indicate an improved water quality value; and red text, a red "X" or arrow "↓" indicate a degraded water quality value. When values are not statistically significant, they are shown in brackets.

These results are not surprising since in estuaries, N concentrations, especially the inorganic forms, typically vary widely seasonally, interannually, and along salinity gradients. As detailed in the discussion on Bay-wide trends, the timing of sample collection and macroalgae uptake and organic contributions may be impacting DIN, DON and PON concentrations. Systems may be achieving water quality standards based on N sampling, measures of algal biomass (e.g., chlorophyll a), water clarity (e.g., Secchi depth) or DO, yet still show inconsistencies in long term data sets because nitrogen fractions are cycling in new ways in response to environmental changes. For example, the concentration of the primary N variables may not correlate well with one or more response variables such as phytoplankton production. Physical factors such as salinity, pH and temperature gradients and input and outputs of fresh or salt water (e.g. flushing) play an important role in the N process and phytoplankton productivity.

Water quality data results identified at the Orleans stations were then assigned to one of three action items (Table 8-2):

- Confirm system health;
- Determine why inconsistent; and
- Treat as impaired.

Confirming system health is recommended when the station is below the TMDL for BioN and other water quality parameters such as total pigments show improved conditions that reflect acceptable BioN concentrations. Five of thirteen stations are in this category. Determining why parameters are inconsistent is suggested for sites where either BioN is at or near the TMDL, but other parameters indicate impairment, or BioN is above the TMDL but other parameters seem to show that the system is in good condition. Five of thirteen sampling stations are in this category. Treating systems as impaired is designated for sub-embayments where the range of water quality parameters consistently show degraded conditions. Three of thirteen stations are in this category.

Table 8-2: Water Quality Parameters with Action Items. Both statistically significant trends as well as trends that are not statistically significant are shown (based on Cadmus 2015)

		BioN Above TMDL (X) or Below/Near TMDL (X)	Pigments Below 5 µg/L or Decreasing	DO Increasing (↑) or Decreasing (↓) or Steady State below 6 mg/L (SS)	DIN Increasing (X) or Decreasing (X) or Steady State (SS)	ACTION
Meetinghouse Pond	(PBA-16)	X	X	[↓]	[SS]	Confirm System Health
Namequoit South	(PBA-12)	X	X	↑	[X]	Confirm System Health
Namequoit North	(PBA-13)	[X]	X	[↑]	X	Confirm System Health
Namequoit Mid	(WMO-6)	X	X	[SS]	[X]	Confirm System Health
Pochet Upper	(WMO-5)	[X]	X	↑	[X]	Confirm System Health
The River at Rattles Dock	(WMO-10)	X	X	↑	[X]	Determine Why Inconsistent
Kescayogansett Pond (Lonnie's)	(PBA-15)	X	X	[SS]	[X]	Determine Why Inconsistent
Paw Wah Pond	(PBA-11)	X	above 5 µg/L	[SS]	[SS]	Determine Why Inconsistent
Pochet Mouth	(WMO-3)	X	X	[SS]	[X]	Determine Why Inconsistent
LPB Near Quanset (Big Bay NE)	(PBA-8)	[X]	X	↑	X	Determine Why Inconsistent
Little Quanset Pond	(WMO-12)	X	[X]	↓	X	Treat as Impaired
Arey's Pond	(PBA-14)	[X]	above 5 µg/L	↓	[SS]	Treat as Impaired
Quanset Pond	(PBA-10)	X	above 5 µg/L	[↑]	X	Treat as Impaired

9.1.4 .Baseline Data Review Conclusions

A review of data from monitoring programs in both Pleasant Bay and Nauset Harbor reveal a significant variability in water quality data. There are several key implications of this analysis:

- Establishing current baseline conditions requires additional sampling locations in Nauset Harbor, and additional study of the biogeochemical processes impacting nutrient cycling in select sub-embayments of Pleasant Bay;
- Establishing baseline conditions that will enable the effect of demonstration projects to be quantified requires site-specific monitoring with high spatial and temporal resolution to capture the localized range in values for water quality and benthic parameters; and
- A recalibration and rerun of the Massachusetts Estuaries Project (MEP) model for Pleasant Bay and Nauset Harbor is warranted based on the changes in physical conditions and measured nutrient concentrations.

Recommended additional monitoring and evaluations include:

- Additional sampling dates;
  - Spring (March/April)
  - Fall (Sept/October)
- DIN and PON concentrations sorted by temperature, based on additional sampling;
- Macroalgae populations and nutrient flux;
- DON changes due to reduced atmospheric deposition;
- Pigment assessments based on Chl-a only; and
- Benthic assessments.

Current data sets are not adequate for establishing a baseline to which the impact of demonstration projects can be compared. There are valuable data collection programs occurring across water bodies in Orleans. To maximize the benefit of these efforts, annual compilation, review and analysis is recommended. In addition, it is suggested that reports present figures in a way that allows the data points to be known.

9.2 Long-Term Water Quality Monitoring Program

The purpose of TM 4.a.2 – *Recommendations for Long Term Water Quality Monitoring Program* (Appendix T) is to provide the details for a monitoring program that can adequately quantify water quality and benthic conditions over the long term. This program includes locations of additional stations, as well as sampling points at different depths within the water column. The frequency of sampling, methodology and parameters for sampling, including benthic analysis are described. Recommendations for future data collection personnel (both volunteer and paid) as well as a system for long term coordination and management of all data sets generated for Orleans are also presented.

Orleans has successfully implemented and maintained a long-term program for water quality monitoring in both Town Cove and Pleasant Bay. Consistent data sets exist for Town Cove starting in 2003, and for Pleasant Bay starting in 2000. These data are collected and analyzed annually by the UMASS Dartmouth SMAST. In order to be able to utilize this data to meet regulatory standards it is recommended that future data sets utilize version-controlled standard operating procedures (SOPs) and include the following information:

- A notes page with the following documentation:
  - GPS coordinates for all sampling stations;
  - Definitions for all terms; and
  - Conversion of micro-Moles (µM) to milligrams per liter (mg/L) for nitrogen species, particulate organic carbon (POC), and phosphate (PO_4; measured as Soluble Reactive Phosphorus-SRP).

- Description of methodology for dissolved oxygen (DO) columns and a discussion of which columns, if any, can be used to analyze trends continuously from 2003 through 2014. Specific explanation of how values are derived for these column headings should be provided:
  - Lab salinity;
  - Field corrected salinity;
  - DI salinity; and
  - Salinity-corrected DO.
- Each year documentation should be provided with the data sets that describes each parameter, including:
  - If the value is a direct measurement;
  - Where measurement is made (field/lab);
  - Field sampling equipment and technique, laboratory used for analysis, laboratory method and instrumentation used, and the instrument's limit of detection;
  - Filter size and standard method used for particulates;
  - If the value is calculated, what calculations are performed; and

If applicable, comments as to why SOPs were not utilized and details concerning alternative methodology used.

9.2.1 Additional Station Locations and Frequency of Sampling

There are currently three monitoring stations in Nauset Harbor. Based on the analysis in Section 8.1, additional monitoring locations are recommended in order to accurately assess this estuary. The MEP Report included data from eighteen monitoring stations. This program recommends monitoring eleven of these stations: WMO Station Numbers 25, 26, 27, 29, 30, 33, 35, 37, 38, 39, and 40. Sampling would be performed twice a month from May 1 through October 15 and once in January.

There are currently twenty-four monitoring stations in Pleasant Bay. Based on the analysis detailed in in Section 8.1, these station locations seem adequate for assessing overall water quality in Pleasant Bay. In addition, the stations in Orleans where different water quality parameters do not show consistent trends are recommended for further evaluation and may require additional stations in Pleasant Bay.

In addition to data collection and laboratory analysis of samples, a data analysis report should continue to be completed annually. Data evaluation should include sorting of DIN and PON concentrations by temperature, as well as pigment assessments based on Chl-a only.

To the extent that data values include data outliers, a discussion of these outliers should be included in these reports.

9.2.2 Additional Future Studies Recommended

One explanation for reductions in DIN that are shown in the Pleasant Bay data sets is that DIN is being assimilated into macroalgae. Macroalgae consume DIN but releases PON. Because pigments seem to be decreasing as DIN increases in some sub-embayments, macroalgae should be surveyed and quantified as a possible sink for DIN and a source of PON. Because taxa respond differently, identifying macrophyte (macroalgae and eelgrass) species can help evaluate changes in nitrogen regimes. Macroalgae may be impacting the nitrogen budget in ways that would otherwise seem contradictory by looking at water quality parameters alone. Therefore, water sampling should be supplemented with an assessment of macrophytes in the water column, as well as in bottom sediments in the following locations in Pleasant Bay and Nauset Harbor:

- LPB Near Quanset (Big Bay NE);
- Pochet Mouth;
- Meetinghouse Pond;
- The River at Rattles Dock;
- Kescayo Gansett Pond (Lonnie's);
- Paw Wah Pond; and
- Pochet Upper.

In addition, a baseline benthic assessment that includes both nutrient flux and infauna surveys should be completed for Pleasant Bay and Nauset Harbor. This will provide a baseline benthic habitat assessment that will aid in assessing overall ecosystem health and improvements after Nitrogen reduction methods have been implemented.

Data from Pleasant Bay that was summarized in TM-AMP-BM shows that since the breach in 2007, DON has been decreasing at a significantly lower rate than before the break (Cadmus Group 2015). Based on the Waquoit Bay study there is reason to believe that contributions to Pleasant Bay from atmospheric sources were higher in previous years and have continued to decrease since 2007 (Valiela and Lloret, in press).

Contributions from the decay of organisms may be contributing to the overall DON pool. This would explain the slower rate of DON decrease in the system. If this is the case, it is a significant problem for the health of the Pleasant Bay ecosystem. Because DON is a major contributor to the total nitrogen that stimulates biological activity, this hypothesis should be confirmed.

The study would entail a review of the literature and analysis of historical data from air quality stations in the area to confirm reductions in atmospheric deposition over time.

9.2.3 Responsible Parties and Next Steps

The main water quality monitoring efforts in Orleans are currently coordinated by the Orleans Marine and Freshwater Quality Task Force (OWQTF) and the Pleasant Bay Alliance (Alliance). The Alliance coordinates a comprehensive water quality monitoring program for Pleasant Bay. Volunteers currently collect samples for 24 stations, although the total number of stations has varied over the years ranging from 20 to 34. SMAST analyzes these samples and provides annual data sets. Every five years, the Pleasant Bay Alliance also commissions an evaluation of this data.

The OWQTF organizes water quality sampling for the Nauset Harbor watershed and the Orleans portion of Pleasant Bay. Volunteers collect samples from three monitoring stations and the SMAST analyzes these samples and provides annual data sets. Historic data sets for the Nauset Harbor watershed are managed by the Town of Orleans planning department as separate Excel spreadsheets for the 2003 through 2014 data.

9.3 Water Quality Monitoring for Demonstration Projects

The main purpose of TM 4.c.3 *Final Technical Memorandum for Non-Traditional Technology Performance Analysis* (Appendix U) is to present a systematic program for monitoring three Non-Traditional water improvement technologies: Shellfish, Floating Constructed Wetlands (FCW), and Permeable Reactive Barriers (PRBs) in ponds and estuaries in the Town of Orleans. The monitoring plans are also discussed in sections 7.1.7, 7.2.5, and 7.3.4, and in the TMs for engineering pertaining to each of the Non-Traditional technologies Preliminary Engineering Design and Work Plan for Preferred Sites which are found in Appendices N, P and R.

9.4 MEP Study Update Monitoring

The original MEP model was set up, calibrated and verified using field data from 2001 through 2004. To accurately represent the impacts of nitrogen removal from different sub-embayments of the main estuarine systems in Orleans, the model should be based on current conditions. The purpose of the TM (Appendix V) is to confirm that the data that was consolidated and documented during baseline data consolidation is applicable to updating the existing MEP model. Additional data that is required for the model to be parameterized, calibrated and verified are also identified.

9.4.1 Data Setup and Requirements

The MEP model setup and requirements are discussed in detail in the TM (Appendix V).

To revise the hydrodynamic model (RMA-2) for Nauset Harbor and Pleasant Bay, there are a number of assessments required to enable recalibration. An updated bathymetric survey and tide gauge measurements are needed because the inlet conditions that established the model's grid and boundary conditions (respectively) have changed. Three surveys that include these parameters have been completed recently for Nauset Harbor and Pleasant Bay as noted:

- Dredging study of Nauset Harbor (Woods Hole Group, 2015, report pending);
- Sidescan sonar for bathymetry in Pleasant Bay and Nauset Harbor (Center for Coastal Studies/Cape Cod National Seashore, 2014 – 2015, report pending); and
- Tide monitoring including time series monitoring of the flood tide cycle at the Nauset inlet (SMAST report pending).

These data should be sufficient for generating an updated grid and boundary condition specification, but may need to be supplemented with updated tide gauge data at inland stations to recalibrate this model.

For the water quality model (RMA-4), it is expected that updated total nitrogen and salinity measurements from the 34 Pleasant Bay monitoring stations as well as the ocean reference station will be adequate for calibration and verification. In Nauset Harbor, only three of the 15 stations used for model calibration and verification have current data. Therefore, to calibrate this model, three years of data from ten additional monitoring stations are recommended. Updated values for the nitrogen concentration in the ocean reference station should also be used when the model is re-run.

MEP uses 26.25 mg N/l, and 90 percent of actual water usage from town records to predict the mass of nitrogen entering an estuary from an average single family residential property. To enable MEP model runs to more accurately verify the results of the amended Comprehensive Wastewater Management Plan (CWMP), updated water use records and land use information should be used in order to revise the nitrogen load data for input to RMA-4. In addition, the concentration of TN below the soil absorption systems of a statistically significant number of septic systems should be measured. This will validate the foundational assumption that is used to calculate the nitrogen load input to RMA-4.

9.4.2 Recommended Plan

To update the MEP model for Pleasant Bay and Nauset Harbor, the first step is to prepare a Scope of Work with SMAST. The following specific items must be confirmed as being needed:

- Adequacy of recently-completed bathymetric and tide surveys in Pleasant Bay and Town Cove;
- Number and locations of monitoring stations needed in Nauset Harbor;
- Number of years of data needed from additional monitoring stations in Nauset Harbor;
- Need and locations of additional stations to acquire tide data on elevation, velocity and ranges;
- Updated watershed boundaries and land use (collected for amendment of CWMP); and
- Advisability of revising the assumption used for septic nitrogen load value.

9.5 MEP Model Update and Implementation Analysis

TM 4.e.7 and 8 *Final Technical Memorandum on MEP Model Update and Implementation Analysis* (Appendix W) discuss the MEP model and a proposed update. In order to coordinate the MEP model update two workshops were held on April 1, 2016 and April 11, 2016. The purpose of the TMs is to document the results of these workshops and provide an integrated work plan for monitoring, modeling and the analytical services needed to support the implementation of the Orleans water quality and wastewater program for the next 5 years.

Workshop agendas and a list of attendees are provided in Appendix A of the TM (Appendix W). The April 1, 2016 schedule included an overview of Orleans's water quality and wastewater planning program, and presentations on the broad range of water quality monitoring programs in Orleans. Representatives from the Orleans BOS, Town Staff, OWQTF, OWQAP, Pleasant Bay Alliance (PBA), AECOM and the UMass SMAST presented details of their monitoring programs. Appendix B of the TM provides copies of the PowerPoint presentations that were made. Discussion followed each presentation to address the following questions:

- Are modifications to existing monitoring programs needed?
- Is additional information needed to supplement current programs?

Prior to the second workshop, a summary of the recommendations from the first workshop was provided to attendees. These "key takeaways" are included as Appendix C to the TM. The second workshop provided time to thoroughly review these recommendations in order to finalize a list of action items and responsible parties. Action items included: the use of volunteers for data collection; continuation of the protocols, frequency and methods currently used for water quality sampling; water quality data base consolidation; Pleasant Bay MEP report (and linked model) update; Nauset Harbor MEP report update; Rock Harbor Creek water quality standards need evaluation; Namskaket Marsh watershed management plan, Cedar Pond Environmental Impact Report (EIR) preparation and continuation of monitoring; and preparation of a freshwater ponds management plan.

In addition, it was determined that SMAST would provide a detailed Scope of Work (SOW), schedule and budget for all analytical work required to continue water quality monitoring in Orleans as well as update the MEP Reports for Pleasant Bay and Nauset Harbor. The following specific items were identified as necessary to include in the SMAST SOW:

- Revision of the assumption used for septic nitrogen load value as part of updating the land and water use analysis;
- Update of watershed boundaries and land use (using data that was collected for amendment of CWMP);
- Adequacy of recently-completed bathymetric and tide surveys in Pleasant Bay and Town Cove from Cape Cod National Seashore/ Provincetown Center for Coastal Studies (CCNS/PCCS);
- Number and locations of monitoring stations needed in Nauset Harbor;
- Number of years of data needed from additional monitoring stations in Nauset Harbor; and
- Need and locations of additional stations to acquire tide data on elevation, velocity and ranges.

9.6 Stormwater and Fertilizer Monitoring

The Town has taken a proactive approach to implementing stormwater and fertilizer management for water resources protection as summarized in the TM in Appendix X. Two separate consultants are currently providing evaluations related to stormwater and fertilizer, including GHD, Inc., and AMEC Foster Wheeler. Both are expected to provide final deliverables by the end of 2016. In addition, Orleans submitted a NPDES Phase II Small MS4 General Permit Annual Report to the Environmental Protection Agency in April 2016, included as Appendix A to the TM (Appendix X).

9.6.1 Stormwater

The annual NPDES report states that the Town has been evaluating program needs based on the draft 2014 Phase II Permit (which has since been issued in final form) and using these evaluations and other activities (e.g., Comprehensive Wastewater Management Plan and BMP projects) to develop a Stormwater Management Plan (SWMP). The following key stormwater management planning activities were listed in this annual report:

- Detailed mapping of the downtown area was conducted by SMC Engineering, Inc. to identify all municipal infrastructure with an emphasis on drainage and other utilities. This effort was coordinated with Greenseal Environmental, Inc. to complete the mapping of drainage systems through the remainder of the Town. The result of these efforts will be a field verified drainage map that identifies each structure, pipe and existing stormwater BMP. The mapping effort is substantially complete and will be finalized in the summer of 2016.

- As part of the 208 Plan Update for Cape Cod, the Town is required to establish watershed management teams. The Town began evaluating teams for specific waters to meet the requirements of the 208 Plan approval. The results of the above efforts are being incorporated into a stormwater pollutant load analysis and dynamic planning tool by Amec Foster Wheeler and will provide the following information: baseline stormwater pollutant loads; analysis of existing stormwater BMPs and benefits; prioritization of stormwater management basins (watersheds); and an evaluation of proposed BMPs, benefits and costs. This effort is anticipated to be completed by the fall of 2016. This information will be used as the basis for future capital projects to design and install stormwater BMPs for water quality improvement.

- There were several stormwater and water quality improvement projects designed:

    - Eldridge Playground Improvement Project – tree plantings and improvements were completed in April 2016 to infiltrate stormwater from the tennis courts;

    - Rock Harbor Dredging – completed in spring 2015;

    - Rock Harbor Parking Lot – stormwater improvement BMPs were designed and construction will be completed in early 2017;

    - Portanimicut Road – design began for stormwater improvements (infiltration and erosion control) to be constructed in 2016;

    - Gibson Road – outfall improvements (infiltration) are under design for the direct discharge to Town Cove;

    - BMP Database – the Town began efforts to complete a comprehensive assessment of all stormwater BMPs (approx. 35) in Town to develop an operation and maintenance plan. This effort is anticipated to be completed by fall 2016;

    - Water Quality Monitoring – ongoing water quality monitoring was conducted throughout Year 13 at the creeks that enter Cape Cod Bay, Pleasant Bay (21 locations), and Nauset Bay (3 locations). The Town also increased funding for 2016 to include additional monitoring locations in Nauset Bay to support the Massachusetts Estuary Program (MEP) update; and

    - Rock Harbor Road – design began for multiple locations to provide stormwater treatment (infiltration) for direct outfalls.

The above efforts are reviewed on an ongoing basis by the Stormwater Team, which consists of the DPW and Natural Resources Director, DPW Manager, Town Planner, Health Agent, Conservation Officer and the Chairperson of the Marine and Freshwater Quality Task Force.

9.6.2 Fertilizer Program

In addition to the efforts to reduce nitrogen loading from stormwater, the Town of Orleans continues to implement BMPs to reduce the use of fertilizers and pesticides. The Pleasant Bay Alliance developed a fertilizer and pesticide use policy for municipal properties in April 2012. The Town developed a Fertilizer Nitrogen Control bylaw that passed at the 2014 Annual Town Meeting. The purpose of the bylaw is to restrict the use of nitrogen based fertilizers throughout Town and it includes the following provisions: no application of nitrogen between October 16 and April 14; no application before or during heavy rain; and no application within 100 feet of Resource Areas protected under the Massachusetts Wetlands Protection Act and Orleans Wetland By-law. In support of these efforts, the Orleans Pond Coalition maintained a robust public education campaign in Year 13 to inform residents and businesses about the proper use of and alternatives to fertilizers. Brochures regarding proper fertilizer and pesticide use are available at the Town Hall. Orleans is one of four Massachusetts towns to have such a bylaw (the others are Falmouth, Mashpee and Nantucket)

9.6.3 Information Relevant to Adaptive Management Plan

Because these programs are scheduled for completion at the end of 2016, and Technical Memoranda have not yet been submitted to the Town, there is no new information on the nutrient -removal attributed to stormwater BMPs or fertilizer reduction available at this time.

10.0 Financial Evaluation

The goal of the Financial Evaluation task of the Town of Orleans Water Quality and Wastewater Planning project is to modify the financial model that was completed in FY15 to provide an updated model with greater functionality. The model has been updated to provide greater definition of revenue generating options, financing options, and program costs, to allow for an evaluation of impact on the residents and businesses of Orleans. The update also included a preliminary evaluation of the feasibility of a public/private partnership which would allow private developers to finance a portion of the wastewater management system. The Financial Evaluation task work is summarized in the following Technical Memoranda:

- Revenue Generating Options;
- Financing Options;
- Financial Model Update – Preliminary Analysis;
- Program Cost Impact and Affordability Assessment; and
- Public Private Partnership Options.

Highlights from these Technical Memoranda are provided below; the complete documents are located in Appendix ##.

10.1 Revenue Generating Options

Traditionally, wastewater programs have been funded by property taxes, betterments or other special assessments, connection fees, and user fees. Recently, the financing of wastewater and stormwater management programs has been funded by other sources including but not limited to regional or local options taxes (for example meals and/or lodging taxes), the water infrastructure fund which is a real estate tax surcharge generating additional tax revenue outside of Proposition 2 ½, septage revenues, and stormwater utility fees.

Attempts are also made by communities to offset charges through grants such as US Department of Agriculture (USDA), US Economic Development Agency (EDA), and Housing and Urban Development (HUD) block grants and EPA 319 Grants. In addition, there are opportunities to reduce costs of a program through alternative procurement methods such as design/build or design-build-operate or through a public private partnership in which private equity is introduced into a project. The Town of Orleans evaluated all of these options which are discussed in greater detail in the Final Technical Memorandum on Revenue Generating Options.

Orleans considered several key factors in looking at sources of revenue: equitable allocation of cost based on the watershed benefitting from the wastewater management method, and customer or user group (both residential and non-residential, and year-round customer versus seasonal or short-term visitor). The financial model was developed with the flexibility to handle a variety of revenue requirements so that the Town could evaluate implications for total costs and impacts to Town businesses and residents. The model includes seven scenarios that contain different combinations of Revenue Generating Options and allows comparison among them.

The revenue options evaluated in the model include:

- Special Assessments – The Town intends to rely on special assessments to recover most, if not all, of the project's capital and financing costs.

- Property Taxes – The Town intends to rely on special assessments to recover most, if not all, of the project's capital and financing costs, but may turn to an increase in property taxes if it chooses to split the funding of capital costs between special assessments and property taxes.

- Connection Charges – The Town does not intend to rely on connection charges to fund capital costs. Instead, the Town seeks to fund capital and financing costs via special assessments and/or property taxes.

- User Fees – The Town expects to rely on user fees to fund operating, maintenance, replacement, and monitoring costs, on an annual basis.

- Grants (or Principal Forgiveness) – The Town continues to seek revenue opportunities to help with the funding of the capital costs. The Town will consider all grant possibilities.

- Septage Revenue – The Town is interested in constructing the downtown plant such that it is a septage-processing facility. The Town can expect about $580,000 in annual septage revenue if it constructs such a facility. Constructing the facility to handle septage costs about $500,000 more than not constructing it to handle septage and the facility would require about $200,000 more in operating and maintenance costs. However, the Town could expect approximately $350,000 net revenue if it were to construct a septage-processing facility in the downtown area.

- Design/Build – The Town could realize 21 percent savings in capital costs related to the wastewater treatment facilities if it were to construct them as design/build projects.

- Design/Build/Operate – In addition to savings on capital costs with a design/build project, the Town could realize 7 percent savings in operating and maintenance costs related to the plants if it were to operate them as design/build/operate projects.

- Local Option Taxes – The Town is considering increases in existing local option taxes in order to bring in more revenue. An increase in the local option tax is an appealing option for the Town since it is the only revenue option listed here that brings in revenue from people that do not own property in Orleans, like seasonal and daily visitors.

- Public-Private Partnerships – The Town is considering capitalizing on an opportunity to work with private businesses to build a treatment facility in the Downtown. This opportunity would lessen the burden of capital and financing costs on the Town. There are several forms such a private-public partnership could take, and these are discussed in greater detail below and also in Technical Memorandum on Public-Private Partnership Options.

10.2 Evaluation of SRF and Other Financing Options

The Financing evaluation considers financing available through the Massachusetts' Clean Water State Revolving Fund (CWSRF) program and USDA and conventional financing. The State Revolving Fund (SRF) Program is the financial assistance program for water pollution abatement projects authorized under M.G.L. c21, S 27A and the Clean Water Act, including the Water Pollution Abatement Revolving Loan Program. Each of these programs is described in detail in the Final Technical Memorandum on Evaluation of SRF and Other Financing Options, provided in the Appendix.

SRF financing includes an origination fee and administrative fees, but typically allows towns to finance projects at interest rates lower than those with conventional financing. Under the SRF program, certain nutrient management projects may receive an enhanced state-financed subsidy on the Interest rate.

The Town may receive:

- 0 percent financing on certain nutrient-management projects over a 20-year period;
- 2 percent financing on non-nutrient-management projects over a 20-year period; and
- 2.4 percent financing on non-nutrient-management projects over a 30-year period.

A nutrient-removal project is defined as a water pollution abatement project undertaken by the Town primarily to remediate or prevent nutrient enrichment of a surface water body or a source of water supply to comply with effluent limitations established under a NPDES permit or an EPA-approved TMDL or to otherwise implement a nutrient-management plan approved by Massachusetts Department of Environmental Protection (MassDEP). Nutrient-removal projects include those portions of such projects approved by the MassDEP as reasonably necessary for cost-effective nutrient removal or recovery, and as evidenced by the Town's Comprehensive Water Resource Management Plan or a corresponding engineering report. Specifically, projects that meet the following criteria are eligible for 0 percent SRF financing:

- The project is primarily intended to remediate or prevent nutrient enrichment of a surface water body or a source of water supply;
- The applicant is not currently subject, due to a violation of a nutrient-related total maximum daily load standard or other nutrient based standard, to a MassDEP enforcement order, administrative consent order or unilateral administrative order, enforcement action by the United States Environmental Protection Agency or subject to a state or federal court order relative to the proposed project;
- The applicant has a Comprehensive Wastewater Management Plan (CWMP) approved pursuant to regulations adopted by MassDEP;
- The project has been deemed consistent with the regional water resources management plans if one exists; and
- The applicant has adopted land use controls, subject to the review and approval of MassDEP in consultation with the Department of Housing and Economic Development and, where applicable, any regional land use regulatory entity, intended to limit wastewater flows to the amount authorized under the land use controls that were in effect on the date the Secretary of the Executive Office of Energy and Environmental Affairs issued a certificate for the CWMP

pursuant to the Massachusetts Environmental Policy Act, M.G.L. c. 30, §§ 61-62H, and the MEPA regulations at 301 CMR 11.00. The Town of Orleans meets all the criteria to be eligible for 0 percent SRF Financing.

The other financing mechanisms evaluated include Conventional Financing and USDA Financing. The updated financial model allows flexibility to users to create scenarios based on the most appropriate financing tool for the type of activity (planning, design or construction) and based on the desired borrowing term. The financing options identified include both short-and long-term financing. Both Conventional and SRF Financing are believed to be appropriate tools for traditional sewering as well as the non-traditional technologies. All phases of planning through construction are eligible for conventional financing, however, SRF only considers planning and construction costs as eligible costs.

10.3 Final Financial Model Update – Preliminary Analysis

The model does contain seven program cost scenarios that are displayed in an easy-to-compare format. The model shows the different financing options and costs offsets (for example, grants) for each scenario, which are identified as "Cases", as well as the total program costs for each. Since costs for each scenario are easy to compare to those for other scenarios, it is straightforward to assess the impact different financing options and different costs offsets have on program costs. The updated Financial Model allows the user to generate borrowing schedules. The capital costs of the various elements of the program are input into the model, and multiple borrowings can be identified as needed. Having this ability has given the Town a tool to determine the combination of financing options, costs offsets, and revenue options most beneficial to the Town's ability to finance the program

The new financial model has the ability to present program costs in two ways: (1) total program costs together as if the entire program were completed in the first year; and (2) program costs subject to phasing over a 20-year period. Both ways of presenting the costs are summarized below. However, for the purpose of this summary of a phasing option, only costs tied to one year are shown; the year presented is Year 4, when the Downtown Area wastewater treatment facility is proposed to come online. Program costs shown are depicted as annual costs and include capital, financing, operating and maintenance, replacement, and monitoring costs.

10.4 Program Cost Case Summary

A summary of the Total Equivalent Annual Cost for each of the cases is presented in Table 1 below.

Table 1 - Total Equivalent Annual Cost Case Summary

Case	Description	All in Year One Scenario	Phasing Scenario
1	Conventional Financing; 20-year term; 4 percent interest rate	$12,555,346	$6,247,824
2	SRF Financing; 20-year term; 0 percent interest rate	$10,469,068	$5,181,138
3	Same financing option as Case 2; plus septage	$10,694,650	$5,410,638
4	Same financing option and costs offset as Case 3 since costs are the same	$10,694,650	$5,410,638
5	Same financing option and costs offset as Cases 3 and 4; plus a grant at 90 percent of the program's capital costs	$5,829,016	$2,866,389
6	SRF Financing; 30-year term; 0 percent interest rate; plus a grant at 25 percent of the program's capital costs; savings on wastewater treatment facility capital costs at 21 percent for design/build; savings on operating and maintenance costs at 7 percent for design/build/operate; and savings on annual costs in the form of 5 percent local options taxes	$8,395,343	$2,933,888
7	Same financing option and costs offsets as Case 6; Meetinghouse Pond wastewater treatment facility capital costs funded by grant	$8,195,073	$4,137,555

10.5 Background and Framework for Assessing Affordability

Background and baseline information on the affordability of the Orleans water quality and wastewater management program was compiled to provide a foundation for more detailed evaluation of the impacts on residents and businesses. The United States Environmental Protection Agency (EPA) guidance on financial capability and affordability is used as one tool to conduct the analysis because it provides recognized benchmarks for community financial health and residential affordability. The EPA guidance does not address non-residential affordability; thus a separate discussion is provided to begin the discussion of the potential cost to the non-residential users in the Downtown. Wastewater management costs and wastewater management user charges in several other communities on the Cape that are also undertaking water quality and wastewater management programs are provided for information purposes. Direct comparison among communities is difficult because the communities may or may not include property tax charges, connection costs, or other charges in the annual user fees they report. The comparison is informative, although differences in the various elements and size of programs must be recognized. It is important to note that the costs of the Orleans program are still at a planning level at this time.

This assessment provides a preliminary insight into the ability of Orleans to pay for the water quality and wastewater management program, but it will be refined as additional design information becomes available.

Baseline data show that while the Town has reasonably strong financial capability based on several of the EPA Financial Capability Criteria (debt, socioeconomic, and financial management indicators),the benchmark for the Residential Indicator (RI) at 2 percent of MHI ($58,235, 2010 ACS 5-year Estimate) would represent in excess of $1,100 per year, which is quite high. It is also important to note that the Town has a particularly large share of population over the age of 65 (41.2 percent compared to 14.4 percent for the State of Massachusetts according to recent Census data), many of whom may be on a fixed income and, thus, face even greater challenges in paying increased wastewater costs. The combination of the fairly strong Town Financial Condition and the anticipated heavy burden on the average residential household would result in an overall medium to high financial burden on residents of the Town, indicating that additional financial assistance and/or a longer program implementation are required.

Businesses and other non-residential users would be responsible to pay their fair share of the anticipated wastewater management costs. These non-residential users would pay any costs allocated through property taxes and would also pay for special assessment charges and annual user fees. Under several of the Cases, the costs of the downtown collection, treatment, and disposal system components of the project would be paid for solely by the downtown businesses.

For the purpose of establishing a baseline for evaluating affordability, the anticipated cost to maintain and/or replace their wastewater management systems was estimated. Restaurants and motels have higher annual water and wastewater use, while the retail stores and offices have lower annual flows. The historic average for all non-residential properties is 367 gpd and 433 gpd for all mixed use properties. The estimated current cost to maintain an on-site wastewater disposal system is approximately $6,300 per year, assuming that the non-residential establishment is required to pay approximately $200 to $400 for annual maintenance, $500 for each pump out (assumes an average of one pump out every month) and no financing costs.

All septic system owners face the inevitable need to replace their system at some point in time. The replacement cost of a conventional septic system (440 gallons) is estimated to be approximately $18,000, and $35,000 for an Innovative/Alternative Technology (I/A) system. The cost would be higher for larger systems that serve the various restaurants and motels in the Downtown Area.

It is important to note that if the Downtown Area is sewered in the future, there may be opportunities for both residences and businesses to change use or increase density of development on their properties, depending on revised zoning regulations approved by the Town. The changed uses and higher densities allowed under revised zoning may provide opportunities for greater revenue generation. The Planning Board is in the process of developing amendments to the zoning bylaw that would modify existing zoning, thereby allowing increased densities in certain parts of the downtown area.

Anticipated program costs and affordability considerations are presented in the Technical Memorandum Program Cost Impact and Affordability, dated June 30, 2016 and included in Appendix XX. Given the concerns about affordability of the program the Town is continuing to explore other types of financing and will look closely at the resulting costs to customers. As noted above, phasing the program would result in lower annual costs to customers although total program costs would increase due to the additional cost of financing over time. The costs presented in Table 1 represent phasing program implementation over a 20 year time period. The Town is now looking at extending the program over an even longer period, potentially 40 years. The Town is also actively investigating the potential for public private partnerships to introduce private equity into the program and potentially reduce costs to the public. These efforts are ongoing and are briefly described in the following section.

10.6 Public-Private Partnerships

The Town is also continuing to explore the feasibility of private-public partnerships with private entities. Numerous sources define the term P3 as "a long-term contract between a private party and a government entity, for providing a public asset or service, in which the private party bears significant risk and management responsibility, and remuneration is linked to performance" (PPP Knowledge Lab).

The primary use of P3 in water quality and wastewater planning is to introduce private equity and management structure into the construction and operation of the wastewater infrastructure, potentially reducing overall construction and operations costs, and thus the outlay of public dollars and associated financial burden to ratepayers. Private equity in water quality and wastewater programs has been demonstrated in many cases to reduce overall project costs due to lower labor costs (i.e. avoiding need to comply with Davis Bacon Act), to reduce costs due to more aggressive, professional management techniques (e.g. equipment inventory sharing) and to produce an expedited overall implementation schedule.

In addition to cost reduction, P3 has the potential benefit of reducing risk to the public entity by shifting some of the performance, construction, operation and compliance risks to the private entity. All risks must be evaluated closely when considering a P3 to confirm suitability for a particular application. P3s have the potential to be advantageous to the Town, but there are also potential disadvantages that the Town should be aware of. All the potential advantages and disadvantages need to be fully vetted with the Town and its technical, legal and financial representatives before any commitments are made. Specific advantages and disadvantages depend on the form the P3 would take and the specific terms and conditions of the contractual arrangement. The goal of the Town would be to eliminate or minimize risk through negotiated contract terms and conditions. As part of the P3 assessment, the Town is evaluating potential options for alternative delivery such as Design-Build (DB) and Design-Build-Operate (DBO). These delivery methods can result in substantial savings as compared to a traditional design-bid-build project. Capital cost savings can average 21 percent and O&M savings can be an additional 5-7 percent, based on data obtained from recent DB and DBO projects.

10.7 Conclusion

Efforts to further refine potential capital and O&M costs will be made over the next several months as additional design information becomes available. Additional sources of funding and alternative implementation schedules are also being investigated and will be incorporated into the model so that a more accurate assessment of affordability can be made.

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11.0 Regulatory Review and Coordination

11.1 Regulatory Review and Coordination

No formal MassDEP or MEPA review is required for the ACWMP, but coordination efforts with the CCC and informal coordination with MassDEP was conducted throughout the course of executing the current scope of work.

11.2 Cape Cod Commission

The DRI issued 10-13-2016 included several conditions. Many of these conditions require communication with the CCC on on-going efforts to design, plan and implement the CWMP. The CCC also wanted to be involved in the AMP process. These conditions have been met, as the CCC has been informed of and involved in the current scope of work.

Meetings were held with the OWQAP on (other dates) April 20, and May 15, 2016 where staff from the CCC were in attendance. The April 20th meeting included a discussion of the Consensus Plan and proposed revisions. The May 15th meeting discussion centered on moving forward with P3s, including the plan as well as financial implications.

Additional meetings held in Orleans included April 1 and 11, 2016 which covered the Adaptive Management Plan (AMP).

Additional informal meetings were held at the CCC on ###.

Additional DRI conditions include actions that will take place in the future, as the plan is implemented. No other conditions were applicable to the current level of action within the process, but will be addressed in the future.

One condition included in the DRI (WRC16) called for Orleans to consult with the Town of Brewster as part of the Namskaket Creek Monitoring requirements for the AMP and Ground Water Discharge Permit, and provide a draft and final GWDP application to the Town of Brewster. A hydrogeological site evaluation has been completed at a single potential GWD site, and has been sent to MassDEP indicating discharge to the Atlantic Ocean at the proposed flow amount, or if increased flow a portion might discharge to Pochet Neck. However, if plans for the discharge location change and there is to be any discharge to Namskaket, a copy of the GWDP will be forwarded to the Town of Brewster.

11.3 MassDEP

MassDEP staff were also in attendance at the AMP meetings help in Orleans on April 1 and 11, 2016. Additional informal meetings with MassDEP staff were held on (need dates).

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12.0 References

Cadmus Group. 2015. Pleasant Bay Alliance Water Quality Monitoring Program: Statistical Analysis of 2000-2014 Water Quality Monitoring Data. July 2015. 97 pp.

Dodkins, I and AF Mendzil. 2014. Enterprise Assist: Floating Treatment Wetlands (FTWs) in water treatment: Treatment efficiency and potential benefits of activated carbon. SEACAMS Swansea University. Prepared for FROG Environmental Ltd, Ban y Berlan, Llansadwrn, Llansadwrn, SA19 8 NA.

Hein, M, Pedersen, M, and Sand-Jensen, K., 1995. Size Dependent Nitrogen Uptake in Micro- and Macroalgae, Marine Ecology Progress Series, 118: 247-253

Howes, B., R. Samimy, D. Schlezinger, E. Eichner, Kelley, S, Ramsey, J and Detjens, P 2012. Massachusetts Estuaries Project: Linked Watershed-Embayment Approach to Determine Critical Nitrogen Loading Thresholds for the Nauset Harbor Embayment System Towns of Orleans and Eastham, Massachusetts. 188 pp.

Howes, B., R. Samimy, D. Schlezinger, E. Eichner, Kelley, S, Ramsey, J and Detjens, P, 2006. Massachusetts Estuaries Report: Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Thresholds for the Pleasant Bay System, Orleans, Chatham, Brewster and Harwich, Massachusetts

MT Environmental Restoration and GHD Inc., April 2015, Orleans landfill nitrate data evaluation report.

National Aquarium and Waterfront Partnership of Baltimore, Inc. 2011. Initial assessment of the habitat value, local water quality impacts and nutrient uptake potential of floating island wetlands in the Inner Harbor, Baltimore, MD. A report to the Maryland Department of the Environment. February 2011. 16 pp.

Valiela, I, and Lloret, J., Eutrophication of Cape Cod estuaries: Effect of Decadal Changes in Global-Driven Atmospheric and Local-Scale Wastewater Nutrient Loads, Ecosystems Center, Marine Biological Laboratory, Woods Hole MA 02543, USA (submitted for publication)

Vymazal, J. (2007). Removal of nutrients in various types of constructed wetlands. Science of the Total Environment, vol. 380, no. 1-3, p. 48-65.

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